Mainstreaming climate resilience into agricultural development: Readiness of the extension system in Kerala

By

T. P. ANSEERA

(2016-11-003)

THESIS

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Department of Agricultural Extension

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DECLARATION

I hereby declare that the thesis entitled **"Mainstreaming climate resilience into agricultural development: Readiness of the extension system in Kerala"** is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other university or society.

Vellanikkara

04-09-2018

T. P. ANSEERA

(2016-11-003)

CERTIFICATE

Certified that the thesis entitled **"Mainstreaming climate resilience into agricultural development: Readiness of the extension system in Kerala"** is a record of research work done independently by **Ms. T. P. Anseera** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

04.09.18

Vellanikkara
04-09-2018

Dr. Jiju P. Alex
(Major Advisor)
Professor
Dept. of Agricultural Extension
College of Horticulture, Vellanikka

CERTIFICATE

We, the undersigned members of the advisory committee of **Ms. T. P. Anseera (2016-11-003)**, a candidate for the degree of **Master of Science in Agriculture**, with major field in **Agricultural Extension**, agree that the thesis entitled **"Mainstreaming climate resilience into agricultural development: Readiness of the extension system in Kerala"** may be submitted by **Ms. T. P. Anseera** in partial fulfilment of the requirement for the degree.

04.09.18

Dr. Jiju P. Alex
(Major Advisor)
Professor
Dept. of Agricultural Extension
CoH, Vellanikkara, KAU, Thrissur

Dr. Jayasree Krishnankutty
Professor and Head
Dept. of Agricultural Extension
CoH, Vellanikkara, KAU, Thrissur

4/9/18

Dr. Mercykutty M.J.
Associate Professor
Agricultural Extension
Dept. of Vegetable Science
CoH, Vellanikkara, KAU, Thrissur

4/9/18

Dr. S. Krishnan
Professor and Head
Dept. of Agricultural Statistics
CoH, Vellanikkara, KAU, Thrissur

4/9/18

Dr. C. Karthikeyan
(External Examiner)
Professor
Dept. of Agricultural Extension
Tamil Nadu Agricultural University (TNAU)
Coimbatore

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Affectionately dedicated to
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Chapter 1

INTRODUCTION

Of all the human activities, agriculture is the largest employer as well as the most weather dependent in the world. With climate change looming day by day, agriculture is becoming increasingly vulnerable to its deleterious impacts. With majority of people depending on agriculture and the pressure on natural resources mounting, the impact of climate change would be much severe than expected.

The Inter-governmental Panel on Climate Change (IPCC) defined climate in a narrow sense as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period ranging from months to thousands or millions of years.

Although climate change is a global problem, its impacts differ from region to region, country to country, sector to sector and community to community (Adger *et al.*, 2003). As stated earlier, agriculture is the sector most vulnerable to climate change due to its high dependence on climate and weather conditions and due to poor adaptive capacity added with limited access to alternate means of production (IPCC 2007). Climate change will further reduce access to drinking water, negatively affect the health of poor people, and will pose a real threat to food security in many countries in Africa, Asia and Latin America. Agricultural outputs, as well as the livelihoods of people who depend on it, are particularly vulnerable to climate change, and it is important that we assess adaptation mechanisms to reduce these vulnerabilities. Though climate change is a global issue, climate change adaptations measures are to be localized so as to make the system sustainable.

1.1. Climate change impacts on Indian agriculture

As the global threat of climate change looms large day by day, developing countries like India appear to be increasingly vulnerable to its deleterious effects. For instance, climate change in India implies 10-15 per cent increase in monsoon precipitation in many regions, a simultaneous precipitation decline of 5-25 per cent in drought-prone central India and a sharp decline in winter rainfall in northern India. It also implies decrease in number of rainy days (5-15 days on an average) over much of India, along with an increase in heavy rainfall days in the monsoon season. These changes are expected to increase the vulnerability of Indian agriculture to a considerable extent (Senapati *et al.,* 2013). IFAD (2012) while describing the impact of climate change observed that even while the primary interface between climate change and agricultural development was through agricultural production, climate hazards also had impacts on the storage, processing and market access of produces. Thus, climate has a major say in every aspect of agricultural activity, making it more sensitive to climate change.

Climate change has become an important area of concern for India to ensure food and nutritional security for growing population. In India, significant negative impacts have been implied with medium-term (2010-2039) climate change, predicted to reduce yields by 4.5 to 9 per cent, depending on the magnitude and distribution of warming. Since agriculture makes up roughly 16 per cent of India's GDP, a 4.5 to 9 per cent negative impact on production implies a cost of climate change to be roughly up to 1.5 per cent of GDP per year (Venkateswarlu *et al*., 2013; Jasna *et al.,* 2014). The Government of India has accorded high priority on research and development to cope with climate change in agriculture sector. The Prime Minister's National Action Plan on climate change has identified agriculture as one of the eight national missions.

Adding to the woes, agricultural land is declining year after year across the country and food grain production is stagnated mostly due to weather aberrations. Increase in temperature is likely to be around 3°C by 2100 A.D. in India. 1972, 1979, 1987, 2002, 2009 and 2016 were the severe drought years during which the kharif food grains production was adversely affected to a considerable extent. Crop simulation models indicate that area under rice and wheat across the country is likely to decline in ensuing decades and total food grains production is under threat as a result of increase in temperature and rainfall uncertainties. Changes in temperature and rainfall will lead to frequent occurrence of floods and droughts and heat and cold waves. Rise in current food prices, as a result of increase in global prices, inadequate monsoon and severe droughts in addition to increase in support prices, is a crisis at present. Therefore, it is high time to project climate change at the site/local/region level and its impact on crops as agriculture is the main sector which suffers to a great extent and the Indian economy is agrarian based.

In estimating the economic impacts of climate change on Indian agriculture in the short-term and medium-term, found farmers were constrained in their ability to recognize and adapt quickly to changing mean climate. The results also suggests that climate change is likely to impose significant costs on the Indian economy unless farmers can quickly recognize and adapt to increasing temperatures. Such rapid adaptation may be less plausible in a developing country, where access to information and capital is limited (Guiteras, 2007).

Adaptation and mitigation are the core of climate resilient agriculture, which are complementary activities. For a developing country like India with a countable size of farm economy, the greatest challenge lies in ensuring enough food for our population by adapting our farming to climate variability. In this endeavor, deployment of new technologies and policy reforms play equal role. Mitigation can have a direct effect on climate change, *per se*, adaptation can combat the severity of the impacts. Judicious natural resource management in vulnerable areas such as drought and flood prone areas, coastal zones and hilly regions would be the first step towards promoting climate resilient agriculture. Rational and cost effective technologies with local level adaptations need to be mainstreamed along with supporting policies and critical interventions at all levels of governance with the aim of capacity building from grassroots level itself. Considering the herculean task involved in building resilience, several attempts have been initiated in this line. For instance, ICAR has set up a network project viz. National Initiative on Climate

Resilient Agriculture- (NICRA) at the national level. The objective of the programme is to demonstrate site specific technology packages on farmers' fields for adapting to current climate risks; and to enhance the capacity building of scientists and other stakeholders in climate resilient agricultural research and its application. The project envisages introduction of crops, livestock breeds, management practices that help in adaptation and mitigation. The project also expects to generate inputs for policy making to mainstream climate resilient agriculture into developmental planning. The focus of the programme is not only to demonstrate climate resilient agriculture technologies but also to institutionalize mechanisms at the village level for continued adoption of such practice in sustainable manner.

1.2. Climate change: Kerala scenario

Kerala, with its receding share of agriculture is also under the pressure of climate change. As per projections made in the action plan for climate mitigation by the Government of Kerala, proportion of irrigated to net sown area in the state is 19 per cent and much of this land is located in coastal and low lying regions which are vulnerable to rising sea level, salinity ingress and ground water depletion. It is also feared that productivity of rice is likely to decrease by 4 per cent and more heat stressed days in the Western Ghats would lead to thermal discomfort to livestock and decreased productivity. Unprecedented trends of erratic monsoons and warmer summer season in recent times have impacted agricultural production in many places in the state (GOK, 2013).

Kerala state is reportedly facing serious threats in major areas of food security, agriculture, health and marine resources due to climate change. We have just witnessed the unexpected floods that devastated the entire state. Experts suggest that untimely rain is a clear evidence of climate change.

Impacts of climate change may vary at the field level. To cite a few examples, heavy pre-monsoon showers (and a lethal attack by wasps) may hit pepper production in Kerala, the main producer of the commodity in India. The prolonged wet spell in kharif (summer crop) and unusual rains had been devastating paddy production in Kerala to a large extent almost every year in the recent past. Records also show that almost all the plantation crops suffered to a great extent due to disastrous summer droughts. The thermo-sensitive crops like black pepper, cardamom, tea, coffee and cocoa will be badly affected as temperature range (the difference between maximum and minimum temperatures) is likely to increase and rainfall is likely to decline. Increase in maximum temperature of 1-3° C during summer adversely affected thermo-sensitive crops like black pepper and cocoa in Kerala (Rao *et al.*, 2008). Unlike in seasonal crops, the impact of weather aberrations will be having long standing ill effects as the crops are perennial in nature and as a result the state's economy is adversely affected.

1.3. Climate resilience

Science and knowledge are critically important to enable society to understand and respond to threats posed by climate change. Decision makers need sound information on vulnerabilities to climate change and the potential social and economic impacts of climate change, particularly on more vulnerable groups like the extreme poor.

In the absence of planned adaptation, the consequences of long-term climate change could be severe on the livelihood security of the poor. Therefore, it is of utmost importance to enhance the resilience of Indian agriculture to climate change. Resilience is the ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, through preservation, restoration, or improvement of its essential basic structures and functions (IPCC, 2012). Planned adaptation is essential to increase the resilience of agricultural production to climate change. Management practices that increase agricultural production under adverse climatic conditions tend to support climate change adaptation because they increase resilience and reduce yield variability under variable climate and extreme events.

Resilience mechanism can be adaptive, mitigation or coping. Adaptation refers to adjustments in ecological, social or economic systems in response to harmful impacts (e.g.; use of bio resources) (Lin, 2011). Mitigation refers to those actions that reduces the severity, seriousness or loss by lessening the impact of disasters (e.g.; promoting biodiversity) whereas coping mechanism towards resilience address specific efforts, both behavioral and psychological.

1.4. Mainstreaming climate resilience into agricultural development

The impacts of climate change are likely to undermine planned development outcomes in a number of countries, posing significant challenges to the resilience of livelihoods and ecosystems. Of course, development planning responses play an important role in addressing these challenges; as such, mainstreaming climate resilience into these responses is fast emerging as a major policy agenda. When it comes to mainstreaming climate change, officials aim to integrate aspects of adaptation and/or mitigation-oriented responses to climate change into development planning. For this to happen, planners need to focus on how to support the process of integrating climate resilience into development planning responses.

Mainstreaming climate resilience needs to be a strategic, country-led approach. It needs to integrate climate resilience into development planning in efficient and effective ways. It must enable development planners to rationalize what could be done with what needs to be done and what feasibly can be done within the structures, resources and capacity available. Of course, this will change and develop over time as the mainstreaming process continues.

Various stakeholders advocate mainstreaming climate resilience into development planning, broadly referring to processes for integrating climate change considerations into development planning *objectives* – such as national development plans – and *processes* such as annual planning cycles and public finance management systems. Climate mainstreaming is seen as a rational policy response; however, the *way* in which it is achieved is crucial to its technical and institutional sustainability.

To have real impact, mainstreaming must have a greater sense of ownership by government staff. The response to climate change must be built into the government's most vital institutions and policies, using existing capacity and priorities to integrate climate resilience into existing decision-making processes.

Because climate change challenges development, climate resilience must be integrated into development policy objectives. Climate change impacts – increased temperatures, rising sea levels, unstable and more extreme rainfall patterns – can impede development and threaten the effectiveness and sustainability of development investments. At the same time, people's capacity to adapt to these impacts depends on their access to economic, ecological and social resources, and infrastructure and governance. Hence, development planning must be climate resilient while also building climate resilience.

The cross-scale impacts of climate change demand better integration of local and national policy responses. The impacts of climate change will be felt first and foremost by local people, groups and enterprises. National adaptation planning must therefore be informed by, and supportive of, local adaptation planning, which focuses on location-specific needs and so better reflects local realities and contexts. Local adaptive planning can be more agile than national planning and can make seasonal adjustments, thus enabling better responses. National planning can enable adaptation by providing the necessary infrastructure, public services and resources.

Mainstreaming at a country level means moving towards the strategic integration of climate resilience into development planning. This kind of country-wide programmatic approach necessitates looking at national budgets, development and investment plans as well as institutional arrangements.

Climate resilience into development planning rises from the need to design adaptation and resilience interventions to enable people to escape poverty despite climate change. Global climate program are also supporting the strategic integration of climate resilience into development planning. These bring multiple projects and planning processes under a single policy framework, achieving strategic integration across climate change and development policy objectives.

As explained earlier, India is experiencing the unrelenting impacts of climate change. Now the focus is switched over to climate adaptation from yield intensification. Practices imparting climate resilience are the best adaptation option available. Awareness creation and better incorporation of people from various strata can enhance adoption of these practices. It is seen that adoption and diffusion of climate resilient technologies in rainfed Kerala is relatively low which has led to low resilience to climate change, though we receive copious amount of monsoon showers. The impact of climate resilient technologies is to be analyzed to find out the extent to which these technologies could induce resilience of the stakeholders in the current scenario of erratic climatic variability. Moreover, it is important to quantify the vulnerability of districts and panchayats so as to make location specific planning and policies. In this backdrop, it is necessary to streamline climate resilience into agricultural development to safeguard the agricultural sector in Kerala.

1.5. Objectives of the study

The study intends to focus on the following researchable objectives:

1. To explore various dimensions of climate resilient agriculture as experienced by the farming community and the extension system

2. To assess the readiness of the public sector extension system in the state to mainstream climate resilience into agricultural development

3. To measure level of awareness on climate change by stakeholders

4. To measure level of awareness and extent of adoption of climate resilient technologies

5. To study the role of institutions/agency in mainstreaming climate resilience

1.6. Scope and importance of the study

Realization that climate change could have negative consequences on agricultural production has enhanced the desire to build resilience into agricultural systems across the world. Mitigating the impact of climate change involves multiple approaches and interventions that would engage several agencies and stakeholders. This requires mainstreaming climate resilience into agricultural systems through research, awareness building, standardization of new cultivation practices, evolution of innovative adaptation actions, targeted extension delivery, special support packages, action research programs, and participatory problem solving etc. This necessitates reorientation of the extension delivery system towards this objective, which in turn demands equipping the extension institutions with the scientific content and action programs to propagate the strategies to mitigate climate change.

Under these circumstances, an appraisal of the readiness of the public extension system would help formulate exclusive extension strategies for addressing this issue constructively. The findings of the study would help understand farmers' viewpoints towards climate change and climate resilient technologies. Further it would provide a reasonable understanding on level of acceptance of climate resilient technologies among the farming community. Incorporating critical points from the results of the study, some suggestions can be put forward for designing various developmental interventions. The study is expected to be relevant for the state planners, policy makers, and researchers to identify points of success and failures, thus to reshape further step of their action.

1.7. Limitation of the study

Since the study area was limited to only ten villages from Palakkad and Wayanad, generalization of the findings to the entire rainfed agro-ecosystem of Kerala will be a difficult task. The findings of the study were based on expressed opinion of the respondents. Hence, the objectivity would be limited to the extent of the respondents' honest opinion. Even if the data were cross checked to minimize the error, it is a fact that the results of the study may be apt only for the area where the study had been conducted. Like any other single student research, time frame available for the study also appears to be a limiting factor. The study focused on limited variables due to paucity of time and resources. The study also had limitation of fund and physical facilities. In spite of the above limitations, no effort was spared to make the study as objective and systematic as possible.

1.8. Organization of the thesis

The study compiled into thesis is organized into six chapters. Chapters start with the introductory section, describing the objectives, scope, importance and limitations of the study. Review of literature in accordance with the objective is provided as second chapter. The third chapter deals with methodology followed by conducting the research. Results and discussion constitute the fourth chapter. The fifth chapter include summary, conclusion and future line of the study and finally ends up with references, appendices and abstract of the study.

Review of Literature

Chapter 2

REVIEW OF LITERATURE

Literature review, which is of paramount importance for any research is done to situate the topic under study theoretically. Here the most recent works on the concepts, methods, variables and policy implications related to the topic have been reviewed.

This chapter attempts to systematically compile existing information on important aspects of climate change and climate resilient agricultural development. Review of previous studies would help us understand the present status of research work on the topic and provide the back drop for interpreting results. Relevant studies in this area of research are presented chronologically under the following subheads.

2.1. Vulnerability to climate change at the farm level

2.2. Climate resilience and climate resilient agriculture

2.3. Dimensions of climate resilient agriculture

2.4. Importance of mainstreaming climate resilience into agricultural development

2.5. Mainstreaming climate resilience into agricultural development: Policy imperatives

2.6. Role of institutions in facilitating adoption of climate resilient practices

2.7. Awareness on climate change and climate resilient technologies

2.8. Factors affecting adoption of climate resilient strategies

2.9. Personal and socio-economic attributes of various stakeholders included in the study

2.1. Vulnerability to climate change at the farm level

Climate change vulnerability is both biophysical and social process, which is dynamic in nature (O'Brien *et al.*, 2012; IPCC, 2012), though earlier studies on vulnerability assessment viewed it more as a biophysical impact of climate change. Recent studies on vulnerability also consider the importance of non-climatic factors in dealing with climate change.

Mc Carthy *et al.* (2001) described vulnerability to climate change as a function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity and its adaptive capacity.

However, according to O' Brien *et al.* (2004), in the context of climate change and agriculture, vulnerability refers to the propensity of the entity to face a climate shock, suffer loss in production and/or income from agriculture, though the latter is not always specified explicitly.

It is widely accepted and proven beyond doubt that agriculture in developing countries is one of the most vulnerable sectors of the global economy to changing climate (Kurukulasuriya *et al.*, 2006; Seo and Mendelsohn 2008).

Srivastava *et al* (2010) analyzed the impacts of climate change on the production system and its vulnerability in India for various crops. Using simulation model, the same was analyzed for sorghum, which is considered to be a crop suited for drought affected area. It was observed that more low-cost adaptation strategies should be explored to further reduce the net vulnerability of sorghum production system in India as the model revealed a reduction in the climate change impacts and vulnerability of winter crop to 1–2 per cent in 2020, 3–8 per cent in 2050 and 4–9 per cent in 2080, as a result of adoption of adaptation strategies.

Varghese (2012) found that 30 per cent of the farmers were vulnerable to water shortage for domestic purpose, and more than fifty per cent farmers were vulnerable to water shortage for agricultural purpose in the district of Wayanad in Kerala.

Sharma (2011) while analyzing the impact of water availability for agriculture described India as a water stressed country and so the vulnerability would be high. It was reported that about 52 percentage of the cropped area was unirrigated and some area were drought affected.

Rao *et al.* (2016) analyzed the vulnerability of agriculture to climate change and variability at the district level considering the fact that most of the development planning and programme implementation was done at district level in India. The analysis which was done for the 572 rural districts suggested the need for redesigning rainwater harvesting structures and strategies to handle higher runoff in a shorter period so as to harvest surplus runoff preventing soil loss. According to the study, four districts of Kerala were identified to have medium vulnerability, seven district come under low vulnerability and three districts with very low vulnerability.

2.1.1. Factors affecting vulnerability

Several studies have tried to delineate the factors that affect vulnerability to climate change. Given below are brief references of some of the relevant findings and observations on factors affecting vulnerability.

A paper on social vulnerability to climate change by Adger and Kelly (1999) identified vulnerability to climate change as the first step in evaluating and understanding the social and economic processes.

The vulnerability of rainfed lands to climate change and variability had been exposed by the devastating effects of floods and prolonged droughts in different parts of the country (Singh *et al.*, 2004).

In this regard, Pandey *et al.* (2004) also observed that water vulnerability of rural farm households were due to high dependency of agriculture on water and poor infrastructure. Moreover, low level of education, low diversification of income sources and low access to local government services were found contributing to it.

According to Fussel (2007), climate related vulnerability assessments were based on the characteristics of the vulnerable system spanning over physical, economic and social factors.

A study conducted by Heltberg *et al.* (2009) concluded that vulnerability varied according to socio-economic and institutional development, especially in agriculture. This was observed while mapping vulnerability to climate change in the areas that were most vulnerable to the impacts of climate change and variability.

In another similar context, it was found that major factors deciding level of socio-economic vulnerability of farmers of Wayanad district included share of livestock income, total household income, number of sources of soil and water conservation measures (Varghese, 2012).

Highlighting the importance of water, Rao *et al.* (2016) observed that inadequate or lack of irrigation facilities and low ground water availability were important factors determining vulnerability of Indian agriculture to climate change.

2.1.2. Measuring vulnerability to climate change

Many authors have emphasized the need to develop measures to quantify vulnerability to climate change. As climate change vulnerability encompasses productive, economic and social dimensions, there are potentially a wide range of metrics to assess vulnerability which is not easily quantifiable (Alwang *et al.*, 2001) and thus the biggest challenge in vulnerability research is developing robust and credible measures (Adger, 2006).

Atkins *et al.* (1998) calculated the methodology for measurement of vulnerability and construction of suitable composite vulnerability index for developing countries and island states, and found that small states were especially prone to vulnerable when compared to large states.

Ravindranath *et al.* (2010) assessed the vulnerability of districts in north-eastern states by constructing separate vulnerability indices for agriculture, forestry and water sectors. They incorporated the data on climate projections into models that predicted the forest cover, which were then included in the construction of vulnerability index following the IPCC framework.

Ranganathan *et al* (2010) observed that calculating vulnerability index and identifying vulnerable areas especially for river basins and farm households, would help policy makers concentrate more on highly vulnerable areas by developing suitable adaptation strategies. He also pointed out that identification and analysis of the existing adaptation mechanisms to climate change in different environments would help fine-tune the strategies for mainstreaming and up-scaling them with focus on research and policy.

Palanisami *et al.* (2011) assessed the vulnerability of districts in the Krishna-Godavari basin based on indicators related to agriculture and demography.

Sridevi *et al.* (2014) while indexing and mapping climate change vulnerability of south Indian states used socio-demographic, climatic, agricultural, occupational and common property resources vulnerabilities as the sources of vulnerability indicators to compute a composite vulnerability index.

Several authors had regarded Livelihood Vulnerability Index (LVI) analysis as an effective indicator-based method to identify vulnerable communities, understand factors contributing to vulnerability at community level and prioritize the potential interventions recommended to policy makers, local authorities and development organizations. The LVI analysis was first applied in Mozambique (Hanh *et al.*, 2009), then in countries like Nepal, Ghana, Trinidad and Tobago. Later, LVI was used by many researchers in different contexts (Pandey and Jha, 2012; Aryal *et al.*, 2013; Etwire *et al.,* 2013; Shah *et al.,* 2013).

Data on socio-demographics, livelihoods, health, social networks, physical, financial and natural resources, natural disasters and climate variability were collected from a survey of 120 households by Can *et al.* (2013) and obtained the overall LVI of study villages. The analysis indicated that LVI method could be applied for other purposes such as monitoring vulnerability, evaluating development programmes or ensuring policy effectiveness by incorporating with scenario comparison.

Recently, Panthi *et al.* (2015) extended the LVI developed by Hahn *et al.* (2009) and IPCC vulnerability (VI-IPCC) index to assess the vulnerability of agro-livestock smallholders of Nepal.

As seen from earlier works on measuring vulnerability, a pragmatic approach to vulnerability assessment involved finding how vulnerable a community was compared to other and which component pushed up the level of vulnerability within the community.

2.2. Climate resilience and climate resilient agriculture

The concept of resilience is central to have an understanding on the vulnerability of agriculture sector to climate change. Agriculture sustains on the resilience of both social and ecological systems. Resilience is referred to as the capacity of the system, communities, households or individuals to bounce back by either preventing, mitigating or coping with risks and it essentially involves judicious and improved management of natural resources, land, water, soil, and genetic resources through adoption of best practices (Bodin and Wiman, 2004; Rao *et al.*, 2016).

As defined by FAO (2012), resilience is the ability to prevent disasters and crises as well as to anticipate, absorb, accumulate or recover from them in a timely, efficient and sustainable manner. In other words, resilience was defined as the ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, by ensuring the preservation, restoration, or improvement of its essential basic structures and functions (IPCC, 2012).

According to Venketeswarlu (2014) resilience is the capability of the production system to resist the negative impact of climate change and the capacity to recover quickly after the damage. Both application of improved technology and new policies will contribute to resilience.

2.2.1. Characteristics of climate resilient agriculture

It is commonly agreed that building resilience to climate change in agricultural production would help ensure agricultural-based livelihood security and reduce their vulnerability to climate change impacts.

Venkateswarlu and Shanker (2012) concluded that the resilience to predicted climate change would depend on increasing agricultural productivity with available water resources; refining technologies and timely deployment of affordable strategies to accomplish potential levels of arable land and water productivity. They suggested adaptation strategies to increase resilience to combat climate change related effects, mainly by management of water, soil and biodiversity. They also recommended research for enhancing adaptive capability of crops by increasing their resilience to abiotic stresses, pests and diseases with a biological systems perspective and sustainable natural resource management perspective.

Explaining the pre-requisites on climate smart agriculture further, Raghuvanshi *et al.* (2018) observed that strong mechanisms for finance, capacity development and technology transfer were very important for the success of various adaptation and mitigation practices and technologies used in climate-smart agriculture.

2.2.2. Specific interventions for climate resilience in agriculture

The diversity in agriculture across the world has called for diverse interventions at the field level to combat the diverse consequences of climate changes. A brief review of specific interventions required to combat climate change impacts in agriculture is given below:

Lal (1987) reported that conservation tillage practices could increase farm system resilience and improve the capacity of farmers to adapt to climate change. Such practices might also reduce carbon losses that occur with ploughing, and further sequester carbon via residue incorporation and reduced erosion.

Antle (1995) examined the impacts of climate change on agricultural resources and production with given technology and institutions in developing countries, especially tropical agriculture. This study also analyzed the challenging task to predict how agricultural technologies and institutions might evolve futuristically to be climate resilient with the adoption of specific interventions.

Tompkins and Adger (2003) proposed to build resilience through the extension and consolidation of social networks, both at the local scale and at the national, regional or international scale.

Crop diversification was suggested as a measure to combat vulnerability due to variability in rainfall (Adger *et al.*, 2003; Orindi and Eriksen 2005).

The need to enhance resilience of rainfed agriculture to climate change through planned adaptation of appropriate inter/sequence cropping systems and other management practices of natural resource management was emphasized by Singh *et al.* (2004) while assessing the vulnerability of rainfed lands exposed to devastating effects of floods and prolonged droughts in different parts of the country.

According to Singh *et al.* (2004), adoption of climate resilient and short duration pulses like chickpea, pigeon pea, black gram and green gram had played important role in crop diversification and increased cropping intensity and further opened up scope for their inclusion in new regions and seasons.

Building resilience into agricultural system, according to FAO (2010) could be possible only through climate smart agriculture which could sustainably increase productivity, enhance resilience, reduce/remove greenhouse gas emissions, and enhance the achievement of national food security and development goals.

Lin (2011) pointed out that implementation of diversified agriculture could be the productive way to build resilience into agricultural system. Increasing adoption of this was challenged both scientifically and at policy level. He suggested that better idea on how to optimize a diversified structure to maximize production and profits would help in overcoming this challenge.

Pathak *et al.* (2012) while elaborating the benefits of various climate resilient practices reported that furrow irrigated raised-bed system of wheat cultivation could provide savings in seed by 25-40 per cent, water by 25-40 per cent and nutrients by 25 per cent, without affecting the grain yield production.

Emphasizing on the importance of building awareness on climate resilient agriculture, Lal (2013) suggested improvement in education curricula at state agricultural universities to include courses on climate change and the concept of carbon sequestration. He also suggested establishment of National Climate-Resilient Agriculture Programme (NACRAP) and development of mechanisms to compensate farmers and land managers through payments for ecosystems services (e.g., soil carbon sequestration).

Reddy *et al.* (2015) revealed that adoption of intercropping systems was a proven climate resilient system which had helped in improving food security in rainfed black soil areas.

Singh (2015) in his studies on productivity enhancement among cereal crops by mitigating climate change effect through deployment of climate resilient varieties in India, concluded that various policies/schemes, crop development programmes and increased varietal and seed replacement rates (VRR and SRR) of newly released climate resilient varieties were responsible for increased productivity in cereal and coarse cereal crops.

While exploring the possibilities of building climate resilient agriculture through traditional floating rice in Assam, Neog *et al.* (2016) stated that it was imperative to identify indigenous technical knowledge and integrate this with mainstream technologies to mitigate climate change.

