SOCIO-ECONOMIC VULNERABILITY AND ADAPTIVE STRATEGIES TO ENVIRONMENTAL RISK: A CASE STUDY OF WATER SCARCITY IN AGRICULTURE

By

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THESIS

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DECLARATION

I hereby declare that the thesis entitled **"Socio-economic vulnerability and adaptive strategies to environmental risk: A case study of water scarcity in agriculture"** is a bonafide record of research work done by me during the course of research and that it has not been previously formed the basis for the award to me any degree, diploma, fellowship or other similar title, of any other University or Society.

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Introduction

Chapter – I

Introduction

The Intergovernmental Panel on Climate Change (IPCC), the apex global body dealing with climate change, had made clear that the evidence of warming of the climate system is unequivocal. Over the last century, there are empirical records of widespread increase in observed air and sea temperatures, sea-level rise, melting sea-ice and glaciers, and reduction of snow cover (Solomon *et al.*, 2007). According to the United Nations (2006), India is one among the nations which suffer acute water scarcity. As per IPCC analyses, India could suffer from outright water stress – annual availability of less than 1000 cubic meters per capita by 2025, and gross water availability could fall as much as 37 per cent by mid century. The average annual per capita availability of water as per 2001 was 1820 m^3 which will reduce to 1140m^3 in 2050. In the coming decades, food and water security will be affected in significant and highly uncertain ways. The impact of climate change on communities or sectors or individuals is decided by the extent of vulnerability of the communities.

The ordinary use of the word vulnerability refers to the capacity to be wounded, i.e., the degree to which a system is likely to experience harm due to exposure to a hazard (Turner *et al.*, 2003). Vulnerability is conceptualized in different ways by scholars from different knowledge domains, and even within the same domain. For instance, natural scientists and engineers tend to apply the term in a descriptive manner whereas social scientists tend to use it in the context of a specific explanatory model (O'Brien *et al.*, 2004a; Gow, 2005). The most prominent interpretations of vulnerability in the climate change context are contextual vulnerability and outcome vulnerability. Contextual vulnerability or internal social vulnerability is determined exclusively by internal characteristics of the vulnerable system or community that determine its propensity to harm for a wide range of hazards and is commonly used in social sciences. Outcome vulnerability or integrated cross-scale vulnerability represents an integrated vulnerability concept that combines information on potential climate impacts and on the socio-economic capacity to cope and adapt (O'Brien *et al.*, 2007; Fussel, 2007). It is commonly used in natural sciences.

The IPCC (2007) definition characterizes vulnerability to climate change as a function of a system's exposure and sensitivity to climatic stimuli and its capacity to adapt to their adverse effects, which corresponds to outcome vulnerability. Generally, vulnerability is seen as the outcome of a mixture of environmental, social, cultural, institutional and economic structures and processes related to poverty and health risk and not a phenomenon related to environmental risk only. Assessing vulnerability, therefore, requires an integrated assessment across a range of disciplinary spheres and scales requiring new geographical assessment tools and frameworks. The two commonly used approaches for measuring vulnerability are bottom-up or starting point approach and top-down or end point approach. In top-down or end point approach, the net or residual impact is calculated assuming either no adaptation or hypothetical adaptations where as the objective of the bottom-up analyses, is to document the ways in which communities are sensitive to changing conditions and the ways in which they currently deal with the changes, in order to identify needs and practical opportunities for future adaptation (Schroter *et al.*, 2005; Sutherland *et al.*, 2005; Smit and Wandel, 2006).

It has been a well established fact that vulnerability is a function of the magnitude of the risk, the sensitivity of the system to the risk and the ability to adapt. For instance a study conducted by O'Brein *et al.* (2004b) in India shows that the districts with the highest (or lowest) climate sensitivity under the scenario of climate change are not necessarily the most (or least) vulnerable. For example, most districts in southern Bihar have only medium sensitivity to climate change, yet are still highly vulnerable as the result of low adaptive capacity. By contrast, most districts in northern Punjab have very high sensitivity to climate change, yet are found to be only moderately vulnerable as the result of high adaptive capacity. Assessment of both adaptive capacity in combination with climate change sensitivity and exposure is thus crucial for differentiating relative vulnerability to climate change.

Adaptive capacity is considered as a process of adaptation to structural and/or incidental sources of environmental stress. It consists of distinct social, economic, technological, institutional and cultural adaptive mechanisms (Cardona, 2001). Social mechanisms include social networks of relatives and neighbours, livelihood diversification and savings. Technical mechanisms include technologies to manage drought (soil and water conservation practices). Institutional mechanisms consist of formal political – organizational structures and associated collective action to lessen vulnerability (access to productive assets or community micro-credit systems) and cultural mechanisms are perceptions and beliefs about the nature and avoidance of water stress.

The rural populations of developing countries for whom agricultural production is the primary source of direct and indirect employment and income will be the most affected due to agriculture's vulnerability to global change processes (Ringler, 2008). The impact may be varied, according to the social settings and adaptive capacity.

Management of potential risks of climate change necessitates scientific estimates of the level of potential damage, accommodating the adaptive mechanisms of the communities. The resource which are scarce, are to be allocated spatially and sectorally considering the relative vulnerability status. The study attempts to measure the vulnerability status taking the case of marginal communities who are exposed to a situation of severe water stress.

Kerala is known as a water rich region endorsed with high rainfall and large number of water bodies. But Rao *et al.* (2009) reported that the state is moving from wetness to dryness with in humid climates. Wayanad, one of the high-range districts of Kerala is traditionally known to be rich in water resources. But for the last 15 years, a decline in the annual monsoon rainfall was noticed in the district.

Among the 150 districts in India categorized as backward by the Planning Commission, Wayanad is the only one in Kerala. The social fabric of the district is distinctly different from the rest of Kerala, with the highest proportion of tribes, the low sex ratio and environmentally most fragile ecosystem (the highest proportion of geographical area under forests/ high gradient). The Gender Development Index and Human development Index for Wayanad is occupying the 12^{th} and 13^{th} position among 14 districts in Kerala. The district has a purely agricultural dependent economy. The district suffered severe economic and environmental shocks mainly from the sharp fall in prices of the major crops like black pepper and coffee, which was further aggravated by declining rainfall since the 1990's (Nair *et al.*, 2007) which in turn resulted in large number of farmer suicides. The change in climate in terms of extreme water stress along with the socio-economic backwardness has made the farming community of the district highly vulnerable. Simultaneously, the people try to adapt to these changes, within their constraints. This study tries to address this situation of environmental and economic risks, and farmer behaviour. The specific objectives are:-

1. To measure farmers' vulnerability to water stress in agriculture and its impact on household welfare
2. To identify and assess the relative influence of various factors on the level of vulnerability, and
3. To delineate the short term and long term adaptive strategies to water stress among farmers of different socioeconomic conditions.

Scope of the study

This is a pioneering study in Kerala to measure the vulnerability of farmers to water stress in agriculture, based on indicator based approach using primary data. The results of the study may help to streamline policies for evolving support mechanisms to farmers in the event of shocks due to environmental factors, depending upon their resilience, and the relative influence of factors that influence the level of risk. The study can help in developing and piloting a range of coping mechanisms for reducing vulnerability of farmers to future stress conditions. It helps in fine tuning and scientific validation of coping strategies currently adapted, which makes its social acceptance much easy. It can also aid to raise awareness on appropriate coping mechanisms and develop capacity of farmers, extension workers, community leaders and agro meteorologists to apply risk management techniques. This can support in assisting local communities in choosing appropriate coping mechanisms, thus improving resilience of farmers in vulnerable areas to climate change.

Limitations of the study

The present research work is a part of post graduate programme which has all the limitations of time, finance, mobility and other resources. The study was restricted to nine panchayats of Wayanad. So it may not be possible to generalize the findings of the study for the entire state and can only be taken as indicative in nature. Data was collected from farmers based on their memory and the chance of recall bias is high. In spite of these limitations, every effort was made by the researcher to carry out the study as systematic as possible.

Presentation of the thesis

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

Review of Literature

Chapter II

Review of Literature

A comprehensive review of the past studies is useful to formulate concepts, methodologies and tools of analysis for any research. In this chapter, an attempt has been made to review the important concepts, analytical tools and findings of the past studies relevant to the present study. The presentation is made under three major headings viz., climate change and water stress, vulnerability to water stress and adaptive capacity and strategies.

2.1 Climate change and water stress

There are growing volumes of literature dealing with the significant shifts in global weather pattern. Intergovernmental Panel on Climate Change (IPCC), which is the apex technical body to study the phenomena in detail, defines climate change as any change in climate over time, whether due to natural variability or as a result of human activity where as United Nations Framework Convention on Climate Change (UNFCC) defined it as a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods (Mirza *et al.*, 2003).

The social, economic and ecological impact of climate change is predicted, based on studies conducted across the globe under varying conditions. Munasinghe (1997) observed climate change as becoming the major concern to human society because of its potentially adverse impact worldwide, through its effect on different economic sectors. It poses significant threats to sustainable development in developing countries, which have fewer resources and are more vulnerable. Agricultural production is predicted to be naturally impacted by the shifts in mean climatic conditions and increases in climate variability (Lemmen and Warren, 2004; Sauchyn and Kulshreshtha, 2008; Tartleton and Ramsey, 2008).

The impact of climate change on rainfall pattern and water availability by various researchers world over, during the past 100 years shows that precipitation has decreased by 50 percent (Cepeda *et al.*, 2004) and a decrease in average precipitation is predicted by 30 percent by 2059 ((IPCC, 2007). It is expected that hydro-climatic variability would increase and summers are expected to be drier (Barrow, 2009; Sauchyn *et al.*, 2009). More frequent and prolonged droughts conditions are predicted (Downing, 1992; IPCC, 2001; Cepeda *et* *al.*, 2004; Souvignet *et al.*, 2008). Increase in temperature, inter-annual rainfall variability and enhanced moisture deficits would enhance stresses on crop production and could result in complete crop failure (Rosenzweig *et al.*, 2001; Boko *et al.*, 2007).

Agriculture plays a key role in poverty reduction and thereby economic development (Irz and Roe, 2000; World Bank, 2005). In-order to achieve the Millennium Development Goals (MDGs) of eradicating hunger and poverty, growth in the agricultural sector is very much essential. Climate change may further weaken attempts to mobilize the necessary water resources, due to observed reductions in rainfall in the lower tropical latitudes (Zhang *et al.*, 2007). The world likely is facing a water crisis with no hope for further expansion of large-scale irrigation. This emphasizes the need for water management in agriculture; not only to secure the water required for food production, but also to build resilience for coping with future water related risks and uncertainties.

Changes in climate and water could have severe implications for ecosystems, economic development and social well-being (Beniston, 2003; IPCC, 2007). Arid and semi arid regions are particularly vulnerable (Miller *et al.*, 1997; Sivakumar *et al.*, 2005). As changes in precipitation, evaporation, infiltration and runoff affect hydrologic processes, these drylands are expected to experience further decreases in moisture availability (Arnell and Liu, 2001; Mata and Campos, 2001). By 2080, additionally three billion people will experience significant decrease in water resources due to climate change (McCarthy *et al.*, 2001). This could have serious implications for water use, water management and livelihoods for the nearly 40 per cent of the world's people who inhabit dryland areas (IISD, 2003).

The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) in 2007 makes specific projection for Asian continent. By the middle of the 21st century, annual average river runoff and water availability are projected to decrease by 10–30 per cent relative to 1900–70 over some dry regions at mid-latitudes and in the dry tropics. Reduced water availability is also projected for regions supplied by melt water from glaciers and snow.

More than half of the world population is susceptible to drought every year. Among the Climate-Induced Natural Disasters (CINDs), drought is considered by many to be the most complex but least understood phenomenon affecting more people than by any other hazard (Hagman, 1984). In the coming decades, the extent of drought risk and vulnerability is expected to increase, irrespective of the changes in drought exposure mainly due to development pressure, population increase, and environmental degradation (ISDR, 2002).

According to the estimates of WHO (2003), 1.2 billion people lack access to safe and affordable water for their domestic use. As said by Rijsberman (2006) an individual is water insecure, when he does not have access to safe and affordable water to satisfy his or her needs for drinking, washing or their livelihoods. When a large number of people in an area are water insecure for a significant period of time, then we can call that area water scarce.

Falkenmark *et al.* (1989) proposed a water stress index, according to which an amount of 1700 m^3 of renewable water resources per capita per year is taken as the threshold, estimated on the basis of water requirements in the household, agricultural, industrial and energy sectors, and the needs of the environment. Countries whose renewable water supplies cannot sustain this figure are said to experience water stress. Raskin *et al.* (1997) presented water scarcity as the total annual withdrawals as a percent of available water resources, referred to as Water Resources Vulnerability Index. According to it, a country is said to be water scarce if annual withdrawals are between 20 and 40 per cent of annual supply, and severely water scarce if this figure exceeds 40 per cent.

Researches on global water scarcity analysis concluded that a large share of the world population – up to two-thirds – will be affected by water scarcity over the next several decades (Shiklomanov, 1991; Raskin *et al.*, 1997; Seckler *et al.*, 1998; Alcamo *et al.*, 1997; Vorosmarty *et al.*, 2000; Wallace, 2000; Wallace and Gregory, 2002). The most obvious conclusion from these analyses is that water will be scarce in areas with low rainfall and relatively high population density. Many countries in the arid areas of the world, particularly Central and West Asia and North Africa, are already close to, or below the 1000 m^3/capita/year threshold and no wonder this is the part of the world that is most obviously and definitely water scarce in the physical sense.

Yang *et al.* (2003), from an analysis of water availability, food imports and food security, concluded that there is a threshold of about 1500 m^3/capita/year below which a country's cereal imports become strongly inversely correlated with its renewable water resources. He predicted that Asian countries like India, Pakistan, Afghanistan and many countries of Africa will be having renewable water resources below the calculated threshold level by 2000 and some other Asian and South-African countries will be entering the water deficit situation list by 2030.

No economic sector consumes as much freshwater as agriculture, with an estimated $1300 m^3$ cap^{-1} $year^{-1}$ required to produce an adequate diet (Falkenmark and Rockstrom, 2004). Scenario analysis shows that approximately 7100 km^3 $year^{-1}$ are consumed globally to produce food, of which 5500 km^3 $year^{-1}$ are used in rainfed agriculture and 1600 km^3 $year^{-1}$ in irrigated agriculture (de Fraiture *et al.*, 2007). The analysis also describes large increases in the amount of water needed to produce food by 2050, ranging from 8500 to 11,000 km^3 $year^{-1}$, depending on assumptions regarding improvements in rainfed and irrigated agricultural systems.

Globally, 80 per cent of the agricultural land is rainfed which generate 65 to 70 per cent staple food but 70 per cent of the population inhabiting in these regions are poor due to low and variable productivity. India ranks first among the rainfed agricultural countries of the world in terms of both extent and value of produce. Rainfed agriculture is practiced in two-third of total cropped area of 162 million hectares (66 %). It supports 40 per cent of the India's population and contributes 44 per cent to the national food basket. The importance of rainfed agriculture is obvious from the fact that 55 per cent of rice, 91 per cent coarse grains, 90 per cent pulses, 85 per cent oilseeds and 65 per cent cotton are grown in rainfed areas (Yadav, 2009).

Kanwar (1999) has identified the various weather factors that affect the livelihood in rainfed region. The adverse meteorological conditions resulting in long dry spells and droughts, unseasonal rains and extended moisture stress periods, with no mechanisms for storing or conserving the surplus rain to use during the scarcity/ deficit periods, constitutes the major cause of low yields and heightened distress in rainfed regions. A decrease of one per cent standard deviation from the mean annual rainfall often leads to a complete loss of the crop in tropical regions (Rockstrom and Falkenmark, 2000). Dry spells (or monsoonal breaks), which usually involve 2–4 weeks of no rainfall during critical crop growth stages, causing partial or complete crop failures, often occur every cropping season.

There are several studies estimating the impact of water stress on agricultural production in various agro-climatic regions of India, both rainfed and irrigated. For instance, Narula and Bhadwal (2003) reported, based on their study in Lakhwar sub-basin, in Uttarakhand state, as highly sensitive to increased water stress due to climate change. The study projected a decrease of 20–30 per cent in total flows with monsoon rainfall likely to become less intense and more sporadic. The potential impacts of such changes could include reduced surface and ground water availability and decline in crop yield and decreased water quality.

Sivakumar *et al.* (2005) have reported that significant reductions in crop yield in Arid and Semi-Arid Tropics have always been attributed to abnormally low precipitation-induced drought rather than warming-induced increases in evapo-transpiration rate.

Future climate change scenario analysis by Boomiraj *et al.* (2010) in India, predicted the impact on mustard yields which are likely to reduce in both irrigated and rainfed conditions. These reductions have spatial variation in different mustard growing regions. Yield reduction by 2080 would be higher in eastern India (67 and 57%) followed by central India (48 and 14%) and northern India (40.3 and 21.4%). This was due to maximum temperature rise in eastern part of the country. In northern India, rainfed crop was found to be more susceptible to changing climate. Adaptation measures like late sowing and growing long-duration varieties would be helpful in preventing yield loss of irrigated mustard.

More than 60 per cent of coconut cultivation is rainfed and over 50 to 60 per cent yield loss in this condition is due to drought stress (Hebbar *et al.*, 2012). The impact of drought on nut yield can be seen up to four years after drought, with the maximum effect occurring about 13 months after the end of drought. The effect was greatest between the eighth and twelfth month after the drought. Annual rainfall and its distribution have greater influence on the nut production. Consecutive droughts in Coimbatore district (Tamil Nadu) reduced the coconut production by about 3 lakh nuts/ year for 4 years. Productivity loss was to the tune of about 3500 nuts/ha/year.

The physical impact of climate change induced factors on major crops in Kerala is reported by Rao *et al.* (2009) and Saseendran *et al.* (2000).

2.2 Vulnerability to water stress- concepts and approaches to measurement

The impact of climate change on communities or sectors or individuals, is decided by the extent of vulnerability of the communities. The thought of vulnerability emerged within development debates in the 1990s to assess the integrated nature of rural agricultural development challenges (Chambers, 1994) and has been widely applied to a range of climate-related issues. In the IPCC's Third Assessment Report, McCarthy *et al.* (2001) defined vulnerability as "the degree to which an environmental or social system is susceptible to or unable to cope with adverse effects of climate change, including climate variability and extremes". Furthermore, the vulnerability of a system to climate change may be characterised as a function of the exposure, sensitivity and adaptive capacity of the system. Exposure was defined by O'Brien *et al.* (2004a) as the degree of climate stress upon a particular unit of analysis; it may be represented as either long-term change in climate conditions, or by changes in climate variability, including the magnitude and frequency of extreme events. The characterisation of exposure in the vulnerability literature has often included the stressors as well as the entities under stress (Turner *et al.*, 2003). For instance, Polsky *et al.* (2007) argued that the characterisation of exposure should consider the intensity and frequency of exposure.

Sensitivity reflects the responsiveness of a given system to climatic stimuli, either positively or negatively, and may be influenced by the socioeconomic and ecological conditions of the system (IPCC, 2001).

Adaptive capacity is thought to be closely linked to livelihood asset ownership (Moser, 1998). This means that people who have more assets (financial, human, natural, physical and social) are generally considered to have a higher adaptive capacity and therefore less vulnerable. Adaptive capacity in the context of climate change has been defined by the IPCC (2007) as the capacity of a system to adjust to the changing climate in order to reduce potential damages and take advantage of associated opportunities.

Vulnerability to climate change does not manifest due to climate alone, but rather arises in the presence of multiple stressors, including social, political, environmental, cultural and institutional characteristics, exogenous and endogenous to the community (Belliveau *et al.*, 2006; Diaz, 2008). The role of multiple forces should be recognized, and an understanding of how these forces interact to produce vulnerability should be developed to have a better perception of vulnerability. Assessing vulnerability, therefore, requires an integrated assessment across a range of disciplinary spheres and scales requiring new geographical assessment tools and frameworks.

There are certain generic determinants of vulnerability including developmental factors that are likely to influence the vulnerability of a particular region or community even in diverse socioeconomic contexts. Thus, one of the key features of vulnerability is its dynamic nature that may change as a result of changes in the biophysical as well as the socioeconomic characteristics of a particular region (Adger and Kelly, 1999). Hence, vulnerability assessments should be ongoing processes in order to highlight the spatial and temporal scales of vulnerability of a region (Luers, 2005). Further, vulnerability is context-specific and what makes one region or community vulnerable may be different from another community (Brooks *et al.*, 2005).

There are mainly two approaches, top-down approach and bottom-up approach while considering the vulnerability assessment of a system. In top-down or starting at "end point" approaches, the net or residual impact is calculated with scenarios of future climate change models (typically temperature norms), physical and biological effects and sometimes estimating economic impacts, assuming either no adaptation or hypothetical adaptations. These top-down studies usually employed in the conventional climate change impacts, serve the central purpose of estimating impacts of specified changes in climate (Brooks, 2003; O'Brien *et al.*, 2004a; Fussel and Klein, 2006; Smit and Wandel, 2006; Polsky *et al.*, 2007). But they neither focus on the socio-economic systems' sensitivities, nor the processes by which these systems experience and deal with changes in conditions.

The vulnerability or "bottom-up" or "starting point" approach has a direct practical focus on adaptation. Its objective is to identify the climatic conditions to which a community is sensitive and it recognizes the role of other forces that interact with climate. It identifies the actual types of adaptive management that are operational and feasible in the community and what facilitates or constrains them, and it employs this characterization of the community's vulnerability as the basis for assessing both the risks and the adaptation prospects under a changing climate (Jones, 2001; Lim and Spanger-Siegfried, 2005; Smit and Wandel, 2006). It is very important in the vulnerability research that the stakeholders should start identify rather than assuming the attributes of a changing environment including climate that are important for the livelihoods and lives in the community, as well as the various other stresses and conditions that shape exposures, sensitivities and adaptive capacities (Fussel and Klein, 2006; Smit and Wandel, 2006). The empirical work on multiple stresses has identified combinations of social factors and environmental risks that describe vulnerability as it is evident at the level of communities (Bohle *et al.*, 1994; Adger, 1999; Handmer *et al.*, 1999; Ford and Smit, 2004).

Several scholars have attempted to holistically assess the vulnerability of communities or farming systems to climate change through a variety of approaches (Luers *et al.*, 2003; Turner *et al.*, 2003; Fraser, 2007; Simelton *et al.*, 2009). Some have applied quantitative crop modelling to identify whether harvests may decline or increase due to climate change (Lobell *et al.*, 2008; Challinor *et al.*, 2009). Challinor *et al.* (2010) used a crop model that simulates biophysical adaptive capacity, and added a socioeconomic vulnerability index to highlight socioeconomic adaptive capacity. But, crop models as vulnerability assessment tools are subjected to various limitations. For instance, the adaptations included in most crop models are hypothetical and often assume either "no adaptation" or "optimal adaptation" by farmers (Kandlikar and Risbey, 2000). However, these quantitative models offer useful communication and visual tools to policy makers by making complex scientific data more comprehensible (Fraser, 2006).

Another typical approach to quantify vulnerability is to define a set of proxy indicators (Luers *et al.*, 2003) and assess the vulnerability by estimating indices or averages for those selected indicators. Indicators are limited by lack of information on the choice of appropriate variables and the relative weights required for establishing a vulnerability index in a particular region. These limitations led Simelton *et al.* (2009) to use statistical tools and correlate crop drought vulnerability with socioeconomic indicators as a way of identifying the factors that make regions resilient or vulnerable to drought in China. This approach is useful in that it uses rainfall and harvest data to establish the characteristics of vulnerable and resilient cases. The limitation, however, is that this approach considers only two components of vulnerability (exposure and sensitivity) without fully capturing adaptive capacity. However, indicators are useful for monitoring and studying trends and exploring conceptual frameworks and are also applicable across different scales including household, district, regional and national (Gbetibouo *et al.*, 2010).

Different models have been evolved to assess vulnerability of a system. The Social Amplification of Risk Framework (SARF) developed by Kasperson *et al.* (1988) examines biophysical risks and the ways in which they may be amplified or attenuated depending on how they are generated, received, interpreted and communicated and it also examines the social qualities, values and institutions that may either trigger or hinder the experience or management of a risk. The "disaster pressure and release" model (Blaikie *et al.*, 1994) and the "hazards of place" model (Cutter, 1996) considered vulnerability as a combination of biophysical risk and the social characteristics that render a society cognizant of and susceptible and able to respond to that risk within a specific place, highlighting the location and context specificity of vulnerability. Kasemir *et al.* (2003) described a method where climate change integrated assessment model outputs were shared with citizen focus groups. According to them, the way the public understands and defines the issues becomes a complementary input to the scientific assessment and ultimately the policymaking process. In the same year, Turner *et al.* employed the framework of "coupled human environment systems" to explain the multiple and complex processes of vulnerability. Using the concepts of exposure, sensitivity and resilience, the model presents the linkages between human and physical systems, the stresses that emerge from these linkages, and the processes of vulnerability within these, distinguishing the multiple interacting forces that operate on local, regional and global scales. Initial models of vulnerability to environmental change focused on either the nature of the physical hazard or the inherent societal characteristics, where as recent models of vulnerability recognize the interaction of social and biophysical forces (Fussel, 2005; Adger, 2006; Evans *et al.*, 2006; Smit and Wandel, 2006).

Thus vulnerabilities to climate related and other stimuli should be documented from the perspectives of community members and then complimented with socioeconomic and biophysical data on the region to increase the usefulness of the implementing project (Ford and Smit, 2004; Belliveau *et al.*, 2006; Paavola and Adger, 2006; Young *et al.*, 2010).

The socio-economic factors that affect the vulnerability status were discussed by different authors. Poverty can lead to marginalisation and limit the amount of capital assets that may be needed to reduce the impacts of drought on livelihoods of farming communities (Adger and Kelly, 1999). Though poverty may not be directly equated with vulnerability, it constrains the capability of communities to cope with the impacts of drought (Sen, 1999). Moreover, poverty may compel people to live in environmentally fragile areas which could worsen their vulnerability to climate and other environmental changes. High poverty levels in these vulnerable regions will further inhibit the potential of poor farmers to manage the impacts of climate change (Morton, 2007). This is because the poor are confronted with other non-environmental shocks and stresses that place additional constraints on their limited assets to cope with the impacts of drought (Stringer *et al.*, 2009). According to Wandel *et al.* (2009), the implications of drought reflect the region's physical landscape, the existing human land- use system, and the human and financial capital of its occupants and thus a region's vulnerability to a persistent dry period is related not only to a deviation from hydrological norms but also to the human use of and reliance on water and the available coping mechanisms to manage periods of insufficient moisture.

A combination of factors may increase vulnerability or enhance resilience to stresses (the capacity to cope or respond to stress in different ways). Within the context of climate studies, the most vulnerable are considered to be those who are most exposed to perturbations, who possess a limited capacity for adaptation, and who are least resilient to recovery (Bohle *et al.*, 1994). Indeed, vulnerability is greatly influenced by the degree of development and socioeconomic status of a particular group or community (Ribot *et al.*, 1996). Various factors shape the differences in vulnerability of individuals or groups: entitlements, personal heterogeneity, variations in social obligations, environmental location, livelihood diversification strategies, support networks, empowerment or power relations, access to knowledge, information, and technology (Noronha, 2003).

Brugere and Lingard (2003) in their research on vulnerability assessment in Lower Bhavani Project (LBP) irrigation system in Tamil Nadu established by means of the deficit calculations that farmers who are at the tail of canals, where water supply was lower and more erratic are highly vulnerable in spite of their larger land ownership. This supports the assumption that access to a reliable water supply was crucial in sustaining livelihoods.

O'Brien *et al.* (2004b) described climate change vulnerability in India using the district-level index of adaptive capacity with climate sensitivity index under exposure. They assessed adaptive capacity by selecting significant biophysical, socioeconomic, and technological factors that influence agricultural production. The resulting climate vulnerability map represented current vulnerability to future climate change across districts. It is important to note that the districts with the highest (or lowest) climate sensitivity under the scenario of climate change used here are not necessarily the most (or least) vulnerable. For example, most districts in southern Bihar have only medium sensitivity to climate change, yet are still highly vulnerable to climate change as the result of low adaptive capacity. By contrast, most districts in northern Punjab have very high sensitivity to climate change, yet are found to be only moderately vulnerable as the result of high adaptive capacity. Assessment of both adaptive capacity in combination with climate change sensitivity and exposure is thus crucial for differentiating relative vulnerability to climate change.

Brouwer *et al.* (2006) in their research on vulnerability and adaptability assessment in one of the poorest and most flood prone countries in the World, Bangladesh, investigated the complex relationship between environmental risk, poverty and vulnerability. They concluded that, households with lower income and less access to productive natural assets face higher exposure to risk of flooding. Disparity in income and asset distribution at community level tends to be higher at higher risk exposure levels, implying that individually vulnerable households are also collectively more vulnerable. They also noted that the people that face the highest risk of flooding are the least well prepared, both in terms of household-level ex ante preparedness and community-level ex post flood relief.

Wandel *et al.* (2009) in their study on analysis of vulnerability and adaptation in Alberta's special areas found out that vulnerability was not experienced equally by all members of a community or residents of a region, even if they were subjected to the same climatic stress and it depends on the ways in which they rely on water and the means in which they secure water supplies. Dryland farmers were more exposed to the drought event than other producers, and town residents were merely inconvenienced. Even though the drought had harmful effects on soil moisture, dugouts and feed reserves and resulted in the outbreak of grasshopper as a major pest which destroyed the pastures, the farmers were far less vulnerable during the recent drought years compared to the previous drought years. This is mainly because of their higher adaptive capacity by attaining an additional income from oil and gas wells located on their owned or leased lands apart from farming and through strategic adaptations such as the construction of shallow pipelines or carrying greater feed reserves, growing drought resilient native prairie grass and adopting zero tillage to avoid wind erosion. Though adaptation occurs at individual levels, they are frequently facilitated by institutions.

The study by Young *et al.* (2010) on vulnerability in water resource use in Elqui Valley, Chile reflected multiple exposures as changing physical and socio-economic conditions in the community. A dominant risk to the community was rainfall abundance and intensity as this tends to trigger debris flows along the steep and unstable slopes. Surface water shortages were also found to be problematic for some sectors of the community. Goat herders and small landholders were severely affected. The agricultural companies, which rely on surface water, use highly efficient irrigation, purchase additional water rights, and have water storage systems to reduce their sensitivity to variations in supply. Potable water access has been a problem for the community during the summer months, due to a combination of high demand and slower recharge of the aquifer. There have been some adaptations to help cope with lack of accessibility, by keeping small reserves and subsidies and also by public education and some infrastructure adaptations.

Antwi-Agyei *et al.* (2011) in their study on mapping the vulnerability of crop production to drought in Ghana by a quantitative, multi-scale and multi-indicator analysis has identified the relative vulnerabilities of the various regions in Ghana. The spatially-explicit methodology is integrative in that it shows both the biophysical conditions of the farming regions by way of an exposure index and a crop yield sensitivity index by considering the socioeconomic conditions of the regions. The vulnerability to drought in Ghana is linked to the level of socioeconomic development and is spatially differentiated. This suggests the need for region and district specific climate adaptation policies, as different regions and districts within them display different levels of vulnerability. The farming communities in the most vulnerable regions (Northern, Upper East and Upper West) largely depend on rain-fed agriculture and thus, livelihood diversification strategies including nonfarm income sources should be vigorously pursued by policy makers in these regions.

Pittman *et al.* (2011) in their study of vulnerability to climate change in rural municipality of Rudy demonstrates that local contexts and processes and multiple stressors have major roles in shaping vulnerability to climate variability and change. The most significant and profound adaptation to climatic variability in the community has been the development of irrigation farming. Assuming sufficient water supplies exist to meet irrigation needs, dryland crop and livestock farmers will likely be more vulnerable to future drought than irrigated farms. The inability to organize and work together acted as a great barrier to adaptation even with the help of technology and infrastructure and hence adapting to economic, climatic and social conditions is still a challenge and unattained in certain cases.

Swain and Swain (2011) had assessed the nature of drought vulnerability to agricultural drought, coping capacity and risk in the Bolangir district in Orissa by using the indexing and vulnerability profile method and it was revealed that the three most influential biophysical factors of drought vulnerability are rainfall variability, drought intensity and shortage of water holding capacity of soil. Three most influential socioeconomic factors are low irrigation development, poor crop insurance coverage and smaller forest area. It was found that while drought risk varies widely across the study blocks and drought vulnerability and physical exposure to drought vary moderately, the coping capacity of study blocks differed marginally. However, the level of coping capacity has been found significantly lower than the level of drought risk and vulnerability. This implies that there is a need for strengthening the coping capacity for effectively dealing with drought risk that seems to be rising in the region. Further, the researchers also suggest different adaptive strategies.

2.3 Adaptive capacity and strategies

Adaptive capacity refers to a system's potential or ability to adjust to exposures in order to regulate damages, take advantage of opportunities or cope with effects (Smit *et al.*, 2000; Yohe and Tol, 2002; Fussel and Klein, 2006; Adger *et al.*, 2007). Adaptive capacity varies between countries, communities, among social groups and individuals, and over time. The adaptive capacity of a community is a dynamic function of local processes and conditions which, in turn, are influenced by broader socio economic and political processes. It is influenced by assets and access to resources such as economic wealth, technology, information, infrastructure, knowledge and skills, social capital and institutions (Watts and Bohle, 1993; Adger, 2003; Klein and Smith, 2003; Smit and Wandel, 2006). The level of vulnerability can be decreased by increasing the adaptive capacity.

Adaptations, or particular adjustments in a system to better cope with external stress, are manifestations of adaptive capacity. Adaptations to climate change are not just discrete technical measures, but are modifications to farm practices with respect to multiple climatic and non-climatic stimuli and conditions. It can take many forms, can occur at different scales, and can be undertaken by different agents (producers, agribusiness, industry organizations, and governments) (Bryant *et al.*, 2000). Anticipatory or reactive, autonomous or planned, local or widespread, and technological, behavioural, financial, institutional and/or informational are the different forms of adaptations (Smit *et al.*, 2000; Adger *et al.*, 2007).

Integrating adaptive strategies with sustainable development and livelihood initiatives is seen as a way to address immediate vulnerabilities and to improve the ability to deal with future exposures in light of climate change (Nelson *et al.*, 2002; IISD, 2003). Research on adaptation processes shows that modifications of existing resource management, risk management or sustainable development initiatives are the most common actions taken to adapt to environmental risks (Burton *et al.*, 2002; Davidson *et al.*, 2003; Huq and Reid, 2004; Smit and Wandel, 2006).

To date, the consideration of farmer responses and adaptations has been largely by assumption when the problem of water scarcity was addressed. The MINK study includes scenarios in which 'smart' farmers are assumed to adapt to the changed climate (Easterling *et al.*, 1992a). However, there has been very little analysis of how farmers actually respond, adapt, or adjust, to changed climatic conditions. A selection of assessment methodologies (Carter *et al.*, 1994) shows modelling, expert judgement, and qualitative estimates as the predominant methods, with only one empirical analysis listed.

However, the view that 'dumb farmer' assumption has to be replaced by the 'clairvoyant farmer' assumption (Smit, 1991), is widely accepted. Farmers are presumed to accurately perceive the future climatic conditions and adapt their farm types and production practices accordingly.

In vulnerability perspective, adaptation strategies are often considered as a process involving the socioeconomic and policy environments, producers' perceptions, and elements of decision-making (Luo and Lin, 1999). Vulnerability studies examine adaptive capacity and the factors that enhance or discourage it. The standard approach for identifying possible adaptation practices often referred to as the "scenario approach", begins with climate change scenarios (plausible future climate conditions) which, in turn is derived from General Circulation Models (GCMs) and focuses on estimated impacts (Wall *et al.*, 2004). This approach treats adaptations as mostly technical adjustments such as change in cropping pattern, choice of different crops, adopting efficient irrigation systems, or altering production systems to the impacts identified (Smit and Skinner, 2002; Wall and Smit, 2005). The adaptation options used are assumed by the researchers to be reasonable or logical strategies for managing climate risks.

Farm responses are frequently distinguished as two types, short-term decisions and longer-term decisions. Short-term decisions help to cope with or mitigate an impact, sometimes called 'adjustments' or tactical responses (Easterling *et al.*, 1992b; Burton *et al.*, 1993). Those which involve longer-term commitments, perhaps changing a feature of the farm operation, such as type of crop or livestock or management system, are called adaptations or strategic responses. These responses will result in observable changes in a farming system beyond a single season.

The results of the study conducted by Smit *et al.* (1996) suggested the need to review assumptions that farmers do not adapt to climatic variation or that seasonal production effects represent the essence of agricultural impacts. In this study, moisture appeared to be an important climatic attribute for farming, particularly the frequency of dry years. Farmers reporting more frequent, recent experience with dry years had a greater tendency to respond strategically. This study also illustrates that the role of climatic variations in prompting changes in agriculture cannot be understood without careful consideration of the role of other forces - economic, policy and environmental. These forces are inexorably intertwined with climatic forces such that it is very difficult to separate impacts or to assign independent stimuli for adaptations. This has implications for integrated regional impact studies. Certain non-climatic forces (economic or government policy) may magnify or moderate or nullify a climatic effect, and this may greatly influence the nature (or occurrence) of responses. There is a need for integrated assessments to identify, rather than simply assume, significant interactions among forces and responses.

For instance, Stoorvogel and Smaling (1990) reported the case of adaptation to water stress through investments in water management techniques. Management approaches aimed at capturing more water often lead to higher water productivity, as denser crop canopies shadow the soil and thus reduce soil evaporation (Rockstrom, 2003). Wani *et al.* (2003a) reported the case of higher sorghum and pigeon pea yield realized through improved water management techniques. Water management strategies can be followed by capturing more water and allowing it to infiltrate into the root zone; and by using the available water more efficiently i.e. increasing water productivity by increasing the plant water uptake capacity and/or reducing non-productive soil evaporation (Rockstrom *et al.*, 2010).

Water harvesting is suggested as an important technological adaptation strategy. It can be either in-situ water harvesting (the capture of local rainfall on farmland) or ex-situ water harvesting (the capture of rainfall that falls outside the farmland) (Oweis and Hachum, 2001). During the past 50 years, water management in rainfed agriculture mostly focused on soil and water conservation, or in-situ water harvesting which can be applied on any piece of land and is affordable to most smallholder farmers (Wani *et al.*, 2003b; Sreedevi *et al.*, 2004). Conservation agriculture is a common practice in in-situ water harvesting techniques that include a range of non-inversion cultivation systems; those that involve minimum disturbance of the soil by machines, such as ripping the soil where seeds will be planted, deep ripping the soil to break up hard or compacted layers (sub soiling), or using direct planting techniques (no-till). Examples from sub-Saharan Africa show that converting from ploughing to conservation agriculture results in yield improvements ranging between 20 per cent and 120 per cent, with water productivity improving from 10 per cent to 40 per cent (Rockstrom *et al.*, 2009). Any of these techniques when used in combination with mulching will build organic matter and improve soil structure which in turn reduces soil evaporation which constitutes to 50 per cent loss of rainfall (Rockstrom *et al.*, 2010).

Supplemental irrigation systems are ex-situ water harvesting systems, providing water during periods when rainfall is insufficient to provide essential soil moisture to secure a harvest. In such systems, water scheduling is not designed to meet the plant water requirements fully, but to provide capacity to bridge dry spells and, consequently, to reduce risks in rainfed agriculture. But, the feasibility of irrigation is also influenced by producers' willingness to irrigate (Kulshreshtha and Brown, 1993), the development of markets for higher valued crops, and the ability to generate the funds necessary for regional and on farm irrigation development. According to Oweis (1997), supplemental irrigation of 50–200 mm can bridge critical dry spells and stabilize yields in arid to dry sub-humid regions. The potential yield increase in supplemental irrigation varies with rainfall. An example from Syria illustrates that improvements in yields can be more than 400 per cent in arid regions. Several studies indicate that supplemental irrigation systems are affordable for small-scale farmers (Fan *et al.*, 2000; Fox *et al.*, 2005). On a regional basis, collecting small amounts of runoff using limited macro-catchments during the rainy season, using this resource for supplementary irrigation and adopting improved agronomic practices can improve agricultural production in rainfed areas (Pathak *et al.*, 2009).

A climatic water balance analysis of 225 dominant rainfed districts of India by Sharma *et al.* (2010) provided information on the possible surplus runoff during the year and the cropping season. On a potential (excluding very arid and wet areas) rainfed cropped area of 28.5 million ha, a surplus rainfall of 114 billion m^3 (Bm^3) was available for harvesting. Only a part of this amount of water is sufficient to provide one turn of supplementary irrigation of 100 mm depth to 20.65 Mha during drought years and 25.08 Mha during normal years. Water used in supplemental irrigation had the highest marginal productivity and increase in rainfed production above 12 per cent was achievable even under traditional practices. Under improved management, an average increase of 50 per cent in total production can be achieved with a single supplemental irrigation. Water harvesting and supplemental irrigation are economically viable at the national level. Net benefits improved by about threefold for rice, fourfold for pulses and six fold for oilseeds. Droughts have very mild impacts on productivity when farmers are equipped with supplemental irrigation.

Rockstrom *et al.* (2010) suggested that in rainfed agriculture, emphasis must be on securing water to bridge dry spells and to increase agricultural and water productivity through new technological water management options like Integrated Water Resource Management (IWRM) that encompasses both green and blue water resources from the catchment to basin scale, which can be facilitated through institutional and policy interventions. This must be done without decreasing resilience in agricultural landscapes.

The evidences suggest that water markets have developed on a very large scale in the recent years in South Asia mostly in a localized manner. These markets ofcourse have created certain issues related to sustainability, efficiency and equity. There are studies looking at the structure and determinants of these water markets (Kolavalli and Chicone, 1989; Dhawan, 1991; Shah, 1993; Satyasai *et al.*, 1997; Palanisami and Balasubramanian, 1998; Singh and Singh, 2006; Sharma and Sharma, 2006) especially that of ground water. Most of these studies are conducted in the arid/ semi arid regions of the country focusing on the ground water markets, showing high variation among respondent behaviour.

In a study identifying the coping strategies of people to water scarcity in Kolar District of Karnataka (Chandrakanth and Arun, 1997), it was seen that reducing area under seasonal water intensive crops was the important short run strategy. As a long run response they opted for drilling additional wells (with an average investment level of Rs.48370/-), automatic starter and competitive deepening of wells. These strategies in turn will surely result in a ground water market in favour of the rich.

Narain (2003) recommended a range of strategies to cope with water scarcity, which include improving their access to available water (e.g. make shift storages, digging deeper tube wells, exchanging irrigation time shares, buying groundwater), reducing their demand for water (e.g. switching to less water consumptive crops ,adopting more efficient irrigation practices, and altering dates for agricultural operations), coping with the adverse impacts of periodic drought (e.g. credit, sale of valuables and livestock, use of stored seeds and food grains) and diversifying their sources of livelihood (e.g. alternative employment opportunities, migration) which could be employed by households engaged in agriculture.

Kar and Kumar (2007) suggested rice straw mulch application as an adaptation strategy to reduce the soil moisture stress and regulate the soil temperature and found out that this increased the potato tuber production upto 24-42 per cent depending on the irrigation treatments. The crop evapo-transpiration was reduced with 77–103 mm when applying rice straw mulch at a rate of 6 t ha^{-1} in the various irrigation treatments. Water use efficiency for the mulched plots was 34.19 kg $ha^{-1}mm^{-1}$.

Water saving technologies like micro-irrigation technology is an important adaptation strategy. Seckler *et al.* (2003) and Narayanamoorthy (2004) examined the potential of drip irrigation to help solve the water scarcity crisis in India and concludes that there is an enormous potential. Molle and Turral (2004) analysed the potential for demand management to make water use sustainable at the basin level, but conclude that the potential is over-estimated.

Pereria *et al.* (2007) recommended different management practices for water under scarcity in irrigated agriculture like appropriate irrigation water management policies, supply management and demand management. Supply management aiming at higher reliability and flexibility of deliveries plays a major role in reducing the demand because, off farm decisions affect farm irrigation systems management and irrigation scheduling decisions. Waste water, saline water and other low quality water can be used for irrigation after appropriate treatment. Reduced demand can be achieved by adopting improving farm irrigation systems and deficit irrigation.

The survey in Lakhwar and Chhotau villages of Uttarakhand by Kelkar *et al.* (2008) revealed that current coping capacity of people in the region to climate variability and water stress is quite low and the types of responses to poor rainfall are only temporary. Selling assets or taking loans from traditional moneylenders, may actually increase their vulnerability over time by worsening impoverishment or indebtedness. Households are considerably dependent on low-value rainfed agriculture. Institutional capacity is also poor, particularly in terms of connectivity and the availability of formal credit, which constrains their ability to use their agricultural skills and assets more effectively. They also have limited human resources in terms of formal education or vocational skills, which limits their options in seeking off-farm employment opportunities.

A study on adaptive strategies followed by the paddy farmers of Kuttanad and Kole lands of Kerala by Susha (2011) revealed that the most common strategies followed were varietal selection, crop rotation, adjustments in planting time, income diversification and System of Rice Intensification (SRI). Researcher suggested some policy interventions like introduction of Weather based Crop Insurance and Agromet Advisory Services for better adaptation to climate change.

Social capital and the ability to work together have been found to have significant affects on adaptive capacity (Adger, 2003). Community-based watershed management and participatory planning has been explored as an adaptation strategy for agriculture with significant benefits (Neudoerffer and Waltner-Toews, 2007; IACC, 2009a; 2009b)

Appropriate policy needs are to be formulated for adapting to increasing vulnerability and a precautionary approach at different levels is essential, because the benefit of risk management is larger than the cost of repeated crisis management (Anderson, 1990; Dzeiegielewski, 2000), which in turn, brings much more stability to diversified livelihood systems and puts the rural economy on an upward trajectory.

Materials And Methods

Chapter III

Materials and Methods

A proper research design is essential to evaluate systematically the research objectives. The design of the study is an important component of the research process. In order to conduct a study and to fulfil the objectives, a prescribed methodology should be followed. This chapter deals with the methodology used for the present study including the details of study area, collection of data and the different tools for analysis.

3.1 The Study Area

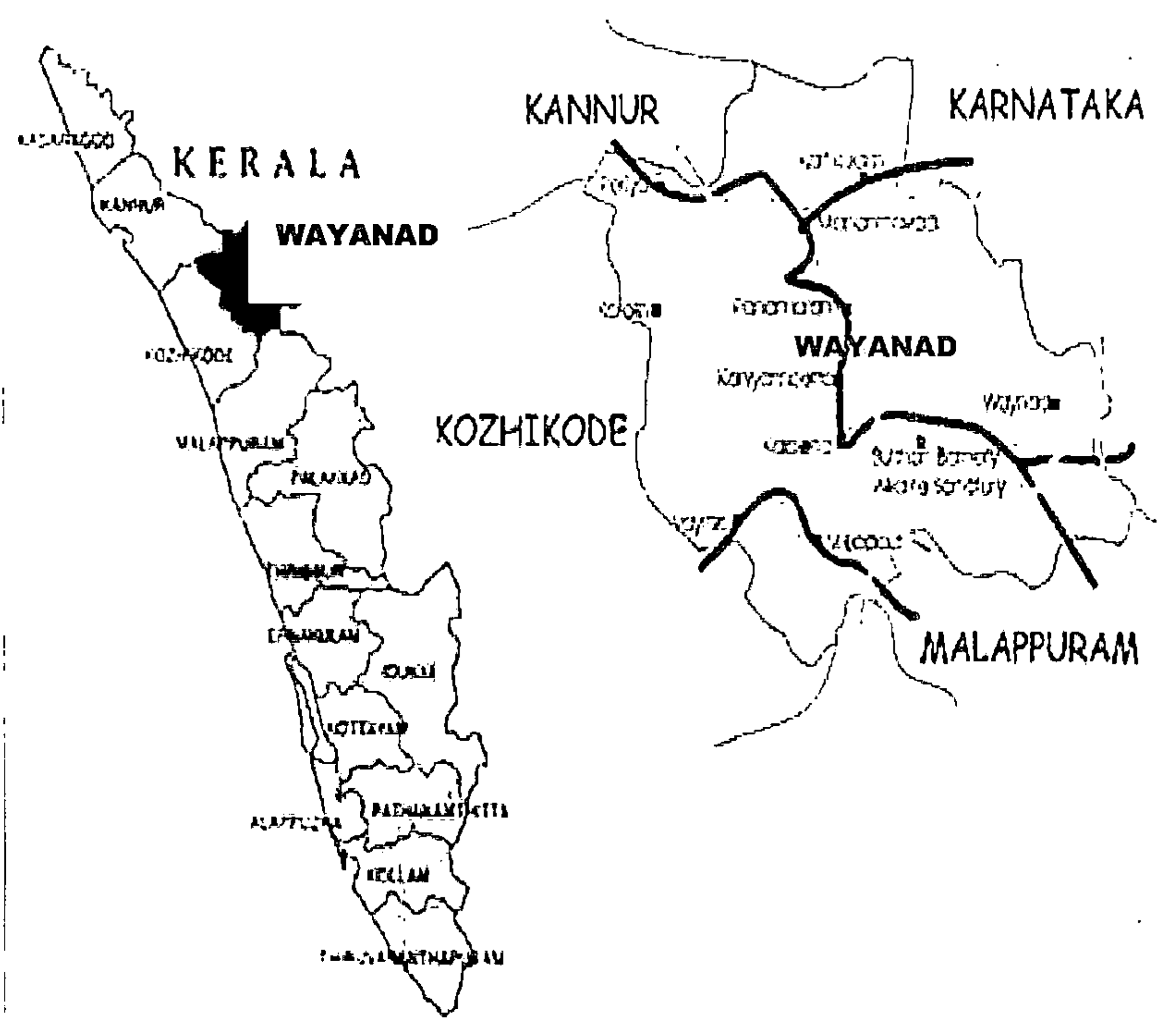
The study was conducted in Wayanad district of Kerala state (fig 3.1.1). Wayanad district lies at an altitude of 700-2100 m above mean sea level on the north eastern part of the State. The district lies between northern latitude 11^0 27' and 15^0 58' and east longitude 75^0 47' and 70^0 27'. It is bounded on the east by Nilgiris and Mysore districts of Tamilnadu and Karnataka respectively, on the north by Coorg district of Karnataka, on the south by Malappuram and on the west by Kozhikode and Kannur. The present district of Wayanad was carved out, from the parts of Kozhikode and Kannur districts and came into being on the first November 1980 as the 12^{th} district of Kerala. The area of the district is 2126 sq.kms and has three taluks viz. Vythiri, Sulthan Batheri and Manathavady. There are 25 panchayats and 1 municipality.

Its geographical position is peculiar and unique. Placed on the southern tip of the Deccan plateau, its primary glory is the majestic Western Ghats with lofty ridges interspersed with magnificent forests, tangled jungles and deep valleys. In the centre of the district, hills are lower in height, while the northern area has high hills which give a wild and mountainous appearance. The difference in the altitudes of each locality within the district presents a variation of climatic conditions.

Wayanad experiences four seasons namely, cold weather (December – February), hot weather (March – May), southwest monsoon (June – September) and northeast monsoon (October – November). The district experiences a high relative humidity.

According to 2011 Census, the district has the lowest population in the state, 8.16 lakhs of which 4.01 lakhs (49.15 %) are males and 4.15 lakhs (50.85 %) are females. Density of population is 383 persons per square kilometre.

Figure: 3.1.1 Political map of Kerala showing the study area



3.2 Methodology

3.2.1 Selection of Sample

There are four Community Development Blocks (CDBs) in Wayanad district. A random sample of two panchayats each was selected from the three CDBs. From one block (Panamaram), three panchayats were chosen. The details are furnished in table 3.2.1.1. From the selected panchayats, a list of practising farmers were prepared (sampling frame) with the help of Krishibhavan officials. A random sample of 15 farmers each was selected as sample respondents. Thus the total sample size was 135.

Table: 3.2.1.1 Details of Panchayats Selected for Study

Sl.no	Community Development Blocks	Panchayats selected
1.	Kalpetta	Vythiri, Muppainad
2.	Sulthan Batheri	Ambalavayal, Noolpuzha
3.	Panamaram	Pulpally, Mullankolly, Poothady
4.	Manathavady	Thondernad, Thavinjal

3.2.2 Data Collection

The study is based on both primary and secondary data. The primary data included the details of socio-economic information of the farmers, holding size of land, cropping pattern and production, sources of water for domestic purpose and irrigation, perceptions and adaptive strategies to climate change. Data was gathered through the method of personal interview using pretested structured interview schedule (Appendix I). A pilot study was conducted to test and finalize the schedule. Participatory Rural Appraisal (PRA) and Rapid Rural Appraisal (RRA) were also conducted among the respondents to have the general information. The following institutions/ organisations helped in various stages of the data collection.

1. Department of Agriculture, Government of Kerala (Respective Krishibhavans)
2. Kerala Agricultural University (Regional Agricultural Research Station, Ambalavayal)
3. Wayanad Social Service Society (WSSS)
4. Farmers' Organizations (*Padashekara saamithies*, *Kurumulaku Samrakshana Samithies)*

The survey was conducted during the period from January to March, 2012. The secondary data sources included government publications, data maintained by development departments of government and other similar sources.

3.3 Analytical framework

3.3.1 Conventional Analysis

Tabular method using percentages and averages were adopted to interpret the data related to land use pattern, cropping pattern, water use for domestic purpose and irrigation, perceptions and adaptive responses and to understand the characteristics and other features of sample farmers and their area.

3.3.2 Developing the Composite Vulnerability Index (CVI)

Watson *et al.* (1996) defined vulnerability as the extent to which a natural or social system is susceptible to climate change, and is a function of the magnitude of climate change, the sensitivity of the system to changes and the ability to adapt.

Among the methods suggested to measure vulnerability, indicator based approaches are common. It is based on the concept that a combination of relevant variables and its interactive effect can provide a more comprehensive insight than a single indicator. Different researchers develop their own method based on this approach, like Vulnerability-Resilience Indicator Prototype (VRIP) model by Brenkert and Malone (2004) and that by Brooks *et al.* (2005).

Olmos (2001) has developed basic concepts and methods for the assessment of vulnerability, which forms the basis of measurement. Based on these concepts, Brook *et al.* (2005) has constructed national level indicators of vulnerability and adaptive capacity to climate hazards. Later on, Balasubramanian *et al.* (2007) has developed an index based on the concept suggested by these researchers. In this study, Vulnerability Index has been calculated based on the method developed by Balasubramanian *et al.* (2007) with modification as demanded by the changed socio-economic conditions.

There are a number of factors which affect vulnerability to water scarcity. Identifying these factors that reflect or indicate the influence to water stress was the first step in the process. This was done based on review of literature, farmer responses and discussion with experts in the field of agriculture. All these indicators were grouped under three major groups as social, economic and agronomic factors.

a. Social Factors (SoF)

Social factors reflect the personal knowledge level of the farmer as well as his social status. This include,

i. Literacy (years of schooling)

ii. Crop insurance (whether insured or not and number of crops covered)

iii. Land ownership status (leased/ owned/ combined)

b. Economic Factors (EF)

This consisted of three components which reflect the economic status of the respondents which in turn acts as a proxy for their resource base and adaptive capacity.

i. Number of sources of income (number)

ii. Total household income (Rs.)

iii. Proportion of livestock income to total household income (%)

c. Agronomic Factors (AF)

Eight variables that directly affect the vulnerability are included in this section.

i. Cropping Intensity (CI) (%)

It was calculated using the formula,

$$\text{Cropping Intensity} = \frac{\text{Gross Cropped Area}}{\text{Net Cropped Area}} \times 100$$

ii. Diversity Index (DI)

As measured by Simpson's Diversity Index

$$\lambda = \sum_{i=1}^{R} P_i^2$$

Where, R = Total number of plant species/ Crops

P = Proportion of area under individual crop to Total Cropped Area

Only major crops of the farm were considered for calculating the index. All those trees and shrubs which are common in homesteads are not taken into consideration.

iii. Varietal tolerance to water scarcity

Based on farmers' perception and scientific validation, the drought tolerance level of commonly cultivated varieties of paddy and black pepper were identified. Since only these crops had a wide range of varieties in cultivation among farm households, they were selected. For other important crops like coffee, all the farmers were using the same variety.

iv. Percentage of Gross Irrigated Area to Gross Cropped Area (%)

v. Water and Soil conservation practices (adopted / not adopted)

vi. Sources of water (Number)

vii. Ownership status of source of water (owned/ not owned)

viii. Percentage of deviation in water table in the wells during summer season from that of water table during August-September.

Based on the range of values of the variables, as well as scientific consultation, the farmers were grouped into three groups, Severe (S), Moderate (M) and Low (L) as detailed in table 3.3.2.1.

Table: 3.3.2.1 Criteria for Vulnerability Scale

Sl.no	Indicator	Scales		
		Severe (S)	**Moderate (M)**	**Low (L)**
I.	**Social Factors (SoF)**			
1.	Literacy	Up to 4 class	5- 10	>10
2.	Crop insurance	Not insured	Insured 1 – 2 crops	Insured >2 crops
3.	Land ownership status	Leased	Leased + owned	Owned
II.	**Economic Factors (EF)**			
1.	Sources of income	1	2-3	>3
2.	Total Household Income	≤1 lakh	1.01 – 2 lakh	> 2 lakh
3.	Proportion of livestock income to total income	0-31%	31-61%	61-90%
III.	**Agronomic Factors (AF)**			
1.	Cropping intensity	≤166 %	167-273 %	>273%
2.	Diversity index	>0.362	0.226-0.362	<0.226
3.	Variety tolerance	Non-drought tolerant varieties	If any one – drought tolerant	Both drought tolerant
4.	% of Gross Irrigated area to Gross Cropped Area	>45%	24-45%	<24%
5.	Water & Soil conservation practices	No Conservation practices	Mulching	Mulching + contour bunds/& rain pits
6.	Sources of water	1	2-3	>3
7.	Ownership of source of water	External	External + owned	Owned
8.	Percentage of deviation from normal water table in Summer	No well	≥50 %	<50 %

Based on the frequency of farmers belonging to the three categories (Severe, Moderate and Low), for each indicator under any particular group (SoF, EF, AF) points were awarded. Thus, the points were estimated for SoF, EF and AF under three categories of sensitivity to vulnerability. This was considered as the Main Factor Effect, which gives the effect of each and every variable on vulnerability independently.

The interaction effect helps to determine the effect of various combinations of variables (combined effect) on vulnerability. In interaction the first indicator in SoF interacted with the other two indicators within SoF and also with 3 and 8 indicators respectively in EF and AF. These 14 indicators were separately considered and thus the interaction effect was between 14 X 14 indicators. Further, each indicator was considered under three levels of vulnerability, i.e. severe (S), moderate (M) and low (L). Thus there were 3 X 3 vulnerability levels. Hence on the whole there were 1764 (14 X 14 X 3 X 3) interactive points. The points were calculated based on the frequency of sample respondents coming under each interaction. Based on the direct and interaction points obtained, the farmers were grouped under two categories, high and low vulnerability status.

Similarly, Vulnerability Index for the year 2005 was also constructed. But due to recall bias, some factors were eliminated. Details of factors included are given in table 3.3.2.2.

Table: 3.3.2.2 Indicators used for the construction of Vulnerability Index

Sl.no	Indicators	2010	2005
I.	**Social Factors (SoF)**		
1.	Literacy	√	
2.	Crop insurance	√	
3.	Land ownership status	√	
II.	**Economic Factors (EF)**		
1.	Sources of income	√	
2.	Total Household Income	√	
3.	Proportion of livestock income to total income	√	
III.	**Agronomic Factors (AF)**		
1.	Cropping Intensity	√	√
2.	Diversity Index	√	√
3.	Variety tolerance	√	√
4.	% of Gross Irrigated area to Gross Cropped Area	√	√
5.	Water & Soil conservation practices	√	√
6.	Sources of water	√	√
7.	Ownership status of source of water	√	√
8.	Percentage of deviation from normal water table in Summer	√	√

3.3.3 Logistic Regression Model

Logistic Regression (Logit) analysis is a uni/mutivariate technique which allows for estimating the probability that an event occurs or not, by predicting a binary dependent outcome from a set of independent variables. For example, Singh *et al.* (2011) has used logistic model to estimate the factors affecting migration in Indo-Gangentic Plains. Ali (2011) employed it to analyse the factors influencing the adoption of mass media information for decision making.

In this study, the model is used to identify different factors affecting the vulnerability of the respondents and predict the probability of any respondent becoming more vulnerable for a change in any of the independent variable. To generate the dependent variable, respondents were divided into two groups, those who are having vulnerability index more than 33245 (high vulnerability) and those below that (low vulnerability). The model is explained as:

$$P_i = E\,(Y=1 \mid X_i) = \frac{1}{1 + e^{-(\alpha + \beta_i X_i)}}$$

Where, P_i is the probability

X_i is the vector of independent variables

β_is are the coefficients to be estimated

$$P_i = \frac{1}{1 + e^{-Zi}} = \frac{e^{Zi}}{1 + e^{Zi}}$$

Where $Zi = \alpha + \beta_i X_i$

$$1 - P_i = \frac{1}{1 + e^{Zi}}$$

is the probability of the respondent to be grouped as less vulnerable for a given set of independent variables.

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

Taking logarithm on both sides,

$Li = \ln\,(P_i / 1 - P_i) = Z_i$

$= \alpha + \beta_i X_i$

L is called the logit.

In this study, the model is

$$Y = \alpha + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8$$

Where α is the intercept and β's are the coefficients of the corresponding variables. Table 3.3.3.1 provides the details of the dependent and independent variables and their expected signs. The regressors include social, economic and agronomic variables.

Table: 3.3.3.1 Description of independent variables in the model

Sl.no	Particulars	Unit	Expected sign
1	Education level of the farmer (X_1)	Number of years of schooling	-
2	Experience in farming (X_2)	Number of years	-
3	Diversity Index (X_3)	Diversity index of farm	+
4	Cropping Intensity (X_4)	Cropping intensity of farm	-
5	Crop Insurance (X_5)	0 – not insured 1 - insured	-
6	Sources of income (X_6)	Number of sources of income of the farmer	-
7	Percentage of irrigated area to total cropped area (X_7)	Percentage	+
8	Net Cropped Area (X_8)	Hectare	-
9	The dependent variable (Y)	1- High vulnerability 0- Low vulnerability	

The analysis was done in SPSS 16 package.

Results and Discussion

Chapter IV

Results and Discussions

Results of the study are presented and discussed under the following major headings:-

4.1 Socio-economic profile of the respondent farmers in the study area

4.2 Land use pattern

4.3 Cropping pattern changes and agricultural production

4.4 Farmers' perception on climate change and impacts on different crops

4.5 Water stress and vulnerability

4.6 Adaptation to water stress

4.1. Socio-Economic Profile of the Respondent Farmers in the Study Area

Socioeconomic and institutional characteristics of a farmer influence his decision making behaviour and his capacity to implement decisions at farm level. This forms the basis of adaptability decisions as well. In this section, the socio economic and institutional features of sample respondents are discussed. The respondents are categorized as Marginal Farmer (MF with holding size less than 1 hectare), Small Farmer (SF with holding size 1 to 2 hectares) and Large Farmers (LF with holding size more than 2 hectares). The general socio economic status of the respondent farmers are furnished in table 4.1.1

The average size of the respondent family was 4.4 reflecting the general trend of nuclear family system in the State. Nair *et al.* (2007) and Devi *et al.* (2009a) also have reported the small family size in Wayanad. Average family size remains almost the same in all categories. This low family size implicates the limited scope of family labour employment in agriculture.

The state of Kerala is well known for its education status, which is even comparable with that of developed countries. As per 2011 census, Kerala stands first among the Indian states and Union territories in literacy (93.91 %). The female literacy is 91.98 per cent. Though, Wayanad is one of the districts with lowest literacy rate (89.32 %) in 2011, there is an appreciable growth during the last decade from 74.63 per cent (2001). The low literacy level in Wayanad is due to the high proportion of tribes in the district. The formal schooling among them is generally low.

Table 4.1.1 Socio-economic profile of the respondent farmers

I. Family Size (Number)	MF	SF	LF	Total
2-4	29 (59.18)	39 (61.90)	10 (43.48)	78 (57.78)
5-10	20 (40.82)	24 (38.10)	13 (56.52)	57 (42.22)
Total	49 (100)	63 (100)	23 (100)	135 (100)
Average family size	4.2	4.4	4.5	4.4
II.Educational status	**MF**	**SF**	**LF**	**Total**
Illiterate	1 (2.04)	0 (0.00)	1 (4.35)	2 (1.48)
Primary	6 (12.24)	7 (11.11)	2 (8.70)	14 (10.37)
Up to tenth	34 (69.39)	45 (71.43)	13 (56.52)	93 (68.89)
Higher secondary	4 (8.16)	8 (12.70)	6 (26.09)	18 (13.33)
Graduate	4 (8.16)	3 (4.76)	1 (4.34)	8 (5.93)
Total	49 (100)	63 (100)	23 (100)	135 (100)
III. Farming experience	**MF**	**SF**	**LF**	**Total**
< 10 years	7 (14.28)	5 (7.94)	2 (8.70)	14 (10.37)
11- 25 Years	9 (18.37)	17 (26.98)	6 (26.09)	32 (23.70)
> 25 Years	33 (67.35)	41 (65.08)	15 (65.21)	89 (65.93)
Total	49 (100)	63 (100)	23 (100)	135 (100)

Figures in bracket shows the percentage to the total

Table 4.1.1 Socio-economic profile of the respondent farmers (Contd.)