Rao *et al.* (2017) noticed that farm ponds offered a remedy to overcome the increased frequencies of drought under climate change scenario, and selection of crops and cropping pattern systems based on profitability and irrigation requirement needed to utilize the harvested water were crucial in bringing resilience to agricultural systems.

Vernooy *et al.* (2017) argued that community seed banks could enhance the resilience of farmers, in particular of communities and households most affected by climate change. Community seed banks could secure improved access and availability of diverse, locally adapted crops and varieties, and enhance related indigenous knowledge and skills in plant management, including seed selection, treatment, storage, multiplication, and distribution.

Khatri *et al.* (2018) recommended that promotion of climate resilient crop varieties, animal breeds and efficient technologies would help achieve climate resilience in agriculture in the country in its efforts to double the farmers' income by 2022, without compromising the present rate of enhancement in agricultural productivity.

2.3. Dimensions of climate resilient agriculture

As seen from the above review, resilience to climate change is understood as a multi-dimensional concept, which has to be accomplished through multi-pronged strategies. Several authors had tried to delineate the dimensions of vulnerability to climate change and climate resilience. Mainstreaming climate resilience in the strategy for agricultural development require clear understanding of the dimensions involved in the impact of climate change. Building resilience to climate change in agricultural production can ensure sustainability of agriculture based livelihoods and reduce their vulnerability.

Chinwe (2013) identified various conservation practices that increased buffering capacity by evaluating farmers' economic, social, ecological and other dimensions. Through climate resilient agriculture, it was found that most farmers improved their productivity and incomes despite drought along with improvement in their environment and social relations.

According to Pervin *et al.* (2013), the key dimensions that climate resilience mainstreaming efforts should address include integration between policy objectives and temporal and spatial planning scales.

As Devarajan (2016) observed, there could be ecological, economic and social dimensions for climate resilient agriculture. Ecological dimension of resilience was about attaining sustainability by means of improving soil fertility, enhancing water availability, conservation of biodiversity and adaptation to climate change by improving drought resistance and stress tolerance. Economic dimension included various approaches like promotion of integrated farming, enhancing seed security, adopting eco-technologies and commercialization of agricultural technologies. According to him, intensification and diversification along with convergence extension approach could make climate resilient agriculture development possible, particularly in Kerala.

2.3.1. Ecological dimension of climate resilience

Ecological dimension of climate resilience focuses on eco services, natural resource management and sustainable management of resources. Carpenter *et al.*

(2001) defined ecological resilience as the ability of an ecosystem to absorb or recover from disturbance and change while maintaining its functions and services.

According to Abramovitz *et al.* (2001), the implementation of targeted conservation of natural buffer systems as a strategy for building climate resilience offers several potential co-benefits that include biodiversity conservation, poverty alleviation and enhanced sink capacity.

While explaining the dimensions of resilience, Tompkins and Adger (2004) opined that building resilience into both human and ecological systems was an effective way to cope with environment due to climatic changes. They argued that these emerging insights had implications for policies and strategies for responding to climate change.

In a significant study on the effect of human intervention in building resilience, Colls *et al.* (2009) pointed out that reduction of non-climatic anthropogenic stressors could help to foster ecological resilience to climate change.

Reiterating the above observation, Ramesh *et al.* (2015) found that the socio-economic status of farmers of Durgada Nagenahalli had improved when they started water resource management to combat climatic vulnerability.

2.3.2. Economic dimension of climate resilience

Economic dimension of climate resilience focus on the issues of maintaining economic profitability and sustainability in the face of deleterious impacts of climate change. Since climate change impacts livelihood security, measures have to be taken to ensure livelihoods to the farmers and other stakeholders. Internationally, economic dimension of climate resilience has developed into several policy initiatives like carbon trading and other actions. Moreover, enhancing economic resilience should include measures that reduce vulnerability to both physical and socio-economic systems.

According to Aggarwal (2008), policies and incentives were necessary to encourage farmers to sequester carbon in the soil and there by efficiently enhance soil health, water use and energy. He recommended the need for accelerating the evolution of local-specific practices, investing in water storage and water-use technologies, providing value-added climate risk management services to farmers in the form of reliable weather forecasts and agro-advisories along with improved extension services and development of physical and institutional infrastructure. The study analyzed the need to concentrate food security and poverty alleviation central in climate negotiations, by mobilizing national and international bodies.

Khan (2009) found that economic resilience and adaptive capacity to climate change impacts were positively correlated and both moved in the same direction. He emphasized the need to integrate all its dimensions, strategies and tools, expansion of agricultural extension, research and development for new crops, technology and markets, introducing insurance and micro insurance, skill development and institutional capacity building at all levels as measures to enhance economic resilience.

Gbetibouo (2009) in his study on climate resilience among farmers in South Africa reported that government policies should ensure farmers' access to affordable credit, giving them greater flexibility to modify their production strategies in response to climate change to enhance economic resilience. He observed that access to water for irrigation increased farmers' resilience to climate variability and recommended for greater investments in smart irrigation. He also suggested improvement of off-farm income-earning opportunities to facilitate a smooth transition from subsistence to commercial farming as an additional measure to build economic resilience.

Several other option have also been pointed out by authors. For instance, Arabi (2013) while explaining mitigation measures that could be adopted in India, pointed out that with the highest technical potential to sequester carbon in agriculture in the world, India could adopt improved crop and grazing land management; restoration of organic soils (including peat land) that were drained for crop production and restoration of degraded lands; livestock management; manure and bio-solid management, and bio-energy use. Moreover, the study also recommended measures for reducing GHG emissions from the agriculture sector through the combination of market-based programs, regulatory measures, voluntary agreements, and international programs.

Regarding various interventions required for resilience to climate change, Devarajan (2016) observed that value chain development, innovation, regulatory and quality services at the grassroots level were necessary in bringing convergence in extension and entrepreneurship development aiding economic resilience.

2.3.3. Social dimension of climate resilience

As observed by many, resilience to climate change has distinct social dimensions, which emphasize the impact of climate change on communities and groups. In the context of climate change, social resilience is the ability of groups or communities to adapt in the face of external social, political, or environmental stresses and disturbances (Adger, 2000). Social resilience is often used to describe the capacity for positive adaptation despite adversity (Luthar and Cicchetti, 2000).

Many studies had emphasized the significance of the nature of social relationships as a factor that could enhance resilience. Although the lessons from these studies were context-specific, they had suggested some broad criteria by which the adaptive capacity of communities could be assessed. The nature of relationship among community members was found to be very critical, as their access to, and participation in the wider decision-making processes could aid in bringing community resilience to changing climatic vagaries (Adger, 2003).

Review of social dimensions of climate resilience revealed the prospects of building successful community-based resource management that could potentially develop resilient communities as well as maintain ecosystem services and ecosystem resilience (Brown *et al.* 2001*c*).

With regard to social dimension of climate resilient agriculture, several authors had explained the concept of adaptive capacity, which was often used to refer to the set of preconditions that enabled individuals or groups to respond to climate change (Olsson and Folke, 2001; Brooks, 2003; Berkhout *et al.*, 2004).

Reiterating the importance of attaining the capacity for resilience, Tompkins and Adger (2004) argued that to be resilient, societies must generally demonstrate the ability to buffer disturbance, self-organize, learn and adapt.

While elaborating on the social dimensions of resilience, Alex (2012) observed that building and empowering resilient rural communities would require programmes for sustainable natural resource management and livelihood security, in the Kerala context.

Devarajan (2016) in his attempt to delineate the components of social dimension of resilience found that promoting low external inputs, participatory mode of development activities, community grain banks and community seed banks would constitute social dimension of climate resilience.

2.4. Importance of mainstreaming climate resilience into agricultural development

As understood by now, the rural poor dependent on agriculture in developing countries are impacted by climatic changes the most. Considering this, many writers have explained the need to mainstream climate resilience into the development programmes and interventions

Mainstreaming, in other words mean, integrating various interventions for climate change mitigation and resilience into policies and programmes for agricultural development at the international, national and state level, with definite implications at the field level.

Apropos this, Tompkins and Adger (2003) suggested a strategy to build resilience through extension programmes and consolidation of social networks, both at the local scale and at the national, regional or international scale.

Samuel *et al*. (2009) in their study observed people's perception about climate change related strategies employed in South Western Nigeria. They concluded that there was a need for agricultural economists and other stakeholders in developing countries to understand issues related to environmental management and agricultural sustainability and thus to focus on the negative impacts of climate change. They also emphasized the need to think about positive and beneficial response strategies to global warming and beat them with climate proof policies.

Gbetibouo (2009) indicated the necessity to design policies aimed at improving factors that inhibit adaptation to climate change. In the study conducted by him at Limpopo River Basin in South Africa, it was observed that approximately half of the farmers had adjusted their farming practices in response to the impacts of climate change and lack of access to credit was the main factor inhibiting adaptation.

With regard to situations in India, Venkateswarlu and Shanker (2009) pointed out that policy initiatives were imperative in relation to access to banking and micro-credit/insurance services before, during and after a disaster event. Access to communication and information services in the envisaged climate change scenario were also found to be important. According to them, adaptations should be mainstreamed into all major development initiatives by considering impacts and facilitating greater adoption of scientific and economic pricing policies. Financial incentives and packages for improved land management should also be ensured. They had even suggested initiating a 'Green Research Fund' for strengthening research on adaptation, mitigation and impact assessment.

Reiterating the above, Ranganathan *et al*. (2010) opined that mainstreaming adaptation and enhancing adaptive capacity could be increased by encouraging partnerships between informal processes and formal interventions to facilitate adaptation by the poor. Significantly higher cost of adaptation in developing countries and the need to pay more attention in addressing future climate scenarios through agricultural research and development, irrigation development, infrastructure, and improved irrigation efficiency were critically observed during the study.

Since climate is a major long term problem that requires a long term solution, Sharma (2014) analyzed the stakeholder's necessity in taking medium term and long term measures by mainstreaming it into all kinds of development initiatives at all levels in a transparent way. He also suggested planned adaptation, which was through deliberate policy decisions for anticipatory and localized adaptation for immediate and visible outcomes, for which bottom-up approach, capacity building and development of an alternative paradigm of people-oriented development demanding proactive policy formulations were required.

Devarajan (2016) suggested an idea of empowerment extension, which was nothing but building ecological resilience where the major reform in governance was to facilitate mainstreaming climate resilient agricultural development, through improved structural reforms like farm school and legal reforms regarding farm and rural services, and though administrative reforms in the form of improving access to resources. He also suggested for participatory/ livelihood extension which should focus on social resilience.

As regards the pre-requisites for mainstreaming climate resilience, Muralidharan *et al.* (2016) observed that climate resilient agriculture in vulnerable agro-ecosystem could be promoted only by flexible framework for technology management with participatory communication and eco-friendly resource use as its defining features.

2.4.1. Specific interventions for mainstreaming climate resilient agriculture

Mainstreaming climate resilience would materialize only if specific interventions are formulated in terms of grassroots level programmes. Even while broader policy initiatives are drawn out, specific interventions to address the two most important issue have to be formulated. One is about addressing various factors that contribute to climate change at the local level. Secondly, the programmes to address the consequences of climate change at the farm level should be taken care of.

As observed by Reddy *et al.* (2010) in the study to understand farmers' adaptability to climate variability at two differently endowed locations in the semi-arid region of Andhra Pradesh, neither physical capital nor financial capital would be significant at the household level in addressing the issues at the farm level. This indicated the importance of assessing the adaptation levels at the household level in order to arrive at better insights for policy purposes.

Ranganathan *et al.* (2010) observed that short term interventions to mitigate climate change normally included adoption of crop varieties and water management practices to suit the changes of climate. Long-term interventions identified were mostly government programmes that had helped in addressing climate change impacts. Concentrating on highly vulnerable areas and making adaptation practices accordingly through capacity building programmes with strategies that could also resolve financial constraints was also suggested.

Mutamba (2016) focused on the need to formulate new institutional arrangements to take on climate change. He suggested that governments could enable public-private partnerships to promote climate resilient agriculture. Need of the regulatory and policy environment to recognize, promote and reward such partnerships, creating an environment where doing business with smallholder farmers becomes attractive for the private sector were also recommended. He further explained that working with the private sector to establish crop insurance schemes could help provide security for farmers, so that they would be more willing to take risks by adopting new agricultural techniques.

Similarly, CSISA (2017) advocated partnerships with private sector, associated with development and strengthening of capacities of service provider networks, which would lead to a wider adoption of more efficient technical solutions, as evidenced by the case of irrigation and agricultural mechanization technologies and practices among smallholders in Bangladesh.

Rao *et al.* (2017) argued for policy interventions to promote programmes like 'one pond for each farm' holding having an area of 2.0 ha at individual farm level or on community-sharing basis to enhance climate resilience.

2.5. Mainstreaming climate resilience into agricultural development: policy imperatives

Mainstreaming climate resilience into agricultural development would be possible only through appropriate policy measures that would address multiple requirements and interests.

Emphasizing the policy interventions required for evolving the academic content required to address the issues related to climate change, Tompkins and Adger (2003) pointed out the entire natural and social sciences should be brought within such an integrated policy framework, coupled with a learning-based management system. They argued that this might increase ecological and social resilience and hence increase ability to respond to climate change. They also suggested that social and ecological resilience could be enhanced by including stakeholders in an inclusive, sectorally and vertically integrated decision making process.

The importance of creating knowledge on climate change management was further underlined by Howden *et al.* (2007) who stated that developing the capacity to manage climate risk involved increasing the climate knowledge of decision makers so that they would be more aware of climate impacts on their systems. It would also help use management options to intervene effectively, thereby reducing negative impacts and utilizing opportunities. More importantly, this would enable shift of rhetorical focus from adaptation to climate change to management of climate risk, integrating climate change into a broader research domain.

According to Verner (2013) effective coordinated governance, improved access to agro-meteorological information, and enhanced climate-related human and technical skill development were critical factors in enabling climate change action by advisory services and other subjects.

Schubert (2015) suggested government's role in bringing alignment across policy domains, facilitated by dialogue across relevant ministries, including organizations delivering rural agricultural services, to address trade-offs and overlaps to mitigate climate change impacts.

Moreover, promoting adaptation and mitigation measures over entire landscapes, or up scaling climate resilient practices at the community and landscape levels, required coordination across different agricultural sectors, as well as other related sectors, such as forestry, energy, water, finance and insurance (ACT, 2016).

Apart from all these, according to Tesfaye and Seifu (2016), policy measures should include provisions for necessary resources such as credit, information and extension services on climate change adaptation strategies and technologies, and investing in climate smart and resilient project.

2.6. Role of institutions in facilitating adoption of climate resilient practices

Adoption of climate resilient practices is seemingly influenced by several factors. While technological options are important, institutional factors also play major roles particularly because the impact of climate change affects larger geographical units and population. Even while regular interventions are important, collective effects through social groups and community organizations are the key factors that determine the extent of adoption of climate resilient practices. Wider adoption of such practices across the country may lead to the evolution of climate resilient communities which are capable of tackling the negative impacts of climate change effectively.

It was earlier seen that mainstreaming climate resilience required new institutional arrangements along with technological solutions. Importance of rural institutions in enhancing ecological resilience has been reported by many authors (Ostrom, 1990; Baland and Plateau, 1996; Agrawal, 2001).

Handmer *et al.* (1999) examined the coping mechanisms to environmental shock or hazard brought about by biophysical vulnerability. Factors like institutional stability and strength of public infrastructure were of crucial importance in determining the vulnerability to climate change. They further explained that a well-connected population with appropriate public infrastructure would be able to deal with a hazard effectively and reduce the vulnerability. Such a society could be said to have low social vulnerability. If there is an absence of institutional capacity in terms of knowledge about the event and ability to deal with it, the vulnerability of the population would be high.

Agrawal (2008) opined that adaptation to climate change would be inevitably local and that institutions would influence adaptation and climate vulnerability in three critical ways: a) they structure impacts and vulnerability, b) they mediate between individual and collective responses to climate impacts and thereby shape outcomes of adaptation, and c) they act as the means of delivery of external resources to facilitate adaptation, and thus govern access to such resources.

With regard to mobilization of human resources for combating the perils of climate change, Swaminathan (2009) introduced the concept of local level risk managers who could spread both climate and genetic literacy and create awareness about climate change among the people at grassroots level.

Jodha *et al.* (2012) concluded that implementation of mitigation strategies that highlight dynamism, diversity and flexibility would need both enhancement and reorientation of the capacities of the farmers and rural communities, as well as that of the institutional arrangements and innovations supporting them.

Nagaraj *et al.* (2013) while explaining the impact of technological and institutional interventions by ICRISAT in Rajasthan, Gujarat, Haryana and Maharashtra named 'HOPE' (Harnessing Opportunities for Productivity Enhancement of Dry Land Cereals) found that with diffusion of innovations, provision of quality seeds, efficient input delivery and market linkage, more than 75 per cent of the farmers benefitted through bridging the productivity gaps and thereby enhanced incomes in both crop and livestock sectors. The welfare gains accrued to the farming community were evident through effective and appropriate institutional interventions and infrastructure tailor made for semi-arid areas.

Apropos institutional arrangements for extension and advisory services for building climate resilience, Simpson and Burpee (2014) observed that assisting farmers and rural communities to adapt to the direct and indirect effects of climate change possess challenge to the role of extension and advisory services providers as to when and where to invest limited human and financial resources in assisting farmers to select which types of specific adaptive changes to take on evolving climate. They also faced the challenge of enhancing technology exchange, adaptation and dissemination practices to match the need for continual climate change adjustments. They concluded that these challenges could be addressed only through new institutional arrangements.

Jasna *et al.* (2016) conclusively defined institutions for enhancing resilient agriculture as social and scientific organizations functioning with improved coping mechanism to sustain the system against climate change impacts and facilitate local innovation.

2.7. Awareness on climate change and climate resilient technologies

Increasing the awareness on the causes of climate change is often considered as the key to public support of mitigation and adaptation policies. However, higher awareness might not always relate to higher risk perceptions.

Nhemachena and Hassan (2007) in their analysis of the micro level issues related to farmer's adaptation to climate change in Southern Africa confirmed that access to credit, extension and awareness of climate change were some of the important determinants of farm-level adaptation of mitigation strategies. They established that enhanced access to credit, information as well as markets would significantly increase farm-level adaptation. The study identified several strategies such as location specific adaptation strategies depending on community mix (ethnicity, religion and cast issues), resource availability, demand patterns and livelihood options.

Swaminathan (2009) also said that climate awareness at the grassroots levels could help local communities manage better the adverse impact of climate change.

Sogani (2011) while documenting the pattern of climate change perceptions and adaptation practices among Uttarakhand farmers reported that communities in the mountain areas were well aware of changing climatic conditions.

Adebayo *et al.* (2012) assessed the awareness level of farmers on climate change in Adamawa state in Nigeria and observed that majority of the respondents (about 96%) were aware of climate change, while only about 4 per cent seemed not to be aware of climate change.

A study by Latha *et al.* (2012) identified the level of awareness on climate change and factors influencing decision making on the coping mechanisms to mitigate the impacts of climate change. The study revealed that climatic variation as incidence of drought had significant impact on production of rainfed crops. The small and medium farmers were more vulnerable to climate change and to a larger extent, adopted coping mechanisms for climate change compared to large farmers.

Shashidahra and Reddy (2012) while examining farmers' adaptation strategies to climate change in Upper Krishna Project area of Karnataka state found that awareness of climate change was an important component of farm-level adaptation.

Baul *et al.* (2013) found that 84 per cent of farmers had awareness on increase in temperature. Similarly, Legesse *et al.* (2013) also revealed that 95 per cent of sample households were aware of increased frequency of drought occurrence.

Marshall *et al.* (2013) empirically found that primary producers with higher levels of awareness on climate change had a higher capacity to adapt on at least three dimensions of adaptive capacity. They also suggested that it might be worth investing in supporting climate change awareness within primary industries.

Tripathi and Singh (2013) in a study on perception, anticipation and responses of people to changing climate in the Gangetic plains of India observed that only 30 per cent of respondents were aware of the term climate change.

Gopal *et al.* (2014) while studying the extent of adoption of adaptation and mitigation measures for climate change by dry land farmers in Chittoor district of Andhra Pradesh found 84.47 per cent of farmers had awareness on climate related changes followed by 74.27 per cent on crop related changes, 73.61 per cent on animal husbandry related and only 61.11 per cent farmers had awareness on soil and water related changes.

Kamruzzaman (2015) observed that level of education and access to extension services had significant association with their awareness on causes of climate change and also, farmers having more education and high access to extension service attributed environmental factors to climate change than supernatural factors and vice versa.

Raghuvanshi *et al.* (2017) reported that adapting with climate change depended on level of awareness about climate change. Farmers who were aware about the climate change, its causes and consequences were more likely to adopt adaptation measures and mitigation practices to cope up with adverse effects of climate change.

In suggesting farm pond for climate-resilient rainfed agriculture, Rao *et al.* (2017) pointed out that insufficient awareness among farmers was a major constraint that impeded adoption of farm ponds on a large scale in rainfed ecosystems of India.

2.8. Factors affecting adoption of climate resilient strategies

Adoption of any new practice, as understood from the large volume of literature on this subject, would be mostly influenced by level of education, size of family, interest in modern farming and sources of information. These factors were found to significantly influence the behavior of small farmers, particularly with respect to new farm technology (Waman *et al.*, 1998).

Soni *et al.* (2000) stated the existence of positive association between the socioeconomic characteristics of farmers and the extent of adoption of modern technologies. Their findings also showed that lack of knowledge was a major obstacle in adopting improved varieties of crops and plant protection. Moreover, high fertilizer cost was also found to be one of the reasons for non-adoption of farm technology.

Antle and Diagana (2003) reported that scarcity of information and thin credit and insurance market reduced adoption incentives in developing countries affected by climate change.

Blanco and Lal (2008) identified adoption of soil and water conservation structures were attributed to awareness of their benefits. For the farmer, these structures could provide benefits by reducing water erosion, improving water quality, and promoting the formation of natural terraces over 12 times, all of which should lead to higher and less variable yields.

A study by Jodha *et al.* (2012) examined the mitigation strategies against climatic variability in arid and semi-arid regions of India and found that the farmer's perception of coping practices were largely governed by village level variables governed by weather conditions. Moreover, the study concluded the need for enhancement and reorientation of the capacities of farmers, rural communities, as well the institutional arrangements and innovations supporting them to bring success in implementation.

Latha *et al.* (2012) concluded that small and medium rainfed farmers were highly vulnerable to climate change and to a larger extent the small and medium rainfed farmers adopted coping mechanisms for climate change compared to large farmers.

Pathak (2012) identified ten adaptation options having the highest priority in mitigating climatic vulnerability through experts ranking. These options were climate ready crop varieties, water-saving technologies, changing planting dates, integrated farming system, growing different crops, integrated pest management, crop insurance, conservation agriculture, improved weather-based agro-advisory and

Shanker *et al.* (2013) observed that major adaptation measures followed by farmers towards changing climate in Mahbubnagar were staggered sowings, changing planting dates, cultivating drought resistant crops, and constructing water harvesting structures. Arunachalam (2014) suggested that efficient selection of adapted germplasm and resource conservation based technologies with focus on soil and water conservation and, increasing crop water use efficiency were the essential pillars of climate resilient agriculture in the country.

Campbell *et al.* (2014) found that farmers weighed the costs and benefits of new farming practice or technology, with a consideration of short-term vs. long-term gain, and often under much uncertainty. Poor farmers were understandably low risk-takers as their resilience was low.

Ramesh *et al.* (2015) revealed that water harvesting structures initiated were crucial in building climate resilience in NICRA village Tumkur in Karnataka where farm ponds and check dams helped farmers to enhance cropping intensity along with increased area under irrigation and ground water recharge.

According to Rao *et al.* (2017), the major constraints that impeded adoption of farm ponds for climate resilient agriculture on a large scale in rainfed ecosystems of India were relatively high initial investment, evaporation and seepage loss, small land holding, insufficient awareness among farmers and moderate benefits during normal years

Sathyan *et al.* (2018) reported the results of field experiments conducted to evaluate the effect of pink pigmented facultative methylotrophic bacteria (PPFM), nutrients, growth regulators, anti-transpirants and compatible solutes (synthetic materials) against the drought stress of cardamom in Idukki district. Cardamom variety Green Gold *(Njallani)* was found to be tolerant to climate change. Results revealed that the plants treated with PPFM showed high levels of drought mitigating factors like higher chlorophyll stability index and proline content under stress (drought) condition with no inhibition of endophytic fungi.

2.9. Personal and socio-economic attributes of farmers selected for the study

Since the variables selected for the study and mentioned in the review are likely to be influenced by various socio-economic and personal attributes, a detailed review of the literature on the relationship between these attributes and dependent variables has been attempted as given below:

As rightly observed by Kandlinkar and Risbey (2000), adaptation had the potential to significantly reduce the negative impacts of changes in climatic conditions as well as other changing socio-economic conditions.

According to Adger *et al.* (2003), climate change would have greater negative impacts on poorer farm households as they had the lowest capacity to adapt to changes in climatic conditions. Adaptation measures were therefore important to help these communities to better face extreme weather conditions and associated climatic variations.

Ahmed (2013) identified the factors, which were mainly responsible for the adoption of new technology in agriculture. These factors were: farm size, income, risk bearing ability, irrigation facility, credit facility, education, market price, age and use of fertilizers. However, traditionalism and ethnicity were found to be negatively related with adaption.

2.9.1. Age

Kumaran (2008) in his study on rice farmers in Palakkad district observed that educated youth were not interested in farming since they had perceived farming as risky and a non-profitable occupation with low status.

Whereas, a study conducted by Adebayo *et al.* (2012), showed that presence of relatively young and physically active people had a bearing on the availability of manpower for agricultural production and also on the ease of adoption of climate change adaptation strategies. Moreover, age influenced the ability to seek and obtain off-farm jobs and income, which could increase income of farmers and help cope with adverse change in climate.

A study by O'brien *et al.* (2012) concluded that age was important consideration in managing the impact of natural disasters as the elderly and young persons were inherently more susceptible to environmental risk and hazard exposures.

2.9.2. Gender

Women have been found to be more vulnerable to the impacts of natural calamities as well as climate change. Studies have shown that women actively engaged in farming always try to build resilience in their system as they are fundamentally good planners and managers of their scarce resources.

Nirmala and Venkateswarlu (2012) suggested an adaptation strategy to offset climate change impacts being gendered. According to them, the common division of labour in agriculture, static gender relations, gender inequality in land rights, education, social participation, malnourishment of women becoming acute with climate change and natural hazards were the issues to be mainstreamed to design climate-resilient agriculture.

Nelson and Stathers (2009) also observed that rapid changes to climate would pose challenges to women's empowerment and gender equality on a completely new scale.

Availability of water was found to be a major factor that impacts the lives of women, since they were the homemakers. Many studies had reported that drudgery and fatigue of rural women would be high in households that are depended on outside sources of water during the summer season (Rajalakshmi, 2000; Narayana, 2005).

Varghese (2012) found that farm women of Wayanad travelled an average distance of 236 meters and took nearly one hour to fetch water daily.

2.9.3. Education

Education has been widely regarded as the most important factor that determines level of awareness and extent of adoption, particularly with regard to agriculture. Better education would help farmers choose best course of action from alternatives, especially in the present scenario where climate change warrants immediate decision making quite often.

Waman *et al.* (1998) found that the level of education, size of family, interest in modern farming and sources of information were the main factors that significantly influenced the behavior of small farmers regarding new farm technology.

Literate farmers were found to have access to wide ranging scientific and general information from reliable sources and this education allowed them to enjoy meaningful social integration (Kumar and Parikh, 2001).

Reiterating the above, Adebayo *et al.* (2012) pointed out that education was an important factor that determined the ability of an individual to understand the policies and programmes relating to climate change adaptation. This study had revealed that literacy level was high among the respondents and this could have implication for agricultural production and also for adaptation to changes in the climate. Adoption of measures that could result in climate change adaptation was also easier and faster among the educated farmers than the uneducated farmers.

2.9.4. Farming experience

Experience of farmers is found to have major impact on decisions made to adopt a new resilient practice. Experience determines the level of understanding on adaptation of various resilient practices that could be improvised to suit local situations.

Many studies have found that experienced farmers had a higher probability of perceiving the importance of climate change as they were exposed to past and present climatic conditions over their life span (Maddison, 2006; Ishaya and Abaje, 2008, Deressa *et al*., 2009).

Varghese (2012) observed that experienced farmers in Wayanad were helping the sustainability of agriculture even in the hard times of climate change.

It was observed that most of the famers involved in full time farming activity were well experienced with more than ten years of rich experience and were well known about various practices to cope with changing scenario (Senthilkumar, 2000; Sobha, 2014)

In this connection, Jasna (2015) also observed that greater the years of involvement with farming practices, more the adoption of climate resilient technologies.