IV. Occupation		**MF**	**SF**	**LF**	**Total**
Agriculture only		6 (12.25)	9 (14.29)	4 (17.39)	19 (14.07)
Agriculture as main occupation		26 (53.06)	40 (63.49)	13 (56.52)	79 (58.52)
Agriculture as Subsidiary occupation	Govt. Service	3 (6.12)	3 (4.76)	2 (8.70)	8 (5.93)
	Private Service	0 (0.00)	4 (6.35)	0 (0.00)	4 (2.96)
	Self Employed	6 (12.25)	7 (11.11)	4 (17.39)	17 (12.59)
	Agricultural Labours	5 (10.20)	0 (0.00)	0 (0.00)	5 (3.70)
	Non-agricultural labours	3 (6.12)	0 (0.00)	0 (0.00)	3 (2.22)
	Sub Total	17 (34.69)	14 (22.22)	6 (26.09)	37 (27.41)
Grand Total		49 (100)	63 (100)	23 (100)	135 (100)
V. Household Income		**MF**	**SF**	**LF**	**Total**
Total household income (Farm Income + Nonfarm income) (Rs./ household)		146920	187765	429159	214066
Average agricultural income (Rs./ household)		70900	94933	336880	127431
Average agricultural income (Rs./ ha)		42568	33892	52746	42532
% share of agricultural income to total income		48.26	50.56	78.50	59.53

Figures in bracket show the percentage to the total

However, literacy of the sample farmers was very high (98.52 %). Majority of them have studied up to 10th standard (68.89 %). Nearly 14 per cent have studied up to higher secondary level and about six percent had University level education. The pattern remains almost the same for all the categories with the exception that an equal proportion of MF had higher secondary and university level education. This high level of education status underlines the use of print media in agricultural extension activities. The chances of adoption of modern technologies and scientific approaches in decision making are also on the higher side. This in turn paves way for development of the whole society. Besides, education plays a decisive role in occupational diversification of the farmers.

Farmer gains improved knowledge of farming (crop selection to suit climatic conditions) with experience or by observation. Many researchers emphasized that farming experience, level of education and extension contacts have significant influence on the farm efficiency (Kaliragan and Shand, 1985; Ali and Flinn, 1989; Weir, 1999). Thus farmer wisdom in association with scientific knowledge makes farming more efficient.

The agricultural history of Wayanad is marked by the immigration of farmers from central Kerala. Currently most of the farmers in Wayanad are the second or third generation of such farmers. Two- third of the sample farmers were with experience in farming of more than 25 years; one-fourth of them were with an experience ranging from 11 to 25 years and the rest were comparatively recent practitioners (10 years) of farming. There is the general notion that older farmers (traditional) are reluctant to adopt modern technologies or they are slow adopters. Schnitkey *et al.* (1992) reported that older farmers rely less on external information, and therefore do not get in touch with innovations in the market as early as their younger colleagues. However, the higher proportion of experienced farmers in Wayanad is helping to sustain the agriculture scenario in Wayanad.

Wayanad has been known to be an agrarian economy. But in this study, it was seen that only 14 per cent of the households depend solely on agriculture. Nearly 60 per cent practice agriculture along with dairy farming. Farming was taken up as a subsidiary source of income by 27 per cent. Their main source of income was from salaries (both government and private sector employment) in case of LF and SF. MF worked as wage labourers in farm and non-farm sector. The non farm income was mainly sourced through self employed enterpreunarial activities by majority of them. Off farm employment is an important means by which farm households can manage risk through diversification of income sources. Mishra and Goodwin (1997) noted the importance of off-farm employment as a means for managing the financial risks experienced by the farmers.

Nearly two-third of the total income of farmers was realised from agricultural enterprises as it is the main or only source of income for majority (59.53 %). Total income includes farm and non-farm income. Non-farm income consisted of income from livestock rearing and self enterprises. Income of other family members was also considered for arriving at total household income. The average annual household income from farm and nonfarm sources amount to Rs 2.14 lakh, ranging from Rs. 1.4 lakh in case of MF to Rs. 1.8 lakh for SF and Rs. 4.2 lakh for LF. The share of farm income was comparatively high (78.50 %) in LF households, and almost 50 per cent in the other two cases. It was found that the productivity of MF and LF households were more as the average farm income per hectare (Rs.42568 and 52746 respectively) was high compared to that of SF household (Rs.33892) and on an average it was to Rs. 42532 per hectare for the whole sample. However study by Devi *et al.* (2009a) showed a low average farm income (Rs. 18109) in 2009 on the backward panchayats of the district.

Household expenditure towards food, education, health and utility was collected from the respondents by taking a statement on these expenses in the previous month. The average annual consumption expense was found to be Rs. 97370 which was about 45 per cent of the total household income (Table: 4.1.2). It could be seen that, there is a decrease in the proportion of consumption expenses to the total household income with increase in land holding size. For MF and SF, more than half (56 % for MF and 53 % for SF) of the total household income was for consumption, where it was only one-fourth for LF. A higher share of the consumption expenses was attributed to food (46.47 %) followed by education (26.56 %) which is in accordance with Angel's law. It was seen that share of food expenses shows a decreasing trend across the different sections, highest with MF (50.18 %) and least with LF (44.19 %) where as that of the other expenses (education and utility) shows an increasing trend. It means that there is an increase in the standard of living with increase in average annual income (land holding size).

Table: 4.1.2 Consumption pattern among respondent farmers

Particulars (Rs./ Year)	MF	SF	LF	Aggregate
Food	41560 (50.18)	46080 (45.87)	48090 (44.19)	45243.33 (46.47)
Education	20520 (24.77)	27296 (27.17)	29780 (27.37)	25865.33 (26.56)
Utility	9800 (11.83)	13420.8 (13.36)	15250 (14.01)	12823.6 (13.17)
Health	10950 (13.22)	13664.04 (13.60)	15700 (14.43)	13438.01 (13.80)
Total	82830 (100.00)	100460.8 (100.00)	108820 (100.00)	97370.28 (100.00)
% share of consumption expenses to total household income	56.38	53.50	25.36	45.49

Figures in bracket show the percentage to the total

Credit Facilities

In agricultural sector, capital is one of the major factors of production. Most of the farmers face resource scarcity and they have to depend on non equity sources. Availability of adequate capital at appropriate time ensures efficiency in production process (Ali and Flinn, 1989; Obwona, 2006).

The network of institutional financial agencies in Kerala is often projected as one among the highest in India. The total number of commercial bank branches in the State shows a steady increase. It is 4227 with 2444 nationalised banks, 404 Regional Rural Banks (RRBs) and the remaining commercial banks. The average Credit-Deposit (CD) ratio for the State is 63.60 (Economic Review, 2011).

Wayanad district has 17 branches of State Bank group, 29 branches of nationalized banks, 28 branches of RRBs and 13 branches of other commercial banks, totalling to 87 branches. The CD ratio is 125.8, highest for the State. The total credit advanced to priority sector by all these banks including co-operatives amounted to Rs.119170 lakhs in 2009-10. 67 per cent of this was for direct agriculture (Rs. 80202 lakh).

Kerala has a wide network of cooperatives engaged in various promotional activities, such as credit supply, marketing, agro-processing, consumer activities, public health, education, insurance and infrastructure development. There are 13197 cooperatives under the Registrar of Cooperative societies of which 10449 are functional. The cooperative credit structure comprises 1603 Primary Agricultural Credit Societies (PACS), 14 District Central Co-operative Banks (DCB) and one State Cooperative bank for short and medium term loans. The long term loans are managed by the Primary Cooperative Agriculture and Rural Development Banks and State Cooperative Agriculture and Rural Development Bank.

The Agriculture advance in Wayanad by the 327 co-operative institutions was Rs.65770 (2007-08). This was 4.1 per cent of the State level advances. There is a District Co-operative Bank, three Co-operative Urban Bank, 29 Primary Agricultural Service Banks, a Land Mortgage Bank, and one Farmers' Co-operative Bank. There are 25 SC-ST Co-operative Societies and 39 Agricultural Marketing Societies.

Even with the comparably high reach by the organised sector, the informal sector has a visible presence in Wayanad. The Non Banking Finance companies (NBFC) and other microcredit institutions like Self Help Groups (SHGs) are also present.

In the present study it was seen that 61.48 per cent of the total respondent farmers as indebted to various sources for their farm and nonfarm requisites. The level of indebtedness was highest (47 %) among the SF, compared to MF (33.73 %) and LF (19.28 %). Details are furnished in table 4.1.2.

The baseline survey conducted as part of the National Agricultural Innovation Project (NAIP) in the backward Community Development Blocks (CDB) of Wayanad by Devi *et al.* (2009a) reported the level of dependency of credit from organised institutional sources as only 37 per cent. However this study shows that all indebted farmers irrespective of holding size depend on organised sector, viz. Regional Rural Banks (39.77 %), Commercial Banks (36.36 %) and Co-operatives (18.18 %) (Table 4.1.4). But MF mostly depend on commercial banks (38.71 %) followed by RRBs and co-operatives (25.81 % each). This shift from the non-institutional organisations was mainly because of the flexible approach followed by banks in sanctioning loans to farmers and also low interest rate as compared to non–institutional credit. Gulati and Bathla (2002) also pointed out that the unorganised sector charges high interest rate besides the high value securities to be pledged. Since most of the respondent farmers are educated, they are well aware of the demerits of the non-institutional credit in spite of the easy and quick access.

The total borrowed capital by the respondents amount to Rs. 130 lakhs. Of this 45 per cent was credited by the commercial banks and 37 per cent by RRBs and the rest by Co-operatives (17.85 %) (Table 4.1.3). Commercial banks supply major share of total credit flow, though RRBs have a better reach (Fig 4.1.1 and Fig 4.1.2). The average credit per respondent was around Rs. 1.55 lakh, with SF on the top with Rs.1.81 lakh and MF at the bottom with Rs. 1.18 lakh. But on average cropped area basis, MF top (Rs.49785) compared to SF (Rs.47735) and LF (Rs 31205) (Table 4.1.3). On an average, this amounts to Rs.42908 for the sample respondents.

Table: 4.1.3. Indebtedness among sample farmers

Group	No	Average credit per farmer (Rs in Lakh)	Av credit per ha. of GCA (Rs)
MF	28 (33.73)	1.18	49785
SF	39 (46.99)	1.81	47735
LF	16 (19.28)	1.67	31205
Aggregate	83 (61.48)*	1.55	42908

Figures in bracket show the percentage to the total indebted
**percentage to the total respondent farmers*

Table: 4.1.4. Source wise indebtedness among sample farmers

Group	Organised Sector						Un organised		Total	
	Co-operatives		RRBs		Commercial Banks		Non-institutional Credit			
	No	Amount (Rs. in lakh)	No	Amount (Rs. in lakh)	No	Amount (Rs. in lakh)	No	Amount (Rs. in lakh)	No	Amount (Rs. in lakh)
MF	8 (25.81))	10.49 (31.30)	8 (25.81)	7.38 (22.02)	12 (38.71)	15.02 (44.82)	3 (9.68)	0.62 (1.85)	31 (100.00)	33.51 (100.00)
SF	7 (17.07)	8.22 (11.61)	17 (41.46)	25.56 (36.11)	15 (36.59)	36.5 (51.57)	2 (4.88)	0.5 (0.71)	41 (100.00)	70.78 (100.00)
LF	1 (6.25)	4.5 (16.98)	10 (62.50)	15.05 (56.79)	5 (31.25)	6.95 (26.23)	0 (0.00)	0 (0.00)	16 (100.00)	26.5 (100.00)
Total	16 (18.18)	23.21 (17.75)	35 (39.77)	47.99 (36.69)	32 (36.36)	58.47 (44.70)	5 (5.69)	1.12 (0.86)	88 (100.00)	130.79 (100.00)

Of the total loanee farmers 88 per cent took credit for a single purpose (farming or non-farm activities). Majority of loanee farmers availed the credit only for farming (79.52 %). 12 per cent had availed more than one type of loan (i.e. for farming and household consumption purposes). Eight per cent have availed for only nonfarm consumption purposes like constructing houses and for education of their children (Table 4.1.5).

Apart from the banking institutions, Kudumbasree programme (Self Help Group) and Vegetable Fruit Promotion Council Keralam (VFPCK), also act as a source of credit. Moreover, Self Help Groups (SHG) patronised by religious groups are also present. These microcredit institutions are mainly for the upliftment of the poor sections of the society. Sharma (2011) has defined microcredit as a tool for poverty reduction based on the premise that improved access to credit by the poor is crucial to improve the returns to economic activities.

Kudumbashree was conceived as a joint programme of the Government of Kerala and National Bank for Agriculture and Rural Development (NABARD) implemented through Community Development Societies (CDSs) of poor women, serving as the community wing of local self governments (Kudumbashree, 2012). Established in 1998, Kudumbashree plays a vital role in enhancing the financial status of the less privileged women in the State through its credit societies. These societies facilitate them to save and provide them with cost-effective and easy credit. The savings of the women are pooled together and given out as loans to the most deserving. Because of the organisational characteristics, credit availed from these are mostly taken by the female members of the households who are also active members of the programme.

Vegetable and Fruit Promotion Council Keralam (VFPCK) is a certified company and was established in 2001, with an objective to bring about overall development of fruit and vegetable sector in Kerala. VFPCK is a company with majority stake of farmers and has the Government and financial institutions as the other major shareholders. It lends credit with the association of selected commercial banks. One of the salient features is that they provide credit facility to lease land cultivators also, which will help the landless farmers to have farming and thereby increase their income.

The borrowings from friends and relatives, non professional money lenders and NBFC are also there to a limited extent. About six per cent of the sample respondents depend on non-institutional credit. Mainly MF (10.71 %) and SF (5.13 %) depended on these. LF, because of their better asset position has better access to institutional sources.

Repayment of credit availed by the farmers are influenced by many factors. Wilful and non-wilful defaulters have different factors that influence the behaviour. The timely repayment was reported by only 29 per cent of loanees in this study.

There is a general practice by the institutional lending agencies to effect book adjustments to report timely repayment through rescheduling of loans. Fresh loans are sanctioned at the end of existing loans and the system continues. The policy decision of declaring the moratorium or writing off agricultural loans during the Wayanad crisis had benefitted the farmers who were indebted to organised credit agencies and were defaulters. Those farmers who (despite being crisis hit) managed to repay, were left out of the advantage. Some of them managed to repay by selling the livestock, which further narrowed down their livelihood options. This experience has adversely influenced the repayment ethics of the borrowers and many of them openly reported that they are deliberately taking the decision of non repayment.

Table: 4.1.5. Indebtedness among sample farmers – purpose wise classification

Group	Farming	Agriculture and Household	Household	Total
MF	20 (71.43)	5 (17.86)	3 (10.71)	28 (100)
SF	31 (79.49)	5 (12.82)	3 (7.69)	39 (100)
LF	15 (93.75)	0 (0.00)	1 (6.25)	16 (100)
Total	66 (79.52)	10 (12.05)	7 (8.43)	83 (100)

Figures in bracket show the percentage to the total

Fig: 4.1.1 Farmer dependence on credit sources (% of farmers)

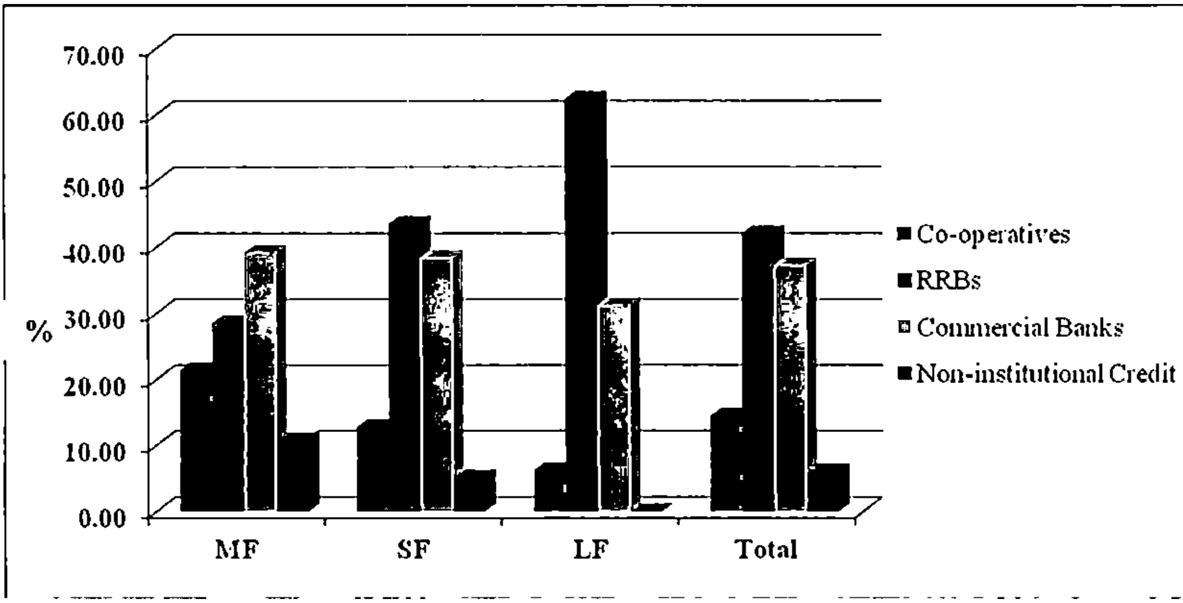
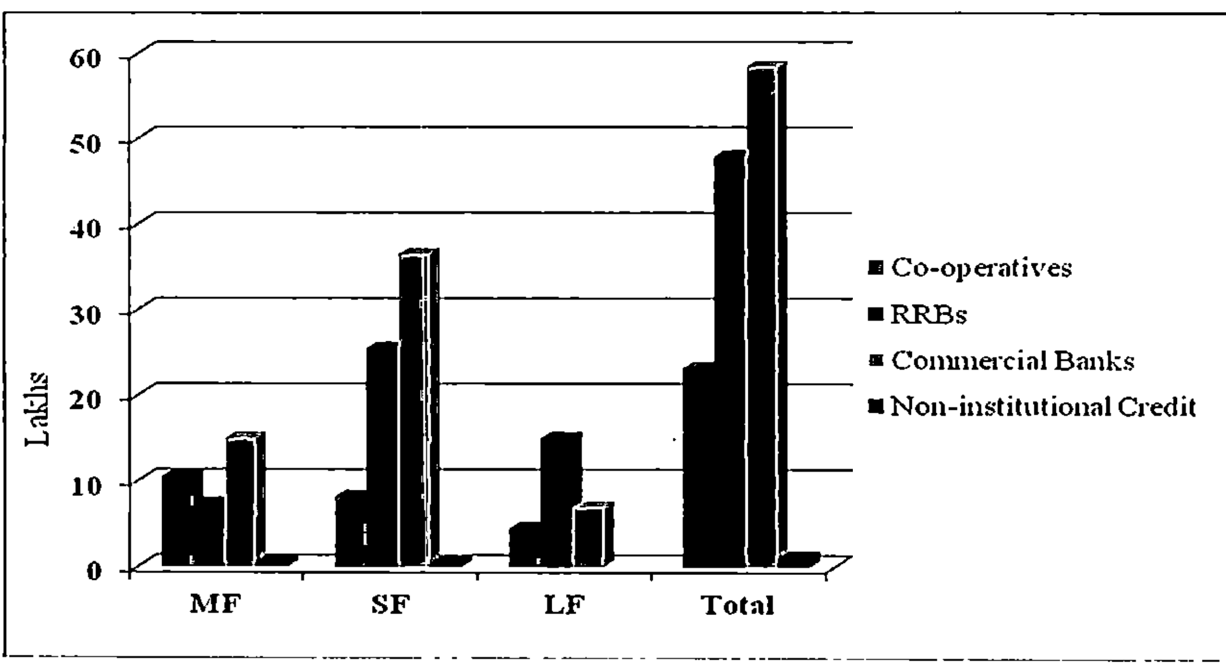


Fig: 4.1.2 Farmer dependence on credit sources (Volume of credit)



4.2 Land Use Pattern

Land is the basic livelihood asset in any agrarian economy. The minimum size of the land should be such that it should keep the farmer fully employed and at least provide him with an income sufficient to sustain himself and his family.

Wayanad district consists of 5.47 per cent of the total geographical area of the state (212560 ha). The district has the highest proportion of area under forests (37.07 %) higher than the state average of 28 per cent (Table 4.2.1).

Table 4.2.2 furnishes the land use pattern of sample farmers. The total operational holding size of the sample respondents is 221.06 ha and the average holding size is 1.41 ha. The holding size of MF is only 0.57 ha against that of SF (1.34 ha) and LF (3.39 ha). More than one tenth of the cultivated land is leased in. Compared to LF (15 %), SF and MF have a large proportion of leased in land (48.34 % and 30.67 %).

Wayanad got its name from *'Wayalnad'* meaning the land of paddy, implying the dominance of rice cultivation in this area. In 1985, when the district was formed rice cultivation was nearly 15 per cent of the total geographical area while it is only 6.1 per cent (in 2010) and for sample farmers it was reported as 23 per cent. However, it is to be pointed out that the area reported as paddy lands includes all area categorised as paddy land under revenue records. But practically, a major part is converted as garden land, with coconut and arecanut cultivation. Currently, a sizeable part of paddy lands that still remain as wetland is used for banana or vegetable farming. This large scale conversion of paddy lands has severely impacted the ecosystem of Wayanad. The natural water recharge and drainage of the area is badly affected. This, the farmers reported necessitate irrigation for most of the crops which previously was rainfed. About 12 per cent of the net cropped area of the district is irrigated and among the sample farmers it is nine per cent. For LF and MF (10.77 % and 10.61 % respectively), irrigated area is significantly more than that of SF (5.72 %).

Cropping intensity of Wayanad (179) was fairly higher than the state average (122) implying the proper utilization of the resource. The intensity among the sample farmers (187) was higher than the district average. The land utilization efficiency of MF (215.44) is greater than SF (182.22) and LF (180.03). The extent of fallow lands was very less, least among the MF and highest among LF (0.24 ha).

Table: 4.2.1 Land use pattern of Wayanad and Kerala

Sl No:	Particulars	Wayanad (ha)	Kerala (ha)
1	Total Geographical Area (TGA)	212560	3886287
2	Forest	78787 (37.07)	1081509 (27.83)
3	Land put to non agrl. use	14210 (6.69)	361695 (9.31)
4	Barren and uncultivable land	248 (0.12)	17912 (0.46)
5	Permanent pastures and other grazing land	45 (0.02)	96 (0.002)
6	Land under miscellaneous tree crops	489 (0.23)	4423 (0.11)
7	Cultivable waste	1051 (0.49)	98014 (2.52)
8	Fallow other than current fallow	400 (0.19)	45374 (1.17)
9	Current Fallow (CF)	1438 (0.68)	76945 (1.98)
10	Net Cropped Area (NCA)	115892 (54.52)	2180679 (56.11)
11	Area sown more than once	92038 (43.30)	488026 (68.67)
12	Total Cropped Area (TCA)	207930 (97.82)	2668705 (68.67)
13	Cropping Intensity (CI)	179	122
13	Net Irrigated Area (NIA)	13908 (6.54)	386330 (9.94)

Source: Economic Review, 2010

Figures in brackets show the percentage to total geographical area.

Table: 4.2.2 Land use pattern of respondent farmers

Sl.no		Particulars		MF (ha)	SF (ha)	LF (ha)	Aggregate (ha)
1.	Operational holding size	Owned	Wetland	7.38 (26.37)	19.19 (22.70)	17.58 (22.56)	44.14 (23.18)
			Garden land	20.6 (73.64)	65.32 (77.30)	60.34 (77.44)	146.26 (76.82)
			Total	27.98 (100.00)	84.51 (100.00)	77.92 (100.00)	190.40 (100.00)
		Leased	Wetland	2.52 (22.42)	1.62 (10.93)	2.2 (47.83)	6.34 (20.68)
			Garden land	8.72 (77.58)	13.2 (89.07)	2.4 (52.17)	24.32 (79.32)
			Total	11.24 (100.00)	14.82 (100.00)	4.6 (100.00)	30.66 (100.00)
2	Total Operational Holding Size			39.22	99.33	82.52	221.06
3	Av holding size			0.57	1.34	3.39	1.41
4	Rainfed Area			74.01	158.57	120.9	353.48
5	Irrigated Area			7.6	17.9	25.5	50.9
6	Gross Cropped Area (GCA)			81.61	176.47	146.4	404.38
7	% of Gross Irrigated Area to Gross Cropped Area			10.61	5.72	10.77	8.53
8	Net Cropped Area (NCA)			37.88	96.84	81.32	216.04
9	Cropping Intensity (CI)			215.44	182.22	180.03	187.22
10	Current Fallow (CF)			0	0.4	0.24	0.64

Figures in brackets show percentage to total holding size.

4.3 Cropping Pattern Changes and Agricultural Production

Kerala is famous for its traditional homestead farming and Wayanad is not an exception. Coffee has been the main crop in Wayanad continuing its position accounting for about 32 per cent of the total cropped area followed by black pepper and paddy (7.97 % and 6.25 % respectively). Thus these three crops together constitute 47 per cent of gross cropped area. Coconut, arecanut, banana, ginger, cardamom, turmeric, rubber and tea are also there. Coffee based cropping pattern is the main feature which is unique to Wayanad. Coffee is grown both as pure crop and as mixed crop. Black pepper is generally grown as intercrop which is trailed on live standards. The GCA in Wayanad district is 207930 ha. Table 4.3.1 furnishes the details of cropping pattern of the district. Changes in cropping pattern in the district over the period 1985-86 to 2009-10 are depicted in fig 4.3.1.

The cropping pattern in the sample households is in tune with the general pattern. The cropping pattern during three points of time viz. 2000, 2005 and 2010 is presented in the table 4.3.2. The cultivated area among the sample holdings registered an increase of six per cent during 2005, but has declined by nine per cent during the subsequent period. This can be taken as an indication of a gradual shift from farming vocation by the practicing farmers. The practice of lease land farming has been very common in Wayanad. It is not clear from this data whether this change is due to changes in the habit of leasing in/out.

The changes in relative share of important crops is to be analysed to know further micro level changes in the farming behaviour.

Results of the primary data collected from the sample respondents were comparable with that of the district. Coffee is the main crop which contributes nearly 19 per cent of the total cropped area (Fig 4.3.2). Arecanut (9.81 %) and ginger (9.19 %) shares a major portion after coffee. Coconut occupies about eight per cent of the area and paddy land constitutes about seven percent. Black pepper contributes only six per cent of the area though it is one of the economically important crops in the district.

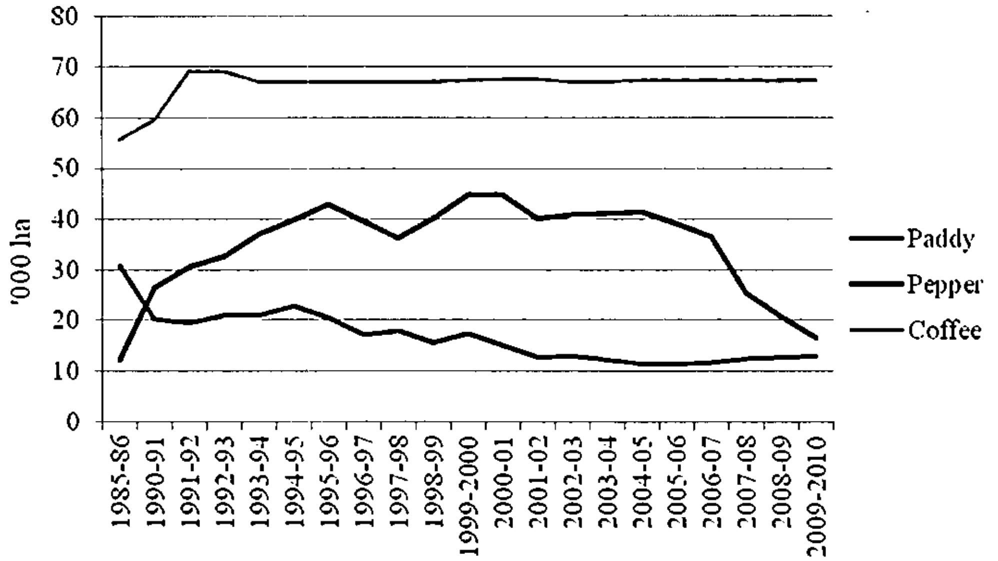
Table: 4.3.1 Cropping pattern in Wayanad district and Kerala state (2009-10)

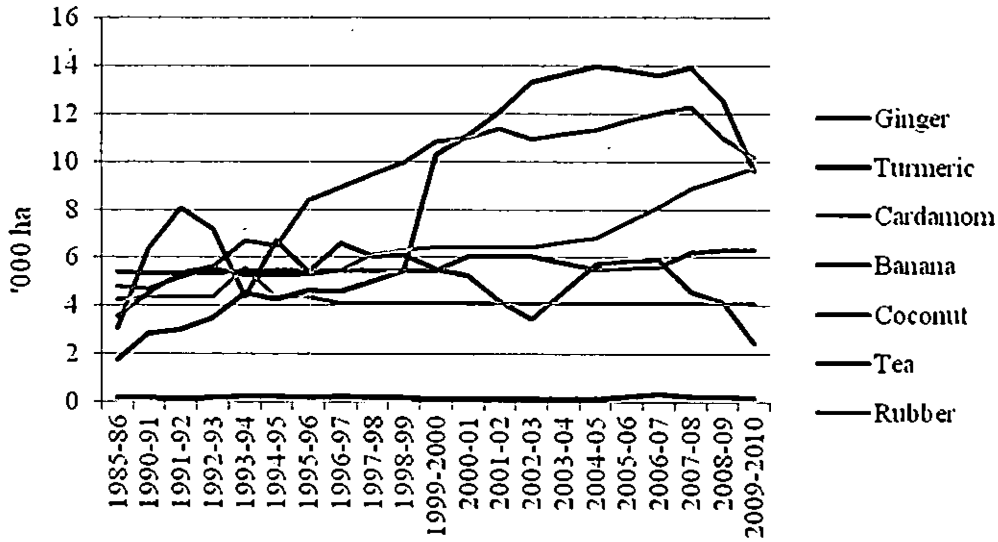
Sl.No	Crop	Wayanad (ha)	Kerala (ha)	% Share to that of Kerala
1	Paddy	12995 (6.25)	234013	5.55
2	Black Pepper	16571 (7.97)	171489	9.66
3	Ginger	2446 (1.18)	5408	45.23
4	Turmeric	189 (0.09)	2438	7.75
5	Cardamom	4103 (1.97)	41593	9.86
6	Banana	9629 (4.63)	99077	9.72
7	Coconut	10200 (4.91)	778618	1.31
8	Tea	6343 (3.05)	36845	17.22
9	Coffee	67366 (32.40)	84796	79.44
10	Rubber	9723 (4.68)	525408	1.85
11	Vegetables	1504 (0.72)	43412	3.46
12	Tubers	3741 (1.80)	96299	3.88
13	Fruit trees	22780 (10.96)	327449	6.96
14	Arecanut	10862 (5.22)	99188	10.95
15	Total Cropped Area	207930	2668705	7.79

Source: Department of Economics and Statistics, Kerala

Figures in brackets show the percentage to total cropped area.

Fig: 4.3.1 Trend in area under major crops of Wayanad





Source: Department of Economics and Statistics, Wayanad.

Table: 4.3.2 Cropping pattern of respondent farmers

Particulars		Area (ha) 2000		Area (ha) 2005		Area (ha) 2010		Pattern of change
			Total		Total		Total	
Paddy	Nancha	36.82 (8.79)	51.04 (12.18)	29.8 (6.73)	40.66 (9.18)	23.18 (5.73)	29.99 (7.41)	↓
	Puncha	14.22 (3.39)		10.86 (2.45)		6.81 (1.68)		
Black Pepper			55.06 (13.15)		49.61 (11.21)		25.16 (6.22)	↓
Banana			12.16 (2.9)		19.8 (4.47)		20.16 (4.98)	↑
Coffee			74.11 (17.7)		74.75 (16.88)		74.88 (18.51)	-
Arecanut			23.51 (5.61)		35.43 (8.00)		39.71 (9.81)	↑
Ginger			38.88 (9.28)		52.17 (11.78)		37.2 (9.19)	-
Turmeric			2.82 (0.67)		3.73 (0.84)		4.27 (1.06)	↑
Cardamom			0.76 (0.18)		1.16 (0.26)		2.20 (0.54)	↑
Tapioca			10.3 (2.46)		6.25 (1.41)		5.95 (1.47)	↓
Yams			3.64 (0.87)		4.12 (0.93)		4.97 (1.23)	↑
Coconut			33.1 (7.90)		33.05 (7.46)		32.77 (8.10)	-
Rubber			4.34 (1.04)		7.07 (1.60)		12.03 (2.97)	↑

Tea	3.01 (0.72)	4.56 (1.03)	5.73 (1.42)	↑
Vanilla	0.15 (0.04)	2.31 (0.52)	0.31 (0.08)	-
Vegetables	5.22 (1.25)	5.8 (1.31)	6.01 (1.49)	↑
Miscellaneous Trees	100.73 (24.05)	108.08 (24.41)	103.15 (25.50)	-
Gross Cropped Area	418.83	442.75	404.48	

Figures in bracket show the percentage to gross cropped area

- *Indicates there was no specific trend in area over the decade*

Cropping pattern in the district shows gradual change over the years (Fig 4.3.3). Coffee still continues to occupy a dominant position. However, crops like coconut, arecanut and rubber can be considered as new additions in the cropping pattern. The area under crops like paddy and black pepper shows decline during the period under study (2000-10), while banana, arecanut, rubber, tea and turmeric shows an increase in area (Fig 4.3.4). The area under the crops like coffee, ginger and coconut remains almost same. There is no difference in the pattern among the different sections of farmers (Appendix II). Here a detailed discussion on the performance of major crops in the cropping pattern is attempted.

Coffee

Wayanad is the major coffee growing area in Kerala. Occupying 79.44 per cent of total coffee area in Kerala, coffee gardens in Wayanad constitute nearly one third (32.4 %) of the GCA of the district. The area under coffee remains the same among the respondent farmers. Coffee, as reported is a major component in the economy of Wayanad, and not much price instability was observed during these years. There were no major pest/disease outbreaks as well. Farmers are aware of the alternate bearing habit of the crop and wait for the next year after every bad year.

The production status of the crop (49950 t) is more or less stable and it accounts for nearly 85 per cent of the total production of the state. The productivity of coffee in Wayanad was 0.74 t/ha (Table: 4.3.3). But the sample farmers were realising double this (1.6 t/ha).

Fig: 4.3.2 Cropping pattern of respondent farmers in 2010

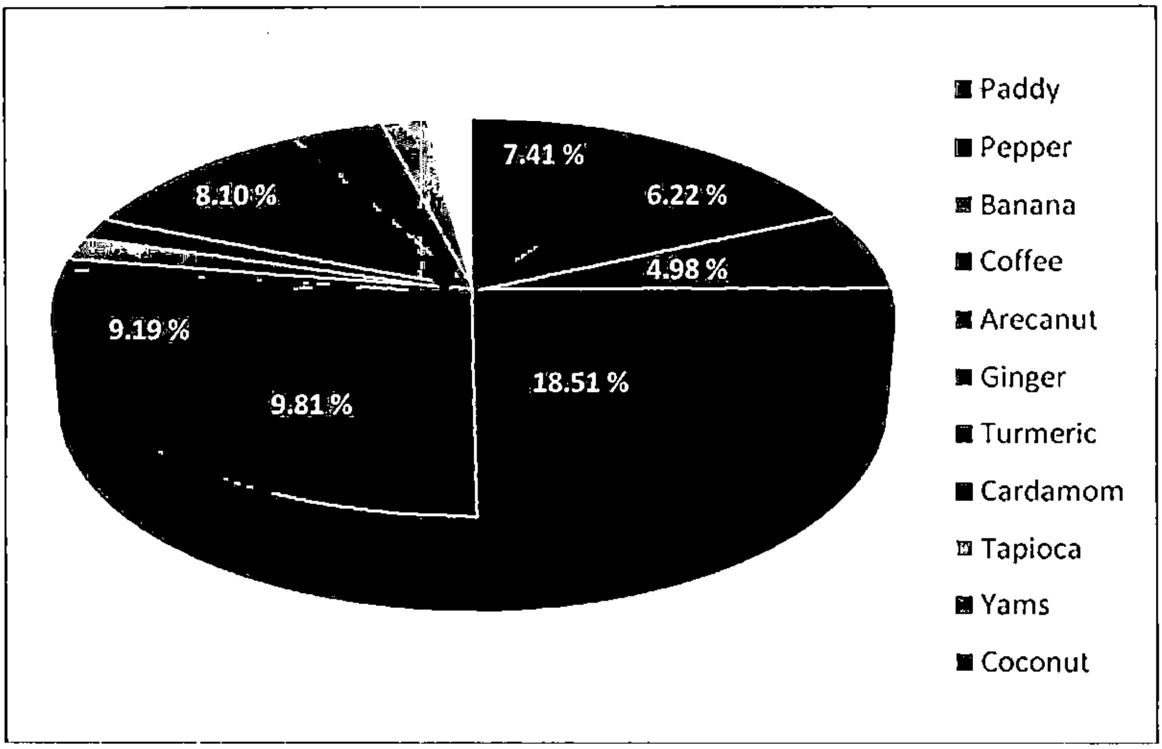


Fig 4.3.3 Cropping pattern changes in farm of respondents (2000 to 2010)

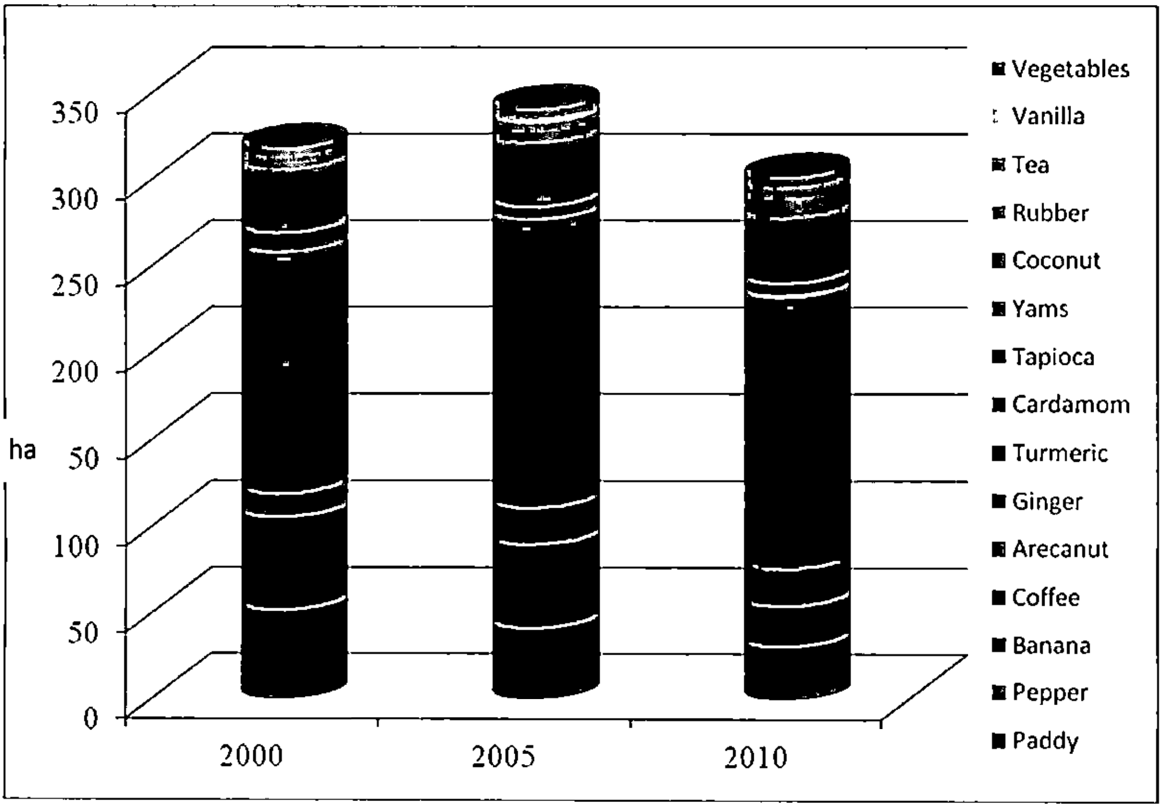
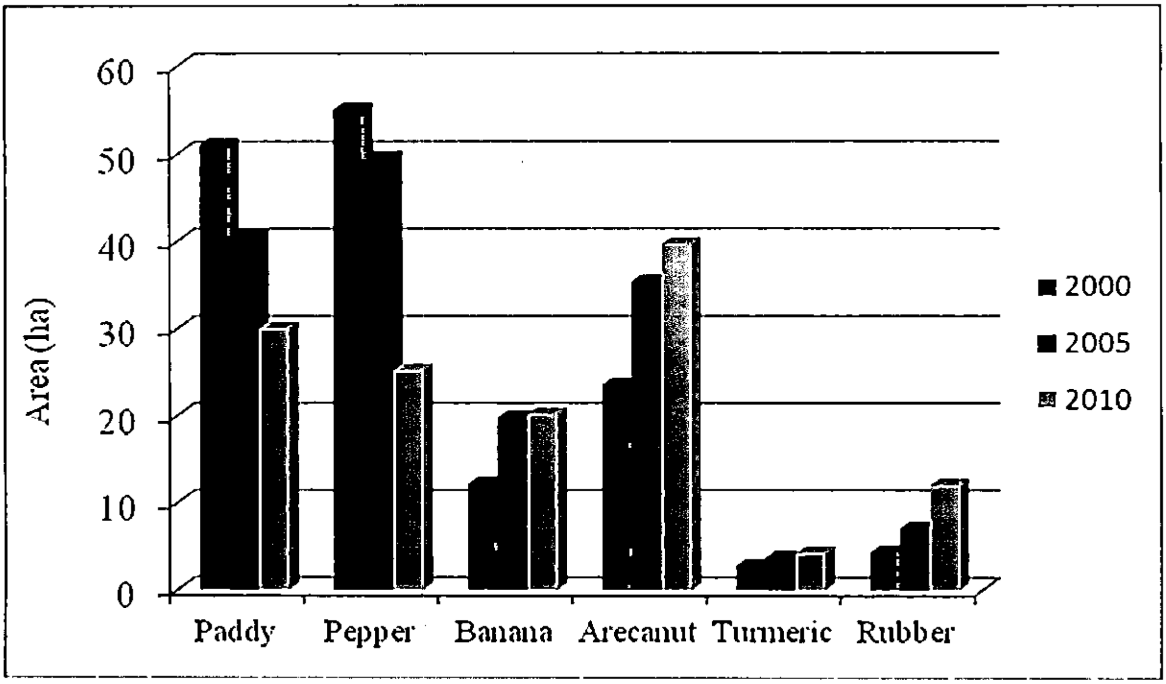


Fig: 4.3.4 Changes in relative area under major crops (2000-10)



However, this is not the yield from yielding plants alone, and remains stagnant over the years (Table: 4.3.4).

Black Pepper

Black pepper, the *King of Spices,* was one of the most predominant crops in homesteads of Wayanad and in the export basket of spices from Kerala. Of the 171489 ha of black pepper cultivated area in the state, 9.66 per cent is in Wayanad. Black pepper is mainly grown as a component crop in home gardens and rarely pure plantations are seen. This crop occupies 7.91 per cent of GCA in the district. In the sample farmers selected for the study the share of black pepper is observed as 6.22 per cent of GCA, occupying 25.16 ha.

Black pepper cultivation in Wayanad has been facing various threats. Hence the area under the crop shows a steady decline since 1995 (Fig 4.3.1). The black pepper presence in the homestead of sample respondents declined by 54 per cent, since 2000. The difficulties posed in the management of devastating diseases (quick and slow wilt) and the liberalization policies in international trade have been acting against the returns from the crop. Besides, the severe drought in the summer of 2004 had a devastating effect on the black pepper gardens. But the most important reason for the decline in area was attributed to the loss of crop due to the emergence of diseases like quick wilt and yellowing. Farmers opined that even if they replaced the diseased ones with healthy ones, the vines were infected at the third year of the crop when it starts yielding. Many farmers attributed climate change as the major reason for this where as others think that it is due to the excessive use of plant protection chemicals, that the pathogen became resistant to chemicals. It is interesting to note that in organic farms, disease attack was less compared to that of inorganic farms and hence some farmers have shifted from inorganic farming to organic farming at least in black pepper. Nair *et al.* (2007) and Devi *et al.* (2009a) have also reported about the decline in the area of pepper due to pests and diseases. The decline in area was more pronounced among LF households compared to SF and MF.

The crop shows a declining trend in production and productivity status as well. The productivity nearly halved during the period. The district produces 4497 tonnes of black pepper which contributes to about 10 per cent of the state's production and the productivity is higher than that of the state (0.27 t/ha.). However, the farmer's in the study area could realise higher level of productivity (1.28 t/ha).

Table: 4.3.3 Production and productivity of major crops (2009-10)

Crop	Wayanad		Kerala		% share to Kerala in Production
	Production (t)	Productivity t/ha	Production (t)	Productivity t/ha	
Paddy	33157	2.55	598339	2.56	5.54
Black Pepper	4497	0.27	42459	0.25	10.59
Ginger	18439	7.54	42459	5.3	43.43
Turmeric	672	3.56	6066	-	11.08
Cardamom	366	0.09	7800	0.19	4.69
Banana	79114	8.22	744788	7.55	10.62
Coconut	46	4509.80	5667	7.3	0.81
Tea	9366	1.48	57810	1.57	16.20
Coffee	49950	0.74	59250	0.699	84.30
Rubber	8400	0.86	745510	1.42	1.13
Arecanut	5385	0.50	116763	1.17	4.61

Source: Department of Economics and Statistics, Kerala

Table: 4.3.4 Production and productivity of major crops of sample farmers

Crop	2000		2005		2010	
	Production (t)	Productivity t/ha	Production (t)	Productivity t/ha	Production (t)	Productivity t/ha
Paddy	150.39	2.95	112.8	2.77	106.79	3.56
Black Pepper	148.00	2.69	95.17	1.92	32.32	1.28
Banana	225.26	18.52	344.51	17.40	332.69	16.50
Coffee	114.39	1.54	130.05	1.74	119.72	1.60
Arecanut	34.66	1.47	133.86	3.78	131.02	3.30
Ginger	428.98	11.03	716.74	13.74	457.11	12.29
Turmeric	14.80	5.25	15.28	4.09	21.77	5.10
Cardamom	0.29	0.38	0.6	0.51	4.66	2.12
Tapioca	247.15	24.00	207.05	33.13	206.91	34.77
Yams	137.76	37.87	135.62	32.94	142.84	28.77
Coconut*	21130	6383	20242	6125	17026	5195
Rubber	0.77	0.18	2.50	0.35	4.96	0.41
Tea	12.30	-	11.89	-	11.81	

*- No of nuts

Paddy

Wet land (paddy) conversion to non agricultural and agricultural purpose has been observed in Kerala for long. Wayanad (got its name from '*Wayalnadu*' meaning land of paddy or wetland) has also been experiencing the same. From 1985 to 2010, two third of the paddy area was converted. Presently, 5.55 per cent of paddy land in Kerala is in Wayanad, which constitute 6.25 per cent of GCA. In this 12995 ha, many traditional scented varieties like *Jeerakasala* and *Gandhakasala*, which are unique to Wayanad are cultivated. There are two main crop seasons in Wayanad, for paddy. Nancha (May- November) is the winter crop and Puncha (December - May) is the summer irrigated crop. The GCA under paddy farming was reported as 51.04 ha, of which 72 per cent was Nancha and 28 per cent Puncha (2000). By 2005 there was a decline to the tune of 40.66 ha, the major share being Nancha (36.01 % decline). In later years the rate of conversion was faster at 26 per cent, mainly in Puncha season (37.29 %). Thus, in comparison to the year 2000, the paddy land decline among sample household was observed at 41 per cent; 52 per cent in Puncha and 37 per cent in Nancha. This is faster than the rate of decline in the district as a whole, during the same period.

Nair *et al.* (2007) have reported the large scale conversion of paddy fields into arecanut and coconut plantations since 1990's. This is reported as mainly due to climate change and intensification of commercial cropping. Seasonal conversion of paddy fields also takes place for the cultivation of ginger, turmeric and banana and as a result there is an increasing trend in area under banana and turmeric cultivation (Fig 4.3.4). About five per cent of the cropped area of the sample respondents account for banana cultivation which was only 2.9 per cent in 2000. The water scarcity and relative economic advantage compel the farmers to shift to more remunerative crops like banana. Paddy land conversion is observed to have a neighbourhood effect. Once paddy land is converted, it further intensifies water stress forcing the neighbours also for the same. This further intensifies the conversion process and it has a spiralling effect on water scarcity. Only a community or area based approach can solve this issue.

All the sample farmers cultivating paddy, used it only for household consumption and they were using both traditional varieties (*Palthondi, Adukkan, Thichingam, Kuttiveliyan, Vadakkan, Valichuri, Onatten, Vediyan, Thondi*) and high yielding varieties (*Jaya, Bharathi, Harsha, Uma, Kanchana, Kalyani, Matta, Shabari, Lakshmi*). Wayanad is known for speciality rice varieties like *Jeerakasala* and *Gandhakasala* which are the scented varieties.

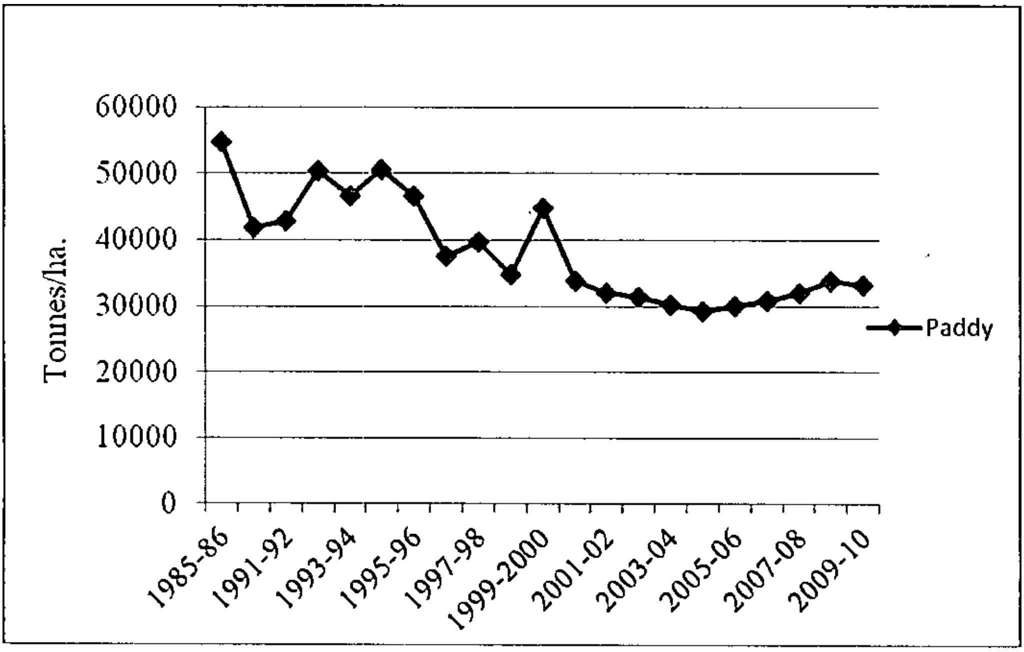
Some farmers were cultivating these also. They believed that even though the productivity of traditional varieties was low, their resistance to pests and diseases were high. Besides most of them are drought tolerant.

Wetland ecosystems provide many services that contribute to human well being and poverty alleviation. Some groups of people, particularly those living near wetlands are highly dependent on these services and are directly harmed by degradation. Padmanabhan (2004) reported that '*Paniya*' – a tribal group in Wayanad as severely affected, because their livelihood depends entirely on employment in the paddy fields. The farming communities of the *Kuruichiyars* and the *Wayanadan Chettys* also face the dilemma of poverty while endangering ecosystem functions (Devi *et al.*, 2009a).

Most important wetland services are ensuring water availability and fish supply, others being water purification, detoxification of wastes, climate regulation and mitigation of climate change (MA, 2005). The trend of turning multifunctional paddy fields into monoculture banana and arecanut plantations has serious economic, cultural and ecological consequences. This accelerates the loss of biodiversity and further weakens the food security. Agro-biodiversity is also severely threatened by the competition of banana and arecanut for commercial purpose thereby converting, integrated agro-ecosystems into unsustainable cash crop plantations.

As a result of the reduction in area, a decrease in production was also noticed. Presently, the production of paddy is only 33157 tonnes which accounts for about six per cent of the paddy production of the state, where as it was 54800 tonnes in 1985-86 (Fig 4.3.5). In 2000, the paddy production in the sample farms was 150 tonnes which reduced to 107 tonnes in 2010. Though the production status shows a declining trend, highest productivity (3.56 t/ha) was obtained in 2010, which was higher than the district average (2.55 t/ha).

Figure: 4.3.5 Production status of paddy of Wayanad (1985-86 to 2009-10)



Source: Department of Economics and Statistics, Wayanad.

Arecanut

Arecanut was not an important component in Wayanad agriculture and got introduced during late 1990's. Presently it is grown in 10862 ha i.e. 10.95 per cent of the total arecanut area in the state. Arecanut, which presently accounts for about 10 per cent of area among sample farmers, was cultivated only in five per cent of area in 2000. This increase was mainly due to the stable price of the crop along with the guaranteed yield. Minimum demand for cultivation practices and plant protection measures favours the crop choice. Besides, management of the plantation is easy compared to paddy.

Wayanad contributes to about five per cent of the total production of the state. An increasing trend in production is noticed among the sample farmers. Productivity (3.3 t/ha) was higher than that of the state whereas district average was lower than this.

Banana

Banana, especially *nendran* variety is one of the major commercial fruit crops cultivated in the state. This is one of the very few crops which exhibit a steady increase in area under farming in the state. Roughly 10 per cent of area under this crop is in Wayanad. The major varieties of banana in Wayanad are *Nendran, Mysoreppovan, Robusta* and *Palayankodan.* Banana cultivation in the state is usually taken up in paddy lands.

The area under commercial banana farming shows steady increase in the sample farmers also. During the previous decade till 2010, the area under the crop has registered an increase of 66 per cent, which was faster during the first half.

Presently five per cent of the GCA is under banana cultivation. The extension support, input supply and market support by VFPCK can be attributed as a major reason for the spread of the commercial farming. However, Devi (2009b) reported the environmental consequences of high chemical pesticide use in banana farming in Wayanad. Further, the loss in agro-biodiversity and the ecological damages due to wet land conversion, cause severe ecosystem damage. Hence the long term social cost of banana cultivation may have to be compared with short term private gains.

Banana production of the district accounts to 79147 t with a higher productivity (18.22 t/ha) than the state average (7.55 t/ha). This is to be studied in detail. For the sample farmers, a decrease in production and productivity was observed in spite of the increase in area.

Rubber

Rubber is the most important commercial crop in Kerala, which registers persistent increase in acreage, during the previous decades. The crop was introduced in Wayanad very recently and is presently to the extent of 9723 ha, constituting 4.68 per cent of GCA. This is only1.9 per cent of the area under the crop in the state.

The sample farmers show distinct preference for the crop and the area has increased by 177 per cent during the decade. Presently it is 2.97 per cent of GCA. The policy support and relative economic advantage of rubber cultivation prompt the farmers to shift to this crop. However the ecological consequence of extensive rubber farming in this fragile ecosystem is to be studied in detail. The impact on food security is another matter of serious concern.

There is a visible change in cropping pattern over the years in Wayanad as a result of both climatic and socio-economic factors. Crops like coconut and rubber which were once considered as not adaptable to the local environment, have already found a place in many homesteads and area under these crops are continuously increasing. As on 2010, about five per cent of the net area cultivated is occupied by these crops. Increasing area under these crops acts as an indicator for the severe changes happening in the local climate. Another crop which occupied an important position recently among the crops of Wayanad is arecanut which accounts for almost five per cent of the cultivated area. This crop is becoming a serious threat to the food security and biodiversity of the district, since the cultivation is practised by mainly replacing paddy (conversion of wetlands to garden lands). Cultivation of food crops like banana, tubers and vegetables are also there which is meticulously promoted by the Department of Agriculture and Vegetable and Fruit Promotion Council Keralam (VFPCK). Banana cultivation has attained a commercial status which is mainly cultivated in wetlands and area under banana accounts to nearly five per cent. Area under turmeric shows an increasing trend over the years (0.67 per cent in 2000 to 1.06 per cent in 2010). Not much variation could be noticed in the share of ginger to the total cropped area. Tubers and vegetables occupy only a small proportion.

Thus it could be seen that food crops like paddy and tapioca (which was a major staple food) registered a steep fall in acreage along with a major income earning component, black pepper.

Meanwhile the farmers slowly shift to commercially stable crops like arecanut, coconut, rubber, cardamom, turmeric and tea. Banana and yam which shows a rising importance are the only two food crops in this group. Vanilla, cauliflower, floricultural enterprises that was a boom in Kerala during the last decade exhibits the same pattern in Wayanad also. Apart from the direct effect on food security and employment generation, the cropping pattern changes in Wayanad is to be analysed and studied in sustainable perspective of ecosystem balance.

4.4 Farmers perception on climate change and impacts on different crops

Agricultural change does not involve a simple linear relationship between the changes in the farmers' decision making environment (e.g. environmental change, policy changes, economic and social changes) and farm output. Furthermore, the changes can be analysed at a variety of geographic scales (Smit and Smithers, 1993; Bryant *et al.*, 1997) for each of which it is necessary to trace out the key forces affecting agriculture, how they are perceived by farmers and how these perceptions could be translated into agricultural decisions. Farmers develop their perceptions through experiential processing of mental samples (experience) gathered over a long period of time. Scientific remedies to problems can be effectively implemented only if the user level understanding of the problem is scientific. The farmers can be convinced about the causes, consequences and remedial measures only if they have a better perception and knowledge level.

The discussion of climate change has been confined to policy briefs and academic circles. But the mass media attention and the micro level weather aberrations have made the lay man aware of the phenomena. Hence there is a general tendency among people to link all changes to climate change.

All the sample respondents opined that there is an increase in temperature over the years, both in minimum and maximum temperature. Most of the farmers opined that there is a significant change in rainfall pattern too. About 88 per cent of the farmers were of the view that there is a steady decline in annual rainfall where as the rest believed that there is not much change in the total amount of rainfall received, but only the pattern has changed (table 4.4.1). The older generation recollected the rainfall pattern in Wayanad as distinctly different from that of today. There used to be year-round rainfall. This was locally known as '*Noolmazha*' the rainfall that resembled a thread (*Nool* means thread and *mazha* means rain in Malayalam) because of its thin and continuous nature. Because of the low intensity and continuous nature, the runoff was low and thus the groundwater recharge was high. This also facilitated the maintenance of cool climate. Wayanad was often a favourable place for tourists because of this.

Presently, the pattern of rainfall is reported to have changed to a high intensity rain during season and long spells of drought in summer (76.30 %). This result in low water recharge (because of the slope, runoff is high). The agricultural systems and livelihood pattern are also severely affected, because of the water stress (91.56 %).

Table.4.4.1 Farmers' perception on climate change

Sl.no	Impact	Farmers Responded (%)
1	Increase in temperature	100
2	Rainfall	
a.	Decline in annual rainfall	88.89
b	No change in annual rainfall	11.11
c	Delay in the onset of monsoon	14.81
d	Early onset of monsoon	8.15
e	Heavy rainfall in rainy season followed by drought in summer	76.30
f	Decline in water availability	91.56
3	Crop Pest / Disease Incidence	
a	Increase in pest attack	76.30
b.	Minor pests becoming major pests	32.60
c.	Increase in disease incidence	75.45
d.	Increasing crop management problems	37.78
4	Decreased crop yield	95.56

Apart from the direct effect through water stress, the changes in weather affect the crop management through its effect on pests or pathogen characteristics. Increase in temperature, variability in rainfall intensity and distribution, increasing CO_2 concentration in the atmosphere, extreme events like floods, droughts, hurricanes and storms will result in the increase incidence of pest and diseases (FAO, 2008). About three – fourth of the sample respondents have perceived the increased incidence of pest and diseases as due to the changing climate. Nearly 33 per cent of the sample respondents reported about the emergence of minor pests as major, whereas 37 per cent shared their view of diseases becoming uncontrollable over the years. Majority of the farmers (95.56 %) pointed out the considerable yield reduction in recent years. They believe that there is a negative relationship between the yield performance and climate change.

As a whole the general perception of climate change effects include a decline in annual rainfall and its skewed nature. This lead to water stress condition. There are differing reports from across the globe, on the impacts of climate change on crop productivity (Challinor *et al.,* 2005). Some reports predict a desirable outcome, while others reported a negative impact. The effect, however seems to vary depending up on the region, crops and socio-economic settings. The respondents in this study reported a decreased crop yield as a result of changes in weather parameters experienced in Wayanad.

The farmer level observation and perception of changing climate and its impact on individual crop may differ. Here, an attempt is made to get the responses from farmers on the impact of climate change on major crops grown in the district.

4.4.1. Paddy

Studies suggest that the temperature increases, rising sea levels and changes in rainfall patterns and distribution expected as a result of global climate change could lead to substantial modifications in land and water resources for rice production as well as in the productivity of rice crops grown in different parts of the world (Kumary, 2011). As for Kerala, rice is not only the staple food crop but also socially, economically and politically important crop of the State. Impact of climate change on rice production in Kerala depends on the actual pattern of change in different rice growing regions in the State.

Climatic elements such as temperature, precipitation, radiation, humidity and wind speed are found to have a profound influence on the growth, development and yield of paddy crop. In Kerala the study conducted by Saseendran *et al.* (2000), made projection on the effect of changes in weather variables on paddy output. It is projected that paddy maturity period will be reduced by eight per cent and yield increase by 12 per cent when temperature elevations only are taken into consideration. An increase in CO_2 concentration leads to yield increase, due to its fertilisation effect and enhanced water use efficiency. For a positive change in temperature up to 5 and 17^0C, there is continuous decline in the yield. For every one degree increment, the decline in yield is about six per cent. In another experiment conducted by the same authors, it was observed that the physiological effect of ambient CO_2 at 425 ppm concentration compensated for the yield losses due to increase in temperature up to 2 and 17^0C. Increase in paddy yield due to increase in rainfall above the observed values were near exponential. But decrease in rainfall results in yield loss at a constant rate of about eight per cent per 2 mm/day, up to about 16 mm/day.

A study by Susha (2011) on the economic impact of climate change on Farm Business Income of the paddy farmers of *Kuttanad* and *Kole*, the major paddy growing tracts of Kerala revealed that an increase in temperature by 1^0C and a rise in rainfall by 1cm during the initial stage of the crop would have a positive impact on farm business income by 0.82 units. If this increase in temperature and rainfall is received in the second half of the cropping season only, there would be net decline in income by 10 units. If these changes are there both in the first and second half of the cropping season, there would be a net decline of farm business income by 9 units.

Paddy production in Wayanad is usually practiced in valley bottoms, which are relatively broad and extensive. Predominantly it is a transplanted crop, season commencing in July and harvested in December. Change in the amount and distribution of rainfall is the most important factor limiting the yield of rainfed rice. Variability in the onset of the rainy season leads to variation in the start of the planting season. In freely drained highland, that receives precipitation of 200 mm in one day and then receives no rainfall for the next 20 days, moisture stress severely damages or even kills rice plant (Saseendran *et al.*, 2000). Complete crop failure usually occurs when severe water stress takes place during the reproductive stages.

Most of the farmers were of the opinion that climate change, in particular water scarcity along with other socio-economic factors had severely affected the paddy cultivation of the region which is revealed by the reduction in area under paddy. Water stress has led to a situation where paddy lands are kept fallow or converted for plantation crops which are cultivated as rainfed. Apart from this direct effect, the yield and performance of paddy is reported to have affected by several indirect influences. About half of the respondents suspected pest outbreak as the serious impact. Major pests reported were stem borer (*Scirpophagus incertulas*), rice bug (*Leptocorisa acuta*) and leaf folder (*Cnaphalocrosis medinalis*). Details of farmer perception on impact of paddy production is given in table 4.4.1.1

Nearly 45 per cent opined increased occurrence of diseases as a main issue. The most important diseases causing crop damage being sheath blight, leaf blast and yellowing. Some farmers reported 'Tungro' as an emerging disease.

Higher competition from weeds (27.41 %) and wilting (5.19 %) were also reported as an indirect effect of climate change. However, the farmer perception on climate change impact on pest incidence and management is to be analysed with caution. There is a chance that the general awareness and mass media exposure may make the farmer link everything to climate change. However this can be taken as indicative results which can be validated scientifically.

Table: 4.4.1.1 Farmers' perception on impact of climate change on paddy production

Sl.no	Impacts	Farmers responded (%)
1	Increased pest attack	49.63
2	Increased disease incidence	45.19
3	Water stress	60.55
4	Increase in weeds	27.41
5	Wilting	5.19
6	Decrease in yield	15.55

4.4.2 Black Pepper

Total rainfall and its distribution play an important role in black pepper production. An annual rainfall of around 2000 mm with uniform distribution is ideal for crop growth. It can also be grown in areas receiving low rainfall, provided the distribution of rainfall is uniform. The maximum annual growth of black pepper i.e. new flushes initiation and its growth, spike emergence and development coincide with the peak rainy period. Kannan *et al.* (1987) reported that a dry spell from February to April should prevail for satisfactory spiking in black pepper. Rainfall of 70 mm received in 20 days during May-June has been sufficient for triggering off flushing and flowering process. Once the process is set off there should be continuous shower until fruit ripening. Any dry spell even for few days, within this critical period of 16 weeks (flowering to fruit ripening) would result in low yield (Pillay *et al.*, 1988). Heavy rains during flowering reduce the rate of pollination and it promotes vegetative development and limits flowering. Kandiannan *et al.* (2012) reported that decline in rainfall and temperature increase has resulted in the wiping out of several black pepper gardens in Wayanad during summer 2004. Similar result was also reported from Idukki, a predominant black pepper growing zone by John *et al.* (1999).