2.9.5. Farm size

Gbetibouo (2009) observed that farm size, tenure rights, farming experience, wealth, access to credit, access to water, off-farm activities, and access to extension were the main factors that could enhance adaptive capacity.

Farm size has been the most influencing factor which affects the decision to adopt and continue various resilient practices, especially diversification. As concluded by Jansa (2012), t probable reason for the positive and significant relation between land holding leased-in and adoption of resilient practices could be that farmers tend to avoid chances of crop failure due to climate change and the resultant risk associated with indebtedness due to inability to pay the rent.

Similarly, Varghese (2012) observed an inverse relationship between e land holding size and vulnerability level.

2.9.6. Annual income

There is a general notion that agriculture as a non-profitable venture particularly in the present climate changing arena. Kerala, where monsoon is the single factor that determines the success or failure of seasonal crops, family income is highly uncertain for a full time farmer.

Ezedinma (2001) found that farm size was positively correlated with family income whereas labour and capital cost were negatively correlated with income.

On assessing the vulnerability of Wayand farmers on account of water scarcity, Varghese (2012) reported that the average household income was 2.41 lakh of which 60 per cent was from agriculture.

It was also observed that there was an increase in income diversification (60 per cent of the sample households) through off-farm livelihood options among the farmers of Wayanad. This option reduced agricultural risks due to climatic, production or market events. The study also reported that share of livestock income and total household income were some of the major factors that determine the level of socio-economic vulnerability.

2.9.7. Extent of farming integration

Climate resilient agriculture would be possible only when intensification and diversification go hand in hand, so that farming could be sustained as a profitable venture. A wise integration of agriculture with animal husbandry brings resilience to a considerable amount.

However, as an alternative to mitigate the negative impact of biotic and abiotic stresses, Wassmann *et al.* (2009) suggested mixed cropping, which would efficiently utilize nutrients and soil moisture.

Varghese (2012) observed that 60 per cent of the sample households were rearing cattle as a subsidiary source of income, enabling them to reduce input cost substantially and the vulnerability to climate change.

2.9.8. Innovativeness

According to Jasna (2012), farmers innovativeness and decision making ability play a major role in the context of increased vulnerability of agriculture to climate change. She also emphasized the crucial role of institutions in facilitating local innovations.

Shinde and Modak (2013) observed that application of technological innovation along with local knowledge and improved access to infrastructure facilities and services were the key actors that aided the reduction of vulnerabilities and enhancement of adaptation capacity in Indian agriculture

Smith (2010) argued that resilient agriculture needed adaptive innovations with organic inputs. In another context, Arunachalam (2014) reported that adoption of innovative agricultural practices and new crop varieties could neutralize the stress caused by water scarcity and adverse weather conditions.

Devarajan (2016) opined that innovation, value chain development, regulatory and quality services would bring convergence in extension initiatives leading to resilience in agricultural system.

2.9.9. Exposure to training

As climatic uncertainties are affecting farm productivity, frequent and relevant training to farmers are always proposed in development programmes. Exposure to training would help farmers identify the problems and prospects of adopting resilient farming practices to overcome

Winarto *et al.* (2008) reported that Climate Smart Farmers' Field School in Indonesia raised awareness of climate change and promoted solutions to cope with changing rainfall patterns, such as recording and interpretation of on-farm rainfall measurements and in-field water harvesting.

From the point of water resource management, studies by Innes and Kane (1995) and Kakumanu (2009) argued that informal institutions set up with the support of NGOs providing training had improved water productivity by 21 percentage in comparison with formal institutions in Andhra Pradesh, India.

Rao *et al.* (2012) reported that Farmer Field Schools (FFS) that addressed climate change primarily focused on improving practices in the field to increase production sustainably and adapt to climate change. They observed that such learning processes reinforced participants' understanding of the local ecology to improve their management and decision-making skills.

Emphasizing the impact of training programmes, Jasna (2015) reported that as a result of effective training activities undertaken in NICRA villages, the knowledge level of NICRA farmers were found to be higher than that of non-NICRA members.

2.9.10. Contact with extension agency

As seen from the extensive reviews made as part of this study, it was generally found that awareness and adoption of climate resilient practices were influenced by the frequency with which farmers sought institutional assistance from extension agencies.

Adebayo *et al.* (2012) in their study on climate change awareness, vulnerability and adaptation found that majority of the respondents (about 77%) had no contact with extension agents, while only 23 per cent farmers were frequently visiting extension agents. They concluded that this could affect climate change adaptation among farmers, since their understanding of climatic change depended only on their previous experience.

Athira (2017) found that more than 50 per cent of the rice farmers in Palakkad had regular contact with agricultural officers, about 60 per cent with agricultural assistants and about 52 percent with ATMA officials. The study also concluded that this contact facilitated better access to latest information on climate change, plant protection, crop management and various government schemes. The study found that nearly half of the farmers did not have any contact with the agricultural scientists, officials of the department of agriculture or KVK.

It was also found that extension approaches with two-way information flow were particularly valuable to address climate change adaptation. Raghuvanshi *et al.*, (2018) observed that the system of two way information flow enabled collection of real-time agricultural information and detection of the effects of climate change on a local scale that could be used for decision makers to react to threats to agriculture.

2.9.11. Social participation

As stated earlier, social participation was operationalized as the non-involvement or involvement of the farmer in any social organization either as a member or as an office bearer, which would be a means in building resilience among the community.

In this regard, Handmer *et al*. (1999) found that a well-connected population with appropriate public infrastructure would be able to deal with climate related hazards effectively and reduce vulnerability.

Meinke *et al*. (2004) reported that the network created among scientists and farmers by building partnership with stakeholders on climate change was very effective in increasing the awareness among farmers.

2.9.12. Access to climatological information

Access to customized climatological information is vital in tackling the issues of climate change. In this regard, Baethgen *et al*. (2003) observed that access to better climatological and agricultural information helped farmers make comparative decisions among alternative crop management practices and this had enabled them to cope well with changes in climatic conditions.

Dietz *et al*. (2007) indicated that people generally had greater trust in environmental groups and less trust in industrial groups. Only 9 per cent of the respondents of the study said that they had lot of knowledge about climate change and only 25 per cent obtained climate change information from five or more sources.

Aggarwal (2008) stressed the need for providing value-added climate risk management services to farmers in the form of reliable weather forecasts and agro-advisories.

Timely weather-related information and crop advisories provided on the basis of local weather conditions helped farmers in growing crops on the basis of advisories provided. Moreover, as Raghuvanshi *et al*. (2012) reported, timely weather information through posters in cooperative dairy centers or messages aided better planning of crops resulting in better yields. It also increased the decision-making ability of farmers, which was important to deal with changing climate.

2.9.13. Institutional support

Since climate change is a universal phenomenon and has wider implication over a larger geographical area, singular interventions by farmers would be generally ineffective. It has been observed that unless there are robust institutional interventions, climate resilience cannot be attained.

Handmer *et al.* (1999) asserted that factors like institutional stability and strength of public infrastructure were of crucial importance in determining vulnerability to climate change.

Importance of rural institutions in enhancing ecological resilience had been reported by many authors (Ostrom, 1990; Baland and Plateau 1996; Agrawal 2001).

The most relevant institutional traits that supported community resilience were the characteristics of institutions, context of institutions, characteristics of groups served by institutions and characteristics of ecological context.

Methodology

Chapter 3

METHODOLOGY

Research methodology has been defined as the systematic and theoretical analysis of the procedures applied in the field of study. Methods and procedures followed in the study are described in this chapter. In order to accomplish the objectives of the study, appropriate data collection tools and analytical methods have been employed. Details of the methodology used are presented under the following heads:

3.1. Research design of the study

3.2 Locale of the study

3.3. Sampling procedure

3.4. Selection of variables

3.5. Operationalization of variables

3.6. Measurement of variables

3.7. Tools used for data collection

3.8. Statistical methods used to analyze the data

3.1. Research design of the study

The overall framework in which the study is conceived and conducted is termed as research design. Research design is a plan which describes how, when and where data are to be collected and analyzed, by which the foundation for conducting the research is laid.

As the major objective of the study was to appraise the existing readiness of the public extension system in mainstreaming climate resilience in terms of financial and institutional support and assess the extent of adoption of resilient practices by the farming community in relation to awareness of stakeholders on climate change mitigation and strategies thereof, *ex-post facto* design of research was employed. *Ex-post facto* research is the systematic empirical enquiry in which the scientist does not have any direct control over the independent variables because they have already occurred or they are inherently not manipulative. The methodology used for the study at different stages of data collection and analysis are explained below.

3.2. Locale of the study

Palakkad and Wayanad districts were purposively selected based on the incidence of severe climate change due to excessive rain and/or drought and its reported impacts on agriculture (Plate 1).

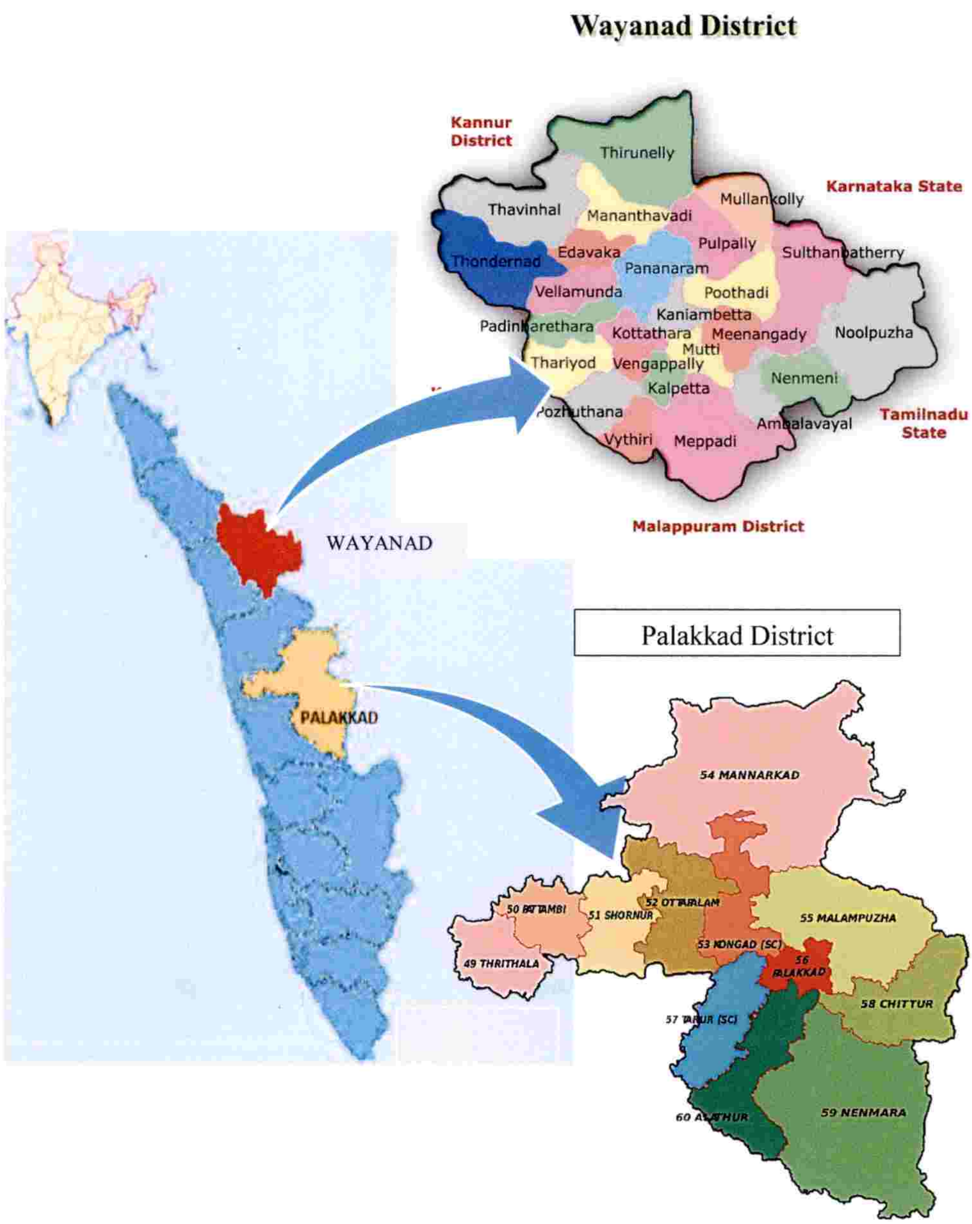
3.2.1. Brief description of the area

Palakkad

Palakkad, is the largest district in Kerala with 4,478 km^2 land area. The district is bordered on the northwest by the Malappuram district, on the southwest by the Thrissur district, on the northeast by the Nilgiris district and on the east by Coimbatore district of Tamil Nadu. Its economy is primarily agriculture. Palakkad district has extensive paddy fields and is suitably known as the granary of Kerala.

The climate of the district is somewhat different from the rest of the state, as it is influenced by the presence of Palakkad gap. The district has a tropical climate with an oppressive hot season and fairly assured seasonal rainfall. It receives an average annual rainfall of 2391 mm. About 72 per cent of the rainfall is concentrated during the south west monsoon period from June to September and only 18 per cent is received during north east monsoon from October to December. There is irregularity and fluctuations with rainfall over the years. The meteorological observatory records show that March and April are the hottest months with the mean daily maximum temperature at 37.1 °C and the daily mean minimum temperature at 24.6°C.

Plate 1. Locale of the study



The major rivers that flow through Palakkad include the Bharathapuzha, the Bhavani, and the Siruvani. The main tributaries of Bharathaphuzha are Gayathri puzha, Kannadi-puzha, Korayar-puzha and Thuthapuzha. Major dams of the district are located at Malambuzha, Meenkara and Chulliar and they supply irrigation water through an extensive canal system. Approximately 33512 hectares of land in this district have been brought under major irrigation schemes.

In fact, the luxuriant vegetation of the district gives a false impression that it has enough water to irrigate her vast paddy fields. But the real state of affairs is far from satisfactory, as the rain often fails at the required time and the crops suffer. The peculiar feature of this district, particularly the region facing the Palakkad gap; are the hot winds which rush from the burning plains of the neighboring Coimbatore District of Tamil Nadu during the month of December onwards and the severe dry spells. This contributes to higher evaporation rates during November to February months which coincides with the *Mundakan* cropping period.

Wayanad

Wayanad, which may be elaborated as *'vayal nadu'* or the land of paddy fields is situated on the picturesque plateau at a height between 700 meters and 2100 meters above the mean sea level nested among the mountains of Western Ghats on the eastern portion of north Kerala and on the sides of Tamil Nadu and Karnataka states. Its geographical position is unique and peculiar. The culture of Wayanad is mainly tribal oriented and is characterized by the cultivation of perennial plantation crops and spices. The major plantation crops include coffee, tea, pepper, cardamom, and rubber. Coffee based farming system is the notable feature of Wayanad. The rice fields of Wayanad are in the valleys formed by hillocks and in majority of paddy lands, only a single crop is harvested. Homestead farming assumes importance in the district and the average size of holdings is 0.68 ha. Though considered as backward, it is perhaps one of the biggest foreign exchange earners of the state, with its production of cash crops like pepper, cardamom, coffee, tea, spices and other condiments. This district stands first in pepper cultivation and coffee plantation.

Wayanad experiences four seasons namely, cold weather (December-February), hot weather (March-May), southwest monsoon (June - September) and north east monsoon (October-November). The district experiences high relative humidity. The average maximum temperature of Wayanad is 29°C and the average minimum is 18°C. Wayanad has been experiencing plentiful water supply for years, but presently, 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 district is drained by Kabani river and its tributaries, viz. Panamarapuzha, Mananthawadypuzha, Bavelipuzha and Noolpuzha. Kabani is one of the three east flowing rivers in Kerala and is an important tributary of Cauvary river which originates from the Western Ghats. Kabani and its tributaries carved the present landscape of the district. Other drainages in the district are Chaliyar and Valapattanam.

There are no major irrigation projects in the district, apart from a few minor projects. One is Karapuzha Irrigation Project constructed in Karapuzha, tributary of Panamarapuzha and the second is Banasura Sagar Irrigation Project in Choornipuzha, which is also a tributary of Panamarapuzha. Wyanad has been experiencing distinct climate change patterns during the last few decades, with severe dry spells in recent years, inflicting great damage to pepper, coffee and other valuable crops.

3.3. Sampling Procedure

The sample of respondents included 40 officers of the Department of Agriculture (Agricultural Officers and Agricultural Assistants) and 100 farmers. Based on the proportion of the number of Grama Panchayats in Palakkad and Wayanad (i.e.; 95 in Palakkad and 26 in Wayanad), 30 and 10 Krishi Bhavans were selected randomly from Palakkad and Wayanad districts respectively. One officer of the selected 40 Krishi Bhavans constituted the sample of officers for the study.

100 farmers were selected randomly from ten selected Grama Panchayats that have experienced severe precipitation or drought during the previous year. The 30 Krishi Bhavans in Palakkad were selected randomly from 4 blocks in Palakkad, namely Nenmara, Kollengode, Chittoor and Alathur. Remaining 10 were selected from Wayanad i.e.; from Panamaram and Sulthan Bathery blocks. The list of Krishi Bhavans selected for study is given in the Table 3.1 below.

Based on the above proportion, ten Krishi Bhavans - seven from Palakkad and three from Wayanad- that have experienced severe precipitation and/or drought during the previous years were selected from among the 40 Krishi Bhavans. From each of the Krishi Bhavans selected, 10 prominent farmers were randomly selected to form the sample of 100 farmers. Krishi Bhavans selected from Palakkad were Kollengode, Perumatty, Muthalamada, Pervemba, Ayilur, Elavanchery and Kannambra and Krishi Bhavans from Wayanad were Poothady, Noolphuzha and Pulpally.

Table. 3.1 List of Krishi Bhavans/ Grama Panchayat selected for the study

District	Block	Grama Panchayath/Krishi Bhavan
Palakkad	Nenmara	Nenmara Pallasseana Ayilur* Elavanchery* Nelliyampathy Melarkode Vandazhi
	Kollengode	Kollengode* Muthalamada* Peruvemba* Puthunagaram Vadavannur Pattanchery Koduvayur
	Chittur	Perumatty* Tattamangalam Eruthempathy Vadakarapathy Elappully Polpully Kozhinjampara Nalleppilly
		Alathur Erimayur Kavassery

	Alathur	Tarur Kannambra* Pudukode Kizakkanchery Vadakkanchery
Wayanad	Panamaram	Panamaram Mullankolly Pulpally* Poothadi* Kaniyambetta
	Sulthan Bathery	Sulthan Bathery Noolphuzha* Meenangadi Ambalavayal Nenmeni

*Grama Panchatat/Krishi Bhavans from which farmers sample were drawn

3.4. Selection of variables

The variables along with their prescribed measurements were selected in compliance with the objectives, review of literature, and advices from experts. The selected dependent and independent variables and the methods adopted for their measurement are as follows (Table 3.2):

Table 3.2 Details of variables and their measurement

Sl. No.	Variables	Method of measurement
	Independent variables	
1	Age	Government of India census report 2011
2	Gender	Arbitrary scores
3	Educational status	Scale used by Jayasree (2004)
4	Farming experience	Scale used by Jayasree (2004) was adopted and modified for the study
5	Farm size	GOK (2011)
6	Annual income	Sivaprasad (1997) and modified
7	Extend of farming integration	Scale developed by Joseph (2016)
8	Innovativeness	Scale developed for the study
9	Exposure to training	Scale followed by Jayawardhana (2007)
10	Extension agency contact	Scale used by Kareem (1974) and modified
11	Social participation	Method used by Jasna (2015)
12	Access to climatological information	Sasikala (1997)
13	Institutional support	Joseph (2016)

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	Dependent variables	
1	Readiness of the public extension system	Compound Annual Growth Rate
2	Vulnerability to climate change impacts	Hahn *et al.* (2009)
3	Awareness on climate change by stakeholders	Adopted from Gopal *et al.* (2014) and modified
4	Awareness on mitigation strategies	Adopted from Gopal *et al.* (2014) and modified
5	Adoption of mitigation strategies	Adopted from Gopal *et al.* (2014) and modified

3.5. Operationalization of variables

An operational definition is a specification of the activities of the researchers in measuring a variable or in manipulating it (Kerlinger, 2004). The operational definition and scoring method used to quantify the variables selected for the study are explained below:

3.5.1. Age

Age, in this study was operationally defined as the number of years completed by the respondents. Respondents were categorized as per the classification procedure followed by Government of India (GOI) in the Census Report, 2011 as given below. Frequency and percentage analysis were used to classify the stakeholders

Sl. No.	Category and scale
1	Young (less than 35)
2	Middle aged (35-55)
3	Aged (more than 55)

3.5.2. Gender

Gender was categorized into male, female or transgender, and the frequency and percentage under each category were estimated.

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3.5.3. Educational status

Educational status was defined as the respondents' ability to read and write and the levels of formal schooling. This was measured by adopting the scale followed by Jayasree (2004), which had categorized this variable into 'illiterate' (do not know how to read and write), 'can read and write', 'primary education', 'high school education', 'higher secondary education', 'collegiate education' and 'master's degree and above'. The scores given to each category is given below.

Sl. No.	Education	Score
1	Illiterate	1
2	Can read and write	2
3	Primary education	3
4	High school	4
5	Higher secondary	5
6	Collegiate education	6
7	Master's degree and above	7

3.5.4. Farming experience

Farming experience was operationally defined as the respondents' engagement in farming activities in terms of number of years at the time of investigation. Experience of extension personnel was defined in terms of their occupational experience as Agricultural Officer (AO) or Agricultural Assistant Officer (AAO). Scoring procedure used by Jayasree (2004) was adopted and the stakeholders were classified into three categories based on their involvement, viz. low, medium, and high, as given below.

Sl. No.	Farming experience
1	Less than 5 years (low)
2	5-10 years (medium)
3	More than 10 years (high)

3.5.5. Farm size

Farm size was operationally defined as the total area of cultivable land owned by the respondents. The categorization used by Government of Kerala (GOK, 2011) was adopted to classify the farmers based on their farm size as given below.

Sl. No.	Classification of farmers
1	Marginal farmers (<1 ha)
2	Small farmers (1-1.99 ha)
3	Semi-medium farmers (2-3.99 ha)
4	Medium farmers (4-9.99 ha)
5	Large farmers (>10 ha and above)

3.5.6. Annual income

Annual income was operationally defined as the total amount (in rupees) earned by the respondents and other family members from agriculture and other sources on a yearly basis. Scoring procedure followed was adopted with slight modification, as given below.

Sl. No.	Income categories	Score
1	Below Rs. 0.5 lakh	1
2	Rs. 0.5 lakh - 1 lakh	2
3	Rs. 1 lakh – 2 lakh	3
4	Rs. 2 lakh – 3 lakh	4
5	More than Rs. 3 lakh	5

3.5.7. Extend of farming integration

Extend of farming integration was operationally defined as the frequency of integration of various non-crop components with cultivation of crops. The scoring procedure developed by Joseph (2016) was used to score this variable as given below.

Sl. No.	Category	Scores
1	No components	0
2	Livestock/ Poultry/Pisciculture	1
3	Livestock + Poultry	2
4	Livestock + Poultry + fish farming	3

3.5.8. Innovativeness

It refers to the keenness of the respondent in accepting new ideas and seeking changes in farming technique in response to emerging situations and needs and to introduce such changes in their farm operations in a practical and feasible manner.

Responses were obtained on a five point continuum ranging from 'strongly agree' to 'slightly agree' with scores 5, 4, 3, 2 and 1 respectively. Scoring process was reversed for negative statements. The possible scores ranged from 15 to 75.

Category	Range (score)
High	(<Q1)
Medium	(Q1-Q3)
Low	(>Q3)

3.5.9. Exposure to training

Exposure to training was measured as the frequency of training programs on climate change attended by the farmers in terms of the number of training sessions attended. Scale used by Jayawardana (2007) was used for the study.

Sl. No.	Category	Scores
1	No training	1
2	Less than eight training	2
3	More than eight training	3

3.5.10. Contact with extension agency

Contact with extension agency was operationally defined as the frequency of interaction between the respondent and extension agents from any given public agency. Scoring procedure used was adopted with slight modification to score the frequency of contact, as given below.

Sl. No.	Category	Scores
1	Once in a month	1
2	Once in a fortnight	2
3	Once in a week	3
4	Twice or more in a week	4

3.5.11. Social participation

This refers to extent of involvement of the respondent in any organization (Grama Panchayat, co-operative society, SHG, farmer organization) either as a member or as an office bearer, which would signify their role in building community resilience to climate change. The scoring followed by Jasna (2015) was followed to categorize respondents as given below.

Sl. No.	Category	Scores
1	Non-member	0
2	Member	1
3	Office bearer	2

3.5.12. Access to climatological information

Access to climatological information refers to degree of utilization of various forms of mass media (TV, radio, newspaper, magazine, mobile, and the Internet) to access climatological information. Scoring followed was adopted with slight modification to measure this variable.

Sl. No.	Category	Score
1	Daily	5
2	Weekly	4
3	Fortnightly	3
4	Monthly	2
5	Never	1

3.5.13. Institutional support

Institutional support was operationally defined as the status of services availed by the farmer from different public sector agencies involved in agriculture in support of climate resilient practices. Institutional support was quantified based on the frequency of availing ten different types of support services. The frequency was recorded as 'availed, 'sometimes' or 'not availed' for which scores '3', '2' and '1' were accorded respectively. Procedure used by Jaiswal *et al.* (1971) and followed by Sobha (2014) and Athira (2017) with slight modification was used for measuring this variable. The score on institutional support was estimated by summating the scores for each item.

Sl. No.	Category	Availed (3)	Sometimes (2)	Not availed (1)
1	Subsidy			
2	Credit			
3	Insurance			
4	Training			
5	Weather forecast			
6	Seminar and classes			
7	Demonstration plots			
8	Marketing support			
9	Exposure visit			
10	Agro advisory services			

3.6. Measurement of dependent variables

The dependent variables selected for the study included 'readiness of the extension system in mainstreaming climate change', 'extent of vulnerability at the farm level', 'awareness on climate change by the stakeholders' and 'extent of awareness' and 'adoption of mitigation strategies by the farming community'. Details of the methodology adopted to measure each of them are explained below:

3.6.1. Extent of vulnerability to climate change at the farm level

Vulnerability is operationally defined as the degree to which a system is susceptible to, or unable to cope with the adverse effects of climate change,

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including climate variability and extremes. Vulnerability, according to the IPCC definition, is an integrated measure of the expected magnitude of adverse effects to a system caused by a given level of certain external stressors. There are several methods for evaluating the level of vulnerability each one having some or other limitation. The index used in the study was Livelihood Vulnerability Index (LVI) that uses primary data from households combined with data obtained from secondary sources. Secondary data was used for variables such as risks from flooding, temperature and rainfall. LVI used for this study is based on the livelihood vulnerability analysis technique developed by Hahn *et al.* (2009), followed and modified by Panthi *et al.* (2015), with replacement of some indicators to suit the local context.

LVI is a practical method to understand the demographic, social and other related factors contributing to climate vulnerability at the community level as well as at various other higher aggregate levels like the district level. For calculating LVI for the study, eight major components viz. socio-demographic profile, livelihood profile, livelihood strategies, social networks, crop health, access of food and nutrients, access of water, natural disaster risks and climate variability were used. Each major component included several indicators or sub-components developed based on available data collected through farm household surveys of the two districts selected for the study. The sub-components or indicators were customized to the local context, with the help of review of literature and consultation with experts (Table 3.3.).

Calculating the LVI

In this study LVI was calculated by applying a balanced weighted average approach. Each sub-component contributes equally to the overall index even though each major component comprises of different numbers of sub-components. A simple method with equal weights was applied for all major components. Since each sub-component was measured on a specific scale, it was normalized as an index. For this purpose, the equation used in constructing the Human Development Index - HDI (UNDP 2007) was applied (Eq. 1).

$$\text{Index } S_d = \frac{S_d - S_{min}}{S_{max} - S_{min}} \qquad \text{(Eq. 1)}$$

Here, S_d is the averaged value of sub-component for district d; S_{min} and S_{max} are the minimum and maximum values that reflect low and high vulnerability respectively, for each sub-component determined using the data from the two districts surveyed. For example, the sub-components quantified on average, the minimum value and maximum value were used to transform this indicator into a standardized value between 0 and 1 so that it could be integrated into the major component of the LVI. For variables to measure frequencies, the minimum values were set at 0 and the maximum at 100. Some sub-components such as the 'natural resource diversification index' were constructed as the inverse of the crude indicator because it was assumed that increase in the number of components by the household decreases vulnerability. The expression for this will be [1/ (number of components integrated) + 1]. The maximum and minimum were also transformed using this logic, and Eq. (1) was then used to standardize this sub-component.