Black Pepper once was an inevitable component of Wayanad's homestead farming. Compared to that presently the presence of black pepper in the homestead is limited. Quickwilt and yellowing, the most common diseases in the area was reported as a major reason. Most of the farmers (88.15 %) attributed this as the consequence of climate change (Table 4.4.2.1). Nearly three-fourth of the farmers reported wilting due to disease and physiological stress. More than half (57.78 %) of the respondents supposed emergence of minor pests as major. Mealy bug and pollu beetle (*Longitarsus nigripennis*), once minor pests are presently reported as economically important ones. The pest or disease incidences led to decreased berry formation and reduction in quality. The weather during the harvesting season influences the quality of marketed produce. The post harvest operation, mainly drying is often affected by unseasonal rains.

Black pepper, the *King of Spices* is a major item in the export basket in agricultural trade. The qualitative supremacy of Malabar pepper was known in the international market which led to premium price recovery. The changes in weather pattern during production and post production stage is reported to be seriously affecting the price recovery and trade. Majority of the farmers (89.63 %) experienced poor yield due to high pest and disease attack, which is partly attributed to climatic factors. In general, it was reported that though proper and timely management practices were carried out, expected outcome was not realised and the returns from black pepper farming was dwindling. The fall in yield of black pepper is mainly attributed to climate change impacts- both direct and indirect. The direct effects are mainly due to the low/ unseasonal/ skewed rainfall pattern. The indirect effects are due to the changes in pest/ disease dynamics. In general, farmers reported the overall effect of climate change on black pepper yield as negative.

Table 4.4.2.1 Farmers' perception on impact of climate change on black pepper

Sl.no	Impacts	Farmers responded (%)
1	Increase in pest attack	57.78
2	Increase in disease incidence	88.15
3	Early / Delay flowering	5.93
4	Increase in berry formation	5.19
5	Decrease in berry formation	43.70
6	Increase in wilting	73.33
7	Decrease in yield	89.63
8	Decrease in quality	10.37

4.4.3 Coffee

Coffee plantations in Kerala are mainly concentrated in Wayanad (79.44 %) (Farm Guide, 2012). Coffee is grown in the district as pure crop and as a component in home gardens. It is the most important crop in the district both in terms of acreage and livelihood dependency. Coffee plantation is highly dependent on climatic conditions. Environmental factors like sunlight, moisture and temperature plays a crucial role in the growth pattern of coffee. Even a slight deviation from the normal pattern can have great impact on the yields of coffee (Prakasan and Vinodkumar, 2012). In several coffee growing regions it was observed that rising temperatures are affecting coffee crop.

There are mainly two cultivars of Coffee, Arabica and Robusta of which Robusta coffee was common in Wayanad (among the respondents). Robusta grows well in areas with abundant rainfall of about 2500 mm annually and the rainfall should be well distributed as the plants are shallow rooted. In coffee, adequate rainfall during blossoming period (February – March) and fruit set period (March – April) is essential for high yields (Kannan *et al.*, 1987). The rainfall distribution is particularly important to coffee growers because untimely rains induce flowering and also impact on the harvesting operation. This leads to multiple fruit stages facilitating berry borer attack and more left over and fallen fruits due to rains during the harvest period. An evenly distributed rainfall, on the other hand assists in keeping the activity of stem borer low (Prakasan and Vinodkumar, 2012).

The optimum temperature range that favours coffee growth is 24 to 30°C, but it is less tolerant to very high or very low temperature. Increase in temperature force coffee to ripen faster than normal, impacting the inherent quality. Increase in temperature coupled with low rain fall and its erratic distribution affect flowering and fruit set adversely.

The changes in the rainfall cause major problems for drying and processing of coffee. Unforeseen rains during the drying process will affect green coffee quality reducing its marketability. During droughts, the pulp sticks to the grain and impedes the de-pulping process of cut coffee.

Coffee growers underline the importance of rainfall pattern on yield performance. There used to be a time when the heavy downpour in February initiated the flowering in coffee, and ensured good fruit set. The ideal rainfall during the critical period helped the farmers to make realistic prediction on yield.

Unlike other crops, incidence of pest and diseases was generally low in coffee. Yield reduction was reported mainly due to decrease in flowering (57.78 %) and berry formation (54.07 %) (Table 4.4.3.1). Some farmers also pointed out that increased shedding of flowers (35.56 %) and premature fall of berries (40 %) as a reason. Increase in temperature cause a decrease in pollination and coffee berry production. About 40 per cent of the sample respondents reported reduction in quality due to the rotting of beans in rain. Thus, the effect of climate change on coffee production is more direct through its effect on berry setting, development and harvesting.

Coffee and black pepper even though known to respond well with the availability of water in the form of rainfall, the yield of the crops are determined primarily by the weather conditions prevailing during March and April, relatively hotter months of the year (Peter and Kumar, 2011). The rainfall in March extending up to April half affects the yield of both the crops in a very contrasting manner, as rains during this period of year enhance the yield of coffee and reduce the yield of black pepper. A well distributed monsoon rainfall during June and September affect the yield of black pepper positively. In a rainfed cropping system where the crop is facing vagaries of unpredictable weather conditions, a combination of coffee and black pepper would be a better proposition.

Table: 4.4.3.1 Farmers' perception on impact of climate change on coffee

Sl.no	Impacts	Farmers responded (%)
1	Decrease in flower formation	57.78
2	Decrease in berry formation	54.07
3	Increase in pest attack	4.44
4	Increase in disease incidence	41.48
5	Increase in flower shedding	35.56
6	Increase in premature fall of berries	40.00
7	Decrease in quality	39.26
8	Decrease in yield	37.78

4.4.4 Other crops

Other major crops in the cropping pattern of Wayanad are banana, ginger, turmeric, arecanut and coconut. For these crops the impact of climate change is mainly through change in pest and disease incidence.

For banana, the major yield constraints are pests, of which rhizome weevil (*Cosmopolites sordidus*) and pseudostem weevil (*Odoiporous longicollis*) is reported to have serious impact (73.33 %). Water stress was also creating problem for banana cultivators as this is a water sensitive crop. It was reported that bunch formation was not uniform due to the variation in the water availability (17.04 %). Apart from this water stress also led to physiological wilt. Though there is water stress, farmers were more concerned about high intensity rains as the latter will destroy the entire crop so that the farmer didn't get even the investment back. Besides, severe crop damage due to wild elephants and pigs were also reported from areas close to the forests.

The major constraint to ginger and turmeric farmers was *Mahali* disease. Due to the increased incidence of this, many farmers has shifted ginger cultivation to other states like Karnataka by leasing in land and some others restricted ginger cultivation for consumption only. Farmers however are not sure about the direct link between climate changes and pathogen population.

Coconut, arecanut and rubber, presently occupying 15 per cent of the Gross Cropped Area are relatively new crops in the district. Farmers find these crops suitable to the present agro-ecosystem of Wayanad.

4.4.5 Water Scarcity

An individual is water insecure, when he does not have access to safe and affordable water to satisfy his or her needs for drinking, washing or their livelihoods. When a large number of people in an area are water insecure for a significant period of time, then we can call that area water scarce (Rijsberman, 2006). Water insecurity can arise from physical scarcity, resulting either from climatic or geographical factors, or from unsustainable consumption or overexploitation. It can also have economic origins, with poor infrastructure or capacity preventing access to the water resources available, or occur where pollution or natural contamination renders water resources inaccessible.

All the respondents in the study expressed their concern of growing water scarcity and shared their views of further worsening situations in future. About 30 per cent of the sample respondents were experiencing water shortage for domestic purpose and this normally occurs during the summer season (March – May). Some farmers (16 %) expressed that this used to be there for more than five years, but for the rest it was a recent constraint. One third of MF and SF experience water shortage whereas it was only 17 per cent among LF.

Table 4.4.5.1 details the responses of the sample respondents on the possible reasons of water scarcity. 73 per cent of them attribute the large scale deforestation as the major reason. Though Wayanad district still have highest proportion of forests, the extent of forest cover has declined over the years. Moreover, the homesteads of Wayanad were known for its high biodiversity with a high proportion of perennial trees. This facilitated water retention and recharge. The erosion in structural diversity owing to the spread of monoculture farming reduces the ecosystem functions considerably.

About 70 per cent strongly believe water scarcity as a result of climate change. As already discussed, there is significant change in the weather parameters (rainfall intensity and pattern, maximum and minimum temperature, humidity, atmospheric moisture etc.) which resulted in water stress in the region.

Conversion of paddy lands was pointed out as a major reason for water scarcity by about half of the respondents. Large scale conversion of paddy lands has been taken place either for cultivation of crops like banana and arecanut or for construction purpose. Area under paddy in the district had declined steadily over the years.

One-third of the respondents reported increasing population as a cause for water scarcity. Presently, population density of the district is 383 persons per square kilometer which was only 366 persons/sq.km in 2001. As the population increases the water requirement for domestic and productive purposes increases which in turn would result in scarcity.

Change in land use pattern (13.33 %) and undulating topography (9.62 %) were also pointed as reasons for water scarcity. There is significant change in the land use pattern and cropping pattern over the years as already discussed in section 4.2 and 4.3. This change along with the existing undulating topography reduces the infiltration rate, thus affecting the ground water recharge resulting in water scarcity.

Table: 4.4.5.1 Reasons for water shortage as perceived by the respondents

Sl.no	Reasons	Farmers Responded			
		MF	SF	LF	Total
1	Climate change	26 (53.06)	50 (79.37)	18 (78.26)	94 (69.63)
2	Conversion of paddy fields	31 (63.27)	26 (41.27)	8 (34.78)	65 (48.14)
3	Deforestation	39 (79.59)	44 (69.84)	16 (69.57)	99 (73.33)
4	Change in land use pattern	2 (4.08)	12 (19.05)	4 (17.39)	18 (13.33)
5	Topography	2 (4.08)	6 (9.52)	5 (2.17)	13 (9.62)
7	Increased population density	10 (20.41)	25 (39.68)	10 (43.47)	45 (33.33)

Figures in bracket show the percentage to the total number of respondents in respective group

4.5 Water Stress and Vulnerability

Water in public domain has always remained a critical factor in our livelihood systems. The role of water in the development of human civilization and livelihood is also undisputable. Water is used for most of the livelihood based activities and the most important among them being agriculture and food supply. Though Earth has a huge quantum of water resources, usable water is extremely limited and so also its access. Across the World, per capita water use continues to rise while the availability is declining (Deshpande, 2011).

Kerala is a water resource rich state owing to its tropical and coastal location. It is blessed with 44 rivers and an average annual precipitation of 300 cm. The actual rainfall received in Kerala during the south west monsoon of 2011, was 2215.8 mm as against the normal rainfall of 2039.6 mm. All the 10 districts in the state received normal rainfall, Kozhikode and Ernakulam had excess rainfall while two districts (Thiruvananthapuram and Wayanad) received deficient rainfall (-33% and -25% respectively) (Economic Review, 2011).

During the north east monsoon season 2011, the state received 450.8 mm of rainfall as against 480.7 mm of normal rainfall with a percentage departure of -6 % from the normal. All the 12 districts in Kerala received normal rainfall during this season except Ernakulam and Pathanamthitta districts which recorded deficient rainfall.

Kerala received 313.3 mm pre monsoon rainfall in 2011, which was normal. Seven districts in the state (Alappuzha, Ernakulam, Idukki, Kasaragod, Kottayam, Pathanamthitta, and Wayanad) received normal rainfall while seven districts (Thiruvananthapuram, Thrissur, Malappuram, Palakkad, Kozhikkode, Kollam and Kannur) received deficient rainfall.

The long term mean annual rainfall of the state is 2817 ± 406 mm and it is highly stable and dependable (Rao *et al.*, 2008). However, spatial and temporal variation in rainfall is common nowadays (Kandiannan *et al.*, 2008). Rao *et al.* (2009) studied the long term series of climatological data for 140 years over Kerala and indicated a cyclic pattern in rainfall with a declining trend in annual and southwest monsoon rainfall during the past 60 years. In contrast, there was an increasing trend in post monsoon rainfall, indicating likely shifts in rainfall patterns. Rise in maximum and minimum temperatures was also noted since last 49 years over Kerala. The day maxima increase was 0.64°C while the night minimum 0.23°C.

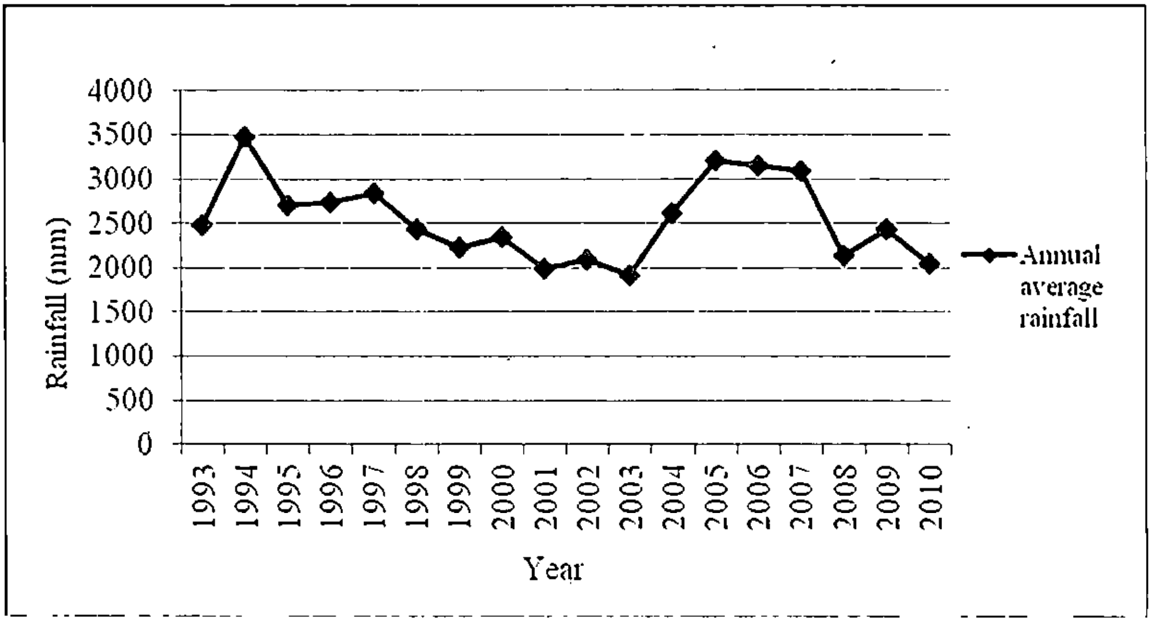
These changes in thermal and moisture regimes have resulted in climate shifts from B4-B3 to B2-B1, moving Kerala from wetness to dryness within the humid climate.

The prosperity of Wayanad fully depends on weather, as the major sources of income being agriculture and tourism which are directly linked to weather. It is reported that climate change has already affected the district in terms of declining rainfall and increasing temperature (Krishanmurthy *et al.*, 2011; Kandiannan *et al.*, 2012). Rainfall pattern of the district over the years demonstrate a declining trend (Fig 4.5.1) and also the district receives deficient rainfall continuously for more than ten years (Fig 4.5.2).Variation and erratic nature in the rainfall pattern has affected agriculture adversely. It is believed that the summer showers determine the corresponding year's yield and failure of summer showers have a deleterious effect on pepper and coffee yield, the major crops of the district.

The district cannot utilize the rainwater properly because of its highly undulating topography. This often leads to heavy water scarcity during summer especially by March-May.

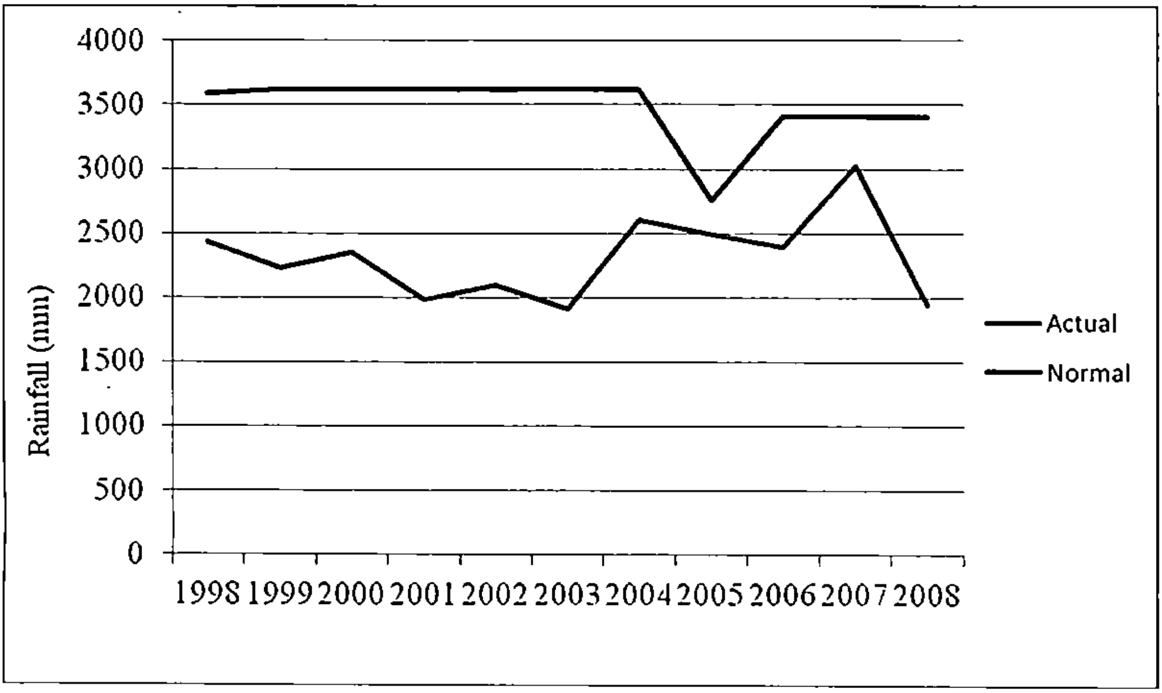
The study conducted by Sunil *et al.* (2012), projects very high variation in the rainfall pattern of the district in future years. An increase in the average annual rainfall coupled with lower levels of summer showers are predicted. By 2020, summer showers may decline to 43.6 mm as against the present, 70 mm. High intensity rains with low duration will be the major characteristic. A gradual increase in annual temperature by about 1.5°C is predicted and it also projects an increase in temperature in the April (hottest month) would be by 1.4°C and that in December (coolest month) 1.1°C. High intensity rains within short period may further worsen the water scarcity apart from causing natural disasters like landslides and soil erosion. All these predicted changes in weather factors foretell a negative effect on agricultural economy of the region.

Fig: 4.5.1 Trend in annual rainfall pattern in Wayanad (1993-2010)



Source: Department of Economics and Statistics, Wayanad

Fig: 4.5.2 Deviation of actual rainfall from normal rainfall in Wayanad (1998-2008)



Source: Department of Economics and Statistics, Wayanad

Wayanad has been experiencing plentiful water supply for years. But today the entire region is facing drought due to change in rainfall pattern, unchecked deforestation and large-scale conversion of paddy fields into plantations. Almost the entire Wayanad district is drained by *Kabani* and its tributaries viz. *Panamarampuzha, Mananthawadypuzha, Bavelipuzha* and *Noolpuzha. Kabani* is one of the three east flowing rivers in Kerala and is an important tributary of Cauvery river which originates from the Western Ghats. *Mananthavadypuzha* originating from *Thondanmudi Malai* on the West of the district flows towards east and joins *Panamarampuzha* at 7 km north of Panamaram. *Panamarampuzha,* originating from Lakkidi flows towards North and North-East direction, which is fed by *Karamanthode, Venniyodupuzha, Karapuzha* and *Narsipuzha* in different places. *Bavelipuzha*, flowing towards east in the north of the district joins *Kabani* river at state boundary in Bavali, while *Noolpuzha*, which drains in the eastern part of the district, join *Kabani* river just outside the state boundary. *Kabani* and its tributaries carved the present landscape of the district (CGWB, 2007). Other drainages in the district are *Chaliyar* and *Valapattanam.*

There are no major irrigation projects in the district, but construction of two minor irrigation projects is under progress. One is Karapuzha Irrigation Project constructed in Karapuzha, tributary of Panamarampuzha. Other is Banasura Sagar Irrigation Project constructed on Choornipuzha, which is also a tributary of Panamarampuzha.

4.5.1 Measuring vulnerability to water stress

The IPCC defines vulnerability as the extent to which an environmental or social system is susceptible to and unable to cope with adverse effects of climate change, including climate variability and extremes (IPCC, 2007). Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which the system is exposed, and the sensitivity and adaptive capacity of that system (Adger *et al.*, 2005). Exposure is defined as the degree of climate stress upon a particular unit of analysis whereas sensitivity is the degree to which a system is affected, either adversely or beneficially by climate-related stimuli. And adaptive capacity is the ability of a system to adjust to climate change to moderate potential damages, to take advantage of opportunities, or to cope with the consequences. A highly vulnerable system would be a system that is very sensitive to modest changes in climate, where the sensitivity includes the potential for substantial harmful effects, and for which the ability to adapt is severely constrained.

The index of vulnerability tries to measure the extent of vulnerability by focusing on indicators that measure the exposure of the system (in this case, farmer), the sensitivity of the farmer to the exposure and the capacity to adapt to it. Hence it acts as an indicator of the development of the farmers and his capacity to progress further. Specifically, the index looks at three different aspects of viz. the social, economic and agronomic factors. This index is integrative in nature and is a multidimensional concept for the assessment of the potential effects of climate change. This necessitates the identification of proxy variables. The resulting single index value provides a measure that is simple and can clearly bestow the vulnerability of a system.

Social and economic factors exert direct impact on the vulnerability of the farmers as these directly influence their decision making and adaptive capacity. Social factors include literacy, crop insurance and land ownership status whereas sources of income, total household income and percentage of livestock income to total income are considered as economic factors. These social and economic factors try to measure the sensitivity of the farmer.

Agronomic factors mainly reflect the exposure level, indirectly. The major variables included under this are cropping intensity, diversity index, varietal tolerance, percentage of irrigated area to total area, percentage of deviation in water table in the wells during summer from that of the normal. Water and soil conservation practices, sources of water and ownership status of sources of water which measure the adaptive capacity of the farmer, are also incorporated in agronomic factors.

As per the methodology detailed in chapter III, farmers were categorised into three groups based on the extent of vulnerability as severe, moderate and low for each and every indicator under consideration and based on this, main factor effect (Table 4.5.1.1) and interaction points (Table 4.5.1.2 and 4.5.1.3) were calculated. Thus, the total points were 688871, 332415 and 95657 respectively for severe, moderate and low vulnerable group. The point 688871 is the maximum value for the most vulnerable farmer and point 95657 is the lowest value for the least vulnerable one. Hence, the farmers were categorised into two groups as low and high. All those farmers whose points are below the midpoint 332415 were categorised as belonging to low vulnerable and those with higher values than 332415 is categorised as high.

Table: 4.5.1.1 Basis for main effects (points)

Sl.no	Criteria	Severe (S)	Moderate (M)	Less (L)
I	**Social Factors (SoF)**			
1	Literacy	263	183	104
2	Crop insurance			
3	Land ownership status			
II	**Economic Factors (EF)**			
1	Sources of income	247	204	160
2	Total Household Income			
3	Proportion of livestock income to total income			
III	**Agronomic Factors (AF)**			
1	Cropping Intensity	476	324	172
2	Diversity Index			
3	Variety Tolerance			
4	% of Gross Irrigated area to Gross Cropped Area			
5	Water & Soil conservation practices			
6	Sources of water			
7	Ownership of source of water			
8.	Percentage of deviation from normal water availability in Summer			
	Total Direct Points (Main Effects)	5339	3753	2167
	Total Interaction Points	683532	328662	93490
	Grand Total	**688871**	**332415**	**95657**

Table: 4.5.1.2 Basis for interaction points

Interaction in between	SoF& SoF	SoF& EF	SoF& AF	EF& SoF	EF& EF	EF& AF	AF& SoF	AF& EF	AF& AF
SXS	700	1880	3653	1880	933	5120	3653	5120	3907
SXM	227	1502	2809	1502	849	3551	2809	3551	2729
SXL	33	482	1453	482	140	1384	1453	1384	2093
MXS	227	1502	2809	1502	849	3551	2809	3551	2729
MXM	68	861	2335	861	385	2767	2335	2767	1170
MXL	40	360	1227	360	67	843	1227	843	1495
LXS	33	482	1453	482	140	1384	1453	1384	2093
LXM	40	360	1227	360	67	843	1227	843	1495
LXL.	33	95	656	95	9	245	656	245	862

Table: 4.5.1.3 Basis for interaction points

		SoF			EF			AF		
		S	M	L	S	M	L	S	M	L
SoF	S	700	227	33	1880	1502	482	3653	2809	1453
	M	227	68	40	1502	861	360	2809	2335	1227
	L	33	40	33	482	360	95	1453	1227	656
EF	S	1880	1502	482	933	849	140	5120	3551	1384
	M	1502	861	360	849	385	67	3551	2767	843
	L	482	360	95	140	67	9	1384	843	245
AF	S	3653	2809	1453	5120	3551	1384	3907	2729	2093
	M	2809	2335	1227	3551	2767	843	2729	1170	1495
	L	1453	1227	656	1384	843	245	2093	1495	862

Note: S – Severe; M- Moderate; L- Low

Based on this approach, it was found that more than half of the respondents were highly vulnerable to water scarcity. An inverse relationship is observed between the land holding size and vulnerability, three- fourth of the MF were vulnerable while most of the SF and LF (41.27 % and 34.78 % respectively) belonged to the other group. Details are furnished in the table 4.5.1.4.

Table: 4.5.1.4 Vulnerability of respondent farmers to water stress

Particulars	**MF**	**SF**	**LF**	**Total**
High Vulnerability	37 (75.51)	26 (41.27)	8 (34.78)	71 (52.59)
Low Vulnerability	12 (24.49)	37 (58.73)	15 (65.22)	64 (47.41)
Total	49 (100)	63 (100)	23 (100)	135 (100)

Note: figures in bracket show the percentage to total

Though vulnerability of the farmer cannot be attributed to any single indicator, some observations indicate interesting associations. Share of income from live stock is revealed as a very prominent indicator. Those farmers with a low share (<30 %) were grouped under the severe category. On an average, 80 per cent of the respondents were in this category, majority being LF. The MF and SF generally consider subsidiary livestock rearing as a complimentary and supporting enterprise to farming. This is a time tested risk management tool, which help the farmer to tide over unforeseen economic crisis.

Number of sources of water was found as an important indicator. It was noticed that about two-third of the respondents were having only one source of water which make them highly vulnerable. Most of the LF (60.87 %) were found to have more than one source of water, whereas about 70 per cent of MF and SF had only one. Poor access to water reduces the adaptive capacity of the farmer, in times of drought.

The factors like total household income and adoption of soil and water conservation practices were also found to be highly relevant. About 37 per cent were not adopting any of the conservation practices. More than half of MF were under this category while it was only a quarter in SF and LF. Adoption of conservation practices has a direct link with moisture conservation and resultant farm income. The total household income, which may be from farm or non-farm activities have a direct bearing on the vulnerability. Resource rich farmers have the capacity to absorb the shocks. Thus, share of livestock income, total household income, number of sources of water and soil conservation measures are the major factors that influence the vulnerability status.

Based on the vulnerability index of the sample farmers an attempt has been made to rank the different panchayats. Highest rank is given to that panchayat with the highest proportion of farmers falling under the highly vulnerable category. Table 4.5.1.5 furnishes the information on vulnerability of panchayats.

Out of the nine panchayats, Thavinjal panchayat of Manathavady block was the most vulnerable region (Fig 4.5.1). In this panchayat, 80 per cent of the sample respondents are found to be vulnerable to water scarcity irrespective of the land holding size. Apart from the unfavourable status of factors like livestock income, water source, household income, most of the farmers were adopting high yielding varieties of paddy and pepper which are relatively sensitive to drought condition. The crop insurance programmes were not popular and the water table in the wells usually went down considerably during summer season. Thus the economic and agronomic factors were generally unfavourable.

Noolpuzha panchayat of Sulthan Bathery block was identified as a vulnerable area with two-third of the sample respondents being highly vulnerable. Cropping intensity and diversity index in the farms was low and most of them adopted high yielding varieties of paddy. However, in most cases, pepper varieties are drought tolerant. For, majority of the farmers, there was only one source of water. High level of vulnerability was the result of high exposure and low level of adaptive strategies though they are having enough capacity to adapt, as the income and literacy levels were high.

Mullankolly panchayat of Panamaram block is ranked three. About 60 per cent of the sample respondents are highly vulnerable in this panchayat. Low cropping intensity along with low adoption of conservation practices was noticed as the major factors. This was mainly due to their low adaptive capacity as revealed by the low household income and relatively less reliance on livestock.

Poothady, Pulpally, Thondernad and Ambalavayal were having the same level of vulnerability with about 47 per cent of the respondents being vulnerable. Better adaptive capacity of the respondents of these regions in spite of their high exposure makes the situation better in these parts.

Vythiri and Muppainad panchayats of Kalpetta block were found to be the least vulnerable. Low level of vulnerability was the combined effect of less exposure and high adaptive capacity. These regions (Vythiri thaluk) receive the highest rainfall within the district. Compared to other areas, water stress is low in these areas. Moreover, better conservation practices, high cropping intensity and diversity index facilitates moisture retention. Generally farmers adopt moisture stress tolerant varieties of paddy and pepper.

In those panchayats which are ranked highly vulnerable (Thavinjal, Noolpuzha and Mullankolly) most of the farmers were vulnerable irrespective of the land holding size, i.e. despite the adaptive capacity, vulnerability is high. There is need for awareness creation on technological strategies to minimize the risk. At the same time resource poor farmers should be assisted with financial support.

Even in low vulnerable areas (Pulpally, Thondernad, Ambalavayal, Muppainad, Vythiri and Poothady) majority of the MF (in some cases, even 100 percent) are highly vulnerable. This suggests the importance of a sectoral approach than a regional approach in management. Awareness programmes should be conducted on investment low adaptive strategies like rain water harvesting, organic farming, varietal selection and soil and water conservation practices.

MF (resource poor) are the most vulnerable because of their higher sensitivity and exposure coupled with lower adaptive capacity. This highlights the need of policy interaction, focusing on inclusive growth rather than technological solution alone, with geographical focus.

Table: 4.5.1.5. Vulnerability ranking of the study area

Sl.no	Panchayat	Level of Vulnerability	MF	SF	LF	Total	Rank
1.	Thavinjal	HV	9 (90.00)	2 (66.67)	1 (50.00)	12 (80.00)	I
		LV	1 (10.00)	1 (33.33)	1 (50.00)	3 (20.00)	
		Total	10 (100.00)	3 (100.00)	2 (100.00)	15 (100.00)	
2.	Noolpuzha	HV	4 (80.00)	3 (50.00)	3 (75.00)	10 (66.67)	II
		LV	1 (20.00)	3 (50.00)	1 (25.00)	5 (33.33)	
		Total	5 (100.00)	6 (100.00)	4 (100.00)	15 (100.00)	
3.	Mullankolly	HV	1 (50.00)	7 (70.00)	1 (33.33)	9 (60.00)	III
		LV	1 (50.00)	3 (30.00)	2 (66.67)	6 (40.00)	
		Total	2 (100.00)	10 (100.00)	3 (100.00)	15 (100.00)	
4.	Poothady	HV	0 (0.00)	7 (70.00)	0 (0.00)	7 (46.67)	IV
		LV	2 (100.00)	3 (30.00)	3 (100.00)	8 (53.33)	
		Total	2 (100.00)	10 (100.00)	3 (100.00)	15 (100.00)	
5	Pulpally	HV	5 (100.00)	1 (14.29)	1 (33.33)	7 (46.67)	IV
		LV	0 (0.00)	6 (85.71)	2 (66.67)	8 (53.33)	
		Total	5 (100.00)	7 (100.00)	3 (100.00)	15 (100.00)	
6.	Thondernad	HV	4 (80.00)	2 (33.33)	1 (25.00)	7 (46.67)	IV
		LV	1 (20.00)	4 (66.67)	3 (75.00)	8 (53.33)	
		Total	5 (100.00)	6 (100.00)	4 (100.00)	15 (100.00)	

Note: HV – Highly Vulnerable

LV – Low Vulnerable

Figures in bracket show the percentage to total

Table: 4.5.1.5. Vulnerability ranking of the study area (contd.)

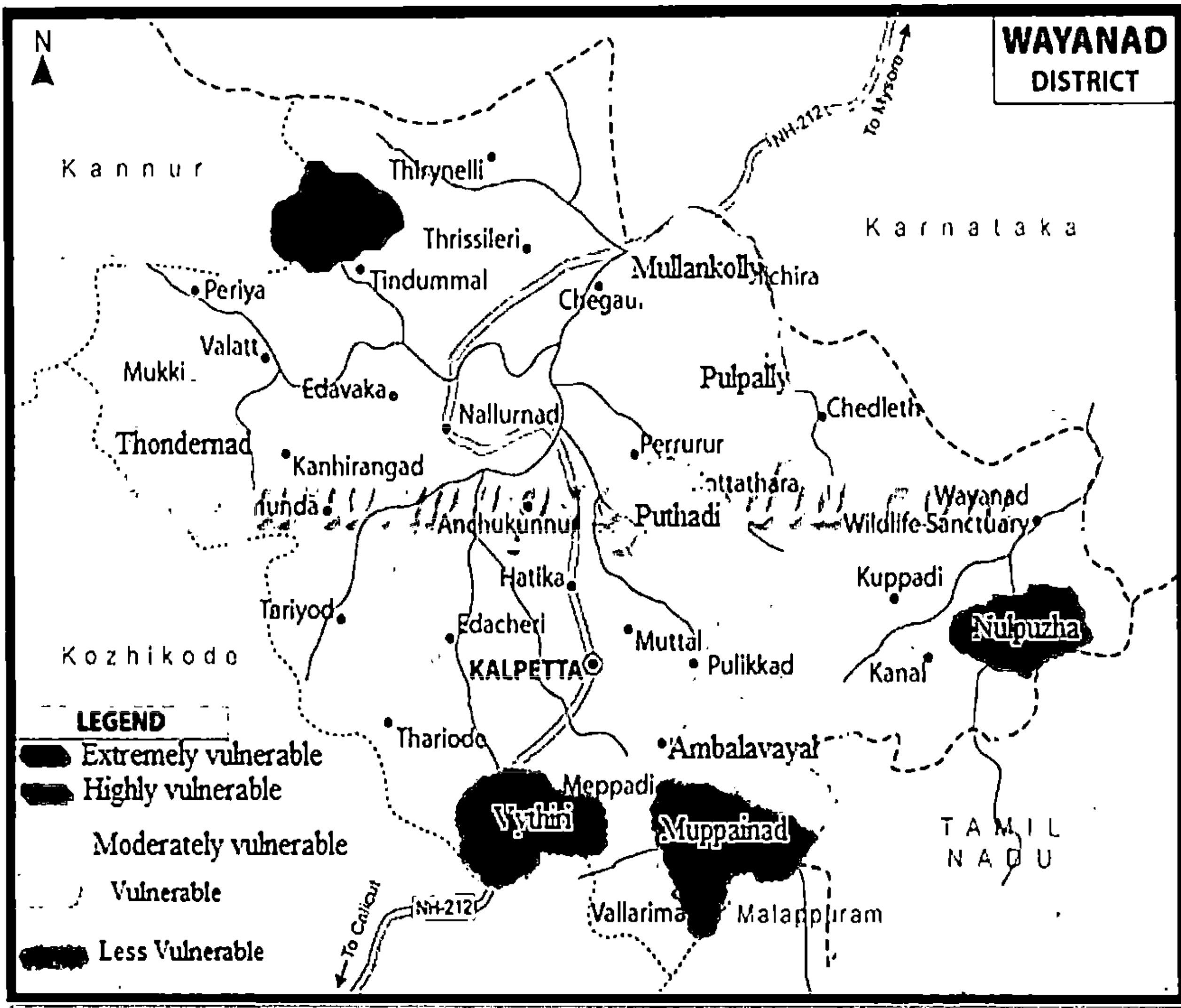
Sl.no	Panchayat	Level of Vulnerability	MF	SF	LF	Total	Rank
7.	Ambalavayal	HV	5 (71.43)	1 (14.29)	1 (100.00)	7 (46.67)	IV
		LV	2 (28.57)	6 (85.71)	0 (0.00)	8 (53.33)	
		Total	7 (100.00)	7 (100.00)	1 (100.00)	15 (100.00)	
8.	Muppainad	HV	4 (100.00)	2 (22.22)	0 (0.00)	6 (40.00)	V
		LV	0 (0.00)	7 (77.77)	2 (100.00)	9 (60.00)	
		Total	4 (100.00)	9 (100.00)	2 (100.00)	15 (100.00)	
9.	Vythiri	HV	5 (55.56)	1 (20.00)	0 (0.00)	6 (40.00)	V
		LV	4 (44.44)	4 (80.00)	1 (0.00)	9 (60.00)	
		Total	9 (100.00)	5 (100.00)	1 (0.00)	15 (100.00)	

Note: HV – Highly Vulnerable

LV – Less Vulnerable

Figures in bracket show the percentage to total

Figure 4.5.1 Vulnerability Mapping



Note: Map is not according to the scale

4.5.2 Changing pattern of vulnerability

A comparison between the Vulnerability Index of farmers for the years 2010 and 2005 was done in order to have a better understanding of the changes in vulnerability status. Data pertaining to social and economic factors for the year 2005 could not be incorporated due to the fear of recall bias. Besides, social factor 'crop insurance' became popular in the district recently (after 2006). Hence a Vulnerability Index for these years was constructed by taking into consideration of the agronomic factors alone using the methodology previously explained.

A specific trend in vulnerability level of farmers could be observed over the years. It is clear that the chances of the farmer becoming vulnerable to water scarcity increased as more proportion of farmers are under highly vulnerable group in 2010 as compared to 2005. All sample respondents were in the highly vulnerable category in 2010 irrespective of their geographical location or land holding size, which was only 48 per cent in 2005 (Table 4.5.2.1). This is mainly due to the increased dependence on irrigation coupled with decreased cropping intensity. The decline in cropping intensity was due to the shift towards commercial monoculture farming, supported by irrigation. This naturally leads to higher level of vulnerability. The number of sources of water has increased over the years and more farmers were focusing on water conservation methods. But the present level of conservation efforts is not enough to compensate the effect of these shifts.

Table: 4.5.2.1 Change in vulnerability status during 2005 and 2010

Particulars	2005				2010			
	MF	SF	LF	Total	MF	SF	LF	Total
High Vulnerability	32 (65.31)	22 (34.92)	11 (47.83)	65 (48.15)	49 (100.00)	63 (100.00)	23 (100.00)	135 (100.00)
Low Vulnerability	17 (34.69)	41 (65.08)	12 (52.17)	70 (51.85)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Total	49 (100.00)	63 (100.00)	23 (100.00)	135 (100.00)	49 (100.00)	63 (100.00)	23 (100.00)	135 (100.00)

4.5.3 Factors influencing the vulnerability status of farmers

A set of factors affect the vulnerability status of the farmer. But it is important to understand the relative importance of each factor and its level of significance. The logit/probit model is used in such situations when the dependent variable is absent or present, say adoption. Devi *et al.* (2007) employed the probit model to assess the probability of falling sick, upon exposure to pesticide. Divya (2007) employed logit model to measure the influence of variables for making a farmer adopt organic methods of cultivation. Suresh *et al.* (2011) in their study on factors affecting the sheep migration in Rajasthan using the logit model identified that the number of male members in the family, flock size, credit absorbing nature of the farmers and caste of sheep farmers as the factors influencing migration.

This study adopts the logit model to have statistical evidence and estimate the influence of each factor on the vulnerability status. The results are presented in table: 4.5.3.1

The model seems to be satisfactory with Hosmer and Lemeshow's chi-square being significant and the likelihood ratio test at 152.315. The signs of all the independent variables were in conformity with the hypothesis. Five out of eight factors viz. diversity index, cropping intensity, percentage of irrigated area to total cropped area, net cropped area and education, have significant influence on the probability of an agricultural household can being vulnerable.

Diversity index and cropping intensity were found to be the most critical factors deciding the vulnerability of a farmer. Both were significant at 1% level. A higher value of Simpson's index implies lower diversity and hence positive coefficient shows an inverse relationship between the diversity and the level of vulnerability. As expected, cropping intensity also has a negative influence. By diversifying and intensifying the farm one can reduce the shock of potential risk.

Percentage of irrigated area to total cropped area was proved to have a direct influence. The coefficient had a positive value implying a direct relationship between irrigated area and the level of vulnerability. Though irrigation is considered as a tactic to cope with the varying climatic conditions, in the coming years of heavy water stress it will become a mal adaptive strategy (Wolff and Stein, 1999). With increase in water stress, more dependence on irrigation for crop production may adversely affect the farmer's welfare as this will demand more investment, making them more vulnerable.

A negative relationship was found in the case of NCA with the vulnerability level at 5% significance. As the net cropped area increases, the possibility of intensifying and diversifying is there which in turn leads to reduced vulnerability.

Education level as measured by the number of years of formal schooling was having a negative effect. Increased education status may improve the exposure and thus farmer's scientific decision making. Besides he could opt for other livelihood options in distress situations.

Table: 4.5.3.1 Logit estimates of factors influencing Vulnerability

Variable	Co-efficient	Standard Error	Wald Statistic	Exp (B)
Constant	3.122*	1.750	3.182	22.687
Education	-.133 *	.072	3.397	.876
Farming experience	-.017	.017	1.005	.983
Diversity Index	10.375***	3.632	8.160	3.206E4
Cropping Intensity	-.010 ***	.004	7.753	.990
Crop Insurance	-.403	.482	.700	.668
Sources of income	-.285	.432	.434	.752
% of irrigated area to total cropped area	.030 **	.014	4.215	1.030
Net Cropped Area	-.552 **	.235	5.525	.576
No: of observations	135			
Chi-square – 5.415	Signifiacane-0.712			

**** Significant at 1% level, ** Significant at 5% level, * Significant at 10% level.*

Crop insurance, sources of income and farming experience which were hypothesised to have a significant effect on vulnerability were found to be not so. All these factors showed a negative impact on the vulnerability as it was hypothesised.

Results of the study were comparable with other similar studies. For instance a recent study conducted by National Bank For Agricultural and Rural Development (NABARD) in 2011-12 in dryland areas in Karnataka showed that the major factors affecting the level of vulnerability of agricultural households as gross sown area, number of crops grown by the farmer and active members to total household members. All of these had an inverse relationship with the vulnerability. Factors like age of the farmer and sources of income turned out to be non-significant.

The analysis highlights the importance of maintaining the diversity and intensity in the farms as the most important adaptive mechanisms. This may be viewed in the background of present shift towards monoculture commercial farming. The policy interventions (educational support mechanisms) towards regulating the farming practise may be given priority.

4.6 Adaptation to water stress

Adaptation constitutes actions that are taken to moderate, cope with or take advantage of actual or expected change of climate and related shocks (IPCC, 2001; 2007). It is an evolutionary process through which population becomes better suited to conditions and habitats which takes place over many generations through experimentation and observation. Adaptation is a way of reducing vulnerability, increasing resilience, moderating the risk of climate impacts on lives and livelihoods, and taking advantage of opportunities posed by actual or expected climate change. Improving social, economic and technical resilience and increasing flexibility within systems is a form of adaptation and allows further adaptation to take place more easily. Increasing adaptive capacity may be achieved through sustainable development, supporting the idea that adaptation activities can occur even in the face of uncertainty.

Adapting to environmental risk involve adjustments and changes at every level of society, from community to national and international. At the national level, governments need to implement strategies that enhance the resilience of national economies to the impacts of climate change. Local communities on the other hand must build their resilience, including adapting appropriate technologies while making use of traditional knowledge, and diversifying their livelihoods to cope with current and future water stress. The local coping strategies need to be employed in synergy with government and local interventions.

An effective way to address the impacts of climate change is by integrating adaptation measures into sustainable development strategies so as to reduce the pressure on natural resources, improve environmental risk management, and increase the social well-being of the poor. It is recognised that climate change impacts do not happen in isolation. Impacts in one sector can adversely or positively affect another. Sectors can be affected directly and/or indirectly by climate change. Sometimes a change in one sector can offset the effects of climate change in another sector. At the same time, adaptation of one group or a single sector may weaken the resilience of another, thus necessitating an integrated approach to adaptation. However in many developing countries there are difficulties in integrating adaptation concerns into national policy due to low staff capacity for planning, monitoring and evaluation; poor data on adaptation options and lack of mechanisms for information sharing and management across sectors; and limited awareness of adaptation among stakeholders and the population (UNFCCC, 2006).

The practical concern over agricultural adaptation is related to the potential damages or costs of climate change and variability to agriculture and society in general (Wheaton, 1990). This includes concern over the costs of measures to mitigate the climate change itself. On the other hand, adaptation to the agricultural system has the potential to reduce other costs, because adaptation implies a 'better fit' to changed conditions (Arthur and Kooten, 1992; Smit *et al.*, 1996).

Adaptive responses can be undertaken at different scales, a farm level response or responses collectively from a locality or community, a particular agricultural sector or a provincial or a regional or the national system. The adaptation strategies include both modern technologies (to be developed) and traditional indigenous knowledge systems and socioeconomic and behavioural changes. UNFCC (2007) list out several mechanisms to combat the impacts like, development of tolerant/resistant varieties (to drought, salt, insect/pests) research and development, soil-water management, diversification and intensification of food and plantation crops, policy measures, tax incentives/subsidies, free market and development of early warning systems.

In this section the farmer responses to growing water scarcity in domestic and agricultural sector is discussed. In general farmers' strategies can be both supply management strategies and demand regulating strategies. The supply management programme includes those activities which ensure the steady supply of water for domestic purpose or irrigation. This includes deepening of existing wells, digging of new ones exploring new sources of water or depending on water markets and soil and water conservation methods. And the demand side management mainly focus on more efficient use of available water resources through better irrigation techniques, appropriate farming techniques and crop rotations. Further the risk management strategies also include other economic and social instruments as well.

These are practised by the farmers knowingly or unknowingly to decrease the vulnerability to water scarcity. Adaptive strategies practiced by the sample respondents can also be classified as short term and long term strategies.

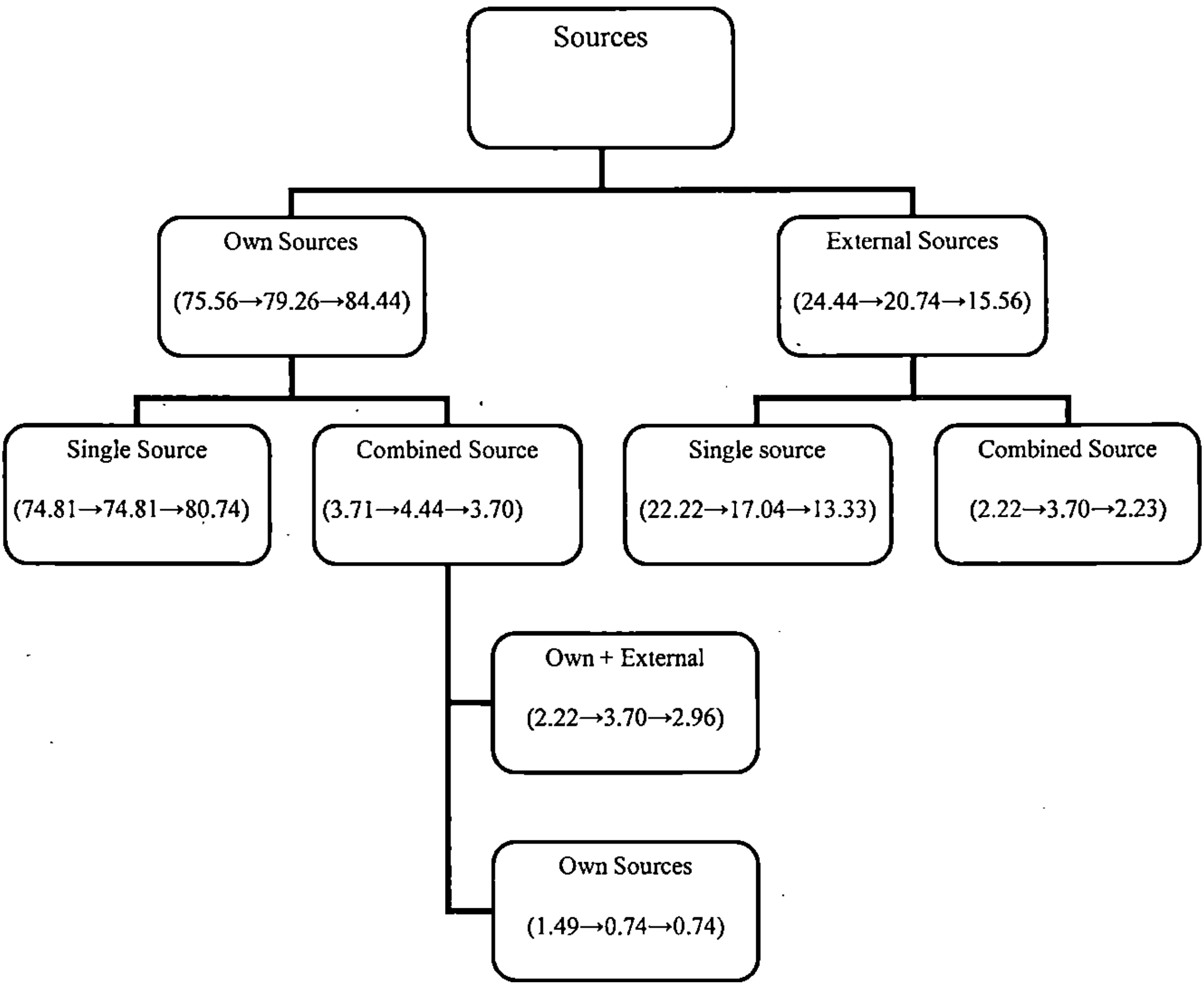
4.6.1 Domestic sector

Figure 4.6.1.1 reflects the status of water sources for domestic purposes among the sample respondents over the years. The changing patterns of water dependence during the period from 2000-2010 indicate the level of growing water scarcity in the study area. It was noticed that among the respondents, a gradual shift from the dependence on external sources of water to owned sources has occurred. Nearly 84 per cent has own source either as open wells, tube wells or ponds as compared to the years 2005 and 2000, when it was 79 per cent and 75 per cent respectively. More farmers are opting for owned sources to assure sustained water availability. Reducing the dependency on external sources for this most basic input is adopted as an adaptive strategy. 80.74 per cent depends only on a single owned source, mainly wells. The number of farmers investing for developing the water sources has shown a steady increase.

Presently about 85 per cent depend solely on owned sources, i.e. open wells (68.15 %) followed by tube wells or ponds (11.11 % and 1.48 % respectively). 5.19 per cent have dug new wells during the decade, pushing up the proportion of sample farmers depending on open wells to 68.15 per cent from 62.96 per cent. Seven open wells are dug during the time.

Majority still depend on the open well. None of the MF have gone for tube /bore wells during the period because of the resource constraint. But the SF has dug seven more bore wells and currently there are 15 bore wells among the sample farmers. The dependence on ponds registers a decline. The number of ponds has declined from four to two. The SF might have converted the pond for some other purpose.

Fig: 4.6.1.1 Classification of sources of water of the respondent farmers



Note: Figures with in the box correspond to the percentage in years 2000-2005-2010 respectively

The average open well depth in the study area as reported by farmers was 10.75 m and the decline in water table was to the tune of 4-5 meters during peak summer season. This estimate is based on the responses from the farmers and not based on actual observations. But the studies by the Central Ground Water Board (CGWB, 2008) and Devi *et al.* (2010) reported that the decline was only about 1-2 meters. About 47 per cent of the sample respondents reported the deviation in the water table as more than 75 per cent from normal. Compared to 2005 and 2000 the situation is worsening, when there were only 36.08 per cent and 6.6 per cent respectively (Table 4.6.1.1). There is a faster rate of decline in water table during these years and the reduction in rainfall together with temperature increase adds on to the situation thus resulting in severe water scarcity in the near future.

Moench (1992) and Shah (1993) reported that the decline in water table gives rise to technological externalities in terms of rising costs of installing new wells, deepening of existing wells and pumping and other maintenance activities. This study also supports this. There is a constant increase in the usage of own open wells (71.85 %) and own tube wells (11.85 %) as compared to previous years. In 2000, only 63 per cent had access to own open wells and six per cent had tube wells. This shows that more farmers are opting for owned sources as they have to ensure the availability of water throughout the year. Increased accessibility to own sources will also reduce the vulnerability to water scarcity. On an average one has to spend nearly Rs. 30,000/- per tube well of average depth of 30 meters. An increasing trend of converting existing open wells into tube wells was there, as these wells dries up in summer. More reliable water delivery and declining extraction costs due to advances in technology and, in many instances, government subsidies for power and pump installation encourages private investment in tube wells. The practice of deepening open wells in summer to ensure water is also there (5 %). This is repeated at least once in two years and the average cost for this is Rs.4000 per well per year.

Some of respondents (3.70 %) depend on more than one source, especially during summer months. Very few (0.74 %) own more than one source, while 2.96 per cent depend on some external source apart from own. The multiple sources of water were seen as declined from 1.49 per cent to 0.74 per cent.

Table: 4.6.1.1 Water table decline in open wells during summer season

Particulars	>75 % deviation from normal	50 – 75 % deviation from normal	< 50% deviation from normal	Total no: of Open wells
2010	47 (47.00)	18 (18.00)	35 (35.00)	100 (100)
2005	35 (36.08)	23 (23.71)	39 (40.21)	97 (100)
2000	6 (6.59)	26 (28.57)	59 (64.84)	91 (100)

Figures in bracket show the percentage to the total.

The external sources may be neighbourhood or public, open/bore wells. The number of functional public open wells has been declined from 15 to 11. Since public wells are mainly relied by the resource poor MF, faulty management of this resource largely affect their welfare. None of the LF depend on this source. 15.56 per cent of respondents depended fully on external sources. Over the decade, number of farmers in this category has shown a steady decline. However, majority still depend on a single source. Open wells in neighbours' farm continue to be the only source of water for 6.12 per cent of MF. Over the years, the SF in this category has moved out to permanently owned sources. This shows that the existing inequality in land holdings also lead to an inequity in access to ground water, which in turn widens the skewness in assets and income distribution. Many studies support this (Nagaraj and Chandrakant, 1997; Dubash, 2002; Sarkar, 2011).

Community water supply schemes have shown an increased presence in the locality, though the regularity of water supply is often not there. Community system follows a collective behaviour where two-three households join together to lay pipes for collecting water from natural streams.

In order to cope with the domestic water shortages, short term supply side strategies were adopted by the respondents. Most common adaptation strategy practiced was reducing the use of water (22.96 %) followed by depending on neighbourhood sources (19.26 %). MF however tried to exploit the neighbourhood sources first and then opted for more efficient water use within the household. In the absence of these two, or in conjunctive approach, people were also exploiting natural water sources even from far off place (Table 4.6.1.2).

Generally domestic water management is the legitimate domain of women. Water scarcity thus directly impacts their welfare, through increased drudgery, loss in leisure time and additional hours of work. Female members of the households that depend on outside sources have to carry it from a distance. On an average they have to travel and carry water from a distance of 236 meters spending nearly one hour (Table 4.6.1.3). During summer months, the average time spend for these activities further goes up by 38 per cent. Many studies report this as a major activity for women in rural areas that lead to drudgery and fatigue (Rajalakshmi, 2000; Narayana, 2005; Kulkarni, 2011).

Table: 4.6.1.2 Short term strategies adopted by respondent farmers for managing domestic water scarcity

Sl.no	Strategies	Farmers Responded			
		MF	SF	LF	Total
1	Dependence on Neighbourhood sources	12 (24.49)	14 (22.22)	0	26 (19.26)
2	Depending on streams, ponds etc	5 (10.20)	7 (11.11)	1 (4.35)	13 (9.63)
3	Collecting water from distant places	5 (10.20)	4 (6.35)	2 (8.70)	11 (8.15)
4	Economising water use	10 (20.41)	13 (20.63)	8 (34.78)	31 (22.96)

Figures in bracket show the percentage to the total respondents in respective category.

Table: 4.6.1.3 Average time taken to fetch water from outside sources

Particulars	Normal months (Hr)	Summer months (% increase compared to normal)
MF	1	30
SF	1	45
LF	0	0
Average	1	38

4.6.2 Agriculture

Agricultural sector consumes nearly 71 per cent of usable water in Kerala, but the efficiency in use of water in this sector is reported to be very low. The water stress adaptation strategies in agricultural sector include irrigation, crop and cropping system related strategies, soil and water conservation measures, crop insurance and migration.

4.6.2.1 Irrigated agriculture and technological adaptations

Irrigation is adopted as the most common adaptive mechanism, when rainfall pattern changes. The gross irrigated area in the state is 17.04 per cent of the gross cropped area. The agriculture in Wayanad has been primarily rainfed and the irrigated area is only four per cent of the irrigation of the state. But a shift from conventional rainfed farming to irrigated farming could be noticed over the years (Fig 4.6.2.1). In 2009-10, gross area under irrigation was 17758 ha which is almost three times than that in 1993-94 (5259 ha) (Economic review, 2010). This trend could be noticed among the sample respondents also. About 13 per cent of the gross cropped area is under irrigation which was only five per cent in the year 2000 (Table 4.6.2.1) and nearly 38 per cent of the sample respondents are practicing irrigated farming as compared to five per cent ten years ago. Major crops under irrigated farming in the district were paddy and banana which accounts for 65 per cent and 27 per cent respectively. Paddy, coffee, black pepper, coconut, banana, arecanut and vegetables are the major irrigated crops in the sample farms.

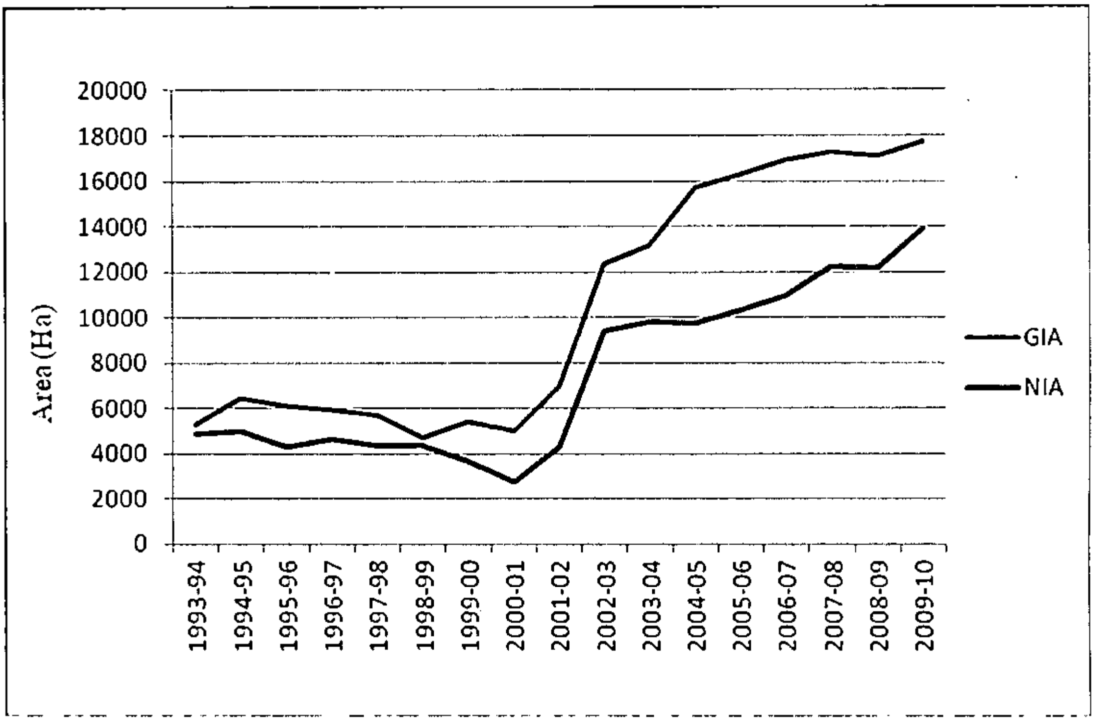
More farmers are adopting irrigation because of the changes in the rainfall pattern. They commented that before 2000 there was no need for irrigation, because of the continuous rainfall throughout the year thus retaining the soil moisture. Besides conversion of paddy lands (wetlands) for banana cultivation and arecanut have a very severe impact on natural water recharge and drainage.

Crops differ both in terms of their daily water needs and the duration of their total growing period. So the choice of crop is a chief factor influencing water needs. Banana requires about 1200- 2200 mm water during the growing period where as that for rice is only 450-700 mm (FAO, 1986). Increased conversion of paddy fields into banana not only affects the natural water recharge and drainage, but its increased demand for water further toughens water scarcity.

The major sources of irrigation in the district are ground water sources followed by canal irrigation. Two - third of the sample area is irrigated using owned sources viz. ponds, open wells and tube wells and the rest being irrigated by canal. Canals in Wayanad are not from irrigation projects. Rather they are natural/manmade streams which depend on natural sources of recharge. Check dams are constructed in many places to control the flow. But many times these dry up and farmers find it difficult to irrigate the crops. Most of the farmers depend on electrified motors for water lifting. Others depend on traditional mechanical methods.

Main source of irrigation for MF is open well (44.74 %) where as that for SF it is canal (59.26 %) and that of LF is pond (65.47 %). MF depends on open well for both domestic and irrigation, which in turn pauses severe competition between these two uses. In severe summer they are forced to stop irrigation in order to assure water availability for domestic purpose, thus reducing farm output. The high investment requirements for water lifting and irrigation management limit the scope of canal water dependence for resource poor farmers. LF usually have separate sources (ponds/bore wells/open wells) exclusively for irrigation. It is a well established fact that the access to good quality reliable irrigation is important as it not only reduces the risks faced by rainfed agriculture but also reduces the cost and increase the quantum of production (Dhawan, 1988).

Fig: 4.6.2.1 Irrigated area in Wayanad (1993-94 to 2009-10)



Source: Department of Economics and Statistics, Wayanad

Table: 4.6.2.1 Trend in area under irrigation for respondent farmers (ha.)

	2000					2005					2010				
	Well	Tubewell	Ponds	Canal	Total	Well	Tubewell	Ponds	Canal	Total	Well	Tubewell	Ponds	Canal	Tot
MF	0 (0.00)	0 (0.00)	0.4 (35.64)	0.7 (63.64)	1.1 (100.00)	0 (0.00)	0 (0.00)	0.9 (54.50)	0.7 (43.75)	1.6 (100)	3.4 (44.74)	0 (0.00)	2.5 (32.42)	1.7 (22.47)	7.5 (10
SF	0	0.9 (19.73)	2.8 (62.31)	0.8 (18.84)	4.5 (100.00)	0 (0.00)	0.4 (3.29)	9.5 (69.97)	3.7 (27.06)	13.6 (100)	0.5 (2.53)	1.2 (6.82)	5.6 (31.15)	10.6 (59.26)	17. (10
LF	0 (0.00)	0 (0.00)	6.6 (44.27)	8.3 (55.47)	15.0 (100.0)	0 (0.00)	0 (0.00)	6.5 (27.78)	16.8 (72.10)	23.3 (100)	0.8 (3.14)	1.6 (6.09)	16.7 (65.67)	6.5 (25.38)	25. (10
	0.0	0.9 (4.31)	9.8 (47.75)	9.9 (47.90)	20.6 (100.00)	0 (0.00)	0.4 (1.16)	16.9 (43.79)	21.2 (55.01)	38.5 (100)	4.7 (9.13)	2.8 (5.49)	24.7 (48.60)	18.8 (36.91)	50 (10

A shift from the public / external sources to owned sources, as observed earlier in the case of domestic sector, is in also noticed irrigation water. Canal irrigation which accounted for about 55 per cent of the area in 2005, presently accounts for only 37 per cent. Conversely, owned sources constitute about 63 per cent which was only 45 per cent in 2005.

Researches highlight the key role of irrigation in future in achieving higher yield and sustaining the food security and it is considered as a major adaptive capacity under failure of natural precipitation (Persaud and Stacey, 2003). However, this necessitates further investment. The average expenditure for irrigation was found to be Rs 18187 per household which is nearly nine per cent of the total household income. This cost includes the expenditure for infrastructure for water lifting and distribution, as well as labour. Production increased up to 10 – 20 per cent which in turn led to an increased return. Expenditure increases with increase in holding size, and it was Rs.15626 for MF (10.6 per cent of household income) and in case of SF and LF, it was Rs. 18908 (10.1 per cent of household income) and 20628 (4.81 per cent of household income) respectively. The rising wage cost of labour may further push up the irrigation expenditure in future. This may cause a welfare loss to the households, especially to MF and SF. About two per cent of farmers opted for deepening of existing open wells or bore wells, at an additional expense of Rs. 4000/ household. Table 4.6.2.2 provides the details of long term strategies adopted by the farmers.

Water use efficiency in irrigated agriculture is reported as very low in India by many authors (Wolff and Stein, 1999). Several techniques like micro irrigation methods (Sprinkler and drip irrigation) that minimize water use has been suggested, and popularised. The on-farm irrigation efficiency of properly designed and managed drip irrigation system is estimated to be about 90 per cent and for sprinkler irrigation method, it is 70 per cent while the same is only about 35 to 40 per cent for surface method of irrigation (INCID, 1994; 1998; Kulkarni, 2005). While increasing the productivity of crops significantly, micro irrigation methods also reduce weed problems, soil erosion and cost of cultivation substantially, especially in labour-intensive operations. The reduction in water consumption in micro-irrigation also reduces the energy use (electricity) that is required to lift water from irrigation wells (Narayanamoorthy, 1999; 2001).

Thus, improved and efficient methods like sprinkler and drip irrigation were adopted by nine percent of sample respondents. About seven percent were having sprinkler and the rest with drip. Devi *et al.* (2011) reported the limited adoption of drip irrigation system in Kerala. Sprinklers were common in coffee gardens. The average investment for sprinkler irrigation was found to be Rs.1.4 lakh per household and that for drip is Rs. 56000/-per household. The subsidy support for these systems is there. In spite of this high investment, these modern technologies are found to be more profitable as there is a significant increase in production (> 40 %) and cost saving as the labour involvement is less.