Secondary data were collected and analyzed for the indicators of natural disasters and climatic variability. Temperature and rainfall data for district were collected from Regional Agricultural Research Stations at (Pattambi and Ambalavayal) for Palakkad and Wayanad respectively. Mean standard deviation of monthly average of average maximum and minimum daily temperature since 2009 and mean standard deviation of monthly average precipitation since 2009 were calculated to find the climatic variability.

After normalizing sub-component values, the value of each major component was calculated by averaging the standardized sub-components most related to it (Eq. 2).

$$M_d = \frac{\sum_{i=1}^{n} indexSd\ i}{n} \qquad \text{(Eq. 2)}$$

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Here, M_d is averaged value of major component for district d; index S_d represents the value of sub-components, indexed by *i* of major component, and *n* is the number of sub-components in major component. Once values for each of the eight major vulnerability components for a district were calculated, they are averaged using the below given equation (Eq. 3).

$$LVI_d = \frac{\sum_{i=1}^{8} WmiMdi}{\sum_{i=1}^{8} Wmi} \quad \text{(Eq.3)}$$

The equation Eq. 3. can be represented as

$$LVI_d = \frac{WsdpSDP_d + WlsLS_d + WsnSN_d + WfF_d + WwW_d + WndND_d + WcvCV_d}{Wsdp + Wls + Wsn + Wf + Ww + Wnd + WcvSDP}$$

(Eq. 4)

SDP= socio-demographic profile, LS = livelihood strategies, SN = social network, H = crop health, F= food and nutrition, ND = natural disaster, and CV = climate variability

Here, LVI_d is the LVI of the district d, equals to the weighted average of the eight major components. The weights of each major component, W_m, were determined by the number of sub-components that make up each major component and were included to ensure that all sub-components contribute equally to the overall LVI. The LVI is scaled to range from 0 (least vulnerable) to 0.5 (most vulnerable).

Table 3.3. Major and sub-components considered for calculating LVI

Sl. No.	Major component	Sub-component
1	Socio-demographic profile	Percentage of dependent people (<15 years and >60 years)
		Percentage of female headed households
		Percentage of household where head of the household is literate male with >50 years of age
2	Livelihood strategies	Percentage of households changes crop variety/new crop
		Percent of household depend solely on agriculture as a source of income
		Natural resource (farming) diversification index
3	Social network	Percent of household not having access to communication media
		Percentage of household not having access to local govt. services
		Percent of household not having access to institutions to purchase of seeds/seedlings
		Percentage of household not associated with any organizations (cooperatives/groups)
4	Crop health	Percent of household reported pest and disease incidence due to climate change
		Percent of household reported stress due to climate factors
		Percent of household reported crop loss (>50 %) due to
		Percentage of household practicing INM
		Percentage of household adopted IPDM
5	Food	Percentage of household saving seeds
		Percentage of household with decreasing production
		Percentage of household depending solely on family farm for food
6	Water	Average number of water sources to a household
		Percentage of households with problem for access to irrigation water
		Percentage of household having persistent water supply
		Percentage of household affected due to water stress
7	Natural disaster	Average no of flood events in the past 10 years
		Average no of drought events in the past 10 years
8	Climatic variability	Mean standard deviation of monthly average of average maximum daily temperature since 2009
		Mean standard deviation of monthly average of average minimum daily temperature since 2009
		Mean standard deviation of monthly average precipitation since 2009

3.6.2. Dimension of climate resilient agriculture

Dimensions of climate resilient agriculture as experienced by the farming community and the extension system were delineated by using a check list prepared in consultation with experts and review of literature.

3.6.3. Awareness of stakeholders on climate change

The level of awareness on climate change was operationalized as the degree to which farmers had taken cognizance of the issue of climate change and its potential consequences. It was analyzed through a schedule followed by Golpal *et al.* (2014) consisting of 28 items which were grouped under four broad categories viz. climate, soil and water, crop and animal husbandry. Awareness of respondents were quantified on a three point continuum as 'fully aware', 'partially aware' and 'not aware ' with corresponding scores of '3', '2' and '1' respectively. The items included in the schedule are reflective of various concepts and implications of climate change. Extent of awareness of a farmer on climate change and its impacts was obtained by summing the scores obtained for each item.

3.6.4. Awareness of farmers on mitigation strategies

Almost similar to the above variable, level of awareness was operationalized as the degree to which the farmers had taken cognizance of various climate resilient technologies. The extent of awareness on mitigation strategies was measured based on a structured schedule consisting of 42 adaptation/ mitigation measures for climate change which were categorized into three, namely 'water and soil conservation measures', 'agronomic practices' and 'institutional measures'. The level of awareness of farmers was measured by following a scoring pattern as given below. Then the items were ranked based on the scores obtained.

Category	Score
Aware	3
Partially aware	2
Not aware	1

3.6.5. Readiness of the extension system in mainstreaming climate resilience

Readiness of the most dominant public extension system of the state, the Department of Agriculture was quantified in terms of the policies, programmes and funds envisaged in view of issues related to climate change. General readiness would include majorly policy readiness and institutional readiness. It would also include readiness in terms of financial resources, research programmes and infrastructure facilities to mitigate climate change. Under the present study, readiness in terms of institutional and financial support only were assessed.

For this purpose, state sponsored programmes of the Department of Agriculture during the period from 2013-14 to 2017-18 were analyzed for various action points that would directly address issues of climate change and/or its impact. These action points would have been included in the programme either consciously or inadvertently. The components thus identified were grouped into different categories viz. resilient practices for crop production, resilient intercultural operations, climate resilient plant protection measures, climate smart marketing and climate resilient postharvest measures. Such components under selected programmes were then enumerated and percentages were calculated. Institutional readiness was also quantified in terms of various services availed by the farmers that could bring climate resilient actions in farming. This included input subsidy, credit facility, insurance support, exposure to training, awareness creation, demonstrations of resilient technologies, marketing support, exposure visits and agro advisory services. The weighted score obtained for the response of the farmers for each item was then categorized into low, medium and high based on the mean and stand deviation obtained.

Readiness in terms of financial support of the public extension system was quantified in terms of the funds allocated for the programmes that have climate resilient components. The total outlays for these programmes over the past five years were tabulated and the compound annual growth rate (CAGR) of funds earmarked for each programme over these years were estimated to identify the underlying trends. Programmes with higher CAGR were considered to be programmes with higher degree of readiness in terms of financial support to mainstream climate resilience.

3.6.6. Adoption of resilient strategies/mitigation strategies by farming community

Adoption is making full use of a new idea as the best course of action available. Adoption in this study refers to the degree to which the farmers had actually adopted various practices to mitigate the impact of climate change on agriculture. A structured schedule was developed consisting of 42 adaptation/ mitigation measures for climate change which were categorized into 'water and soil conservation measures', 'agronomic practices' and 'institutional measures'. Extent of adoption by farmers were measured by using the scoring pattern followed by Gopal *et al.* (2014).

Adoption of selected resilient practices was recorded as 'adopted', 'partially adopted' and 'not adopted' with scores 2, 1 and 0 respectively. The total score that could range from 42- 126 was calculated by summing up the scores of individual items. Then each adaptation measures were ranked based on the weighted scores obtained. The adoption index of each farmer was calculated using the formula given below (Eq. 5.).

$$\text{Adoption index} = \frac{\text{Respondents total score}}{\text{Total possible score}} \times 100 \qquad \text{(Eq. 5)}$$

3.6.7. Role of various agencies/institutions in climate change

The key institutions/agencies involved in mainstreaming climate resilience into the process of agricultural development were identified using review of literature and group discussion with extension officials and farmers during data collection. The institutions/ agencies who had initiated such programmes and their roles in mainstreaming climate resilient agriculture in Kerala were listed out.

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3.7. Tools used for data collection

A structured interview schedule was prepared by reviewing previous research studies and through consultation with experts in the field of agricultural extension. A pilot study was conducted in order to check the validity of the interview schedule. The final interview schedule was prepared after making necessary modifications, additions and deletions based on the pilot study. Data on policies and role of agencies were also collected from primary and secondary sources. Secondary data were collected through review of reports, literature published by various government/non-government agencies and reference materials available on websites.

Suitable parametric and non-parametric statistical methods were used to analyze the data collected. Results have been presented as mean values, standard deviation, frequency, percentage, correlation etc. as required by the type of data, inferences drawn and context of interpretation.

3.8. Statistical methods used to analyze data

Both descriptive and analytical statistics were used in the study. Wherever required, the data were further analyzed with specific analytical tools for testing the significant effects of the parameters under study.

3.9.1. Arithmetic Mean

Mean values of the scores of the variables selected for the study were used to compare different groups and categorize respondents.

3.9.2. Descriptive statistics

Simple frequencies and percentages were worked out to find the distribution of respondents based on the scores for different variables. Results of the independent variables selected for the study were interpreted using this analysis.

Category	Range (score)	Values
High	(≥ Mean + S.D.)	≥ Mean
Medium	(≥ Mean± S.D.) + (≤ Mean – S. D.)	Between
Low	(≤ Mean - S.D.)	≤ Mean

With regard to dependent variables, frequencies, percentages and weighted averages were found out and ranked accordingly.

3.9.3. Spearman's rank correlation coefficient

Spearman rank correlation was done to find out the factors that influenced the awareness and adoption among farmers and extension personnel

3.9.4. Independent sample't' test

The test here was used to compare the adoption and resilience of farmers in the two districts under study, with varying sample size.

3.9.5. Friedman's test

It is a non-parametric statistical test for testing whether samples originated from the same distribution. Friedman two way analysis of variance was done to rank the components of various development programmes that address the issues of climate resilience as explained above. The analysis was done using SPSS.

3.9.6. Compound Annual Growth Rate (CAGR)

The compound annual growth rate (CAGR) is a useful measure of growth over multiple time periods. It was used to find the growth rate of funds allocated for different programmes that had climate resilient agriculture as a functional component either deliberately or inadvertently. CAGR was calculated in MS Excel using the formula given below (Eq. 6).

$$CAGR=\left(\frac{\text{Ending value}}{\text{Beginning value}}\right)(1/\text{ periods})-1 \qquad \text{(Eq. 6)}$$

3.9.7. Mann–Whitney's U test

To compare the levels of awareness of farmers and extension officials on climate change, Mann-Whitney U test was employed, using SPSS.

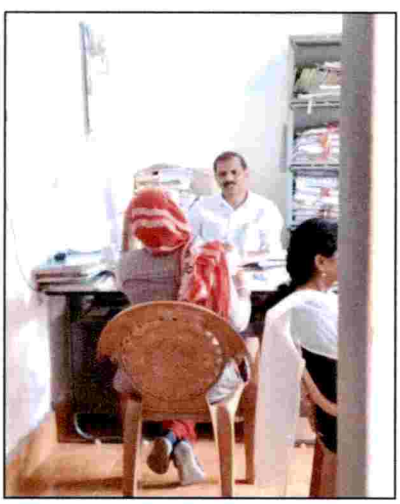
Plate 2. Data collection from officers of department of agriculture at Krishi Bhavan (Palakkad and Wayanad district)

At Meenangadi Krishi Bhavan

At Kollengode Krishi Bhavan

At Nenmeni Krishi Bhavan

At Koduvayoor Krishi Bhavan



At Poothadi, Kaniyambetta, Mullankolly Krishi Bhavan

Plate 3. Conducting farmer interview at Palakkad and Wayanad district

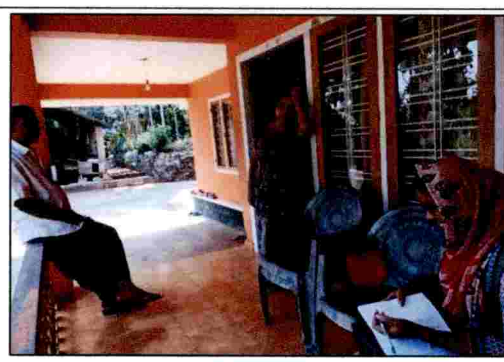
Farmer interview at Sulthan Bathery

Farmer interview at Kollengode

Farmer interview at Ayloor

Farmer interview at Nemmara

Farmer interview at Kollengode



Farmer interview at Pulpally

Plate 4. Field visit made during data collection

Farmer field visit at Koduvayoor

Farmer field visit at Ayloor

Farmer field visit at Pallasana

Farmer field visit at Elappully

Farmer field visit at Elappully

Plate 5. Focused group discussion with farmers at Palakkad and Wayanad

Focused group meeting at Peruvemba

Focused group meeting at Elavanchery

Focused group meeting at Perumatty

Results &
Discussion

Chapter 4

RESULTS AND DISCUSSION

This chapter describes the results of the study based on data collected from the field and other sources and explanation of the findings. The results are based on analysis of data on level of awareness on climate change and mitigation strategies, adoption rate of climate resilient technologies, readiness of the public extension system in mainstreaming climate resilience into agricultural development and the extent of vulnerability at farm level. The results have been discussed with reference to the context and previous works reviewed.

The findings of the study have been presented under the following sub headings:

4.1. Awareness of farmers and extension personnel on climate change and its impacts

4.2. Awareness of farmers on climate resilient technologies and mitigation strategies at the farm level

4.3. Adoption of resilient technologies and mitigation strategies by farming community

4.4. Vulnerability to climate change at the farm level

4.5. Readiness of the public extension system in mainstreaming climate resilience into agricultural development

4.6. Dimensions of climate resilient agriculture

4.7. Role of various agencies in climate change mainstreaming

4.8. Socio-economic profile of the respondents

4.9. Factors affecting awareness on climate change

4.10. Factors affecting awareness on climate resilient technologies

4.11. Factors affecting adoption of climate resilient practices

4.12. Correlation between awareness on climate change and awareness on mitigation strategies

4.13. Correlation between awareness on mitigation strategies and extent of adoption of mitigation strategies

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4.1. Awareness of farmers and extension personnel on climate change and its impacts

Distribution of farmers and extension personnel based on their level of awareness on climate change and its impact as estimated from their responses to various awareness components is presented in Table.4.1. This was primarily assessed to find the level of awareness which the stakeholders possess on different aspects of climate change and its impact so as to identify the knowledge gaps while formulating interventions.

4.1.1. Awareness of farmers on climate change and its impacts

Distribution of farmers based on their awareness on different components of climate change would give clear indication on general awareness of farmers on the issues and impacts of climate change at the field level (Table 4.1). The weighted mean score on overall awareness and the mean of the scores on individual components of climate change clearly indicated the specific components to be emphasized in developing the content and focus of development interventions.

The results indicated that 100 per cent of the farmers who constituted the sample of respondents had cognizance of the important components of climate change that are temporal and spatial in nature. All the respondents were found to be aware of increase in average temperature, decrease in average rainfall, long dry spells, fluctuations in the onset of monsoon and uneven distribution of rainfall.

However, a few farmers were found to be not fully aware of certain components that are not apparent in the climate scenario in Kerala. For instance, as observed from the table, 'increased frequency of heat waves' was not reportedly heard by 3 per cent and 10 per cent had only partial awareness. Similarly, 12 per cent had only partial awareness on 'increase in minimum and maximum temperature'. 'Prolonged cold weather', another component which is not experienced in Kerala was found to be known only partially to 59 per cent and 11 per cent were totally ignorant about this component.

Table 4.1. Distribution of farmers based on different levels of awareness on climate change

Sl. No.	Components of awareness	Frequency (N=100)			Awareness Weighted score	Category wise weighted mean
		Aware	Partially aware	Not aware		
1.	**Climate related**					
1	Increase in average temperature	100	-	-	100	
2	Decrease in average rainfall	100	-	-	100	
3	Long dry spells	100	-	-	100	
4	Fluctuations in onset of monsoons	100	-	-	100	
5	Uneven distribution of rainfall	100	-	-	100	
6	Increased frequency of heat waves	87	10	3	94.67	95.45
7	Increase in maximum and minimum temperatures	88	12	-	96	
8	Prolonged cold weather	30	59	11	73	
2.	**Soil and water related**					
9	Reduced soil fertility	57	29	14	81	
10	Depletion of ground water	100			100	
11	Reduced quality of water	45	36	19	75.34	92
12	Disturbed soil structure	96	4		98.67	
13	Increased soil and water erosion	96	3	1	98.34	
14	Reduced water holding capacity	96	4	-	98.67	
3.	**Crop related**					
15	Reduction in crop duration	83	16	1	94	
16	Increased incidence of pests and diseases	97	3	-	99.34	
17	Susceptibility of the crop for drought	98	1	1	99	
18	Decreased fertilizer use efficiency	44	55	1	81	95.6
19	Increased crop weed competition	87	12	1	95.34	
20	Increased water stress	99	1	-	99.67	
21	Reduced quality of produce	95	4	1	98	
22	Reduction in average productivity	97	3	-	99	
4.	**Animal husbandry relate**					
23	Low productivity of livestock	96	3	1	98.34	
24	Increase in disease occurrence	59	39	2	85.67	
25	Increased mortality	77	22	1	92	
26	Reduced quality and quantity of forage production	92	8	-	97.34	93.72
27	Reduced milk/ meat yield	94	6	-	98	
28	Susceptibility to pests and diseases	74	25	1	91	

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As regards components related to soil and water, the only component about which all the farmers had awareness was 'depletion of ground water'. While 96 per cent of farmers were found to be aware of 'disturbed soil structure', 'increased soil and water erosion' and 'reduced water holding capacity', only 45 per cent of the farmers were fully aware of 'reduced quality of water' which is an important fallout of climate change. Similarly, only 57 per cent of the farmers were observed to be fully aware of' reduced soil fertility'. It is to be understood that among the three components mentioned above, 19 per cent of the farmers were not aware of issues of water quality and 14 per cent about 'reduced soil fertility'.

Frequency distribution of farmers revealed the prominent gaps in their awareness on some key components related to crop management. Out of the eight components tested in this category, 99 per cent farmers expressed that they were fully aware of 'increased water stress', which is a serious impact of climate change. 'Susceptibility of crop to drought', a widely cited impact of climate on agriculture was found to be known to 98 per cent of farmers. Similarly, while 'reduction in average productivity' and 'increased incidence of pests and diseases' were reportedly known to 97 per cent of the farmers, 95 per cent respondents were found to be aware of 'reduced quality of produce', which is a major impact of climate change.

However, 55 per cent of the farmers were not fully aware of the impact of climate change on 'fertilizer application'. This result implies that this component would demand a prominent place in the advisory on climate change mitigation. Though not up to that level, 'increased crop weed competition' and 'reduction in crop duration', two important aspects of cultivation at the field level were found to be known to only 87 per cent and 83 per cent of the respondents respectively.

Awareness on animal husbandry related components was also found to be high as understood from the distribution of farmers across different levels of awareness. As much as 96 per cent of the farmers expressed that they had cognizance of 'low productivity of livestock', as an important component of climate change impact. Impacts like 'reduced milk and meat yield' and 'reduced

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quality and quantity of forage production' were reportedly known to 94 and 92 per cent of the farmers respectively.

Results also showed that significant proportion of farmers had not taken full cognizance of some very important animal husbandry related components of climate change. For instance, only 77 per cent of farmers were reportedly aware of 'increased mortality' and 'susceptibility to pest and diseases' as impacts of climate change. Among the six items tested under this category, 59 per cent farmers had reported that they were aware of 'increase in disease transmission' as a component of climate change.

The weighted scores on awareness, calculated on the basis of frequency of responses of farmers to the extent of their awareness on each component of climate change, showed the relative importance attributed to different aspects of climate change by the farming community. Mean weighted scores on four major categories (viz. climate change, soil and water related, crop related and animal husbandry related) of climate change implications showed that crop related aspects were the most known to the farming community, followed by climate related aspects, animal husbandry related aspects and soil and water related aspects, in respective order.

Some frequently occurring climatic aberrations, which could be directly experienced by farmers, have made their impacts more visible. This could be the reason why almost the entire farmers were found have preliminary awareness on climate change related impacts. Majority of the crop and animal husbandry related implications of climate change were found to be critically observed by farmers as growth and development of crops and animals are monitored by farmers. Similarly, incidence of pests and diseases in crops and livestock as a result of abrupt climate change are also well pronounced in Kerala. This also might have contributed to the awareness of farmers. On the other side, comparatively lesser number of farmers were found to be aware of soil and water related implications of climate change.

These results support the findings of Kemausuor *et al*. (2011) who also observed that large majority (93%) of farmers were aware of irregularity and unpredictability in timing of the rain. The study strongly bolster the findings of Sogani (2011) who in the study on climate change perceptions and adaptation practices among Uttarakhand reported that there had been higher levels of awareness of communities in the mountain areas on changing climatic conditions.

The inference made by Adebayo *et al.* (2012) who observed that large majority of respondents (about 96%) were aware of climate change, while only about 4 percent seemed not to be aware of climate change. Study made by Baul *et al.* (2013) which observed that 84 per cent of the farmers perceived increase in temperature as an indication of climate change, also support the above findings. Results are also in line with the observation by Legesse *et al.* (2013) who found that 95 per cent of sample households perceived increase in frequency of occurrence of drought. Findings of the study on farmers' adaptation and mitigation on dry lands by Gopal *et al.* (2014) also reiterate that awareness of farmers on impacts of climate change varied across different aspects and the level of awareness was more on climate related changes, followed by crop related changes, animal husbandry related and soil and water related changes in the respective order. The results are also consistent with the findings of Raghuvanshi *et al.* (2017) who observed that farmers' awareness on increased incidence of erratic rainfall, diminishing agricultural yield and increase in temperature were the indicators of climate change. The results of the study altogether show that farmers of Kerala have higher levels of awareness on climate change and its implications.

4.1.2. Awareness of extension personnel on climate change and its impacts

As explained above, awareness of extension personnel on different components of climate change was also assessed. The weighted mean score on overall awareness and mean of the scores on individual components of climate change were estimated (Table 4.2).This would help understand the level of awareness of extension personnel and the knowledge gaps that exist among them.

Table 4.2 Distribution of extension personnel based on different levels of awareness on climate change

Sl. No.	Components of awareness	Frequency			Awareness weighted score	Category wise weighted mean
		Aware	Partially aware	Not aware		
I. Climate related						
1	Increase in average temperature	100	-	-	100	95.6
2	Decrease in average rainfall	100	-	-	100	
3	Long dry spells	100	-	-	100	
4	Fluctuations in onset of monsoons	100	-	-	100	
5	Uneven distribution of rainfall	100	-	-	100	
6	Increased frequency of heat waves	60	40	-	86.67	
7	Increase in maximum and minimum temperatures	85	15	-	96	
8	Prolonged cold weather	50	50	-	73	
II. Soil & water related						
9	Reduced soil fertility	100	-	-	100	99.7
10	Depletion of ground water	100	-	-	100	
11	Reduced quality of water	95	5	-	98.34	
12	Disturbed soil texture	100	-	-	100	
13	Increased soil and water erosion	100	-	-	100	
14	Reduced water holding capacity	100	-	-	100	
III. Crop related						
15	Reduction in crop duration	45	55	-	81.67	95.6
16	Increased incidence of pests and diseases	100	-	-	100	
17	Susceptibility of the crop for drought	100	-	-	100	
18	Decreased fertilizer use efficiency	65	35	-	95	
19	Increased crop weed competition	100	-	-	100	
20	Increased water stress	100	-	-	100	
21	Reduced quality of produce	100	-	-	100	
22	Reduction in average productivity	100	-	-	100	
IV. Animal Husbandry related						
23	Low productivity of livestock	100	-	-	100	94.3
24	Increase in disease transmission	62.5	37.5	-	87.5	
25	Increased mortality	85	15	-	95	
26	Reduced quality and quantity of forage production	80	20	-	93.34	
27	Reduced milk/ meet yield	85	15	-	95	
28	Susceptibility to pests and diseases	85	15	-	95	

The results indicated that every official of the department of agriculture was aware of majority of the aspects of climate change. All the extension personnel selected as respondents were found to be aware of 'increase in average temperature', 'decreases in average rainfall', 'long dry spells', 'fluctuations in the onset of monsoon' and 'uneven distribution of rainfall'. However, awareness on increased frequency of heat waves and prolonged cold waves was found to be less, i.e.; only 60 per cent of the farmers were fully aware of 'increased frequency of heat waves' and only 50 per cent were aware of 'prolonged cold weather'.

With regard to soil and water, all of the extension personnel selected as respondents had awareness on 'reduced soil fertility', 'depletion of ground water', 'disturbed soil texture', 'increased soil and water erosion' and 'reduced water holding capacity'. While more than 95 per cent of the extension personnel were found to be fully aware of 'reduced quality of water', only 5 per cent of them were partially aware of this issue.

Distribution of extension personnel based on their awareness on different aspects of crop management showed that every officer was aware of crop management as a component of climate change resilience. More specifically, all the officers were aware of 'increased incidence on pest and disease', 'susceptibility to drought', 'increased water stress, 'reduced quality of produce' and 'reduction in average productivity' as implications of climate change. While 45 per cent of the extension officers were aware of 'reduction in crop duration' as an important fall out of climate change, 55 per cent were only partially aware of this impact. About 85 per cent of the extension officials were found to be aware of 'decreased fertilizer use efficiency' and as much as 99 per cent of them were aware of 'increased crop weed competition', out of which 87 per cent were fully aware and 12 percent officials were partially aware.

Awareness on animal husbandry related components, which has substantial role to play in the scheme of interventions to mitigate climate change, was also found to be high as understood from the distribution of officials across different levels of awareness.

It was observed that 100 per cent of the officials were fully aware of 'low productivity of livestock' as an impact of changing climate. About 80 per cent of the officials were aware of 'increased mortality', 'reduced quality and quantity of forage production', 'reduced milk/meat yield' and 'susceptibility to pest and diseases'. However, only 62.5 per cent of the officials expressed that they were fully aware of increased disease transmission and 35.5 per cent had partial awareness on this component.

4.1.3. Overall awareness of farmers and extension personnel on climate change and its impacts: A comparison

Measures of the awareness of farmers and extension personnel on climate change implications were compared to find out whether the awareness level of farmers and extension personnel differed significantly. The category wise mean obtained for awareness level of the stakeholders are illustrated in Fig. 4.1.

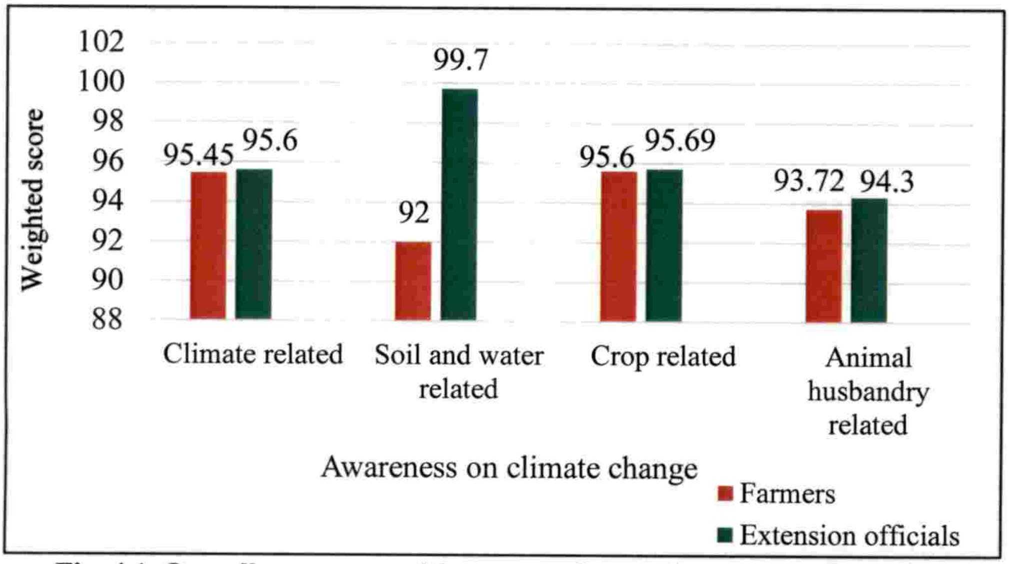

Fig. 4.1. Overall awareness of farmers and extension personnel on climate change and its impacts

While awareness of extension personnel on climate change implications was slightly higher than that of farmers, awareness scores on soil and water related aspects were found to be much more among extension personnel. Nevertheless, their awareness on climate change impacts on components related

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to climate, crop and animal husbandry was relatively on par with each other. The category wise mean score of awareness on these categories for both the stakeholders were nearly equal.

Higher scores of awareness on soil and water related aspects of climate change by extension personnel might be because of the fact that these aspects are not experienced directly by the farmers. The changes in soil fertility and water quality due to climate change are not apparently visible. Extension personnel must have been aware of these aspects out of their theoretical understanding and advance knowledge from literature. The lack of technical capability of farmers to assess the changes that happen in soil and water could be another reason why they are not much aware of these aspects.

Though the results indicated that the awareness levels of extension personnel and their clients are not different in matters related to crops and animal husbandry, an attempt was made to find out if the overall awareness of farmers and extension personnel differed significantly from each other.