The purchase or sale of irrigation water is not reported. It seems that water market in irrigation sector does not exist in this region.

Table: 4.6.2.2 Long term strategies adopted by respondent farmers

Sl. No	Strategies	MF		SF		LF		Total	
		% of farmers	Average Expenditure/ household (Rs.)	% of farmers	Average Expenditure/ household	% of farmers	Average Expenditure/ household	% of farmers	Average Expenditure/ household
1	Irrigation	34.69	15626	39.68	18908	43.48	20628	38.52	18187
2	Deepening of existing wells	0		4.76	4000	0		2.22	4000
3	Micro irrigation methods								
a.	Drip irrigation	0		1.59	52000	4.35	60000	1.48	56000
b.	Sprinkler irrigation	4.08	87500	4.76	145000	21.74	190000	7.41	140833

4.6.2.2 Crop and cropping system related strategies

The common strategies followed by the farmers are varietal selection, mixed cropping, crop diversification, organic farming, soil and water conservation measures and crop insurance. All these strategies can be categorised as demand side management measures as these assure efficient utilization of available water thus limiting the demand for water. Table 4.6.2.3 furnishes the general picture of these strategies.

Table: 4.6.2.3 Adaptive mechanisms of respondent farmers

Sl.no	Adaptive mechanisms	Farmers adopted			
		MF	SF	LF	Total
1.	Varietal selection	49 (100)	63 (100)	23 (100)	135 (100)
2.	Mixed cropping	49 (100)	63 (100)	23 (100)	135 (100)
3.	Crop diversification	49 (100)	63 (100)	23 (100)	135 (100)
4.	Organic farming	5 (10.20)	5 (7.94)	3 (13.04)	13 (9.63)
5.	Soil and Conservation measures	9 (18.37)	17 (26.98)	8 (34.78)	34 (25.19)
6.	Crop Insurance	11 (22.45)	15 (23.81)	5 (21.74)	31 (22.97)

Varietal selection

Developing varieties to suit the changing weather pattern is a research agenda for almost all research organisations. Varieties with high fertilizer use efficiency, novel crops and varieties that can tolerate extreme weather events and which are resistant to common pests and diseases are to be developed. Promoting the cultivation of crops and varieties that fit into the changing crop calendars and seasons, development of varieties with duration that can overwinter the transient effects of change, varieties for high temperature and heat stress tolerance, and varieties that respond positively to high CO_2 are also effective adaptive strategies to deal with changing climate (Challinor *et al.*, 2007). Further, the indigenous varieties and traditional wisdom in their management are also effective strategies.

Wayanad, once known for paddy cultivation was famous for indigenous varieties like *Onaatten, Palthondi, Valichuri, Adukkan* etc. Despite the low yield potential these were suited for the local climate and agro-ecosystem. Later on the High Yielding Varieties (HYV) like *Athira, Harsha, IR-8, Uma, Matta* etc became popular owing to policy support towards yield increase. Presently, there is a tendency among farmers to choose traditional varieties like *Palthondi, Thondi, Adukkan, Thichingam* which are more drought tolerant, especially during the *puncha* season. About one-fourth of the farmers were found switching over to these varieties during the *puncha* season, as an adaptation strategy for water stress.

Similarly, the traditional varieties which are drought tolerant (*Adukkan, Valichuri, Vadakkan, Palthondi*) were also adopted by some. Despite the subsidy support for HYV, these farmers opted for traditional varieties in view of the relative advantage towards disease and stress management.

Black pepper is one of the economically important components of the homesteads of Wayanad. Most of the black pepper varieties were found to be tolerant to water stress. Farmers reported that varieties were selected based on their tolerance to diseases and pests (mainly quik wilt) in addition to their yield. The important varieties in use are *Kalluvally, Karimunda, Chumala, Wayanadan* and *Panniyur* series.

No varietal selection was noticed in coffee, the major crop of the district. All the sample respondents were cultivating *Robusta* cultivar of coffee. The varieties of arecanut and coconut, which are relatively new crops in the farming system of Wayanad, are HYVs or hybrids. It may be remembered that varietal switching is not very easy in the case of perennial crops. Table 4.6.2.4 gives the details of varieties of main crops cultivated by the sample respondents.

Table: 4.6.2.4 Varieties cultivated by respondent farmers

Sl.No	Crops	Varieties
1	Rice	*Traditional varieties* - Palthondi, Adukkan, Thichingam, Kuttiveliyan, Vadakkan, Valichuri, Onatten, Vediyan, Thondi, Geerakashala. *HYV*-Jaya, Bharathi, Harsha, Uma, Kanchana, Kalyani, Matta, Shabari, Lakshmi, Athira.
2	Pepper	Panniyur, Kalluvally, Karimunda, Geerakavally, Chumala, Wayanadan, Nadeshan, Cheriyavally, Balankotta, Kallumukku.
3.	Arecanut	Mangala, Sumangala, Mohitnagar
4.	Ginger	Himachal, Rigodi, Maaran, Wayanadan
5.	Coconut	WCT, TXD, Kuttiadi

Mixed cropping

Diversity in enterprises/ crops has been considered as a risk management strategy. Through more efficient use of nutrients, moisture, and light, yield from mixed cropping alternatives are often relatively higher than those from pure stands of the same species grown in proportional areas (Willey *et al.* 1987). This also reduces the impacts of both biotic and abiotic stresses whose intensity is likely to increase with climate change (Wassmann *et al.*, 2009). Particularly under extreme events like droughts and floods, one of the crops will at least produce sufficient yields and income for the farmers.

All the sample farmers were following mixed cropping, may be continuing the traditional practice. The major components include coffee, black pepper, cardamom, ginger, turmeric, coconut, banana and arecanut. Often pepper vines are trailed in perennial crops like jack, mango and silver oak. Other perennial tree or fruit species like guava, eggfruit, drumstick etc are also there. However, this is not a deliberate action in response to the water stress situation, but a continuation of the traditional culture.

Diversification

In agriculture, diversification be it increasing the variety of production locations, crops, enterprises, or income sources, is one adaptation that has been commonly identified as a potential response to climatic variability and change (Smit, 1993; Kelly and Adger, 2000; Mendelsohn, 2000; Wandel and Smit, 2000). Diversification serve as a buffer of farm business risks, be it yield risk associated with variable climatic conditions or price risk associated with variable commodity markets (Fleisher, 1990; Hardaker *et al.*, 1997). Further, farmers themselves commonly identify diversification as an effective strategy for managing business risks and climatic risks in particular.

Income diversification is increasing the number of income sources through off-farm work or investments which reduces agricultural risks that might result from climatic, production, or market events. Earlier, farmers in Wayanad were predominantly dependent on agriculture for their livelihood. Presently, farm households were observed to gradually adopt a wider range of livelihood options. Climatic risk, especially the frequent, prolonged, and severe droughts and floods forced farmers to devise strategies to cope with the situation. About 60 per cent of the sample households were undertaking cattle rearing as a subsidiary source. This trend could be seen among all the sections. For about 27 per cent respondents farming was a subsidiary occupation, who were involved in public or private services or wage based job. The average farm income was Rs.2.14 lakh, of which about 60 per cent is from agriculture (Table 4.1.1). Apart from this, in most of the households younger generation were engaged in some salary based or wage based jobs.

Crop diversification is regarded as the most important weapon in a farmer's management arsenal to combat crop income risk. It is the practice of increasing the number of crops or varieties/hybrids of a particular crop, in order to reduce the susceptibility of an operation to micro-climatic events such as water stress and other bio-physical events such as a pest outbreak that might result in crop failure. Bantilan and Anupama (2006) based on their analysis of International Crop Research Institute for Semi Arid Tropic's (ICRISAT) village level studies reported that crop diversification appeared to be effective in imparting stability to the household crop income. All the sample farmers in this study were risk-averse and diversified their portfolio of crops. Higher diversity index was observed among the respondents. It was noticed that larger farms with more gross cropped area were more diversified than their smaller counterparts. This difference may be attributed to a more pronounced need to reduce peak season labour requirement, exploit the better potential of location specific production opportunities associated with holding more fields, and greater access to credit to sow land to more input-intensive crops (Walker and Ryan 1990). The level of crop diversification depended much more on farm size than on the degree of risk aversion within a farm-size group.

Organic farming

Conventional input intensive agriculture practiced over the last century has been a major contributor to climate change, second only to the energy sector (World Development Report, 2008). The communities engaged in pesticide and synthetic input agriculture is most vulnerable to the impacts of climate change. Agriculture has the potential to sequester CO_2 in soils. This potential can be best utilized by employing sustainable agricultural practices such as organic farming. Conservative estimates of the total mitigation potential of organic farming amount to 4.5-6.5 Gt CO_2eq/yr, i.e. of ca. 50 Gt CO_2eq total green house gas emissions (Muller, 2009).

Organic agriculture is a resilent system of agriculture that uses crop rotation, green manure, compost, biological pest control, and mechanical cultivation to maintain soil productivity and control for pests. Thus it is a low risk farming strategy optimizing biological functioning. Research also indicates that organic production systems are more resilent than conventional systems under both drought and flood conditions (Bescansa *et al.*, 2006). Organically managed soils are better adapted to weather extremes. These soils can better retain moisture, which can alleviate the impact of periodic droughts. These systems also retain more water during high rainfall events and release the water more slowly. The Food and Agricultural Organisation (FAO) report 2007 found that organic agriculture performs better than conventional agriculture on a per hectare scale, both with respect to direct energy consumption (fuel and oil) and indirect consumption (synthetic fertilizers and pesticides), with high efficiency of energy use. Without sacrificing the yields of conventional agriculture organic farming systems provide benefits to water quality, biodiversity, rural communities and human health.

There is a growing tendency among the farmers to adopt organic farming because of the yield stability and ecological safety and economic attraction. About 10 per cent of the farmers are practising organic farming (Table 4.6.2.3), mainly in pepper. Heavy damage to the crop due to quick wilt and other diseases made farmers shifted to organic. The general awareness on the potential damages of agrochemical use has prompted many farmers to opt organic farming. Further, the market and policy support also favours the adoption. The active promotional efforts by WSSS and Department of Agriculture provide the institutional support for this.

4.6.2.3 Soil and water conservation measures

Soil and water conservation measures are able to bring about perceptible improvements in productivity of crops leading to increase in overall production and there by income generated. These improvements are possible primarily because, these measures will enable extension of the period of availability of soil moisture thus reducing moisture stress to crops. Coupled with this the arrest of soil erosion and surface runoff will help in improving innate soil fertility aiding in better up take of plant nutrients. Sustainability of agriculture may be sought to be accomplished through soil and water conservation activities to a very great extent.

An economic evaluation of soil and water conservation measures undertaken as part of watershed programmes implemented by NABARD shows that there is a positive effect on the area put under crops, productivity of crops and total production from various crops cultivated and thus improvements in income, due to soil and water conservation measures (NABARD, 2006). Seven watersheds were implemented in Mangalassery of Wayanad district as part of this, covering a total area of 600 ha with an estimated cost of Rs. 92 lakh. Important soil and water conservation technologies adopted include mechanical measures like contour bunds, earthen bunds, terraces, check dam, water harvesting structures and retaining wall as well as agronomic measures like mulching, agro-forestry etc. The study shows that adoption of soil and water conservation measures led to the better use of land, measured in terms of cropping intensity. There was 41 per cent increase in cropping intensity and increase in productivity by about 90 per cent in coffee, 63 per cent in pepper, 68 per cent in arecanut and 77 per cent in coconut. This in turn has led to increase in income and the incremental income per hectare was Rs. 26955/-. Thus farmers in Wayanad are generally aware of the importance of soil conservation in their homestead.

The most common soil and conservation practices followed by the sample respondents were mulching, earthen bunds and rain pits. These measures can be considered as demand management strategies.

Mulching is the process or practice of covering the soil or ground to make more favourable conditions for plant growth, development and efficient crop production. It can be done using natural mulches like leaves, dead leaves, straw and compost. Returning crop residues to the soil improves soil quality and productivity through favorable effects on soil properties (Lal and Stewart, 1995). It also increases soil organic carbon content (Havlin *et al.,* 1990; Paustin *et al.*, 1997; Saroa and Lal, 2003). Conservation of soil moisture by serving as a vapour barrier is one of the major advantages of mulch farming system. Mulching protects the soil from water erosion by reducing the rain drop impact and a partial covering of mulch residue on the soil can strongly affect runoff dynamics, and reduce runoff amount (Findeling *et al.*, 2003; Rees *et al.*, 2002).

Mulching is practiced for crops like coffee, ginger, coconut, banana and pepper. All the coffee growers and ginger farmers were adopting mulching as a common cultivation practice and it was done regularly. Mulching is recommended for ginger during the initial days of planting (up to three months after planting) and for coffee, it is applied during the months of October and February. It is done at least twice in a year. Dried leaves were used as a common mulching material. Some farmers reported mulching in banana and coconut also. Mulching is generally considered as a common cultivation practice rather than a conservation or adaptation practice.

On the other side earthen bunds and rain pits were part of the Watershed programmes by the National Bank for Agriculture and Rural Development (NABARD). The Watershed Development Fund was established in NABARD in India in 1999-2000 with an initial corpus of Rs. 200 crore. This programme was implemented to mitigate the drought induced distress of farmers in the area. NABARD anchors four types of watershed development programmes in the country covering over 1.70 million hectare. These programmes are: Indo-

German Watershed Development Programme (IGWDP) in Maharashtra, Andhra Pradesh, Gujarat and Rajasthan, Participatory Watershed Development Programme under Watershed Development Fund (WDF) in 15 States, Prime Minister's Relief package in four States, and Integrated Watershed Development Programme (IWDP) in Bihar, supported by the Planning Commission. Watershed Development Programmes of Kerala is coming under Prime Minister's Relief package. This project is entirely grant based.

Nearly one-fourth of sample respondents were undertaking soil and water conservation measures (Table: 4.6.2.3). These include earthen bunds, contour bunds and rain pits. About one third of the LF practised this whereas it was only one-fourth in SF and for MF it was one-fifth. Most of the SF and MF were stakeholders of watershed development programme while LF has invested their own. Farmers opined that there is an increase in soil moisture and there by productivity. Conservation farming and water harvesting are considered as appropriate adaptation strategies since they reduce dependence on irrigation and thus they would relieve pressure on water resources without reducing crop yields and would allow for greater resilience in adapting to future climate change (du Toit *et al*, 1999).

4.6.2.4 Crop Insurance

Agricultural production in India has been habitually affected by various natural disasters like floods, droughts, cyclones, landslides, earthquakes, lightning etc. Together with this, the outbreak of pest and diseases and the man-made disasters like fire, spurious seeds, fertilizers, pesticides and price crash made the situation still worse. All these events severely affect farmers and are beyond the control of them.

Agricultural insurance is considered to be an effective mechanism to tackle the farm loss and was suggested as a climate risk management tool as early as 1992 by UNFCCC, and included in the 1997 Kyoto Protocol. Crop insurance is a defensive approach and it provides relief to farmers whose crops were damaged by one or the other means. The positive aspect of crop insurance is that farmer pays the premium when he is well off and receives the indemnity when he is at loss. With crop insurance farmers can stabilize farm income and protect against disastrous effect of losses due to natural hazards or pest or diseases. It not only stabilizes the farm income but also helps the farmers to initiate production activity after a bad agricultural year. It acts as a cushion to absorb the shock of crop losses by providing farmers with a minimum amount of protection (Singh, 2010). Crop insurance services are offered to facilitate the farmers to achieve higher production through adoption of modern technologies. This forms a key element in safety-net programmes for farmers.

Insurance schemes specially designed to cover weather related risks were introduced by Agriculture Insurance Company of India. The pilot weather risk index based insurance project in 2004 was created to protect for the loss due to deviation in crop output due to weather condition. Weather Based Crop Insurance Scheme (WBCIS) is a unique Weather based insurance product designed to provide insurance protection against losses in crop yield resulting from adverse weather incidences. It provides payout against adverse rainfall incidence (both deficit and excess) during Kharif and adverse incidence in weather parameters like frost, heat, relative humidity, un-seasonal rainfall etc. during Rabi. It aims to lessen the hardship of the insured farmers against the probability of financial loss on account of anticipated crop loss resulting from adverse weather like excess or scanty rainfall, temperature, high speed wind, frost and humidity. While Crop insurance specifically indemnifies the cultivator against shortfall in crop yield, Weather based Crop Insurance is based on the fact that weather conditions affect crop production even when a cultivator has taken all the care to ensure good harvest. Here, weather parameters are used as 'proxy' for crop yields in compensating the cultivators for deemed crop losses. Payouts under the scheme are decided on area approach based on weather data recorded at the notified 'Reference Weather Station' (RWS) during the risk period in notified unit area. To get the claim, insured need not file separate claim application but if there is any adverse situation all the insured farmers in that area by default are eligible for the indemnity. Cereals, Pulses, Oilseeds, Commercial crops and perennial horticultural crops are being covered by this scheme, in India.

In Kerala, NAIS was in operation since 1999-2000. The state as a whole is considered as a notified area and there are six notified crops namely paddy, banana, tapioca, ginger, turmeric and pineapple. The scheme covered about 3.18 lakh farmers for a premium of Rs. 922 lakhs against claims of Rs. 2168 lakhs till 2008-2009 (Economic Review, 2010).

Weather Based Crop Insurance Scheme (WBCIS) was introduced in the state in 2008-09. The scheme is being implemented on pilot basis in Palakkad district for paddy and mango, Idukki district for pepper and Kazargod district for cashew. In Rabi 2011-12, this scheme was operational for two crops, summer paddy and cashew.

The flowering in coffee is highly sensitive to rainfall and affects the yield very much. The insurance product, Rainfall Insurance Scheme for Coffee growers (RISC) has been designed especially for the coffee growers of Karnataka, Kerala and Tamil Nadu. It is a subsidized scheme to the extent of 50 per cent for small growers by the Coffee Board.

State Crop Insurance Scheme is implemented by the Department of Agriculture since 1995. It covers all the major crops such as paddy, rubber, coconut, tapioca, banana, pepper grown in the state. The implementation is through Krishibhavans.

Other insurance schemes functioning in the state are Coconut Palm Insurance Scheme and Rubber Plantation Insurance Scheme, both implemented by Agricultural Insurance Company.

Despite the high production and economic risks in agricultural sector the insurance coverage among the sample respondents was dismally low. Only about one-fourth were covered under the scheme (Table 4.6.2.3). Devi *et al.* (2009a) also reported about the low crop insurance coverage among the farmers of Wayanad.

The cumbersome procedural formalities and inordinate delay in settlement of claims limits the farmer participation in these schemes. Most often the claim settlements do not cover the loss. Thus the farmers are reluctant for a voluntary participation in the scheme. In a comparative basis, the acceptability of State Crop Insurance Programme is better than that of the central sector one. The respondents expressed their interest and need for a weather based crop insurance scheme in Wayanad.

Devi and Rao (2008) reported the efficiency of early warning systems in managing climate related crop damages. The study reported that the severity of damage due to climate change can be sizably reduced through efficient interventions for mitigation and adaptation strategies. Their analysis established a significant positive impact of Agromet Advisory Service on farm income. Hence they strongly recommend to adopt and strengthen an Agromet Advisory Services based on weather forewarning to include all aspects of farm management for sustenance of crop production and food security in the state of Kerala.

4.6.2.5 Migration

It is a well known fact that characteristics of the natural environment determines the habitability of a region by humans and that the characteristics of people are shaped by the attributes of the natural environment in which they live. One of the potential impacts of climate change for human societies is the possibility of changes in human migration patterns (Glantz and Ausubel, 1988; Doos, 1994; Hugo, 1996; MacKellar *et al.*, 1998; Magadza, 2000; Meze-Hausken, 2000; Hay and Beniston, 2001; Myers, 2002; Barnett, 2003). Migration is often adopted as a coping strategy to deal with stress conditions. Researches show that in recent decade's populations in rural areas especially that of developing and underdeveloped countries have migrated to cope with recurring drought (Afolayan and Adelekan, 1999; Ezra, 2001).

Wayanad district's agrarian population largely constitute early migrants from other parts of the state, mainly Kottayam, Eranakulam, Thrissur, Palakkad etc. They had succeeded in combating the hostile environment and establishing themselves as cultivators in this region out of sheer willpower. But presently practising farmers often are not interested to continue in farming. The main reason for this pessimism was the changes in climatic conditions and the quality of soil (Nair *et al.*, 2007). Educated and skilled youths belonging to the third generation of the in-migrants are now desperately attempting for permanent migration away from the locality. Migration in general may be due to social, economic or other reasons. The onswing socioeconomic status generally prompts people to shift to places of better facilities. This is true in Wayanad conditions, to some extent. On the contrary, poor returns from farming and absence of income earning activities also force people to adopt occupation or geographical migration.

Devi *et al.* (2009a) reported about the geographical migration among the farmers of Wayanad as a common adaptation strategy. However in this study, only a less proportion of respondents were adopting this (3.70 %). This cannot be treated as geographical migration due to climate change, since it is only an extension of farming activities to neighbouring state like Karnataka because of less cost of cultivation and better availability of labour force. Anyway respondents opined that migration as a widely prevalent adaptive strategy among the farmers of Wayanad. Here an attempt was made to have a better understanding about migration from the respondents' observation about the same.

Nearly 44 per cent of the sample respondents reported migration in their locality (Table 4.6.2.5). They pointed out that the decreased production (40.74 %) and the price risk (25.93 %) which together resulted in reduced returns as the major reason for migration. Other reasons being increased cost of cultivation (18.52 %), heavy water stress (7.4 %) and other socio- economic factors like unemployment and reduced standard of living (5.19 %). A difference of opinion was there between LF and MF that LF considered worsening water stress condition as one of the major reason (13.04 %) where as for MF unemployment and reduced standard of living (12.24 %) forced them to migrate.

About one third of the respondents claimed that both geographical and sectoral migration is common. According to MF geographical migration (40.82 %) was more than the sectoral migration while for LF it was the reverse.

Occupational shift mainly include starting self enterprises (29.63 %), followed by working as farm and non-farm labourer (27.41 %) and for the rest, occupational migrants preferred wage based job. This was the trend in all the categories. Mainly MF and SF adopted occupational shift where as LF had geographical migration.

In general the farming activities (ginger) are shifted to Karnataka owing to the large scale loss of ginger crop due to ginger-rot. These farmers pay small lump sum amount to the tribal youth in Wayanad and take them as labourers in these farms. Usually they are treated as like bonded labourers and the payment is very low. Owing to the lack of adequate employment in Wayanad due to the agrarian crisis, migration is opted as a strategy to find alternate livelihood by many tribal communities. Nowadays, main features that favours geographical shift is low cost of cultivation (30.37 %), better availability of resources (land and labour) (31.11 %), and high returns (15.55 %).

Table: 4.6.2.5 Farmers observations on migration in the locality

Sl.No	Particulars	Farmers Responded			
		MF	SF	LF	Aggregate
1.a.	Migration	24 (48.98)	27 (42.86)	9 (39.13)	60 (44.44)
b.	Geographical Migration	20 (40.82)	19 (30.16)	6 (26.09)	45 (33.33)
c.	Sectoral Migration	18 (36.73)	19 (30.16)	8 (34.78)	45 (33.33)
2	**Reasons for Migration**				
a.	Declining production in agriculture	22 (44.90)	25 (39.68)	8 (34.78)	55 (40.74)
b.	Worsening water stress condition	3 (6.12)	4 (6.35)	3 (13.04)	10 (7.40)
c.	Increase in cost of cultivation	11 (22.45)	11 (17.46)	3 (13.04)	25 (18.52)
3	**Preferences in Sectoral migration**				
a.	Working as labour	17 (34.69)	15 (23.81)	5 (21.74)	37 (27.40)
b.	Wage based job	6 (12.24)	3 (4.76)	1 (4.35)	10 (7.40)
c.	Self enterprise	18 (36.73)	16 (25.40)	6 (26.09)	40 (29.63)
4	**Features of Geographical migration**				
a.	Less cost of cultivation	19 (38.78)	17 (26.98)	5 (21.74)	41 (30.37)
b.	Better availability of resources	19 (38.78)	18 (28.57)	5 (21.74)	42 (31.11)
c.	Increase in returns	8 (16.33)	10 (15.87)	3 (13.04)	21 (15.55)
d.	Suitable climate for farming practices	2 (4.08)	2 (3.17)	0	4 (2.96)

Figures in bracket show the percentage to total no. of farmers

Summary

Chapter – V

Summary

Climate change through its adverse impact on water resources has already affected the welfare of the people in terms of water security and food security. These impacts vary across regions and socio-economic settings. The level of vulnerability, adaptive strategies and resources position decide the extent of damage. Vulnerability assessments are very important as far as resource allocation is concerned, i.e. identifying the vulnerable groups and to measure the extent they are vulnerable. The study on 'Socio-economic vulnerability and adaptive strategies to environmental risk: A case study of water scarcity in agriculture' was undertaken in this background in Wayand district of Kerala, during the year 2011-12. The main objectives of the study were to measure farmers' vulnerability to water stress in agriculture and its impact on household welfare and to identify and assess the relative influence of various factors on the level of vulnerability. Further, the short term and long term adaptive strategies to water stress were identified and variability among different socioeconomic conditions was also analyzed.

Multi stage random sampling method was used for sample selection. Primary data regarding the socio-economic status, land use pattern and production, sources of water for domestic use and irrigation, perceptions and adaptive strategies to water scarcity from 15 farmers each from nine panchayats were gathered through the method of personal interview using a pretested structured interview schedule. Thus the total sample size was 135. The secondary data was collected from government publications and development departments of government. A Composite Vulnerability Index was constructed using indicator based approach for assessing vulnerability of the farmers. Conventional tabular analysis was carried out for arriving at conclusions regarding general socio-economic characteristics, perceptions and adaptive strategies of the farmers. Logistic regression analysis was done to identify the factors influencing the vulnerability of the farmer.

Of the sample respondents, about 47 per cent were SF with average holding size of 1.34 ha, 37 per cent were MF with average holding size of 0.57 ha and the remaining were LF with holding size of 3.39 ha. For nearly 14 per cent of the respondents, agriculture was the sole occupation whereas for 59 per cent agriculture was the main occupation and for the remaining 27 per cent, agriculture was a subsidiary occupation. Average household income was found to be Rs 2.14 lakh out of which 60 per cent is contributed by agriculture alone. Almost all the respondents were literate with nearly 69 per cent studied up to tenth standard. The accessibility to formal credit institutions was fairly good. All the indebted farmers (61%) depended on formal credit institutions. However, six per cent of them have availed loan from informal sector as well. Commercial banks supply major share of total credit flow, though RRBs have a better reach.

The total operational holding size of the respondents was 221.06 ha, of which more than 10 per cent is leased in land. A visible change in cropping pattern was observed among the sample respondents. Coffee, one of the predominant crops of the homestead account for about 19 per cent of GCA. But the other important crops like black pepper and paddy show a steady decline. Black pepper presently occupies an area of 25.16 ha which was 55.06 ha in 2000, and for paddy the figures are 29.99 ha and 51.04 ha respectively. Paddy faces a serious threat from commercial crops like arecanut, banana, ginger, turmeric and rubber for which the paddy land was extensively converted. As a result, the area under these crops shows a steady increase. This large scale conversion of paddy lands has severely impacted the ecosystem of Wayanad.

The prosperity of Wayanad fully depends on weather, as the major sources of income being agriculture and tourism which are directly linked to weather. Rainfall pattern of the district over the years demonstrate a declining trend coupled with increase in temperature (maximum and minimum). As a result there is growing water scarcity. The projections for future also foretell further worsening situation.

Scientific remedies to problems can be effectively implemented only if the user level understanding of the problem is scientific and hence it is important to know about the farmers' perception about climate change and water scarcity. All the sample respondents opined that there is an increase in temperature over the years, both in minimum and maximum temperature. About 88 per cent of the farmers were of the view that there is a steady decline in annual rainfall and the pattern of rainfall is reported to have changed to a high intensity rain during season and long spells of drought in summer (76.30 %) which resulted in low water recharge (because of the slope, runoff is high). The agricultural systems and livelihood pattern are also severely affected, because of the water stress (91.56 %).

About three–fourth of the sample respondents have perceived the increased incidence of pest and diseases due to the changing climate. Nearly 33 per cent of the sample respondents reported about the emergence of minor pests as major, whereas 37 per cent shared their view of diseases becoming uncontrollable over the years. Majority of the farmers (95.56 %) pointed out the considerable yield reduction in recent years. They believe that there is a negative relationship between the yield performance and climate change.

About 30 per cent of the sample respondents were experiencing water shortage for domestic purpose and this normally occurs during the summer season. The major reasons, for this as perceived by the respondents, were deforestation, climate change, conversion of paddy lands, increasing population and change in the land use pattern.

In an attempt to measure the vulnerability of farmers to the stress condition, a Composite Vulnerability Index was constructed by taking into consideration 14 indicators, coming under the three broad categories of social, economic and agronomic factors. The farmers were categorised into two groups as low and high vulnerability based on the value of this index. More than half of the respondents were found to be highly vulnerable to water scarcity. An inverse relationship was observed between the land holding size and vulnerability level, three- fourth of the MF were highly vulnerable while most of the SF and LF (41.27 % and 34.78 % respectively) belonged to the other group. The indicators - share of livestock income, total household income, number of sources of water and soil and water conservation measures were the major factors that decided the level of vulnerability.

For ranking the panchayats, highest rank was given to that panchayat with the highest proportion of farmers falling under the highly vulnerable category. Out of the nine panchayats, Thavinjal panchayat of Manathavady block was found to be the most vulnerable region. Most of the economic and agronomic factors were found unfavourable in this case. Noolpuzha and Mullankolly panchayats were ranked second and third respectively. Low cropping intensity and diversity along with the use of high yielding varieties which were not drought tolerant made the farmers of Noolpuzha vulnerable whereas low adaptive capacity (low household income) made the latter vulnerable. Poothady, Pulpally, Thondernad and Ambalavayal were having the same level of vulnerability with about 47 per cent of the respondents in highly vulnerable category. Better adaptive capacity of the respondents of these regions, in spite of their high exposure made the situation better in these parts. Vythiri and Muppainad panchayats of Kalpetta block were found to be the least vulnerable. Low level of vulnerability was the combined effect of less exposure and high adaptive capacity.

MF (resource poor) were the most vulnerable because of their higher sensitiveness and exposure coupled with lower adaptive capacity. Even in low vulnerability areas, the MF were found to be highly vulnerable.

A comparison between the Vulnerability Index of farmers for the years 2010 and 2005 was done and it was observed that all sample respondents were in the highly vulnerable category in 2010 irrespective of their geographical location or land holding size, which was only 48 percent in 2005. Thus, it is clear that the chances of the farmer becoming vulnerable to water scarcity increased over the years. It is mainly due to the increased dependence on irrigation coupled with decreased cropping intensity in the recent years.

A regression analysis (logit model) was carried out to understand the relative importance of each factor and its level of significance on the vulnerability. The results showed that five out of eight factors viz. diversity index, cropping intensity, percentage of irrigated area to total cropped area, net cropped area and education, have significant influence on the probability of an agricultural household being vulnerable, of which the diversity index and cropping diversity being the most influential factors.

Adaptation is a way of reducing vulnerability, increasing resilience, moderating the risk of climate impacts on lives and livelihoods, and taking advantage of opportunities posed by actual or expected climate change. Improving social, economic and technical resilience and increasing flexibility within systems is a form of adaptation and allows further adaptation to take place more easily. In general, adaptation strategies followed in domestic and agricultural sector can be classified into supply management strategies and demand regulating strategies. Supply management strategies adopted by the farmers include deepening of existing wells, digging of new ones, soil and water conservation measures and exploring new sources. Commonly used demand side management strategies include efficient use of available water resources through better irrigation techniques like micro irrigation methods, appropriate farming techniques like diversifying and intensifying cropping, varietal selection, mixed cropping and organic farming. Further insuring crops and geographical and sectoral migration were also adopted by some of the farmers.

The farmers were experiencing the scarcity directly, as there is a decline in water table in open wells during summer to the extent of 4-5 meters. Further, the women folk, who depend on external sources have to spend an additional 38 per cent of time for fetching water in dry season. The external sources may be neighbourhood or public, open/bore wells. 15.56 per cent of respondents depended fully on external sources. Over the decade, number of farmers in this category has shown a steady decline. However, majority still depend on a single source.

It was noticed that among the respondents, a gradual shift from the dependence on external sources of water to owned sources has occurred. Nearly 84 per cent has own source either as open wells, tube wells or ponds as compared to the years 2005 and 2000, when it was 79 per cent and 75 per cent respectively. There is a constant increase in the use of own open wells (71.85 %) and own tube wells (11.85 %) as compared to previous years. In 2000, only 63 per cent had access to own open wells and six per cent had tube wells. This shows that more farmers are opting for owned sources as they have to ensure the sustained availability of water. But the trend is more pronounced among SF and LF. This implies that the existing inequality in land holdings also lead to an inequity in access to ground water, which in turn widens the skewness in assets and income distribution.