The scores of farmers and extension personnel on their awareness on all the four aspects of climate change were analyzed to find out whether the two groups of respondents differed significantly between each other, by employing Mann Whitney U test in SPSS (See Table.4.3)

Table. 4.3 Difference in awareness on climate change possessed by farmers and extension personnel

Test	Value
Mean score of farmers	79.23
Mean score of extension personnel	80.95
Mann-Whitney U	1516.000
Wilcoxon W	6566.000
Z	-2.251
p value	<0.01

Since the computed p-value (<0.01) was less than p value at five per cent level of significance, (ie; p= 0.05), it could be inferred that the level of awareness of farmers and extension personnel on different components of climate change and their implications were significantly different. This showed that there should

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be adequate focus on creation of awareness on various aspects of climate change and its impacts.

4.2. Awareness of farmers on climate resilient technologies and mitigation strategies at the farm level

Awareness level of individuals regarding a management practice is an important factor leading to adoption. Awareness of farmers on various climate resilient techniques and strategies that can be applied at the farm level was found out by recording their responses on a three point continuum viz., 'aware', 'partially aware' and 'not aware' which represented different levels of awareness. Frequencies of their responses were further used to find out the importance ascribed to each technique/strategy and the relative importance of different categories of practices. Distribution of respondents across different levels of awareness and the weighted score on awareness about each technique/strategy are given in Table. 4.4.

Here, probable climate resilient techniques and mitigation strategies at the field level were classified into three major categories, i.e.; 'water and soil conservation measures', 'agronomic practices' and 'institutional measures'. Mitigation techniques/strategies included in each of these categories are also given in the table (Table 4.4).

4.2.1. Awareness on water and soil conservation measures

Distribution of farmers based on their awareness on soil and water conservation measures showed that 100 per cent farmers were aware of rainwater harvesting, water recycling and addition of organic matter as effective climate resilient techniques. Almost on par with this, as much as 98 per cent of the farmers were found to be aware of mulching as an effective technique to mitigate the impacts of climate change. Similarly, vast majority (95 per cent) of the farmers had expressed that they were aware of cover cropping as a climate resilient technique. Cultural practice of 'digging and maintaining farm ponds' and 'construction of live bunds' were found to be known to almost every respondent.

Table 4.4. Awareness of farmers on climate resilient technologies and mitigation strategies

Sl. No.	Climate resilient technologies/ mitigation strategies	Frequency (N=100)			Awareness weighted score	Category wise weighted mean
		Aware	Partially Adopted	Not aware		
I. Water and soil conservation measures						
1.	Digging and maintaining farm ponds	81	19	-	93.67	92.12
2.	Micro irrigation	62	38	-	87.34	
3.	Rain water harvesting	100	-	-	100	
4.	Water recycling	100	-	-	100	
5.	Mulching	98	2	-	99.34	
6.	Construction of check dams	100		-	100	
7.	Cover cropping	95	5	-	98.34	
8.	Organic matter addition	100	-	-	100	
9.	Live bunds	75	10	15	86.67	
10.	Contouring	48	40	12	78.67	
11.	Conservation tillage	24	60	16	69.34	
II. Agronomic practices						
1.	Soil test based fertilizer application	47	48	5	80.67	80.22
2.	Soil health card based practices	45	49	6	79.67	
3.	Pest and disease resistant varieties	30	52	18	70.67	
4.	Drought tolerant varieties	33	49	18	71.67	
5.	Intercropping	100			100	
6.	Agroforestry	50	38	12	79.34	
7.	Alteration in sowing/ planting dates	52	46	2	83.34	
8.	Integrated farming system approach	71	21	8	86.67	
9.	Establishing wind breaks	55	31	14	80.34	
10.	Alteration in fertilizer/ pesticide usage	42	51	7	78.34	
11.	Integrated nutrient management practices	89	11	-	96.34	
12.	Crop rotation	72	28	-	90.67	
13.	Integrated weed management practices	81	19	-	93.67	
14.	High yielding and drought resistant forage crops production	7	33	60	49	
15.	Use of suitable breeds/ varieties for climate	5	30	65	46.67	
16.	Off season cultivation in green house	29	57	14	71.67	

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Sl.	Climate resilient	Frequency (N=100)			Awareness	Category
17.	Rain shelter during rainy season	36	54	10	75.34	
18.	Mixed farming	83	17	-	94.34	
19.	Multi-tier cropping	68	30	2	88.67	
20.	Community nursery for delayed monsoon	68	32	-	89.34	
21.	Shifting to organic farming	86	14	-	95.34	
22.	Crop substitution	55	39	6	83	
23.	Use of fertilizers with higher WUE	38	55	7	77	
24.	PPFM	29	30	41	62.67	
III. Institutional measures						
1.	Weather insurance	86	11	3	94.34	77.27
2.	Supply management through market and non-market interventions	60	39	1	86.34	
3.	Utilizing cold storage facilities	29	53	18	70.34	
4.	Cultivation according to weather based warning/ forecast-	40	51	9	77	
5.	Custom hiring centers	41	56	3	79.34	
6.	Seed bank	91	9	-	97	
7.	Fodder bank	-	10	90	36.67	

with 81 per cent and 75 per cent fully aware of the techniques and the remaining respondents partially aware of these techniques, respectively.

Micro irrigation as a strategy for climate mitigation was found to be recognized by all the respondents, with 62 per cent fully aware of this and 38 per cent expressing partial awareness. However, 'contouring' was found to be known fully to only 48 per cent and 12 per cent not aware of this technique at all. Out of the 11 technique listed, conservation tillage, a fairly new concept was not known to 16 per cent, with as much as 60 per cent partially and 24 per cent fully aware of it.

4.2.2. Awareness on agronomic practices as climate resilient techniques

Among the 24 agronomic practices listed as climate resilient techniques, all the respondents had expressed awareness on 'intercropping' as a strategy for accomplishing climate resilience. Distribution of farmers based on the level of awareness on different techniques showed that all the farmers had taken to cognizance practices such as 'integrated nutrient management', 'organic farming', 'integrated weed management practices' and 'community nursery for delayed monsoon' as climate resilient techniques, with more than 85 per cent being aware and the rest only partially aware of the techniques . It should be specifically noted that techniques of 'soil test based fertilizer application and soil health card based practices', 'alteration in sowing/planting dates', 'integrated farming system approaches', 'crop substitution' and 'alteration in fertilizer and pesticide usage' had not fully gone into the cognizance spectrum of the farming community. About 30-50 per cent farmers were found to be only partially aware of these techniques as effective climate change mitigation practices. Out of them, use of PPFM spray, a comparatively new technique to mitigate drought was known to about only 59 per cent, with 29 per cent fully and 30 per cent partially aware of it.

4.2.3. Awareness on institutional measures

Institutional measures, which are the key intervention points with regard to climate mitigation, are not widely known to the farming community, as understood from the results. Out of the seven strategies tested, except 'seed bank', about which 91 per cent farmers were found to be aware, all other measures were found to be not widely known to farmers. 'Fodder bank', an innovative concept was partially known to 10 per cent farmers and 90 per cent respondents did not have any awareness on it.

Weather insurance, which is gaining currency, was known to as much as 86 per cent of the farmers as a strategy for mitigating the impact of climate change. Nevertheless, only 40 percent of the farmers had awareness on 'supply management', 'cold storage practices', 'cultivation calendar based on weather forecast/warning' and 'custom hiring centers'.

Since water stress has become the greatest concern and there are several localized initiatives that create awareness on the importance of rainwater harvesting and water recycling, farmers were found to be well informed of these technologies. Similarly, as a result of the soil campaign which is being organized state wide in collaboration with national initiatives, farmers were absolutely aware of 'addition of soil organic matter' as a technique to mitigate climate change.

Awareness on the climate resilient technique of deficit root zone irrigation, especially with micro irrigation techniques is gaining momentum in Palakkad and Wayanad districts. This observation is supported by the findings of Yadav *et al.* (2012) who also reported that drip irrigation technologies adopted were essential to generate income and alleviate poverty of the small farmers in frequent drought affected areas. As seen above, conservation tillage is not much popular among farmers, because of the conventional notion that deep tillage is better for plant growth as against the benefits and limitations of conservation tillage pointed out by authors like Lenka and Lenka (2014).

In Palakkad, the practice of growing fringe crops, especially cow pea variety, Bhagyalakshmi on paddy bunds is very common. This was found to give additional benefit to the farmer, mainly when the main crop did not yield well. This fringe cropping is reportedly providing cover cropping benefit, fodder supplement as well as nitrogen supplement as majority of the fringe crops are leguminous vegetables.

Awareness of farmers on different resilient can be enhanced through initiatives like the National Initiatives on Climate Resilient Agriculture (NICRA) as Jasna (2015) reported. NICRA farmers were found to be highly aware of climate change, its impacts, various climate resilient technologies that could give same yield under changing climatic condition, potential of drought tolerant varieties in achieving optimum yield in the face of less rainfall and the need to improve weather literacy.

4.3. Adoption of mitigation strategies/ resilient technologies by farming community

As mentioned elaborately in the review, the magnitude of climate resilience would depend on the nature and extent of adoption of climate resilient practices by farmers. Distribution of farmers across different levels of adoption and the weighted score on adoption of each technique/strategy are given in Table 4.5.

4.3.1. Adoption of soil and water conservation measures

A higher proportion farmers was found to have adopted soil and water conservation measures compared to agronomic and institutional measures. Among this, about 98 per cent farmers had adopted rainwater harvesting, with 97 per cent of them had fully adopting it. 'Water recycling', 'mulching', 'cover cropping' and 'addition of organic matter' were also adopted by the farming community as effective climate resilient techniques. Almost 90 per cent farmers were found to adopt water recycling technologies to mitigate extreme water stress. Micro irrigation was found to have a lower adoption rate among the respondents. As much as 41 per cent farmers had not adopted micro irrigation techniques.

Though mulching and cover cropping were found to be fully adopted by 76 and 68 per cent of the respondent farmers respectively, 10 per cent farmers had not adopted mulching or cover cropping. While almost 26 per cent farmers had partially adopted cover cropping, adoption of live bunds was only 65 per cent, though it is a practice popular in Palakkad district.

Contouring of agricultural lands to reduce soil and water erosion on hilly terrain was found to be fully adopted by 42 per cent of the farmers and 49 per cent farmers had adopted it partially. Almost on par with this, as much as 41 per cent of the farmers had constructed and maintained farm ponds. But there were 39 per cent farmers who had not attempted farm ponds as a water conservation structure.

Construction and proper maintenance of check dams were found to be done by about 87 per cent farmers and about 20 per cent of them had only partially adopted it with little or no maintenance. The novel concept of conservation tillage is yet to gain acceptance among farming community, as 47 per cent of the farmers had not at all adopted it.

Table. 4.5. Adoption of resilient practices/mitigation measures for climate change

Sl. No.	Climate resilient technologies	Frequency (N=100) Adopted	Partially adopted	Not adopted	Weighed adoption score	Category wise weighted mean
	Soil and water conservation measures					
1.	Farm ponds	41	20	39	67.34	81.6
2.	Micro irrigation	33	36	41	70.67	
3.	Rain water harvesting	97	2	1	98.67	
4.	Water recycling	90	8	2	96	
5.	Mulching	76	14	10	88.67	
6.	Check dams	67	20	13	84.67	
7.	Cover cropping	68	26	6	87.34	
8.	Organic matter addition	69	22	9	86.67	
9.	Live bunds	65	17	18	82.34	
10.	Contouring	42	49	9	77.66	
11.	Conservation tillage	20	33	47	57.67	
	Agronomic practices					
1.	Soil test based fertilizer application	33	58	9	74.66	69.14
2.	Soil health card based practices	30	60	10	73.34	
3.	Pest and disease resistant varieties	19	40	41	59.34	
4.	Drought tolerant varieties	21	36	43	59.34	
5.	Intercropping	50	21	29	73.67	
6.	Agroforestry	41	14	45	65.34	
7.	Alteration in sowing/ planting dates	58	37	5	84.34	
8.	Integrated farming system approach	58	24	18	80	
9.	Establishing wind breaks	39	27	34	68.34	
10.	Alteration in fertilizer/ pesticide usage	31	59	10	73.67	
11.	Integrated nutrient management practices	71	27	2	89.67	
12.	Crop rotation	54	16	30	74.67	
13.	Integrated weed management practices	81	17	2	93	
14.	High yielding and drought resistant forage crops production	1	17	82	39.67	
15.	Use of suitable breeds/ varieties for climate	3	19	78	41.67	
16.	Off season cultivation in green house	7	3	90	39	
17.	Rain shelter during rainy season	27	15	58	56.34	
18.	Mixed farming	44	8	48	65.34	
19.	Multi-tier cropping	52	31	17	78.34	

Sl.	Climate resilient	Frequency (N=100)			Weighed	Category
20.	Community nursery for delayed monsoon	51	45	4	82.34	
21.	Shifting to organic farming	57	30	13	81.34	
22.	Crop substitution	38	44	18	73.34	
23.	Use of fertilizers with higher WUE	29	56	15	71.34	
24.	PPFM	30	23	47	61	
	Institutional measures					
1.	Weather insurance	74	21	5	79	72.52
2.	Supply management through market and non-market interventions	55	40	5	89.67	
3.	Utilizing cold storage facilities	10	39	51	53	
4.	Cultivation according to weather based warning/ forecast	44	44	12	77.34	
5.	Custom hiring centers	35	59	6	76.34	
6.	Seed bank	83	17		94.34	
7.	Fodder bank	0	1	99	33.67	

4.3.2. Adoption of agronomic practices as climate resilient techniques

Out of the e 24 agronomic practices listed as climate resilient techniques, 'integrated weed management' and 'integrated nutrient management' were found to have been adopted by 81 per cent and 71 per cent farmers respectively. Though 57 per cent farmers had adopted organic farming practices partially, there were still 13 per cent yet to initiate organic farming practices. Majority of the farmers had adopted any of the cropping system that were found to be climate resilient, like intercropping (50 per cent), multi-tier cropping (52 per cent) or mixed cropping (44 per cent).

Off season cultivation of vegetables in poly houses was not found to be adopted extensively among the farmer respondents. Only 7 per cent were found to have adopted this practice and 90 per cent farmers had not adopted it at all. However, rain shelter, a much more cost effective technique was found to be adopted by 42 per cent farmers either fully or partially.

About 82 per cent farmers had substituted their crops to mitigate climate change, out of which only 38 per cent farmers had fully substituted their crops as a resilient technique. Likewise, though crop rotation was done by 70 per cent of the farmers, it was regularly adopted by only 54 per cent of the farmers.

Though there are several drought resistant varieties, adoption of high yielding drought resistant forage crops was not found among 82 per cent farmers. Similarly adoptions of varieties/breeds that are suitable to the locality was also not found among 78 per cent farmers. Adoption of high yielding drought resistant forage production was reported by only one per cent farmers. However, about three per cent farmers specifically had selected breeds/varieties that suited local climatic conditions. Cultivation of pest and disease resistant varieties and drought tolerant varieties were not practiced by more than 40 per cent of the farmers.

Preparation of community nursery was a common practice among 51 per cent of the farming community during delayed monsoon, and about 45 per cent farmers had partially adopted this strategy. Use of PPFM spray during drought was fully adopted by only 30 per cent of the farmers and 61 per cent farmers were yet to use it.

4.3.3. Adoption of institutional measures

Institutional measures, which are the key interventions points with regard to climate mitigation, are not widely known to the farming community, as understood from the results. Similarly, adoption of institutional measures was found to be among less than 85 per cent in any of the cases. Among them, seed bank was the most widely accepted institutional measure among the farming community, with 83 per cent farmers fully adopting and 17 per cent had partially adopting it.

As much as 55 per cent of the farmers were found to rely on 'supply management of their produce' marketing interventions. Almost equal proportion (44 per cent) of farmers was found to have fully or partially adopted cultivation practices based on weather forecast/warning.

Comparatively newer concepts like fodder bank was found to be partially adopted by only one per cent farmers. Surprisingly, not even a single farmer was found to have adopted fodder bank as a resilient measure to mitigate climate change. However, about 59 per cent farmers had partially availed the services of custom hiring center and about 39 per cent had partially adopted the cold storage facilities.

4.3.4. Overall adoption of climate resilient measures

Considering the overall adoption of the three categories of climate resilient measures, soil and water conservation measures were found to be the most adopted category of resilient measures, with an overall weighted score of 81.6. This was followed by institutional measures and agronomic measures respectively.

Among soil and water conservation measures, rain water harvesting and water recycling were ranked first and second in terms of extent of adoption as evident from the weighted scores. The results were observed to be consistent with the findings of Gbetibouo (2009); Ramaesh *et al.*, (2015); Jasna, (2015) who observed that water-harvesting structures were a popular adaptation strategy by those experiencing the effects of decreased precipitation. According to these authors, mulching, check dam construction, cover cropping, and live bund preparation were also adopted by more than 80 per cent farmers. Shanker *et al.* (2013) also had found that soil moisture conservation techniques like mulching with organic residues and cover cropping in rainfed agriculture were adopted by majority of farmers to cope with climate change.

Due to continuous drought periods in the recent past, rain water harvesting technologies had been found to be highly adopted by the farming community. In fact, rain water harvesting structures adopted were temporary in nature. Though proportion of farmers who had adopted rain water harvesting was found to be higher (97 per cent), it was found to be less in the case of adoption of permanent water harvesting structures like farm ponds (41 per cent). This might be because of the constraints faced by farmers in making larger investment both in terms of capital and area. Rao *et al.* (2012) suggested policy level instruction aiding construction of farm pond as a solution for climate resilient rainfed agriculture, especially by farmers who own more than two hectares of agricultural land.

Conventional soil moisture conservation measures were found to be adopted by comparatively higher proportions of farmers. In terms of weighted scores, mulching was found to be adopted more followed by cover cropping and organic matter addition. This could be due to increased awareness on mitigating climate change in rainfed agriculture by increasing soil moisture and water holding capacity. This conclusion is supported by the observation made by Steiner (1998) and FAO (2015), who also concluded that organic rich soils helped to combat and adapt to climate change by playing a key role in the carbon cycle.

Depletion of ground water and also the farmer's awareness on water stress might have resulted in comparatively better adoption of micro irrigation methods, as understood from the weighted score (70.67).

As far as adoption of institutional measures are concerned, seed bank, supply management and weather insurance were found to be the most adopted measures in the respective order. Since the major crop in the study locations was paddy farmers had been maintaining seeds for the forthcoming season through a well-established seed security system which was institutionalized in the form of Registered Seed Growers Program (RSGP) by Kerala Seed Security Development Authority (KSSDA). Thus, Krishi Bhavans provided paddy seeds at subsidized rate to the farmers utilizing the funds of local self-governments. Adoption of market and non-market intervention in the form of schemes, projects, value addition, branding the produce, contact farming, group farming,, auction centers and organizing weekly or monthly sales counters had also been initiated at various parts of Palakkad and Wayanad districts, in order to sustain farming even in odd times of climate change by ensuring remunerative income.

The results presented above are supportive of similar experiences reported from other parts of the country by Nagaraj *et al.* (2013) who observed that diffusion of innovations, provision of quality seeds, efficient input delivery and market linkages helped in bridging productivity gaps and enhancing incomes in both crop and livestock sectors, in Rajasthan, Gujarat, Haryana and Maharashtra.

Weather based insurance, another important institutional mechanism making farmers resilient to climate change was ranked third, with a weighted score of 79. During field survey majority of the respondents had expressed dissatisfaction with the project. In fact the state department insurance scheme for paddy which is implemented at the premium rate of 25 rupees for 0.1 ha is compulsorily availed by all the farmers to benefit operational support. But, the weather based crop insurance project, currently implemented by Agricultural Insurance Company India Ltd. (AIC), which is a centre- state venture through a private company, was reported to be less beneficial to the farmers. .

Farmers from Ayilur, Elavanchery, Perumatty, Peruvemba villages of Palakkad and Pulpally and Poothady villages of Wayanad raised complaints about the way in which the company estimated weather parameters. According to them, the company relied on general weather reports from satellites and the extremities of climate genuinely experienced by the farmers at the local level were not considered for assessing the losses. This improper estimation render the scheme absolutely inadequate to meet the requirements of the farming community. It was observed that more than 25 per cent of the farmers had stopped subscribing to weather based insurance scheme. Moreover, the premium amount for this insurance was reported to be high by farmers. These observations from the field show that weather based insurance, a feasible mechanisms towards building resilience to climate change by many authors (Raju *et al.*, 2007; Rao *et al.*, 2010; Pathak, 2012) would not be adequate if it did not address the issues of farmers realistically.

Other institutional measures were found to be adopted less by farmers as understood from weighted scores. Cold storage facilities, especially aiding vegetable farmers are being provided by the department of agriculture by giving assistance to build zero energy cool chambers. Moreover, proposal for new godowns and renovation of existing storage facilities are being implemented at panchayat level, especially in Kannambra, Pervemba and Kollengode. Weighted scores on adoption of agronomic practices (69.14) is less compared to those of soil and water conservation and institutional measures. Many authors had cited agronomic resilient measures as the best to make agriculture climate proof, especially crop intensification by multi-tier cropping, intercropping, rotation, substitution and crop diversification (Reddy *et al.*, 2015; Devarajan, 2016; Singh, 2016).

This difference could be due to the recent emphasis on soil health management, through soil health campaign, introduction of soil test based fertilizer application and popularization of soil health card based practices. As another fall out of thee interventions, Integrated Nutrient Management (INM) was found to be adopted by more farmers. Traditional farming had always been integrative in nature, and there is a revival of those integrated systems in the aftermath of deterioration of soil quality due to unscientific usage of fertilizers. This is consistent with the observation made by Varghese (2012) about the increased awareness and adoption on INM by farmers in Wayanad farmers and is widely evident from the results obtained by Joseph (2016) while explaining the transition to organic agriculture in Kasargod district of Kerala.

These could also be the reason for increased adoption of Integrated Weed Management (INM). Farmers reported that even though manual weeding was expensive, it would benefit in multiple ways, like destroying pest and disease inoculum in soil, providing proper anchorage for rice seedlings and reduced weed competition in next season. All these might have added to the higher percentage of adoption of IWM. Farmers of Wayanad district, who practice extensive intercropping of coconut, areca nut and coffee were found to adopt mostly manual weed control along with other intercultural operation. Due to increased concern on health issues of pesticide usage 99 per cent of the vegetable farmers were also found to adopt IWM.

Frequent fluctuations in monsoon might be the major reason for adopting altered sowing dates, as observed by Pathak (2012) and Gopal *et al.* (2014).

4.3.5. Distribution of farmers based on adoption index

Adoption index for each farmer was calculated by dividing the total adoption score obtained for that farmer with the total possible score. Depending on the mean ± standard deviation (mean ± S.D.) of the adoption score obtained, farmers were classified as low, medium and high category as shown in Table 4.6.

Table 4.6. Classification of farmers based on their adoption of climate resilient practices

Category	Farmers (N=100)	
	Score range	Frequency (%)
Low (<Mean- S.D.)	<61.01	18
Medium (Mean ± S.D.)	61.01-83.79	69
High (>Mean + S.D.)	>83.79	13
	Mean= 72.4	**S.D.= 11.39**

From the above Table, it is understood that majority of the farmers (69 per cent) had medium level adoption of climate resilient practices. The mean adoption score obtained is 72.4 which is indicative of the higher adoption of climate resilient techniques among farmers, particularly since the adoption index ranges from 49.2 to 93.65. Farmers who had high and medium adoption level were only 13 per cent and 18 per cent respectively.

4.3.6. Adoption of climate resilient practices by farmers in the two districts selected for the study: A comparison

As climate change vulnerability is inversely related to awareness and adoption of climate resilient practices, an attempt was made to find out whether there had been any difference between the farmers of Palakkad and Wayanad in terms of adoption of resilient practices. The mean adoption index of farmers in both district were calculated and t test was employed to find out the difference (See Table 4.7).

Table. 4.7. Difference in the adoption of climate resilient practices by farmers in Palakkad and Wayanad

District	Mean adoption index	p value of t-statistic
Palakkad	67.94	0.0003
Wayanad	82.83	

As seen from the table, probability of t-statistic obtained (0.0003) indicated significant difference in the adoption of climate resilient practices by the sample of farmers in Palakkad and Wayanad. Since the mean adoption index of farmers in Wayanad wass higherer (82.83) than that of farmers in Palakkad, it could be concluded that adoption of climate resilient strategies by farmers in Wayanad is higher than that of the farmers in Palakkad. The reasons for this difference could be possibly attributed to severity of climate change impacts experienced, which is dependent on the nature of crops and also the intensity of various interventions in these districts.

4.4. Extent of vulnerability to climate change at the farm level

Climate change vulnerability is both biophysical and social process, which is dynamic in nature. In the context of climate change and agriculture, vulnerability refers to the propensity of the entity to face a climate shock, suffer loss in production and/ or income from agriculture. The study attempted to find the vulnerability of the two districts, namely, Palakkad and Wayanad. It used Livelihood Vulnerability Index (LVI) developed by Hann *et al.* (2009), as described in section (3.6.1.). The results obtained are given below (Table 4.8) with detailed calculation procedure of all the major components and its sub-components.

Table. 4.8 Vulnerability to livelihoods of the farmers as indicated by Livelihood Vulnerability Index (LVI) of Palakkad and Wayanad

Major components	Sub-components	Sd Pala-kkad	Sd Waya-nad	Md Pala-kkad	Md Waya-nad
Socio-demographic profile	Percentage of dependent people (<15 years and >60 years)	.37	.30	0.34667	0.35333
	Percentage of female headed households	0	.10		
	Percentage of household where head of the household is literate male with >50 years of age	.67	.66		
Livelihood strategies	Percent of household reported change in sowing/ planting time	.92	1	0.4925	0.4925
	Percent of households changed to new crop variety/ new crop	0.57	0.5		
	Percent of household depend solely on agriculture as a source of income	.91	.77		
	Average agricultural livelihood diversification index	0.37	0.5		
Social network	Percent of household not having access to communication media	0	0	0	0.0575
	Percentage of household not having access to local govt. services	0	0		
	Percent of household not having access to institutions to purchase of seeds/seedlings	0	0		
	Percentage of household not associated with any organizations (cooperatives/ groups)	0	.23		
Crop health	Percent of household reported pest and disease incidence due to climate change	.90	.93	0.436	0.452
	Percent of household reported stress due to climate factors	.95	1		
	Percent of household reported crop loss (>50 %) due to pest/disease incidence	.91	.93		
	Percentage of household not practicing INM	.17	0		
	Percentage of household not adopted IPDM	.25	.4		
Food	Percentage of household not saving seeds	0	0	0.414	0.4
	Percentage of household with decreasing production	.94	1		
	Percentage of household depending solely on family farm for food	.30	.20		

Major components	Sub-components	Sd Pala-kkad	Sd Waya-nad	Md Pala-kkad	Md Waya-nad
Water	Average number of water sources to a household	0.6	0.4	0.4925	0.415
	Percentage of households with problem for access to irrigation water	.81	.80		
	Percentage of household not having persistent water supply	.44	.53		
	Percentage of household affected due to water stress	.92	.73		
Natural disaster	No of flood events since 2009	0.8	0.5	0.5	0.4
	No of drought events since 2009	0.4	0.3		
Climatic variability	Mean standard deviation of monthly average of average maximum daily temperature since 2009	0.43	0.20	0.5	0.29
	Mean standard deviation of monthly average of average minimum daily temperature since 2009	0.57	0.19		
	Mean standard deviation of monthly average precipitation since 2009	0.5	0.48		
			Total	3.881	3.46033
			LVI	**0.14**	**0.12**

Sd = Sub-component of district, Md = Major component of district d

(For variables to measure frequencies, the minimum values were set at 0 and the maximum at 100. Thus, the S_d value obtained for such sub-components is actually the percentage (See section 3.6.1).

Eight major components and 28 sub components were considered for LVI calculation. The LVI scale ranged from 0 (least vulnerable) to 0.5 (most vulnerable) (See Appendix III for the items and other details). The results showed that Palakkad district (0.14) had a higher LVI than Wayanad district (0.12), indicating relatively greater vulnerability to climate change impacts to the farming community in Palakkad. The results of the major components of livelihood vulnerability are presented in Table 4.9.

Table.4.9. Major components of the Livelihood Vulnerability Index (LVI) of Palakkad and Wayanad

Major components	Md Palakkad	Md Wayanad
Socio-demographic profile	0.34667	0.35333
Livelihood strategies	0.4925	0.4925
Social network	0	0.0575
Crop health	0.436	0.452
Food	0.413333	0.4
Water	0.4925	0.415
Natural disaster	0.5	0.4
Climatic variability	0.5	0.29
Livelihood Vulnerability Index	**0.14**	**0.12**

Md is the average of the indexed values of sub-component of a major component of the district d

A figurative representation that compare the magnitude of various components of LVI in Palakkad and Wayanad is given in Fig.4.2.

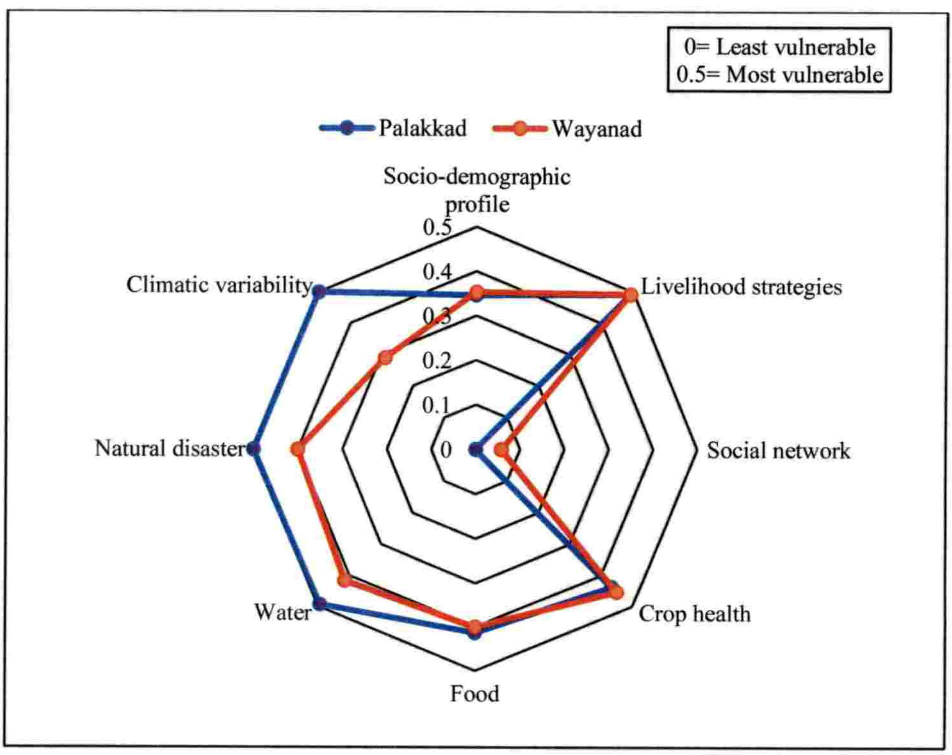

Fig. 4.2 Vulnerability spider diagram for the major components of LVI

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Palakkad farmers were found to be more vulnerable in terms of food, water, natural disaster and climatic variability. Meanwhile, Wayanad showed more vulnerability with respect to socio-demographic profile, social network and crop health. Vulnerability score of livelihood strategies were found to be equal in both the districts. Social network was not at all a vulnerable factor in Palakkad whereas it was found to be slightly higher in Wayanad. Though different components had varying prominence, the farmers of Palakkad were found to be more vulnerable to climate change as indicated by LVI. Palakkad district was more exposed to extreme natural calamity such as frequent flooding of agricultural fields, erratic monsoon showers and was more exposed to climatic variability such as average maximum daily temperature and average minimum daily temperature, even though climatic variation in at high altitudes were high as observed by Panthi *et al.* (2015) during the assessment of vulnerability of mixed farmers in Nepal.

Palakkad was found to be more drought prone when compared to Wayanad. Index of water stress observed in Palakkad was 0.4925 and that in Wayanad was 0.415. In fact, both the districts had been listed as medium vulnerable district by Rao *et al.* (2016) while assessing district level vulnerability of agriculture to climate change throughout India. But while indexing and mapping agricultural vulnerability to climate change over south India, Sridevi *et al.* (2014) ranked Wayanad as fifth and Palakkad district as 14th in terms of climate variability index with indicators like rainfall variation and drought prone area. From this, it is evident that climate change impact on Palakkad has become much more severe and abrupt recently as the cited study had used data before 2011. The socio-demographic vulnerability index calculated for Palakkad and Wayanad were 0.34667 and 0.35333 which did not show much apparent variability. It should be noted that Sridevi *et al.* (2014) had ranked Palakkad and Wayanad as second and seventh in terms of socio demographic vulnerability. This could be indicative of the improvement in the socio economic dimension of vulnerability of these two districts since then.

Livelihood strategies index was found to be 0.4925 in both the districts even though Palakkad was rated relatively higher in adoption of climate resilient varieties/ crops compared to Wayanad. However, overall adoption of climate resilient practices tested was higher among Wayanad farmers. While assessing the vulnerability of villages of Vietnam, Can *et al.* (2013) had observed that households with vulnerable livelihood strategies showed higher vulnerability index. Occurrence of same index values in both the districts on account of livelihood strategies in spite of higher adoption of climate resilient practices in one district could be explained based on this. This could be due to high dependency of households on agriculture as major source of income, without any remunerative non-farm activities and jobs during adverse seasons. This seems to be probable since 91 per cent of farmers in Palakkad selected for the study were solely depending on agriculture as their income source.

With regard to agricultural diversification index, Wayanad scored higher value (0.5). Diversification index was calculated based on the assumption that there would be greater vulnerability for households with less number of livestock species.

Farmers in Palakkad (92 per cent) reported change in sowing time, during *virippu* and *mundakan* seasons. Due to erratic monsoon showers, especially during the last five years, paddy sowing was found to be postponed in order to avoid flooding in *virippu* and advanced in *mundakan* to mitigate drought. In Wayanad, *nancha* and *puncha* paddy were sown early by minimum ten days during the last five years due to uncertain variability in climatic parameters, especially rainfall and temperature.

Regarding introduction of new crops and crop varieties to adapt to climate vagaries, farmers in Palakkad were found to adopt long duration rice varieties which could withstand drought, especially for the second crop. They also reported cultivation of hybrid vegetables with drought tolerance and stress resistance traits. In Wayanad, coffee plantations are reportedly rejuvenated with a coffee having deep tap root system to mitigate increasing water stress. Social network component index was relatively low, since almost all the farmers were found to be well connected to local governments, extension agencies, communication networks and institutions providing inputs. In a state like Kerala with good infrastructure facilities, connectivity and literacy, social isolation is almost nil except in some remote tribal villages. As much as 93 per cent of the total respondents were either members or office bearers in local groups/ organization, particularly in *padashekara samithi* (group of paddy farmers), *kurumulaku samithi (group of pepper farmers)* or *kerasamithi* (group of coconut farmers). More than half of the sample respondents were officer bearers of any of the above mentioned groups. Compared to Wayanad, farmers in Palakkad were found to have more contact with extension officials. Majority of the farmers were found to visit Krishi Bhavans weekly. Pest and disease incidence and crop loss due to climate change was found to be increasing in Palakkad and Wayanad. As much as 90 per cent of the farmers in Palakkad and 93 per cent farmers in Wayanad reported increased incidence of pest and disease and subsequent crop loss. Pest resurgence due to difference in threshold temperature had also been reported widely.

It was observed that 95 per cent of the farmers in Palakkad and cent percent farmers from Wayanad had reported ever increasing stress due to climatic aberrations and its ill effects on crop. Integrated nutrient management was highlighted as a way towards mitigating the impact of climate change. Only 17 per cent of the farmers in Palakkad were yet to adopt INM. With regard to IPDM, about 25 per cent and 40 percent farmers respectively from Palakkad and Wayanad were not practicing it. The result revealed that crop health component of the index was lightly higher for Wayanad (0.457) than that of Palakkad (0.436).

The vulnerability component viz. 'food' of both the district showed relatively higher value since both the districts recorded decreasing production (94 and 100 per cent respectively in Palakkad and Wayanad) and only 30 percent and 20 per cent of the farm households were found to depend solely on their own produce in Palakkad and Wayanad repsectively. Almost cent per cent of the farmers were having seed security, either saving in own house or as in RSGP programme.

Water stress in farming was more severe in Palakkad (92 per cent) than in Wayanad (73 per cent). Monsoon fluctuations in terms of quantity and time always affected paddy cultivation in Palakkad. Even though average number of water sources per household was found to be four in Palakkad, about 81 percent of the farm households found it difficult to have access to irrigation water in the fag end of *mundakan* season. Similarly, 80 per cent of households in Wayanad also faced severe constraints to get water for irrigation with 53 per cent of farmers suffering from persistent shortage of water supply.

4.4.1. Livelihood Vulnerability Index of the Grama Panchayats under study

In order to understand the vulnerability to livelihoods further, LVI of the seven grama panchayats from Palakkad and three from Wayanad were assessed. (See Table 4.10) Grama panchayats selected from Palakkad were Kollengode, Perumatty, Muthalamada, Pervemba, Ayilur, Elavanchery and Kannambra which are seen serially numbered from 1 to 7 respectively. The villages from Wayanad were Poothady, Noolphuzha and Pulpally which are denoted as 8, 9 and 10 respectively in the table. Among the 10 villages, Perumatty, Muthalamada, Ayilur and Elavanchery were rated as the most vulnerable with LVI value of 0.12. Out of the grama panchayats selected from Palakkad, Kannambra was found to be the least vulnerable to climate change impacts on agriculture and livelihood. Whereas in Wayanad, all the three villages were nearly equal in vulnerability with LVI ranging between 0.08-0.09. Noolphuzha was found to be the most vulnerable in Palakkad from among the three panchayats selected from Wayanad.

Majority of the farmers from Kollengode and Ayilur in Palakkad district were RSGP growers. And thus, seed security was well ensured. Noolpuzha, of which 50 per cent of the land is under forest, frequently encountered wild animal attack and uneven weather, leading to higher vulnerability than rest of the villages. While mapping the villages in Wayanad district during his study on vulnerability to water scarcity in agriculture, Varghese (2012) had identified Noolphuzha as ‘highly vulnerable’ and Poothadi and Pulpally as ‘vulnerable’.

Table 4.10. Livelihood Vulnerability Indices of Grama Panchayats selected for the study

Major components	Md 1	Md 2	Md 3	Md 4	Md 5	Md 6	Md 7	Md 8	Md 9	Md 10
Socio-demographic profile	0.34	0.4	0.37	0.3	0.37	0.37	0.3	0.44	0.27	0.37
Livelihood strategies	0.25	0.5	0.35	0.42	0.5	0.5	0.46	0.5	0.5	0.4125
Social network	0	0	0	0	0	0	0	0	0.05	0.125
Crop health	0.54	0.32	0.48	0.28	0.26	0.4	0.22	0.08	0.4	0.38
Food	0.37	0.2	0.4	0.1	0.24	0.3	0.1	0.1	0.1	0.1
Water	0.225	0.37	0.5	0.5	0.45	0.45	0.5	0.475	0.35	0.35
Natural disaster	0.5	0.55	0.55	0.6	0.6	0.4	0.5	0.3	0.45	0.4
Climatic variability	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.29	0.29	0.29
Total	2.815	2.97	3.3	2.73	3.1	3.1	2.65	2.24	2.4	2.42
LVI	**0.10**	**0.12**	**0.12**	**0.10**	**0.12**	**0.12**	**0.09**	**0.08**	**0.09**	**0.08**

M_d= Average of major component of Grama Panchayat d

The study also explained the changing pattern of vulnerability over the years, which was concluded as a result of increased dependency on irrigation coupled with decreased cropping intensity. These results support the findings of the current study as well. Poothady grama panchayat was identified as one of the severely drought affected villages in Wayanad.

A graphical representation of the comparison of grama panchayats in Palakkad and Wayanad districts based on LVI values is given in Fig 4.3

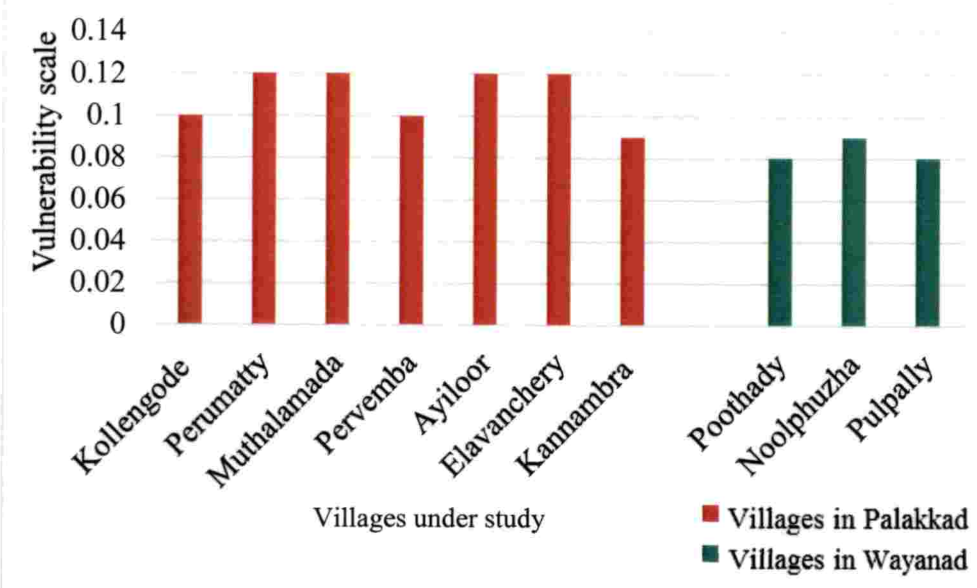

Fig 4.3 Comparison of the Grama Panchayats selected for the study based on livelihood vulnerability

4. 5. Readiness of the public extension system in mainstreaming climate resilience into agricultural development

Readiness of the public extension system of the state to mainstream climate change into the development process was a major objective of the study. Interventions by the Department of Agricultural Development and Farmers' Welfare were analyzed with focus on development programmes, funds and extension interventions to assess readiness. Readiness involves different components which together make the wheel of resilience mainstreaming move forward in a sustainable way. As explained earlier, readiness was assessed in terms of institutional support and financial support that are available to farmers currently to mitigate the perils of climate change. For this, all the development schemes of the Department of Agricultural Development and Farmers' Welfare were examined to delineate the components that have implication on climate change resilience and 16 programmes were identified. These programmes/schemes had one or more components that could apparently address some impacts of climate change. The components identified were grouped into

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major heads viz.; climate resilient practices for crop production, climate resilient intercultural operations, climate resilient plant protection measures and climate resilient strategies aiding postharvest handling and marketing.

4.5.1. Readiness in terms of institutional support

Institutional readiness was assessed in terms of the number of programmes which had explicit climate resilient components that had been incorporated deliberately or inadvertently. Since public delivery of extension services and development interventions are highly institutionalized and mainly done through Krishi Bhavans, implementation of these programmes were categorized as 'institutional support' for climate resilience. Details of the 16 programs that were found to have components facilitating climate resilient agriculture are listed in Table 4.11.

Table 4.11 Programmes of the Department of Agriculture and the components addressing climate resilience (2013-14 to 2017-18)

P.I	Rice development
P.2	Coconut development
P.3	Vegetable development program
P.4	Spices development
P.5	Development of fruits, flowers and medicinal plants
P.6	Location specific schemes
P.7	Hi-tech agriculture
P.8	Soil and root health management and productivity improvement
P.9	Crop health management
P.10	Organic farming and good agricultural practices
P.11	Production and distribution of quality planting material
P.12	Agro advisory centers and service delivery
P.13	Contingency program to meet natural calamity and pest and disease endemic
P.14	Crop insurance
P.15	Wayanad package
P.16	Strengthening market development

Institutional support was analysed under six categories viz. crop production, intercultural operation, plant protection, irrigation, post-harvest and extension. Frequency of programme components that support climate resilient interventions under each of these six major categories of activities were found out,

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The percentage of components that facilitate climate resilience in various development programmes is shown in Table 4.12.

Though there was no exclusive programme to address climate change, it was found that 'vegetable development programme' had the largest proportion of climate resilient components. With an average of 29.8 per cent climate resilient components included in it, this programme was found to address the issue of climate change more comprehensively than any other programme of the Department of Agriculture. This progamme had functional components that facilitated crop production (44 per cent), plant protection (40 per cent), irrigation (25 per cent), post-harvest (40 per cent), and extension support (30 per cent) programme' whereas, the programme on 'fruit, flowers and medicinal plant development programme' was found to have the least number of components that facilitated climate resilience, with an average 5.16 percentage of climate resilient components.

The programme on crop health management was found to have considerable proportion of climate resilient functional components, with an average 25.8 per cent, next to vegetable development programme. This was found to be followed by coconut development programme (17.8 per cent), Wayanad package (16.83) and agro advisory services and service delivery programme (13.5 per cent),

The figures in the table indicated that there were varying emphases on climate resilient practices in the development programmes of the department. Since the presence of climate resilient practices in development programmes are inadvertent, no particular pattern of occurrence of climate resilient components could be observed in any of the programme.

Moreover, the analysis also pointed out the need to consciously include exclusive climate resilient components in every scheme or programme of the department to mainstream climate resilience into the development endeavors. Considering the importance of the impact of climate change, the emphasis on climate resilient strategies in the programmes of the department were not found to be adequate.

Table. 4.12 Climate resilient components in various development programmes of the Department of Agricultural Development and Farmers' Welfare (in percentage)

Functional components	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15	P16
	RD	CD	VDP	SP	FFM	LSS	HIT	SRM	CH	OF	PM	AAS	NC	CRI	WYP	MD
Crop production	33	22	44	27	11	16	11	16	5	22	16	11	5	16	11	0
Intercultural operation and support	0	30	0	0	10	0	0	10	10	0	20	10	10	0	30	0
Plant protection	0	20	40	0	0	0	0	0	100	0	0	0	20	0	20	0
Irrigation	0	25	25	0	0	0	25	0	0	0	0	0	0	0	30	0
Postharvest	20	0	40	0	0	20	0	0	0	40	0	0	0	0	0	40
Extension support	20	20	30	40	10	20	10	40	40	20	20	60	0	20	10	10
Mean Percentage	12.16	17.8	29.8	11.16	5.16	9.3	7.66	11	25.8	13.6	9.33	13.5	5.83	6	16.83	8.33

RD- Rice development programme, **CD-** Coconut development programme, **VDP-** Vegetable development programme, **SP-** Spices development, **FFM-** Fruits, flowers and medicinal plants, **LSS-** Location specific schemes, **HIT-** High Tech Agriculture, **SRM-** Soil and root health management, **CH-** Crop health management, **OM-**Organic farming and good agricultural practices, **PM-** Production and distribution of quality planting material, **AAS-** Agro advisory centers and service delivery, **NC-**Contingency program to meet natural calamity and pest and disease endemic, **CRI-** Crop insurance, **WYP-** Wayanad package and **MD-** Strengthening market development

Institutional readiness was also quantified in terms of various services availed by the farmers that could encourage climate resilient actions in farming. This included input subsidies, credit facilities, insurance support, exposure to trainings, awareness seminars, demonstrations of resilient technologies, marketing support, exposure visits and agro advisory services that addressed impact of climate change some way and helped in building climate resilience into the system. Based on the mean ± S.D. obtained from the weighted scores of institutional support availed, farmers were categorized as low, medium and high as given in the Table No.4.13

Table 4.13. Distribution of farmers based on support availed from various agencies

Category	Farmers (n=100)	
	Score range	Percentage
Low (Mean- S.D.)	<16.9	15
Medium (Mean ± S.D.)	16.9-25.14	68
High (Mean + S.D.)	>25.14	17
	Mean= 21.02	**S.D.= 4.12**

As evident from the results obtained, distribution of farmers who had benefitted out of institutional support was maximum under medium category, with 68 per cent farmers availing services from institutions like Krishi Bhavans, KVK, KAU and RATTC. Though more than half of the farmers were in medium category, there was hardly any support that targeted climate resilience in particular. While I5 per cent of the farmers were found to have availed more support, almost the same per cent of farmers (17) had not at all availed any institutional support. Bridging this gap requires reorientation of the existing extension delivery system which should focus on streamlining climate resilience as a core agenda in all its development programmes.

4.5.2. Readiness in terms of financial support

The pattern of financial support provided by the government for various development programmes showed the trend of emphasis on various climate resilient components as well. Total outlay of the development programmes selected for the study from 2013-14 to 2017-18 and the growth rate of outlay during this period helped quantify the readiness of the public extension system in Kerala in mainstreaming climate resilience, in terms of financial support. Trends in financial support for various components over the five years are given below (See Table 4.14 and Fig 4.4)

Table 4.14. Outlay and compound annual growth rate (CAGR) of department schemes from 2013-14 to 2017-18

Pi	Program name	2013-14	2014-15	2015-16	2016-17	2017-18	CAGR %
PI	Rice development	5000	3352	3382	3500	7000	6.96
P2	Coconut development	5000	4500	4500	4500	4500	-2.09
P3	Vegetable development program	5625	6400	6400	6830	7900	7.03
P4	Spices development	1600	1525	1000	1000	1000	-8.97
P5	Development of fruits, flowers and medicinal plants	0	0	0	0	675	0
P6	Location specific	0	0	0	0	330	0
P7	Hi-tech agriculture	1200	600	410	290	100	-39.16
P8	Soil and root health management	400	3090	2855	2626	2700	46.51
P9	Crop health management	1300	1335	1630	1690	1764	6.29
P10	Organic farming and GAP	1000	1000	1000	1000	1000	0
P11	Production and distribution of quality planting material	620	1075	1075	1250	1340	16.67
P12	Agro advisory centers and service delivery	1100	2750	2765	3100	3200	23.81
P13	Contingency program	80	300	300	300	400	37.97
P14	Crop insurance	500	500	600	1250	1250	20.11
P15	Wayanad package	1900	1900	1900	. 1900	1900	0
P16	Market development	0	1355	1285	975	2175	12.56

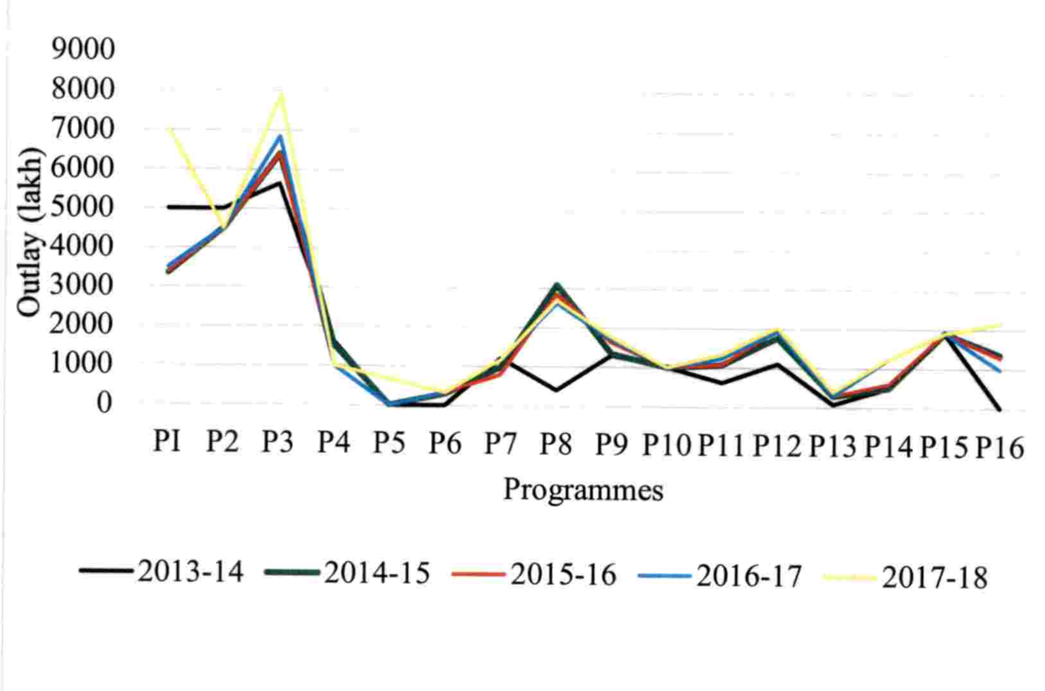

Fig.4.4. Readiness of the extension system in terms of financial support for development programmes (2013-14 to 2017-18)

From the graph it is clearly understood that in a span of five years, there had been more allotment to majority of the programmes though some programmes like 'organic farming and good agriculture practices' and 'Wayanad package' had same outlay.. The outlay for programmes like 'rice development', 'vegetable development', 'development of fruits, flowers and medicinal plants', 'agro advisory centers and service delivery' and 'strengthening of market development' were given more focus during the financial year 2017-18.

Readiness in terms of financial support of the public extension system was analyzed based on the compound annual growth rate (CAGR) of the financial outlay of the 16 programs during the past five consecutive years from 2013-14 to 2017-18.

Results revealed that 'soil and root health management and productivity improvement' had the highest growth rate (46.51) followed by 'contingency programme to meet natural calamity and pest and disease endemic' (37.97). 'Hi-tech agriculture' had the highest negative growth rate (-39.16).

It is to be noted that on assessing the institutional support in terms of functional components addressing climate change, 'vegetable development programme' was found to have maximum functional components that could address climate resilience. However, financial outlay of these programmes from 2013-14 to 2017-18 showed only 7.03 per cent compound growth rate for this porgramme. As explained earlier, some programmes like 'Wayanad package' and 'organic agriculture and GAP' had zero growth rate over the years.

As the national and state government had been giving thrust on improving the soil health and improving productivity, several programmes had been initiated by the central and state governments to address these issues. Addition of organic matter, micro nutrient application, use of soil ameliorants and issue of soil health cards were some of the initiatives under the programme 'soil and root health management and productivity improvement'.

The climatic variability was reportedly more unpredictable in the recent past in Kerala. This had impacted negatively on the agriculture sector with erratic monsoon showers, prolonged drought and increased maximum temperature. Thus, government, therefore was forced to increase the outlay for 'contingency programme to meet natural calamity and pest and disease endemic' as the number of geographical area under natural calamity and pest and disease endemic had increased over the years. The scheme was intended for creating a buffer stock of seeds of paddy and other annual crops for distribution to affected farmers in the event of natural calamities and resultant crop damages. Assistance for strengthening of bunds to prevent breaches during floods and for removal of debris would also be given in a need based manner.

In response to the recent trends of unpredictable climatic conditions, the national government had initiated novel programme in 2017-18,' location specific schemes'. It was to promote cultivation of millets like ragi, finger millet, foxtail millet, little millet and oil seeds like ground nut and sesame and sugarcane in potential areas. The assistance was provided for quality seeds and for other expenses like land preparation, irrigation etc. Conservation of traditional varieties and traditional cultivation practices was also envisaged through the programme. Activities would be taken up on a project mode in coordination with Tribal Department.

The pattern of financial support has shown the growing emphasis on climate resilient agriculture, though the funding pattern is not very structured and the emphasis has not covered all the important crops. Results showed that there should be serious interventions to ensure increased funding for climate resilient practices for food crops as well as commercial crops in Kerala, with well thought out functional components to promote adoption of these practices by farmers.

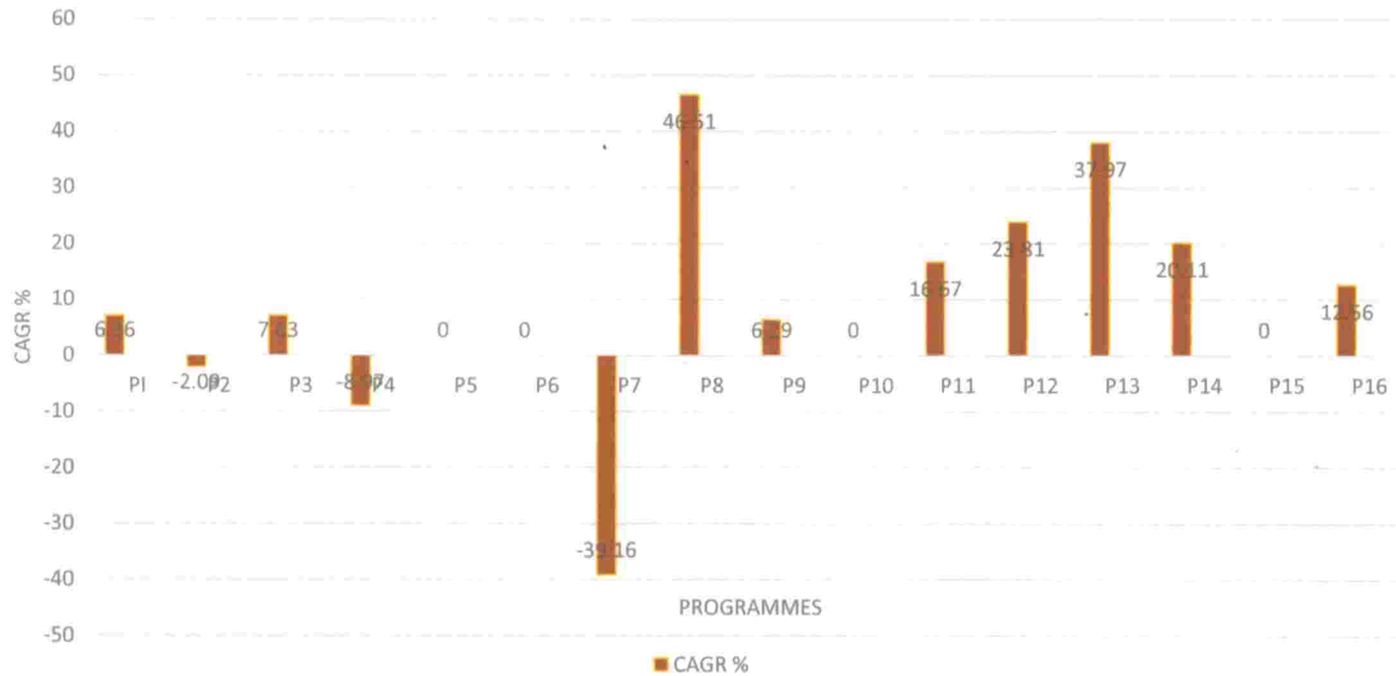

Fig 4.5. Compound Annual Growth Rate (CAGR) of agricultural development programmes implemented in Kerala

4.5.3. Relative importance of climate resilient components (in development programmes) in terms of extent of integration and financial outlay

The relative importance of the major categories of interventions in terms of outlay and number of programme components was estimated by employing Friedman two way analysis of variance. The major categories of climate resilient interventions were ranked based on outlay and number of functional components. The test was done in SPSS and the result obtained given in Table 4.15.