The agriculture in Wayanad has been primarily rainfed. But a shift from conventional rainfed farming to irrigated farming could be noticed over the years. About 13 per cent of the gross cropped area is under irrigation which was only five per cent in the year 2000 and nearly 38 per cent of the sample respondents are practicing irrigated farming as compared to five per cent in 2000. Coffee, paddy, black pepper, coconut, banana, arecanut and vegetables are the major irrigated crops. Main source of irrigation for MF was open well (44.74 %) where as that for SF it was canal (59.26 %) and that of LF it was ponds (65.47 %). MF depends on open well for both domestic and irrigation, which in turn pauses severe competition between these two uses. LF usually have separate sources (ponds/bore wells/open wells) exclusively for irrigation.

About 39 per cent of the sample respondents were adopting irrigated farming and the average expenditure was found to be Rs 18187 per household which is nearly nine per cent of the total household income. About seven per cent of the farmers were having sprinkler irrigation system and for drip, it was low (0.14 %). This low adoption rate is mainly because of its high investment, i.e. nearly Rs. 1.4 lakh per household (about 65 per cent of the household income) for sprinkler and Rs. 56000 (about 26 per cent of the household income) for drip irrigation. This shows that as the water stress increases in the future, farmers have to invest more (in terms of money and time) in adaptation strategies which will adversely affect the consumption expenses and savings and thereby household welfare.

Farmers also opt for cropping systems that suit their water availability and also deliberately choose varieties which are drought tolerant. Organic farming is often considered as a low risk strategy by about 10 per cent. Soil and water conservation measures are adopted by 25 per cent, often with financial support. Crop insurance is the widely prescribed risk management tool. However, the acceptability of the existing insurance protection was not very satisfactory (23 %). Geographic and sectoral migration is also reported as an adaptation strategy by four per cent of respondents.

It can be observed that some of the adaptive strategies are to be scientifically validated and some are to be technologically refined. However, the traditional wisdom and observation power facilitate to address water scarcity through adaptive strategies.

Policy Suggestions:

1. There is a visible shift in cropping pattern of Wayanad, with the major crops like black pepper and paddy being slowly replaced by arecanut and rubber which were once considered as not suitable in the region. Ginger, turmeric and banana cultivation is also on the rise. There is need for urgent research intervention to develop an ecologically, socially and economically sustainable cropping pattern for the area. There should be appropriate policy instruments to ensure its implementation.

2. Scientific evidences indicate a growing water scarcity in Wayanad. The farmers in the area also perceive a rising temperature and declining and erratic rainfall and a negative impact on agricultural output. There should be scientific validation through location specific studies on the extent of impact of climate change on the major crops in Wayanad.

3. Thavinjal, Noolppuzha and Mullankolly Panchayats which are found to be the most vulnerable areas to water stress must be given priority when resource allocation for

mitigation and adaption programmes are done. At the same time there should be special packages for the resource poor farmers (MF), who are highly vulnerable even in low vulnerable areas. While technology, infrastructure and extension support can be the strategy for rich farmers, the poor may also be supported with financial support. Thus the prescriptions must be region specific and section specific.

4. The results show that the chances of a farmer becoming vulnerable to water scarcity as increasing over the years. It is mainly due to the increased dependence on irrigation coupled with decreased cropping intensity in the recent years. So, it is important to have a relook on the irrigation investment policy, which needs to be more focussed towards water resource development rather than investment in water distribution systems.

5. The results showed that five out of eight factors viz. diversity index, cropping intensity, percentage of irrigated area to total cropped area, net cropped area and education, have significant influence on the probability of an agricultural household being vulnerable, of which the diversity index and cropping diversity being the most influential factors. This further, underlines the need for focussing the research on suitable cropping pattern especially in the homestead farming systems.

6. The adaptations to rising water stress include supply side and demand side management as well as short term and long term measures. The practice of developing own sources as open/borewells needs to be studied in detail to assess its potential effect on water table. Similar is the case of irrigated farming. The relative long term effect of irrigated agriculture on water table and its profitability and feasibility in the long run may have to be seriously researched.

7. The adoption of water saving irrigation methods are rather limited .There should be detailed analysis to identify the constraints in the adoption and develop/modify the technology to suit local conditions.

8. Similar is the case of Crop Insurance Programme, the extent of coverage is not satisfactory and the farmers have reported several faults with the programme. The need for Weather based Crop Insurance programme is stressed. But there should be localised

meteorological stations to act as reference points, rather than depending on one single station data, for settlement of claims.

9. The technologies coming under Climate Smart Agriculture may be tested for scientific validation and suitability to the location, and is recommended.

10. The scope of establishing early weather warning systems is to be explored.

Future Line of Work

1. Extending the study to the whole of the district/state including more variables
2. Taking up research on the relative cost of adaptation of technologies/practices
3. Assessing the social cost /gains of scientific adaptive technologies

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Appendices

APPENDIX –I

KERALA AGRICULTURAL UNIVERSITY
COLLEGE OF HORTICULTURE
KAU P. O
Vellanikkara, Thrissur
Department of Agricultural Economics

Socio-Economic Vulnerability And Adaptive Strategies To Environmental Risk: A Case Study Of Water Scarcity In Agriculture MSc Programme

The information furnished will be only used for the research purpose and the data will be kept strictly confidential

SURVEY QUESTIONNAIRE

Block: Panchayat:

I. Individual Details

I. Name of the farmer:
II. Age:
III. Address:

IV. Telephone Number:
V. Education of the farmer: ☐

Class	Code
Up to 12	1
Graduate	2
Post Graduate	3
Technical	4
Others	5

a. If code is 1, specify the number of years of schooling:
b. If code is 4, specify the course:

VI. Occupation- Full time/ Part time:
a. If part time, specify main occupation:

VII. No: of years engaged in agriculture:

VIII. Annual income: ☐

Income	Code
< 25000	1
25000-50000	2
50000-750000	3
750000-100000	4
100000-200000	5
>200000	6

II. Family details

Sl No.	Name	Relationship with the respondent	Education	Occupation	Annual income
1					
2					
3					
4					

Code:

Relationship with respondent: 01- spouse, 02- father/ mother 03-, son/ daughter, 04- son/daughter-in-law, 05-granddaughter/son, 06-grandfather/mother.

Education: 01- up to 12, 02- graduate, 03- post graduate,04- technical qualification,05- others.

Annual income: 1- below 25000, 2-25000 to 50,000, 3- 50,000 to 75,000, 4- 75000 to 100000, 5- 100000 to 200000, 6 - >200000

a. Income from Agriculture (Household):
b. Income from non-agriculture:

III. Details of land holding (acre)

Sl. No	Particulars	Wetland (Season)			Garden land	
		I	II	III	Irrigated	Rainfed
1	Owned					
2	Leased in					
3	Leased out					
4	Area available for cultivation					
5	Current fallow					
6	Area available for cultivation more than once					

IV. **Water sources :**

1. Period (months during which commonly used)

	2000					2005					2010				
	Well	Canal	Rain	Streams	Tubewells	Well	Canal	Rain	Streams	Tubewells	Well	canal	Rain	streams	Tubewells
Domestic															
Irrigation															

2. Water availability changes

Sources		2000					2005					2010				
		Jan	Feb	Mar	April	May	Jan	Feb	Mar	April	May	Jan	Feb	Mar	April	May
Well	Fall in water table(mm)															
	Av. no of pumping to fill the tank															
Canal	Fall in water table(mm)															
	Flow pattern (dry up)															
Rain (Availabili ty)	As usual															
	Higher than average															
	Less than average															
Tubewells	Fall in water table(mm)															

3. Irrigation Details

- Time: from …………..to…………(month)
- Source:

Open well	1
Canal	2
Ground water	3
Lift irrigation	4
Tube well	5

2010								2005							
Crop	Source	Duration/ irrigation	No. of labour/day	Labour charge	Frequency/week	Energy charges	Total cost	Crop	No.	Frequency/ week	Duration/ irrigation	No. of labour/day	Labour charge	Energy charges	[illegible]

2000							
Crop	Source	Duration/ irrigation	No. of labour/day	Labour charge	Frequency/week	Energy charges	Total cost

V. Climate change (Perceptions/observations)

Sl.no:	Parameter	Observations	Details	Adaptation mechanism
1	Temperature	Increase(annual)		
		Decrease (annual)		
		Increasing minimum temperature in winter		
		Increasing maximum temperature in summer		
2	Rainfall	Increase in annual rainfall		
		Decrease in annual rainfall		
		Delay in the onset of monsoon		
		Early onset of monsoon		
		Heavy rainfall in rainy season followed by drought in summer		
3.	Crop Yied	High		
		Low		
		Steady		
4.	Pest outbreak	Minor pests become major		
		Manageable		
		High		
5	Disease outbreak	High		
		Emergence of new diseases		
		Low		
6	Others			

VI. . Cropping Pattern

Crop	2000				2005				2010			
	Season	Area(acre)/ No: of Plants		Variety	Season	Area(acre)		Variety	Season	Area(acre)		Variety
Paddy		Irrigated	Rainfed			Irrigated	Rainfed			Irrigated	Rainfed	
Pepper												
Banana												
Coffee												
Arecanut												
Ginger												
Turmeric												
Cardamom												
Tapioca												
Yams												
Coconut												

Jack												
Mango												
Guava												
Drumstick												
Vegetables												

VII. Production/ productivity changes

Crop	2010			2005			2000		
	Production (kg)	Home consumption*(kg)	Quantity Sold (Kg)	Production(kg)	Home consumption *(kg)	Quantity Sold (Kg	Production (kg)	Home consumption* (kg)	Quantity Sold (Kg
Paddy (Season I)									
Season II									
Season III									
Pepper									
Banana									
Coffee									
Arecanut									
Ginger									
Turmeric									
Cardamom									
Tapioca									
Yams									
Coconut									

**- Consumption includes quantity used as seeds, household use etc.*

VIII. Climate change impacts:

Sl.no:	Crop	Impacts	Increase	Decrease	Comments
1	Paddy	Water availability			
		Pest outbreak			
		Disease			

		outbreak			
		Weeds			
		Wilting			
		Early maturity			
		Delay in maturity			
		Yield			
		Quality of the produce			
2	Pepper	Rainfall			
		Pest outbreak			
		Disease outbreak			
		Early/delay flowering			
		Berry formation			
		Wilting			
		Yield			
		Quality of the produce			
3	Banana	Water availability			
		Pest outbreak			
		Disease outbreak			
		Bunch formation(delay/early)			
		Rotting of pseudostem			
		Wilting			

		Yield			
		Quality of the produce			
4	Coffee	Flower formation			
		Berry formation			
		Rainfall			
		Pest outbreak			
		Disease outbreak			
		Flower shedding			
		Premature fall of berries			
		Quality of berries			
		Yield			
5	Arecanut	Nut initiation			
		Pest outbreak			
		Disease outbreak			
		Yield			
		Quality of nuts			
6	Ginger	Pest outbreak			
		Disease outbreak			
		Rhizome formation			
		Yield			
		Quality of the produce			

7	Turmeric	Pest outbreak			
		Disease outbreak			
		Rhizome formation			
		Yield			
		Quality of the produce			
8	Cardamom	berry formation			
		Pest outbreak			
		Disease outbreak			
		Quality of the produce			
		Yield			

IX. Adaptation Mechanisms:

A. Crop Wise:

Sl.no:	Crop	Strategies		Comments
1	Paddy	Stress tolerant varieties		
		Early sowing		
		Late sowing		
		Keeping fallow in any of the season		
		Crop rotation		
		Mixed farming		
		Irrigation		
2	Pepper	Stress tolerant		

		varieties		
		Irrigation		
		Mixed cropping		
3	Banana	Stress tolerant varieties		
		Irrigation		
		Crop rotation		
		Intercropping		
		Mulching		
		Shifting the planting time		
4	Coffee	Stress tolerant varieties		
		Soil conservation measures		
		Water conservation measures		
		Irrigation		
		Mulching		
		Shifting the planting time		

5	Arecanut	Stress tolerant varieties		
		Intercropping		
		Irrigation		
6	Ginger	Stress tolerant varieties		
		Mulching		
		Intercropping		
		Crop rotation		
		Irrigation		
		Shifting the planting time		
7	Turmeric	Stress tolerant varieties		
		Mulching		
		Intercropping		
		Crop rotation		
		Shifting the planting time		

8	Cardamom	Stress tolerant varieties		
		Shifting the planting time		
		Intercropping		
		Crop rotation		
		Mulching		
9	Coconut	Mulching		
		Coconut husk burial		
		Organic manuring		
		Intercropping		

B. Did you feel any changes in agricultural production in your land?

Yes : No:

C. What are the coping mechanisms practiced by you?

a. Change in cropping pattern:
b. Change in cropping intensity:
c. Choice of crop:
d. Change in planting time:
e. Depending on water markets:
f. Group farming:
g. Water conservation practices:
h. Limiting farming practices in owned land(Avoiding leased land farming):
i. Leaving agriculture:

D. Whether you have insured your crops?

Yes: No:

a. if yes, for which crops?

b. how long you have been insuring your crops?

c. whether you feel it is good for farmers?

E. Do you have any shortage of water for household purpose?

Yes: No:

F. If yes, how long you been experiencing such problems?

a. One year
b. Two years
c. 3-5 years
d. > 5 years

G. During which period of the year you experience such shortage?

a. Summer:
b. All months other than the rainy season:
c. Throughout the year:

H. What would you do to cope with such problems?

a. buying water :
b. depending on nearby households:
c. depending on nearby streams:
d. collecting water from distant places:
e. collecting water from hills:
f. rain water harvesting:
g. reducing the use of water:

I. Do you feel any change in the water availability in your locality?

Yes : No:

J. If yes, what type of changes do you feel?

a. decrease in the availability :
b. drying up of natural streams and lakes during summer:
c. poor quality :
d. decrease in the water table:

e. others -specify

K. In your view, what may be the reasons for these changes?

a. Climate change:
b. Changes in cropping pattern:
c. Conversion of paddy fields for other purposes:
d. Deforestation:
e. Change in land use pattern:
f. Urbanisation:
g. Lack of good management:
h. Sand mining:
i. Others- specify:

L. What sort of adaptation measures would you like adopt to cope with such changes?

a. Constructing conservation structures:
b. Planting trees:
c. Judicial use of natural reservoirs:
d. Preventing sand mining:
e. Migration:
f. Others: specify

X. Migration Pattern

1. Did you see any migration practice due to decreased production/water stress/change in climate?

Yes: No:

2. If yes, what are the factors that force people to migrate?

a. Decreased production:
b. Heavy water stress:
c. Increased cost of cultivation:
d. Unemployment
e. Decrease in returns
f. Others:

3. What type of migration is common?

Sectoral: Geographical:

4. In case of sectoral migration, what is the preference of sector?

a. Working as labour
b. Wage based job
c. Starting business
d. Skilled work
e. Service sector

Purpose: - Farming-1, Education -2, Marriage-3, Housing- 4, others-5

Source:- Co-operstives-1, RRBs-2, Commercial banks-3, money lenders-4, Friends-5

XIII. What type of socio-economic impacts did you face when your agricultural system and environment was affected by environmental risk like climate change?

a. Reduced standard of living
b. Lack of interest in agriculture
c.

XIV. What do you expect from the government and concerned organisation to minimize such impacts?

1. Weather and climate information systems
   a. early warning system
   b. daily and seasonal weather forecasts
   c. Weather based crop insurance
   d. Others
2. A. Have you heard about Weather based crop insurance scheme?

   B. what is your opinion about weather based crop insurance scheme with respect to crop insurance sheme?

3. External support from Government, NGO, and International Organizations through-
   a. raw materials subsidy
   b. cash incentive
   c. infrastructural support such as irrigation and transportation
   d. insurance support
   e. proper guidelines or suggestion

XV. Share some of your traditional knowledge related to weather predictions?

5. In geographical migration, what is the preference?

a. Nearby panchayats
b. Nearby districts
c. Karnataka
d. Tamilnadu

6. Why people prefer geographical migration?

a. Less cost of cultivation
b. Better availability of resources
c. Better policies (govt. schemes)
d. Suitable climate for farming practices
e. High returns
f. Others –specify

XI. Consumption pattern (previous month)

Sl.no	Particulars	Amount (Rs.)
1	Food	
2	Education	
3	Health	
4	Utility bill (water, electric, home telephone, hand phone, Dish connection)	
5	Others	

XII. Borrowing pattern

1. Whether you have taken any loan during the last year?

Yes: No:

2. If yes,

Sl.No	Type of Credit	Purpose	Source	Amount	Interest rate	Amount repaid	Amount due

Code: Type: - short term-1, long term- 2

Purpose: - Farming-1, Education -2, Marriage-3, Housing- 4, others-5

Source:- Co-operstives-1, RRBs-2, Commercial banks-3, money lenders-4, Friends-5

XIII. What type of socio-economic impacts did you face when your agricultural system and environment was affected by environmental risk like climate change?

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   d. Others
2. A. Have you heard about Weather based crop insurance scheme?

   B. what is your opinion about weather based crop insurance scheme with respect to crop insurance sheme?

3. External support from Government, NGO, and International Organizations through-
   a. raw materials subsidy
   b. cash incentive
   c. infrastructural support such as irrigation and transportation
   d. insurance support
   e. proper guidelines or suggestion

XV. Share some of your traditional knowledge related to weather predictions?

Appendix II

Cropping Pattern of the Sample Respondents (Area in Ha.)

Particulars		**2000**				**2005**				**2010**			
		MF	**SF**	**LF**	**Total**	**MF**	**SF**	**LF**	**Total**	**MF**	**SF**	**LF**	**Total**
Paddy	Nancha	10.756	13.36	12.7	36.816	7.54	10.86	11.40	29.80	4.98	8.92	9.28	23.18
	Puncha	6.956	4.86	2.4	14.216	3.44	3.92	3.50	10.86	1.32	1.71	3.78	6.81
	Total	17.712	18.22	15.1	51.032	10.98	14.78	14.9	40.66	6.3	10.628	13.06	29.988
Pepper		11.238	25.744	18.08	55.062	10.86	21.45	17.30	49.61	6.00	12.10	7.06	25.16
Banana		4.644	4.076	3.44	12.16	6.60	8.39	4.81	19.80	6.86	6.60	6.70	20.16
Coffee		15.116	30.52	28.468	74.104	14.62	31.25	28.88	74.75	12.28	30.46	32.14	74.88
Arecanut		5.2964	10.6836	7.532	23.512	6.43	18.93	10.07	35.43	7.27	18.12	14.32	39.71
Ginger		8.26	19.98	10.64	38.88	9.56	26.48	16.13	52.17	10.48	13.72	13.00	37.20
Turmeric		0.4288	1.728	0.6604	2.8172	0.44	2.47	0.82	3.73	0.64	2.08	1.55	4.27
Cardamom		0.0452	0.29	0.4264	0.7616	0.16	0.41	0.59	1.16	0.11	0.80	1.29	2.20
Tapioca		3.848	3.53	2.9188	10.2968	3.40	1.24	1.61	6.25	3.26	1.18	1.51	5.95
Yams		0.338	1.758	1.542	3.638	0.32	2.01	1.79	4.12	0.60	2.14	2.23	4.97
Coconut		5.9728	16.9984	10.1316	33.1028	6.29	16.49	10.26	33.05	7.01	16.43	9.33	32.77
Rubber		0.54	2.804	1	4.344	0.68	3.83	2.56	7.07	2.34	4.57	5.12	12.03
Tea		1.192	1.776	0.044	3.012	1.43	2.69	0.44	4.56	1.07	3.32	1.34	5.73
Vanilla		0.092	0.06	0	0.152	0.36	1.17	0.78	2.31	0.00	0.26	0.05	0.31
MT		18.81	47.53	34.39	100.73	18.84	47.53	41.71	108.08	20.07	47.01	36.07	103.15
Vegetables		1.452	3.048	0.72	5.22	1.61	3.37	0.82	5.80	1.78	3.43	0.80	6.01

Appendix III.

Production of Major Crops of the Sample Respondents (Tonnes)

Particulars		2000				2005				2010				Tren
		MF	SF	LF	Total	MF	SF	LF	Total	MF	SF	LF	Total	
Paddy	Nancha	27.25	43.04	34.1	104.39	23.5	37.4	21.3	82.2	15.55	30.82	31.8	78.17	↓
	Puncha	16.9	18.3	10.8	46	8.5	15.4	6.7	30.6	4.5	7.52	16.6	28.62	↓
	Total	44.15	61.34	44.9	150.39	32	52.8	28	112.8	20.05	38.34	48.4	106.79	↓
Pepper		32.517	68.585	46.9	148.002	20.5745	40.7	33.9	95.1745	5.139	18.134	9.05	32.323	↓
Banana		80.51	72.31	72.435	225.255	121.1	151.73	71.675	344.505	111.65	113.79	107.25	332.69	-
Coffee		23.43	52.76	38.2	114.39	20.07	55.86	54.12	130.05	13.59	46.879	59.25	119.719	-
Arecanut		10.102	9.46	15.1	34.662	23.645	64.61	45.6	133.855	20.158	75.024	35.833	131.015	-
Ginger		99.64	221.95	107.39	428.98	121.42	522.03	73.29	716.74	107.092	202.1	147.92	457.112	-
Turmeric		2.28	9.76	2.7555	14.7955	1.602	8.73	4.9455	15.2775	5.36	8.7355	7.675	21.7705	↑
Cardamom		0.0247	0.187	0.0765	0.2882	0.0212	0.334	0.2365	0.5917	0.0557	1.4162	3.1875	4.6594	↑
Tapioca		158.695	45.85	42.6	247.145	167.545	24.8	14.7	207.045	153.795	30.86	22.25	206.905	↓
Yams		4.215	119.667	13.875	137.757	6.73	120.174	8.715	135.619	5.152	121.75	15.94	142.842	-
Coconut*		3105	10226.5	7799	21130.5	4385	10417.5	5440	20242.5	2299	7505	7222	17026	-
Rubber		0.33	0.44	0	0.77	0.53	1.44	0.525	2.495	1.59	2.84	0.525	4.955	↑
Tea		2.42	9.875	0	12.295	4.89	5.8	1.2	11.89	2.82	5.795	3.19	11.805	↓

*- No of nuts.

Appendix IV

Productivity of Major Crops of Sample Respondents (Tonnes/Ha.)

Particulars		2000				2005				2010			
		MF	SF	LF	Total	MF	SF	LF	Total	MF	SF	LF	Total
Paddy	Nancha	2.53	3.22	2.69	2.84	3.12	3.44	1.87	2.76	3.12	3.46	3.43	3.37
	Puncha	2.43	3.77	4.50	3.24	2.47	3.93	1.91	2.82	3.41	4.40	4.39	4.20
	Total	4.96	6.99	7.19	6.07	5.59	7.37	3.78	5.58	6.53	7.86	7.82	7.58
Pepper		2.89	2.66	2.59	2.69	1.89	1.90	1.96	1.92	0.86	1.50	1.28	1.28
Banana		17.34	17.74	21.06	18.52	18.35	18.08	14.90	17.40	16.28	17.24	16.01	16.50
Coffee		1.55	1.73	1.34	1.54	1.37	1.79	1.87	1.74	1.11	1.54	1.84	1.60
Arecanut		1.91	0.89	2.00	1.47	3.68	3.41	4.53	3.78	2.77	4.14	2.50	3.30
Ginger		12.06	11.11	10.09	11.03	12.71	19.71	4.54	13.74	10.22	14.73	11.38	12.29
Turmeric		5.32	5.65	4.17	5.25	3.60	3.54	6.03	4.09	8.31	4.21	4.95	5.10
Cardamom		0.55	0.64	0.18	0.38	0.13	0.82	0.40	0.51	0.50	1.77	2.47	2.12
Tapioca		41.24	12.99	14.60	24.00	49.28	20.03	9.13	33.13	47.18	26.15	14.73	34.77
Yams		12.47	68.07	9.00	37.87	20.90	59.85	4.88	32.94	8.62	56.89	7.16	28.77
Coconut*		5198.57	6016.15	7697.70	6383.30	6972.71	6315.78	5300.28	6125.40	3278.29	4567.86	7740.62	5195.16
Rubber		0.61	0.16	0.00	0.18	0.78	0.38	0.21	0.35	0.68	0.62	0.10	0.41

*- nuts per hectare.

APPENDIX V

Basic for Main Effect (2005)

Sl.no	Criteria	Severe (S)	Moderate (M)	Less (L)
	Agronomic Factors (AF)			
1	Cropping Intensity	588	403	218
2	Diversity Index			
3	Variety Tolerance			
4	% of Gross Irrigated area to Gross Cropped Area			
5	Water & Soil conservation practices			
6	Sources of water			
7	Ownership of source of water			
8.	Percentage of deviation from normal water availability in Summer			
	Total Direct Points (Main Effects)	**4704**	**3224**	**1744**
	Total Interaction Points	**250880**	**118160**	**46816**
	Grand Total	**255584**	**121384**	**48560**

Interaction in between	AF&AF
SXS	4480
SXM	2840
SXL	2189
MXS	2840
MXM	2110
MXL	1441
LXS	2189
LXM	1441
LXL	836

Appendix VI

Sources of Water for Domestic Use (Respondent farmers)

	2010												
	Own OpenWell	Own Tube/ borewell	Own Pond	GWS & neighbourhood well	Public Open Wells	Neigh-bourhood open well only	Public open wells & Neigh-bourhood open well	Own openwell & neigh-bourhood open well	Own openwell & Own tubewell	GWS only	Canal only	Community Pipes only	Total
MF	27 (55.10)	4 (8.16)	1 (2.04)	2 (4.08)	9 (18.37)	3 (6.12)	0 (0.00)	0 (0.00)	0 (0.00)	2 (4.08)	0 (0.00)	1 (2.04)	49
SF	48 (76.19)	8 (12.70)	1 (1.59)	0 (0.00)	2 (3.17)	0 (0.00)	1 (1.59)	3 (4.76)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	63
LF	17 (73.91)	3 (13.04)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (4.35)	1 (4.35)	0 (0.00)	0 (0.00)	1 (4.35)	23
	92 (68.15)	15 (11.11)	2 (1.48)	2 (1.48)	11 (8.15)	3 (2.22)	1 (0.74)	4 (2.97)	1 (0.74)	2 (1.48)	0 (0.00)	2 (1.48)	135

Appendix VI

Sources of Water for Domestic Use (Respondent farmers)

	2005												
	Own OpenWell	Own Tube/ borewell	Own Pond	GWS & neighbourhood well	Public Open Wells	Neigh-bourhood open well only	Public open wells & Neigh-bourhood open well	Own openwell & neigh-bourhood open well	Own openwell & Own tubewell	GWS only	Canal only	Community Pipes only	Total
MF	26 (53.06)	4 (8.16)	2 (4.08)	2 (4.08)	9 (18.37)	4 (8.16)	0 (0.00)	0 (0.00)	0 (0.00)	2 (4.08)	0 (0.00)	0 (0.00)	49
SF	44 (76.19)	5 (7.94)	0 (0.00)	0 (0.00)	2 (3.17)	2 (3.17)	1 (1.59)	4 (6.35)	0 (0.00)	0 (0.00)	1 (1.59)	0 (0.00)	63
LF	17 (73.19)	3 (13.04)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (4.35)	1 (4.35)	0 (0.00)	0 (0.00)	1 (4.35)	23
Total	87 (67.41)	12 (8.84)	2 (1.48)	2 (1.48)	11 (8.15)	6 (4.44)	1 (0.74)	5 (3.70)	1 (0.74)	2 (1.48)	1 (0.74)	1 (0.74)	135

Appendix VI

Sources of Water for Domestic Use (Respondent farmers)

	2000												
	Own OpenWell	Own Tube/ borewell	Own Pond	GWS & neighbourhood well	Public Open Wells	Neigh-bourhood open well only	Public open wells & Neigh-bourhood open well	Own openwell & neigh-bourhood open well	Own openwell & Own tubewell	GWS only	Canal only	Community Pipes only	Total
MF	21 (42.86)	4 (8.16)	2 (4.08)	2 (4.08)	11 (22.45)	6 (12.24)	0 (0.00)	0 (0.00)	0 (0.00)	2 (4.08)	1 (2.04)	0 (0.00)	49
SF	46 (73.02)	1 (1.59)	2 (3.17)	0 (0.00)	4 (6.35)	4 (6.35)	1 (1.59)	3 (4.77)	1 (1.59)	0 (0.00)	1 (1.59)	0 (0.00)	63
LF	18 (78.26)	3 (13.04)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (4.35)	0 (0.00)	0 (0.00)	1 (4.35)	23
Total	85 (62.96)	8 (5.93)	4 (2.96)	2 (1.48)	15 (11.11)	10 (7.41)	1 (0.74)	3 (2.22)	2 (1.48)	2 (1.48)	2 (1.48)	1 (0.74)	135

Abstract

SOCIO-ECONOMIC VULNERABILITY AND ADAPTIVE STRATEGIES TO ENVIRONMENTAL RISK: A CASE STUDY OF WATER SCARCITY IN AGRICULTURE

By

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ABSTRACT OF THE THESIS

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ABSTRACT

Water stress is predicted as one of the most pronounced risk of climate change in countries like India. Kerala is reported as moving from wetness to dryness. Management of risks of climate change necessitates scientific estimates of the level of potential damage, accommodating for the vulnerability and adaptive mechanisms of the communities. The study entitled 'Socio-Economic Vulnerability and Adaptive Strategies to Environmental Risk: A Case Study of Water Scarcity in Agriculture' was undertaken with the objectives of measuring farmers' vulnerability to water stress in agriculture and its impact on household welfare and to identify and assess the relative influence of various factors on the level of vulnerability. Further, short term and long term adaptive strategies to water stress among farmers of different socioeconomic conditions were also analysed.

The most backward district of the state of Kerala, Wayanad was selected as the study area. Multistage random sampling method was adopted for sample selection. Nine panchayats from four Community Development Blocks were selected, from each of which, 15 farmers were selected. Thus the total sample size was 135. Primary data regarding the socio-economic status, land use pattern and production, sources of water for domestic use and irrigation, perceptions and adaptive strategies to water scarcity were gathered using pretested interview schedule. Indicator based approach was used for constructing the composite vulnerability index to assess the vulnerability level of the farmers. Logit model was employed to identify the factors influencing vulnerability. Apart from these, conventional tabular analysis was also used.

The cropping pattern in Wayanad shows a clear shift in favour of commercial crops like arecanut, banana and rubber. The conversion of paddy lands for these crops was to the tune of 41 per cent during the last decade. The area under pepper shows a decline (54 %) and that of other commercial crops show an increase. Among other reasons, climate change is perceived as one of the major reasons for this decision by the farmers. The analysis of weather parameters and climate predictions for Wayanad also supports the farmer level observation.

The rainfall and temperature pattern of the district during past years indicate an increasing level of water stress. Climate change models project very high variation in the rainfall pattern of the district in future years. An increase in the average annual rainfall coupled with lower

levels of summer showers are predicted. By 2020, summer showers may decline to 43.6 mm as against the present, 70 mm. High intensity rains with low duration will be the major characteristic. A gradual increase in annual temperature by about 1.5°C is also predicted.

In this background, a composite vulnerability index considering social, economical and agronomic factors of the farmers was constructed to measure the vulnerability. More than 50 per cent of farmers were highly vulnerable and the proportion of the farmers in that group was found to be increasing during the past five years. An inverse relationship was observed between the land holding size and vulnerability level, three- fourth of the marginal farmers were vulnerable while most of the small and large farmers (41.27 % and 34.78 % respectively) belonged to the other group. Thavinjal panchayat of Manathavady block was found to be the most vulnerable and Muppainad and Vythiri panchayats of Kalpetta block were found to be the least vulnerable.

The results of the logit model shows that five out of eight factors viz. diversity index, cropping intensity, percentage of irrigated area to total cropped area, net cropped area and education as having significant influence on the probability of an agricultural household being vulnerable, of which the diversity index and cropping diversity are the most influential factors.

Farmers often have their own adaptive mechanism to cope with the water stress condition within the constraints. In general, adaptation strategies followed in domestic and agricultural sector can be classified into supply management strategies and demand regulating strategies or long term and short term strategies. The supply management programme includes those activities which ensure the steady supply of water and the demand side management mainly focus on more efficient use of available water resources and improving water resources.

Among the respondents, a gradual shift from the dependence on external sources of water to owned sources has occurred. The dependence on external sources increases the time spent and drudgery of women folk in such households.

Common adaptation strategies followed by the farmers include irrigation, varietal selection, mixed cropping, crop diversification, organic farming, soil and water conservation measures (mulching, earthen bunds and rain pits) and migration (geographical and sectoral). About 39 percent of the sample respondents were adopting irrigated farming and the average expenditure was found to be Rs 18187 per household which is nearly nine percent of the total household income. Only a few farmers were adopting micro-irrigation methods because of its high investment. This cost of adaptation, further reduces their consumption expenditure leading to household welfare loss.

The study suggests research interventions in developing a sustainable cropping pattern and scientific validation with location specific studies on the impact of climate change on major crops. The need for empowering the farmers through technology, infrastructure, financial and extension support to adapt to water stress is also underlined. It highlights the importance of water resource development and the need for identifying the constraints in the adoption and develop/modify the technologies to suit local conditions. Further the implementation of weather based crop insurance programmes with localised meteorological stations as reference points is also stressed.