Table 4.15. Importance of major categories of climate resilient interventions in terms of outlay and number of climate resilient components

Sl. No.	Program component	Friedman mean Rank
1	Crop production	4.69
2	Intercultural operation and support	3.22
3	Plant protection	2.88
4	Irrigation	2.19
5	Postharvest	3.16
6	Extension support	4.88
		Value
Test statistics		32.065
df		5
p value		0.0001

The result showed that extension support (4.88) scored highest rank among the components that were included in the selected programmes. It was followed by crop production (4.69), intercultural operation and support (3.22), post-harvest (3.16), plant protection (2.88) and irrigation (2.19). Thus, considering both the outlay and number of programme components, extension support (4.88) and crop production (4.69) interventions were found to be the most important climate resilient interventions in the development programmes selected for the study. This also implies that government should focus more on programmes that promote climate resilient intercultural practices, irrigation support, plant protection and postharvest management.

4.6. Dimensions of climate resilient agriculture

An attempt was done to delineate various dimensions of climate resilient agriculture as experienced by the farming community and the extension system. This was done by extensive search of literature and discussion with experts. The dimensions under which various resilient strategies were categorized are; ecological resilience, economic resilience and social resilience.

4.6.1. Ecological dimension of climate resilience

Ecological dimension of climate resilience were identified as factors which make the system sustainable with less sensitivity to climate change shocks. The impact neutralization to the system would be through judicious incorporation and conservation of agro ecological features. This is materialized through practices that enhance soil fertility, restore biodiversity, tolerate stress and location specific adaptations. The key components of ecological resilience identified from the study are listed in Table 4.16.

4.6.2. Economic dimensions of climate resilience

Economic dimensions of climate resilience include components that enhance or ensure economic stability of the farmer. Farmers who have promising sources of income are found to be less vulnerable economically. Alternative livelihood options or allied agricultural activities were found to ensure economic resilience. It was also observed that agriculture as an enterprise with proper value addition and marketing would reduce farmer's distress and wastage during peak production period, thus making the venture remunerative throughout the year. Components that enhance economic resilience of the farming community are listed in Table 4.16.

4.6.3. Social dimension of climate resilience

A well prepared community that is capable of facing the impacts of climate change efficiently is generally termed as a climate resilient community. It was found that climate change awareness and education coupled with better community network and adequate infrastructure would absorb the climate change consequences, particularly in a sensitive sector like agriculture. The key components identified are listed in Table 4.16.

Table 4.16. Key components identified under various dimensions of climate resilient agriculture

Ecological resilience	Economic resilience	Social resilience
Improving soil fertility by bio inputs	Integrated farming	Low input agriculture
Soil health card and soil test based production system	Agroforestry	Recycling
Integrated nutrient management practices	Seed security/ seed bank	Participatory watershed development
Adoption of water saving technologies	Mixed farming	Community seed distribution
Adoption of water saving crops	Alternative livelihood options	Social infrastructure
Cultivation of indigenous crops	Commercialization of agricultural venture	Community preparedness
Conservation of biodiversity	Weather based crop insurance	Availability of social capital
Drought resistant/tolerant varieties	Use of solar power	Climate change education and awareness
Stress tolerant varieties	Value addition	Community network
Indigenous practices/ farmers wisdom	Marketing facilities	-
-	Preservation/ cold storage facilities	-
-	Household assets	-

4.7. Role of various agencies in mainstreaming climate resilience

The key institutions/ agencies involved in mainstreaming climate resilience were identified by means of analysis of the programmes of various development agencies in Kerala followed by group discussion with experts, extension officials and farmers. Table. 4.17 shows the identified institutions and their role in mainstreaming climate resilient agriculture in Kerala.

Table 4.17. Role of development agencies in mainstreaming climate resilience into development interventions

Sl. No.	Institution/agency	Role
1.	Indian Meteorological Department (IMD)	➢ Agro advisory services and bulletins
2.	The Department of Environment and Climate Change (DoECC)	➢ Activities related to National Action Plan on Climate Change ➢ Exercise administrative control of all environmentally related institutes being established in the state ➢ Conduct environmental appraisal at planning level, scrutinize the environment related proposals, involve in various environmental technology activities of local self-government institutions ➢ The nodal department to co-ordinate with other departments on matters related with environment, awareness generation, climate change management etc.
3.	State Agriculture Management and Extension Training Institute (SAMETI)	➢ Provide need based training programmes for middle level extension functionaries on climate resilient technologies ➢ It organize annual workshop focusing on building resilience in to the system
4.	Kerala Agricultural University (KAU)	➢ Research on impact of climate change ➢ Development of resilient technologies ➢ Development of resilient farming systems ➢ Agro Advisory Services ➢ Agro met advisory services ➢ Interdisciplinary task forces on climate change mitigation
5.	Krishi Bhavan	➢ Grassroots level institution in providing extension services (advisory),

Sl. No.	Institution/agency	Role
		information support, training and financial support in building climate awareness and adaptation
6.	Krishi Vigyan Kendra (KVK)	➢ Regional specific sustainable land use system and scientific farming technologies ➢ Agromet advisory services
7.	Kerala Institute of Local Administration (KILA)	➢ Giving sensitizing programme on climate change challenges to the Panchayat Raj Institution Members
8.	Mahathma Gandhi National Rural Employment Guarantee Scheme (MGNREGS)	➢ NREGA funds can be effectively used for executing climate adaptation strategies in agriculture, waste management and livelihoods ➢ Channelizing and mobilizing local initiatives for soil and water conservation activities and building community resilience
9.	State Horticultural Mission (SHM)	➢ Initiating various training and advisory services to develop policies and schemes for sustainability of horticultural crops ➢ Post-harvest management, processing and marketing support for horticultural crops
10.	Farm Information Bureau (FIB)	➢ Publication and broadcasting of locally relevant resilient technologies and updated information through farm news, radio programme, video programme
11.	Kerala State Seed Development Authority (KSSDA)	➢ Ensure seed security of the state ➢ Seed distribution during natural calamity
12.	Vegetable and Fruit Promotion Council Keralam (VFPCK)	➢ Support, maintain, increase and promote the commercial production of vegetable and fruits and their consumption. ➢ Technical support and training on resilient innovative technologies

Sl. No.	Institution/agency	Role
		➢ Haritha Nagari Scheme in urban and semi urban areas to make each house hold self-sufficient in farming ➢ Weather data collection. ➢ Credit and insurance scheme ➢ Group marketing-Swasraya Karshaka
13.	Agro Meteorological Advisory Services (AMAS) under the scheme "Gramin Krishi Mausam Seva (GKMS)" at Ambalavayal	➢ GKMS of IMD rendered twice a week to farmers in collaboration with State Agricultural Universities (SAUs), Institutions of Indian Council of Agricultural Research (ICAR), IITs. ➢ District level weather forecast for next 5-days in respect to- rainfall, maximum temperature, minimum temperature, wind speed, wind direction, relative humidity and clouds, weekly cumulative rainfall forecast ➢ Crop specific advisories to farmers through different print/visual/Radio/ IT based media including short message service (SMS) and Interactive Voice Response Service (IVRS) facilitating for appropriate field level actions.

The list of services offered by various agencies clearly showed the relative roles played by them in mainstreaming climate resilience into the paradigm of agricultural development in Kerala. It could be easily inferred that a single agency would not be able to mainstream climate resilience in the agricultural sector of the state. Accomplishing the objective of mainstreaming climate change requires integration of all these agencies in several patterns. Building up synergy through proper linkages among these agencies appears to be very important in mainstreaming climate resilience in the planning and implementation of development programmes. Roles of these institutions are both complementary and supplementary. Building resilient communities would not be possible unless these agencies redefine their roles proactively to integrate with other agencies.

4.8. Socio-economic profile of the respondents

Since awareness and adoption are found to be greatly influenced by the socio-economic characteristics of the farmer, an analysis was done to draw out the profile of the farmers for the study and to find out whether these characteristics significantly influenced the level of awareness and adoption shown by them. The socio-economic profile of the respondents are described below.

4.8.1. Age

Respondents were categorized into groups *viz.* young (>35 years), middle aged (35-45 years) and aged (>45 years). Similarly, extension officials were also categorized according to their age. Groups and their respective frequency and percentage are given below (Table 4.17).

Table 4.18. Distribution of respondents based on their age (n=140)

Category	Farmers (n=100)	Extension personnel (n=40)	
	Frequency (%)	Frequency	Percentage
Young (less than 35)	1	14	35
Middle aged (35-55)	53	25	62.5
Aged (more than 55)	46	1	2.5
Total	**90**	**40**	**100**

Categorization of farmers based on their age showed considerable difference in the proportion of young and aged groups, with majority coming under the middle aged or aged categories. (See Table 4.17). The average age of the farmers was found to be 55. While 53 and 46 per cent of the farmers belonged to 'middle age' and 'aged' groups respectively, youngsters comprised only one per cent of the total respondents. Whereas, 62.5 and 35 per cent of the officials included in the study were middle aged and young

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respectively. These findings are found to be in agreement with the findings of Kumaran (2008); Adebayo *et al.* (2012) and Joseph (2016).

As widely observed, agriculture sector has been quite unattractive to the youth. Some traditional farmers have also expressed their indifference to pursue farming. This could be attributed to the prolonged nature of agriculture to yield results, sensitivity to climatic fluctuation and unpredictability in getting remunerative profits. While other jobs pay better remuneration, the hardship and tribulation involved in agriculture tend the youth to abandon agriculture for better prospects.

4.8.2. Gender

The distribution of respondents based on their gender revealed that 97 per cent of the farmers were male and only 3 per cent were female. However, regarding the extension personnel, an equal distribution of male and female could be found. (Table 4.18)

Table 4.19. Distribution of respondents based on their gender (n= 140)

Category	Farmers (n=100)	Extension personnel (n=40)	
	Frequency (%)	Frequency	Percentage
Male	97	20	50
Female	3	20	50
Other	0	0	0
Total	**100**	**40**	**100**

As understood from local enquiries and general observations, this trend has been continuing for many years. It was observed that women's contribution to agriculture was strictly influenced by the economic status of the family. This could be due to the fact that majority were paddy farmers, who worked in their own fields as well as in land possessed by the female members of the family. Though women owned land, they were not actively engaged in main farming operations. This was observed by Athira (2017) while studying trend of paddy cultivation in Palakkad.

In the case of farmers in Wayanad, women participation was much more prominent, as most of them had mixed farming activities. Intercultural operations in perennials like coffee and tea were majorly done by women. Another factor determining women inclusiveness is nearness of the farm to the household. Better educational status and social network must be influencing the participation of women in agriculture everywhere in the Kerala, in spite of the proactive involvement of women groups in agriculture, who usually undertake farming in leased lands. Most of the women involved in farming usually do not get included in the category of farmers as they do not own land on their own. All these might have reduced the participation of women in agriculture to such a lower percentage as evident from the results.

4.8.3. Education

Distribution of respondents based on education is shown in Table 4.19.

Table.4.20. Distribution of respondents based on their education (n=140)

Category	Farmers (n=100)	Extension personnel (n=40)	
	Frequency (%)	Frequency	Percentage
Can read and write	4	NA	NA
Primary education	54	NA	NA
High school	33	NA	NA
Higher secondary/ VHSE	4	7	17.5
Collegiate education	5	19	47.5
Master's degree and above	0	14	35
Total	**100**	**40**	**100**

The results showed that 54 per cent of the farmers had primary education whereas 33 per cent had acquired high school education. Respondents with qualification above matriculation was only 9 percentage 4 per cent with higher secondary and 5 per cent with collegiate education.). Farmers who could just read and write constituted only 4 per cent of the total respondents. As much as 47.5 per cent of the extension personnel were graduates, 35 per cent officials had master's degree and only 17.5 per cent officials interviewed had studied up to VHSE.

Distribution of farmers across different categories of educational qualification was in line with the general trend observed in our state. Due to high influence of climatic change on agricultural production and lack of proper institutional mechanisms to streamline climate resilient agricultural development, agriculture is continuously proving to be less remunerative. Uncertainties in the prospects of pursuing agriculture as a career deter a vast majority of the young and educated people in the state from adopting it as their livelihood option. In mainstreaming climate resilient agricultural development, the state should focus on efforts to attract educated youth to agriculture by making it remunerative and knowledge intensive. As Adebayo *et al.* (2012) pointed out. Education was an important factor that determined the ability of an individual to understand policies and programs relating to climate change adaptation.

4.8.4. Farming experience

Experience of the farmers and extension personnel was measured in terms of the number of years of their engagement in respective vocation. Distribution of respondent based on their experience is presented below in Table 4.20.

Table. 4.21. Distribution of respondents based on their experience (n=140)

Category	Farmers (n=100)	Extension personnel (n=40)	
	Frequency (%)	**Frequency**	**Percentage**
Less than 5 years (low)	0	27	67.5
5-10 years (medium)	3	8	20
More than 10 years (high)	97	5	12.5
Total	**100**	**40**	**100**

Majority of the farmers (97 per cent) were found to be highly experienced farmers with farming as their major activity for more than 10 years. About 3 per cent farmers were included in medium category with 5- 10 years of experience. None of the selected farmer respondents came under low experience category. With regard to experience of the extension personnel, 67.5 per cent officials had less than 5 years of experience. Medium and highly experienced officials constituted only 20 and 12.05 per cent respectively. This distribution would influence the attitude of farmers to climate change interventions as opined by many authors (Maddison, 2006; Ishaya and Abaje, 2008; Deressa, *et al.*, 2009), who had concluded that experienced farmers had a higher probability of perceiving climate change as very decisive , as they had witnessed several changes climatic conditions over the long duration of their lives. Varghese (2012) concluded that the higher proportion of experienced farmers in Wayanad was indeed helping the sustainability of agriculture even in the hard times of climate change. Adebayo, *et al.* (2012) in their study on climate change awareness, vulnerability and adaptation found that adaption of farmers to climate change depended only on their previous experience. This results were on par with the observations made by Jasna (2015), who concluded that greater the years of involvement with farming practices more the adoption of climate resilient technologies.

4.8.5. Annual income

Farmers were categorized in to different income categories based on their income from agriculture and other sources on yearly basis. The frequency and percentage of farmers under each category are listed below (Table 4.21.).

Table 4.22. Distribution of farmers based on their annual income (n=100)

Category	Frequency (n=100)
Below Rs. 0.5 lakh	8
Rs. 0.5 lakh - 1 lakh	17
Rs. 1 lakh – 2 lakh	29
Rs. 2 lakh – 3 lakh	27
More than Rs. 3 lakh	19
Total	**100**

As seen from the table, majority of the farmers belonged to income categories with 1-2 lakh (29 per cent) and 2-3 lakh per annum (27 per cent). About 19 per cent farmers were earning income more than 3 lakhs. About 25 per cent of the farmers earned less than one lakh. The average annual income of the farmer respondents was found to be 2.44 lakhs. This analysis showed the real plight of farmers and the low profitability of farming as a means of livelihood. Majority of the respondents were found to have less income, which has implications on their resilience to climate change. This is because climate change invariably impacts the poor farmer. On assessing the vulnerability of Wayanad farmers on account of water scarcity, Varghese (2012) also reported that the average household income was 2.41 lakh of which 60 per cent was from agriculture.

4.8.6. Farm size

Based on the cultivable land holding, farmers were categorized into marginal, small, semi-medium, medium and large. Frequency and percentage distribution of the farmers across these categories are listed below (Table 4.22).

Table 4.23. Distribution of farmers based on farm size (n=100)

Category	Frequency (%)
Marginal farmers (<1 ha)	11
Small farmers (1-1.99 ha)	61
Semi-medium farmers (2-3.99 ha)	22
Medium farmers (4-9.99 ha)	6
Total	**100**

Small farmers (61 per cent) with farm size 1-1.99 ha were found to be the most predominant category among the farmer respondents. Of the respondents, 22 per cent had farm size between 2-3-99 ha and constituted the semi-medium category and 11 per cent fell under the category of marginal farmers with farm size less than 1 ha. Only 6 per cent were medium farmers and none of the farmer respondents selected belonged to the large farmer category.

4.8.7. Extent of farming integration

Since climate resilient agriculture is possible only with the integration of farming with various allied activities, extent of integration was assessed based on frequency of farming integration with livestock (See Table 4.23)

Table 4.24. Distribution of farmers based on their farming integration

(n=100)

Category	Frequency (%)
No components	36
Livestock	10
Poultry	25
Livestock + Poultry	27
Livestock + Poultry + Pisciculture	2
Total	**100**

While 27 per cent of the farmers had livestock and poultry integrated with farming, only two per cent farmers were found to have integrated livestock, poultry and pisciculture together. While 25 and 10 per cent of the farmers had integrated their farming with poultry and livestock respectively, none of the farmer was found to have integrated pisciculture alone with farming. Among the total respondents, 36 per cent farmers had not integrated any of these allied activities with farming. The results clearly showed that integration of various farming activities, which is an important strategy to mitigate climate change is yet to be adopted widely by the farming community.

4.8.8. Contact with extension agency

Mainstreaming climate resilient technologies require regular contact with implementing officials at the grassroots level. The frequency of farmers' contact with extension officials were observed and it was found that more than half (51 per cent) of the respondents had frequent contact with officials. As much as 32 per cent of them were regularly associated to the officials and 14 per cent contacted only rarely. Only 3 per cent were found to have no contact with extension officials. The distribution observed is given in Table 4.24.

Table 4.25. Distribution of farmers based on their contact with extension agency (n=100)

Category	Frequency (%)
Regular	32
Often	51
Rarely	14
No contact	3
Total	**100**

Majority of the farmers who had frequent contact with extension agency would be aware of the new schemes or services implemented and they would also gather updated information on resilient practices. Similar to this finding, high extension agency contact was observed by Athira (2017) while studying rice cultivation in Palakkad.

Compared to Wayanad, farmers' contact with extension officials was found to be more in Palakkad. Penetration of extension agency among the farmers is relatively low in Wayanad. This observation is important as farmers with better extension agency contact would be able to address many of the issues related to climate change efficiently and promptly. Adebayo *et al.* (2012) reported that lower percentage of extension contact resulted in poor awareness on climate change and vulnerability, and observed that farmers adapted based on their past experience.

4.8.9. Exposure to training

Since climate change has been playing major role in changing the agricultural scenario in Kerala, it is imperative that our farming community is made climate resilient. Official records had shown that department of agriculture had provided the farmer with different training programs on various dimensions of climate resilient agriculture. Distribution of farmers based on the frequency of exposure to various training programs that facilitated awareness and adoption of climate resilient practices are categorized below (Table 4.25).

Table 4.26. Distribution of farmers based on exposure to training on climate resilient agriculture (n=100)

Category	Frequency (%)
No training	11
Less than eight training	89
More than eight training	0
Total	**100**

The results showed that majority (89 per cent) of the farmers had attended less than eight trainings. Only 11 per cent farmers had not participated in any of the training programs on climate resilience. There were no farmers who had gained more than eight such exposure training.

4.8.10. Innovativeness

Innovativeness of the farmers is reported to be very important in adopting new practices and evolving new ways of adaptation. Innovativeness was measured by a scoring technique, which elicited the respondent's willingness to accept new ideas and seek changes in farming in the changing climatic scenario. The results are given in Table 4.26.

Table.4.27. Distribution of farmers based on their innovativeness

Category	Farmers (n=100)	
	Score range	Frequency (%)
Low (Mean- S.D.)	<37	27
Medium (Mean ± S.D.)	37-46	53
High (Mean + S.D.)	>46	20
	Mean= 41.05 S.D. = 4.95	

The distribution showed that majority of the respondents had only medium innovativeness and the proportion of farmers with high innovativeness was only 27 per cent. Improving innovativeness would be an important intervention by the development agencies to make adoption of new climate resilient practices possible. Smith (2010) argued that resilient agriculture needed adaptive innovations with organic inputs. Devarajan (2016) opined that innovation, value chain development, regulatory and quality services would bring convergence in extension initiatives leading to resilience in agricultural system

4.8.11. Access to climatological information

Utilization of various forms of mass media (TV, radio, newspaper, magazine, mobile, and the Internet) to access climatological information was observed among the farmers. The result of the distribution of farmers based on their frequency of access to climatological information is as follows (Table 4.27).

Table 4.28. Distribution of farmers based on their access to climatological information (n=100)

Category	Frequency (%)
Daily	76
Weekly	22
Fortnightly	2
TOTAL	**100**

Majority of the farmers (76 per cent) had the facilities to access climatological information on daily basis. About 22 per cent farmers were found to have accessed climate related information on weekly basis and only 2 per cent farmers had accessed such information at fortnightly interval. Raghuvanshi *et al.* (2018) concluded that multilevel institutional platform where farmers can access climate information, which they could use to improve farm planning (i.e. choices of crops, timing of farm preparation, and harvest) would enhance climate resilience of farmers.

4.8.12. Social participation

The involvement of a respondent in organizations like Grama panchayats, cooperative society, SHG, farmer organization, samithies etc either as a member or as an office bearer, was assessed and the results obtained is given in Table 4.28

Table 4.29. Distribution of farmers based on their social participation (n=100)

Category	Frequency (%)
Non-member	7
Member	26
Office bearer	67
TOTAL	**100**

The distribution revealed that more than 90 per cent of the respondents were involved in social activities either as a member (26 per cent) or as an office bearer (67 per cent). Majority of the respondents reported that they were responsible office bearers of various organizations. Only 7 per cent of the respondents had no linkage with social organizations. As Alex (2012) observed, this trend has greater implications as building and empowering resilient rural communities would enhance sustainable natural resource management and livelihood security. Community resilience is enhanced by better social participation. Raghuvanshi *et al.* (2018) also reported that participation in climate resiliency field school at community level had increased farmers' resilience to climate change by initiating localized adaptation strategies.

4.9. Factors affecting level of awareness on climate change by farmers

Since awareness is affected by several socio-psychological and economic factors, an attempt was made to find out the factors that might be affecting farmers' level of awareness on climate change and its impacts. The coefficient of correlation was calculated to find out the relationship between selected characteristics of the farmers and their level of awareness towards climate change. Table 4.30. shows the significant socioeconomic, personal and psychological characteristics that contribute to their awareness on climate change.

Table 4.30. Factors affecting awareness on climate change

Variables	Spearman Rank correlation (ρ)
Farm size	0.472**
Annual income	0.424**
Innovativeness	0.468**
Extent of farming integration	0.667**
Exposure to training	0.288**
Extension agency contact	0.371**
Access to climatological information	0.278**
Institutional support	0.361**

** Sig. at 5% level

Among the selected variables, farm size, annual income, innovativeness, extent of farming integration, exposure to training, contact with extension agency, access to climatological information and institutional support were found to have positive and significant relation with awareness on climate change and its impacts on agriculture. It may be due to the fact that farmer who possessed large landholding observed visible impacts of changing climatic conditions. Level of education and access to extension services had significant association with awareness on climate change which was also observed by Kamruzzaman (2015) and Raghuvanshi *et al.* (2017).

4.10. Factors affecting farmers' awareness on climate resilient technologies/ mitigation practices

Factors that influence the level of awareness in various climate resilient technologies were assessed by correlating socio-economic variables with farmer's level of awareness on mitigation strategies (See Table 4.31).

Table 4.31. Factors affecting farmers' level of awareness on mitigation strategies/climate resilient technologies

Variable	Spearman Rank correlation (ρ)
Education	0.278**
Farm size	0.385**
Annual income	0.352**
Innovativeness	0.368**
Extent of farming integration	0.387**
Access to climatological information	0.213**
Institutional support	0.327**

** Sig. at 5% level

Among the selected variables, education, farm size, annual income, innovativeness, extent of farming integration, access to climatological information and institutional support were found to have significant relation with awareness on climate change and its impacts on agriculture. The results were in consistent with the findings of Latha *et al.* (2012); Shashidahra and Reddy (2012) and Legesse *et al.* (2013) who also observed a positive and significant correlation between awareness on climate change and socio-economic characteristics like farm size, income, innovativeness and institutional support.

4.11. Factors influencing the extent of adoption of climate resilient practices

Since adoption is affected by several socio-psychological and economic factors, an attempt was made to find out the factors that might be affecting farmers' extent of adoption of mitigation strategies. Analysis was done to identify the factors affecting adoption of climate resilient technologies (Table 4.32).

Table 4.32. Factors influencing extent of adoption of mitigation strategies/ climate resilient technologies by farmers

Variable	Spearman Rank correlation (ρ)
Education	0.717**
Farm size	0.773**
Annual income	0.748**
Innovativeness	0.761**
Extent of farming integration	0.692**
Exposure to training	0.304*
Extension agency contact	0.262**
Access to climatological information	0.507**
Institutional support	0.458**

** Sig. at 5% level * Sig. at 10% level

Among the selected variables, education, farm size, annual income, innovativeness, extent of farming integration, exposure to training, contact with extension agency, access to climatological information and institutional support were found to have significant relation with awareness on climate change and its impacts on agriculture. The results indicated that experienced farmers had a higher probability of perceiving climate change as they had been exposed to past and present climatic conditions. The results also suggested that greater the years of involvement with farming practices, more the adoption of climate resilient technologies which was also concluded by many authors (Maddison, 2006; Ishaya and Abaje, 2008; Deressa *et al.*, 2009 and Jasna, 2015).

4.12. Correlation between awareness on climate change and awareness on mitigation strategies

An attempt was done to find out whether there was any correlation between awareness on climate change and awareness on mitigation strategies. The result obtained is shown in Table 4.33.

As expected, positive and significant correlation (0.61) was observed between these two variables which also implied that creating awareness on the multiple dimensions and possibilities of climate change would be a great trigger to enhance adoption of climate resilient technologies by individual farmers and building resilient communities across the state.

Table 4.33. Correlation between awareness on climate change and awareness on mitigation strategies

Correlation between	Spearman Rank correlation (ρ)
Awareness on climate change and awareness on mitigation strategies	0.619**

** Sig. at 0.01 level

4.13. Correlation between awareness on mitigation strategies and extent of adoption of mitigation strategies

Though awareness and adoption are closely related to each other as demonstrated by literature, the magnitude of relationship between the two was estimated. As shown in Table 4.34, positive and significant correlation (0.667) could be observed between awareness on climate change and adoption of climate resilient practices.

Table 4.34. Correlation between level of awareness and extent of adoption of mitigation strategies

Correlation between	Spearman Rank correlation (ρ)
Level of awareness and extent of adoption of mitigation strategies	0.667**

** Sig at 0.01 level

This observation was found to be in agreement with Marshall *et al.* (2013) and Adebayo *et al.* (2012).

Summary & Conclusion

Chapter 5

SUMMARY AND CONCLUSION

5.1. Introduction

As the global threat of climate change looms large day by day, developing countries like India appear to be increasingly vulnerable to its deleterious effects. With majority of people depending on agriculture and the excessive pressure on natural resources and poor coping mechanisms, the impact of climate change would be much severe than expected. Indian agricultural sector is highly vulnerable to climate change than any other sectors as 67 per cent of the net sown area is rainfed, which is contributing 44 per cent of food grain production and supporting 40 per cent of the population.

Kerala, with its receding share of agriculture is also under the pressure of climate change. Unprecedented trends of erratic monsoons and warmer summer season in recent times have impacted agricultural production in many places in the state.

Realization that climate change could have negative consequences on agricultural production has enhanced the desire to build resilience into agricultural systems across the world. This requires mainstreaming climate resilience into agricultural systems through research, awareness building, standardization of new cultivation practices and introduction of adaptation practices all of which call for targeted extension delivery, special support packages, action research programmes and participatory problem solving. Reorientation of the extension delivery system by equipping the extension institutions with scientific content and action programmes to propagate the strategies to mitigate climate change is imminent.

In this context, the present study was under taken to appraise of the readiness of the public extension system. The core task of this research study was to study various dimensions of climate resilient agriculture with special emphasis on finding current resilient practices being adopted by farmers and indexing the vulnerability of the study area. The specific objectives of the study were:

5.2. Specific objectives

To address above mentioned issues the present study was conceived with the following specific objectives:

1. To explore various dimensions of climate resilient agriculture as experienced by the farming community and the extension system
2. To assess the readiness of the public sector extension system in the state to mainstream climate resilience into agricultural development
3. To measure level of awareness on climate change by stakeholders
4. To measure level of awareness and extent of adoption of climate resilient technologies
5. To study the role of institutions in facilitating adoption.

5.3. Research methodology

For the proposed study, *ex-post-facto* research design was used. Palakkad and Wayanad were purposively selected based on the incidence of severe climate change like excessive rain and/or drought and its reported impacts. The sample of respondents included 40 officers of the Department of Agriculture (Agricultural Officers, Agricultural Assistants) and 100 farmers. Based on the proportion of the number of Krishi Bhavans in Palakkad and Wayanad district (i.e.; 95 in Palakkad and 26 in Wayanad), 30 and 10 Krishi Bhavans respectively were selected randomly from each district. Ten Krishi Bhavans were randomly selected from the selected 40 Krishi Bhavans to constitute the sample of farmers .From each of these 10 Krishi Bhavan selected, 10 prominent farmers were randomly selected to form a sample size of 100 farmers. Data were collected from the respondents using personal interview method with the help of structured interview schedule designed for this purpose. Appropriate descriptive and inferential statistical tools were used to analyze the data.

5.4. Major findings

5.4.1. Dimensions of climate resilient agriculture as experienced by the farming community and the extension system

- Ecological dimension of resilience are those components that make the system sustainable with less sensitivity to climate change shocks. The impact neutralization to the system is imparted through judicious incorporation and conservation of agro ecological features. This is materialized through practices that enhance the soil fertility, restore the biodiversity, tolerating stress and through location specific adaptations.
- Economic dimensions of climate resilience basically comprises those components that enhance or ensure economic stability of the farmer. Agriculture as an enterprise with proper value addition and marketing would reduce farmer's distress and wastage during peak production period and climatic aberrations, thus making the venture remunerative throughout the year.
- A well prepared community to face the impacts of climate change is the essential feature for a climate resilient community. Climate change awareness and education coupled with better community network and adequate infrastructure would absorb the climate change consequences, particularly in a sensitive sector like agriculture. All these contribute to social dimension of resilience.

5.4.2. Readiness of the public sector extension system in the state to mainstream climate resilience into agricultural development

- Among the sixteen identified programs, 'vegetable development programme' with an average of 29.8 per cent climate resilient components had higher readiness in terms of the number of components addressing climate change more comprehensively than any other programme of the Department of Agriculture. 'Fruit, flowers and medicinal plant development programme' was found to have the least number of components that facilitated climate resilience, with an average 5.16 percentage of climate resilient components.
- Based on the mean ± S.D. obtained for the weighted score of institutional support was categorized and majority (68 per cent) farmers belonged to medium category who had availed institutional support from various agencies. Input subsidies, credit facilities, insurance supports, exposure to trainings, awareness seminars, demonstrations of resilient technologies, marketing supports, exposure visits, agro advisory services were the support availed by farmers.
- Readiness in terms of financial support revealed that 'soil and root health management and productivity improvement' had the highest growth rate (46.51) followed by 'contingency programme to meet natural calamity and pest and disease endemic' (37.97). 'Hi-tech agriculture' had the highest negative growth rate (-39.16).
- Some programmes like 'Wayanad package' and 'organic agriculture and good agricultural practices' has zero growth rate over the years.
- The result showed that extension support (4.88) scored highest rank among the components followed by crop production (4.69), intercultural operation and support (3.22), post-harvest (3.16), plant protection (2.88) and irrigation (2.19). Thus, considering both the outlay and number of programme components, extension support (4.88) and crop production (4.69)

interventions were found to be the most important climate resilient interventions in the development programmes selected for the study.

- Since the presence of climate resilient practices in development programmes are inadvertent, no particular pattern of occurrence of climate resilient components could be observed in any of the programme.

5.4.3. Level of awareness on climate change by stakeholders

- 100 per cent farmers were found to be aware of increase in average temperature, decreases in average rainfall, long dry spells, fluctuations in the onset of monsoon and uneven distribution of rainfall.
- Only less than 10 per cent farmers were fully aware of those components that are not usually observed in the climate scenario in Kerala.
- With regard to components related to soil and water, the only component about which all the farmers had full awareness was 'depletion of ground water'.
- Only 45 per cent of the farmers had reported that they were fully aware of 'reduced quality of water'. Similarly, only 57 per cent of the farmers observed to be fully aware of reduced soil fertility.
- 19 per cent of the farmers were not aware about the issues of water quality and 14 per cent about reduced soil fertility.
- 99 percent farmers expressed that they were fully aware of increased water stress, which is deadly impact of climate change.
- Increased crop weed competition and reduction in crop duration, the important aspects of cultivation at the field level were found to be known to only 87 per cent and 83 per cent of the respondents respectively.
- Awareness on animal husbandry related components, which has substantial role to play in the scheme of interventions to mitigate climate change was also found to be high as understood from the distribution of farmers across different levels of awareness.

- Farmer's cognizance on climate change impact on crop was found to be higher (95.6), followed by climate related aspects (95.45), animal husbandry (93.72) and soil and water related impacts (92).
- Awareness of extension personnel on climate related and crop related impacts of climate change was higher (95.6) than animal husbandry related (94.3). Whereas the awareness on soil and water related changes (99.7) was far exceeding than the overall awareness on all other components.

5.4.4. Awareness on climate resilient technologies

- Distribution of farmers based on their level of awareness on soil and water conservation measures showed that 100 per cent farmers were aware of rainwater harvesting, water recycling and addition of organic matter as effective climate resilient techniques.
- Cultural practice of digging and maintaining farm ponds and construction of live bunds were found to be known to almost every respondents with 81 per cent and 75 per cent fully aware of the techniques and the remaining respondents partially aware, respectively of the soil and water conservation techniques.
- However, contouring was found to be known fully by only 48 per cent and 12 per cent not aware of this technique at all. Out of the 11 technique listed, conservation tillage, a fairly new concept was not known to 16 per cent, with as much as 60 per cent partially and 24 per cent fully aware of it.
- Integrated nutrient management, organic farming, integrated weed management practices, community nursery for delayed monsoon etc. were found to have been included in the cognizance of all the farmers with more than 85 per cent being aware of the technique and the rest partially aware.
- PPFM spray, a comparatively new technique to mitigate drought was known to about only 59 per cent, with 29 per cent fully aware of it and 30 per cent partially aware.

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- Out of the seven strategies tested in institutional measures, except seed bank, about which 91 per cent farmers were found to be aware, all other measures were found to be not widely known to farmers. Fodder bank, an innovative concept was partially known to 10 per cent farmers and 90 per cent respondents have any awareness on it.

5.4.5. Adoption of climate resilient technologies/practices

- Among soil and water conservation measures, rain water harvesting and water recycling were found to be 98.67 and 96 per cent respectively in adoption and were ranked first and second in extent of adoption and digging and maintaining farm ponds and conservation tillage were found to have least adoption.
- Integrated weed and nutrient management scored higher percentage (93 and 89 per cent respectively) among adoption of agronomic measures
- Alteration in sowing/planting dates (89.67 per cent), community nursery for delayed monsoon (82.34 per cent) and initiatives to shift to organic agriculture (81.34 per cent) ranked second, third and fourth in agronomic measures adopted.
- The measures such as multi-tier cropping system, crop rotation, soil test based fertilizer application, intercropping, soil heath card based practice, alteration in fertilizer/ pesticide usage, crop substitution, use of fertilizers with higher water use efficiency, establishing wind breaks, mixed farming, agroforestry, use of PPFM, pest and disease resistant varieties, drought tolerant varieties, rain shelter cultivation were found to have considerable adoption among farmers ranging from 78.34 to 56.34 per cent of adoption respectively.
- Among the institutional measures, farmer's adoption on seed bank was higher (94.34).
- Adoption of facilities from custom hiring center, weather based warning/ forecast, and cold storage was found to be in the order 79.34, 77 and 70.34.

5.4.5. The role of institutions in facilitating adoption

- Krishi Bhavans are the grassroots level institution in providing extension services (advisory), information support, training and financial support in building climate awareness and adaptation
- Kerala Agricultural University (KAU) is the body that is involved in research on impact of climate change, development of resilient technologies, development of resilient farming systems, Agro advisory services, agro met advisory services, interdisciplinary task forces on climate change mitigation
- Krishi Vigyan Kendra (KVK) are involved in improvising regional specific sustainable land use system and scientific farming technologies.
- Farm Information Bureau (FIB) is exclusively involved in publication and broadcasting of locally relevant resilient technologies and updated information through farm news, radio programme and video programme.
- Kerala State Seed Development Authority is involved in seed security of the state.
- State Horticultural Mission (SHM), Vegetable and Fruit Promotion Council of Kerala (VFPCK) are involved in activities that enhance sustainability in production and distribution of horticultural plants along with schemes providing insurance, subsidy and credit facilities.
- Kerala Institute of Local Administration (KILA) is providing sensitizing programme on climate change challenges to the Panchayat Raj Institution Members.
- Mahathma Gandhi National Rural Employment Guarantee Scheme (MGNREGS) involved in channelizing and mobilizing local initiatives for soil and water conservation activities and building community resilience.
- The Department of Environment and Climate Change (DoECC) and State Agriculture Management and Extension Training Institute (SAMETI) are

providing need based guidance to other departments on subject related to climate change in planning and administration.

- GKMS of IMD center at Ambalavayal has been successful in providing crop specific advisories to farmers through different print/visual/Radio/IT based media including short message service (SMS) and Interactive Voice Response Service (IVRS) facilitating for appropriate field level actions.

5.5. Recommendations

- With the view of the level of awareness and extent of adoption of mitigation strategies, an extension strategy designed to mainstream climate resilient agricultural development should involve researchers, extension functionaries and farmers with the following :
  1. Awareness program on climate change and its impact on agriculture
  2. Technical support in designing suitable farming system according to regional adaptation
  3. Establishing community based soil and water conservation structures
  4. Development and dissemination of new varieties which are resistant to drought and other stresses
  5. Prioritization of forecasting on updated weather data
  6. Capacity building to enhance knowledge level and practices like organic farming, good agricultural practices so as to improve soil fertility
  7. Educating the farmers on contingency crop planning
  8. Incorporating techniques to improve soil moisture conservation
  9. Infrastructural and financial support to the farming community for storages, post-harvest and marketing
- Need to bridge governance gap- role of Local Self Governments (LSG) remains understated in strategic climate resilient planning. Lack of readily available expertise and knowledge tools at LSG level brings down their

decision-making capabilities, despite the crucial role they play during implementation of projects

- Funding is being inadequately mobilized for climate action projects and instead gets underutilized in low-priority or low-impact areas. Climate funding also often seems to be channeled into projects unsuitable to local context (financial gap).
- Research, Awareness, Capacity building, and Training - investment should be made in addressing the knowledge gap and action-based research must initiated to feed back into policymaking. Knowledge gathering/knowledge transfer efforts needs to more organized and given more importance.
- Local strategies to deal with climate change have to be ensuring resilience in the existing natural resource base of the state against influence of the shock of climate change and adaptive actions based on the available and upcoming information's related to the impacts and implications of climate change.

5.6. Conclusions

- Though the farming community and the extension systems in Kerala are becoming increasingly aware of the impact of climate change, adoption of climate resilient practices are not very encouraging.
- Mitigating this issue requires innovative interventions, which should focus on accomplishing ecological resilience, economic resilience as well as social resilience.
- Institutional and financial support mechanisms should be strengthened along with research and development and technology transfer in the domain of climate change.

5.7. Implications of the study

- The findings of the study will provide feedback to the institutions engaged in dissemination of climate resilient technologies for further redesigning the interventions, in order to improve its output and outcome.
- The methodology of the study will be useful for assessing impact of climate resilient technologies in other parts of the country as well as the state. The livelihood vulnerability index modified and used in the present study will be useful for researchers for further assessing the vulnerability of similar areas.
- The study identified and assessed the current climate resilient technologies being adopted by the farming community. Focusing on mainstreaming these technologies along with proper emphasize on the rest of technologies will help to formulate exclusive extension strategies for addressing climate change and its impacts constructively.
- An appraisal of the readiness of the public extension system will help the researchers and policy makers in devising suitable policy framework to mainstream climate resilient agricultural development.

5.8. Suggestions for future research

- Assess the climate change vulnerability of agriculture in the rest of districts in Kerala
- Evolve methodologies to find out the resilience index of farming communities in Kerala
- Study the institutional innovations in dissemination and promotion of climate resilient technologies
- Identify the role of community mobilization for higher adoption of climate resilient technologies along with documentation of the constraints in adoption

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Appendix

APPENDIX – 1

KERALA AGRICULTURAL UNIVERSITY

COLLEGE OF HORTICULTURE

VELLANIKKARA

DEPARTMENT OF AGRICULTURAL EXTENSION

SCHEDULE FOR DATA COLLECTION FROM FARMERS

Mainstreaming climate resilience in to agricultural development:

Readiness of the extension system in Kerala

Serial No: Date:

1. Name of the farmer:

2. Address with Phone No.:

3. Age of the respondent:

4. Gender: Male/ Female

5. Education:

Illiterate	Can read andwrite primary education	High school	Higher secondary	Collegiate education	Masters' and above
1	2	3	4	5	6

6. Farming experience (No. of years):

7. Farm size:

Type of land	**Owned (acres)**	**Leased in (acres)**	**Leased out (acres)**	**Type of farm**
Garden land Crops 1. 2.				
Wet land 1. 2.				
Total				

190

8. Irrigation

Source of water	Number	Ownership details		
		Owned	External	External + owned
Well				
Tube well				
Farm pond				
Others(specify)				

9. Farm details

Crop component

Sl. No.	Crop cultivated	Variety	Area (acre)	Production	Season
	Seasonal crop (specify)				
a.					
b.					
	Perennial crops (specify)				
a.					
b.					

Animal component

Sl. No.	Component	Breed	Number	productivity (milk, meat, egg, honey)
1.	Cow			
2.	Goat			
3.	Poultry			
4.	Honey bee			
5.	Fish			
6.	Others (specify)			

Value addition

Sl. No.	Item	Product	Additional income
1.			
2.			

10. Annual income

Sl. No.	Source of income	Annual income (Rs.)
1.	Crops : Paddy	
	Pepper	
	Vegetables	
	Coconut	
2.	Animal husbandry: Cow	
	Goat	

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	Poultry	
	Honey bee	
	Fish	
3.	Agro processing	
4.	Other sources (specify)	
	Total	

12. Details of stress experienced due to climate change

Sl. No.	Stress	Indicators/ way as experienced	Severity as experienced by farmer			
			Nil	Mild	Moderate	Severe
1	Stress related to water	• Water shortage				
		• Quality issues (salinity, pollution, heavy metal, hard water)				
		• Storage issues				
		• Conveyance issues				
2	Stress related to climate change	• Increase in growing period • Decrease in growing period • Reduction of productivity • Quality deterioration • Decreased shelf life • Pest and disease outbreak • Others(specify)				
3	Stress related to natural calamity	• Flood • Drought • Hailstorm • Heavy rain • Landslide • Others(specify)				
4	Stress related to pest and disease outbreak	• Pest and disease out break • Pest resurgence • Yield decline • Quality decline • Others(specify)				

13. Awareness of farmers on climate change

Sl. No.	Climate change indicators	Awareness		
		Aware	Partially aware	Not aware
I. Climate related				
1	Increase in average temperature			
2	Decrease in average rainfall			
3	Long dry spells			

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4	Fluctuations in onset of monsoons			
5	Uneven distribution of rainfall			
6	Increased frequency of heat waves			
7	Increase in maximum and minimum temperatures			
8	Prolonged cold weather			
II. Soil & water related				
9	Reduced soil fertility			
10	Depletion of ground water			
11	Reduced quality of water			
12	Disturbed soil texture			
13	Increased soil and water erosion			
14	Reduced water holding capacity			
III. Crop related				
15	Reduction in crop duration			
16	Increased incidence of pests and diseases			
17	Susceptibility of the crop for drought			
18	Decreased fertilizer use efficiency			
19	Increased crop weed competition			
20	Increased water stress			
21	Reduced quality of produce			
22	Reduction in average productivity			
IV. Animal husbandry related				
23	Low productivity of livestock			
24	Increase in disease transmission			
25	Increased mortality			
26	Reduced quality and quantity of forage production			
27	Reduced milk/ meat yield			
28	Susceptibility to pests and diseases			

14. Extent of awareness and adoption of mitigation strategies

Sl. No	**Strategy**	**Awareness**			**Level of adoption**		
		Aware	**Partially aware**	**Not aware**	**Adopted**	**Partially adopted**	**Not adopted**
	Water and soil conservation measures						
1.	Farm ponds						
2.	Micro irrigation						
3.	Rain water harvesting						
4.	Water recycling						
5.	Mulching						
6.	Check dams						
7.	Cover cropping						
8.	Organic matter addition						
9.	Live bunds						

10.	Contouring						
11.	Conservation tillage						
	Agronomic practices						
1.	Soil test based fertilizer application						
2.	Soil health card based practices						
3.	Pest and disease resistant varieties						
4.	Drought tolerant varieties						
5.	Intercropping						
6.	Agroforestry						
7.	Alteration in sowing/ planting dates						
8.	Integrated farming system approach						
9.	Establishing wind breaks						
10.	Alteration in fertilizer/ pesticide usage						
11.	Integrated nutrient management practices						
12.	Crop rotation						
13.	Integrated weed management practices						
14.	High yielding and drought resistant forage crops production						
15.	Use of suitable breeds/ varieties for climate						
16.	Off season cultivation in green house						
17.	Rain shelter during rainy season						
18.	Mixed farming						
19.	Multi-tier cropping						

20.	Community nursery for delayed monsoon						
21.	Shifting to organic farming						
22.	Crop substitution						
23.	Use of fertilizers with higher WUE						
24.	Use of Pink Pigmented Facultative Methylotrophs (PPFM)						
	Institutional measures/ others						
1.	Weather insurance						
2.	Supply management through market and non-market interventions						
3.	Utilizing cold storage facilities						
4.	Cultivation according to weather based warning/ forecast						
5.	Custom hiring centers						
6.	Seed bank						
7.	Fodder bank						

15. Source of information

Sl. No.	Ways by which you become aware of climate change mitigation measures	Institution providing/ agency involved	Frequency
1.	Training		
2.	Exposure visit		
3.	Demonstration plots		
4.	Seminars		
5.	Exhibitions		
6.	Social media		
7.	Radio		
8.	Magazines		

9.	Newspaper		
10.	KB		
11.	Fellow farmers		
12.	Any other sources, specify		

16. Innovativeness

Please indicate your response in the appropriate alternative by putting a tick mark

1) SA- strongly agree, A-agree, UD- undecided, DA-disagree, SD- strongly disagree

Sl. No.	Statements	SD	DA	UD	A	SA
1	You go for adopting new water conservation practices like drip, wick, sprinkler, mist irrigation to adapt to climate change					
2	You go for adopting soil conservation strategies like mulching, zero tillage, cover cropping					
3	You follow conventional farming though climate change play adversely on production					
4	You opt varieties and practices that are being used by farmers world around to mitigate the stressful conditions					
5	You using drought resistant/ tolerant varieties/ crops to cope climate change vagaries					
6	You tried several indigenous technologies to cope climate change effects on crop production					
7	You opt for varieties that are newly released, considering its better stress tolerance					
8	You prefer seasonal cultivation, mainly kharif crops due to water scarcity					
9	You try methods that seem to be successful by fellow farmers					
10	You prefer recommended crops for a particular area, season and soil					
11	You try alternative methods of production and crops and choose the best in order to sustain productivity					
12	You always contacting the resource person near to us (extension agent, progressive farmer)					
13	You access need based information through social media, phone calls to research stations					
14	You are cautious about trying new practices					
15	You would prefer to wait for others to try out new practices first					
	TOTAL					

17. Institutional assistance

Sl. No.	Assistance	Agency/ institution involved	Most helpful (Rank)
a)	Credit		
b)	Insurance		
c)	Training		
d)	Access to climatological information		
e)	Supply of tolerant/ resistant varieties		
f)	Funding		
g)	Technical support		
h)	Support prices		
i)	Compensation for crop loss by the Government		
	Others (specify)		

a) Credit

Have you availed any agricultural credit support? *If yes, specify*

Sl. No.	Crops	Purpose for which credit is availed (greenhouse/ micro irrigation, etc.)	Amount	Credit criteria	Source of credit
1.	Paddy				
2.	Coconut				
3.	Banana				
4.	Vegetables				
5.	Others(specify)				

b) Insurance

Have you insured your crops or livestock's? *If yes, specify*

Sl. No.	Insured crop/ stage of crop/ breed	Insured period	Premium rate	Time taken for settlement of claims
1.				
2.				
3.				
4.				

c) Have you participated in any kind of training programmes on climate change mitigation measures/ awareness? *If so, specify*

Sl. No.	**Topic of training programme attended**	**No of trainings days**	**Skill acquired**	**Rating given to the training**				
				Very good	**Good**	**Neutral**	**Bad**	**Very bad**
1.								
2.								

Do you wish to get additional training on specific subjects related to climate change and crop production? Yes/No. if yes, specify

Sl. No.	**Crop/ strategy**

d) Access to climatological information

Sl. No.	**Source**	**Frequency of access to information**
1.		
2.		

- What kind of compiled weather reports are used for various farm operations /decision making?
- How do you comply information on weather from various sources to put in to use?
- Which kind of information is found to be more helpful; monthly or daily? Why?
- In which form and frequency would you like to get information on climate/ weather

e) Details of tolerant/ resistant variety/cultivar/breed in your farm

Sl. No.	**Crop/animal**	**Variety/breed**	**Specialty**
1.			
2.			
3.			

Do you have enough contact with extension agent? *Often/ rarely/ no contact. If no, specify the reasons*

f) Do the extension agents provide adequate knowledge on climate change impacts and mitigation measures for resilient agriculture? *If yes, specify*

Sl. No.	Extension agent	Ways through which knowledge is provided
1.	Agricultural officer	
2.	Agricultural assistant	
3.	Others	

18. Social Participation:

Are you a member or office bearer of any social/ economic organization?

APPENDIX – 11

KERALA AGRICULTURAL UNIVERSITY

COLLEGE OF HORTICULTURE

VELLANIKKARA

DEPARTMENT OF AGRICULTURAL EXTENSION

SCHEDULE FOR DATA COLLECTION FROM OFFICERS OF DEPARTMENT OF AGRICULTURE

Mainstreaming climate resilience in to agricultural development:

Readiness of the extension system in Kerala

Serial No: Date:

1. Name of the respondent:

2. Age of the respondent:

3. Gender: male/ female

4. Education: (VHSE/degree/post graduate/ doctoral degree)

5. Designation:

6. Experience (no. of years):

7. Programmes /projects addressing climate change (year)

Sl. No.	Name of the programme	Outlay	No. of beneficiaries	Socio-economic profile of beneficiaries				
				Age	Sex	Category		
						General	SC	ST
State sponsored program								
1.								
2.								
State sponsored program								
1.								
2.								
LSGI schemes								
1.								
2.								

8. Human resource development (capacity building)

Training to farmers (year)

Sl. No.	Theme/topic of training	Details/ objective	Duration	Skill imparted	No. of participants
1					
2					
3					

Training to officials (year)

Sl. No.	Theme/topic of training	Details/ objective	Duration	Skill imparted	No. of participants
1					
2					
3					

9. Awareness of officers on climate change

Sl. No.	Climate change indicators	Awareness		
		Aware	Partially aware	Not aware
I. Climate related				
1	Increase in average temperature			
2	Decrease in average rainfall			
3	Long dry spells			
4	Fluctuations in onset of monsoons			
5	Uneven distribution of rainfall			
6	Increased frequency of heat waves			
7	Increase in maximum and minimum temperatures			
8	Prolonged cold weather			
II. Soil & water related				
9	Reduced soil fertility			
10	Depletion of ground water			
11	Reduced quality of water			
12	Disturbed soil texture			
13	Increased soil and water erosion			
14	Reduced water holding capacity			
III. Crop related				
15	Reduction in crop duration			
16	Increased incidence of pests and diseases			
17	Susceptibility of the crop for drought			
18	Decreased fertilizer use efficiency			

19	Increased crop weed competition			
20	Increased water stress			
21	Reduced quality of produce			
22	Reduction in average productivity			
IV. Animal Husbandry related				
23	Low productivity of livestock			
24	Increase in disease transmission			
25	Increased mortality			
26	Reduced quality and quantity of forage production			
27	Reduced milk/ meat yield			
28	Susceptibility to pests and diseases			

11. Extension programmes envisaged (Year)

Sl. No.	Programmes	No. of programmes	No. of participants	Content	Types of deliverables
1.	Workshops				
2.	Field visits				
3.	Awareness programme				
4.	Exposure visit				
5.	Demonstration plots				
6	Others (specify)				

10. Insurance programmes (year)

Sl. No.	Crops that can be insured	Insurance period	Premium rate
1.			
2.			
3.			
4.			

APPENDIX- 111

Scale of Livelihood Vulnerability Index

0 0.5

Low High

APPEXDIX – 1V

Climatic data of Palakkad and Wayanad from 2009-2017

Monthly Tmax average of Palakkad district

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
2009	32	38	36	33	27	29	27	28	28	30	29	30
2010	32	37	39	40	35	29	28	30	31	30	31	32
2011	33	35	38	36	34	30	30	30	30	33	32	32
2012	34	37	39	38	34	31	31	31	32	33	33	33
2013	35	36	38	39	35	29	29	32	32	34	35	34
2014	35	38	39	41	37	34	32	32	34	34	33	34
2015	35	36	39	40	36	33	33	34	35	35	33	33
2016	35	38	41	42	38	32	33	33	34	35	35	35
2017	35	37	39	40	33	29	33	32	32	32	32	30

Monthy Tmin average of Palakkad district

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
2009	18	18	20	23	22	23	22	21	21	20	20	19
2010	18	19	19	24	25	23	21	21	20	19	19	17
2011	17	17	19	20	24	21	21	21	20	20	19	18
2012	17	18	20	22	24	27	21	21	20	20	18	18
2013	18	19	21	23	25	22	21	21	21	20	19	17
2014	17	18	20	23	24	23	21	22	21	21	19	18
2015	19	21	23	24	25	24	23	23	23	23	23	21
2016	22	23	24	26	25	23	23	23	22	22	21	21
2017	21	21	23	25	26	23	23	23	23	23	23	21

Monthly Tmax average of Wayanad district

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
2009	27	32	31	32	29	25	24	25	24	25	24	24
2010	26	31	33	34	31	25	24	25	26	26	25	26
2011	28	30	32	30	30	26	26	25	26	27	26	26
2012	29	31	34	32	29	27	27	26	27	27	27	27
2013	29	30	32	33	31	25	24	28	28	29	29	29
2014	30	32	33	36	32	30	28	28	30	28	29	29
2015	28	28	29	29	28	26	26	26	27	26	24	25
2016	27	30	32	33	30	25	25	26	26	27	26	26
2017	26	29	29	32	18	16	26	25	24	24	23	23

Monthly Tmin average of Wayanad district

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
2009	15	16	18	20	21	20	20	20	20	19	18	18
2010	16	16	19	22	22	20	19	19	19	19	18	16
2011	15	16	17	17	19	19	19	19	19	19	17	15
2012	15	16	18	21	21	19	19	19	1	19	16	16
2013	16	17	19	20	21	19	19	19	19	18	17	15
2014	15	17	19	21	21	20	19	19	19	19	17	17
2015	15	14	16	17	18	18	17	17	17	16	16	16
2016	14	15	16	17	18	18	18	17	17	16	14	14
2017	13	13	16	17	13	12	17	18	19	18	17	15

Mean monthly rainfall of Palakkad from 2009-2017

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
2009	6.71	0.2	114.48	175.85	327.59	405.13	621.96	472.69	534.45	384.35	578.03	174.44
2010	67.63	10.57	29.3	111.49	194.16	418.42	406.98	327.96	484.58	267.76	339.02	56
2011	9.81	63.77	39.7	242.44	254.45	306.46	124.5	151.01	128.48	344.08	193.39	12.15
2012	0.1	2.92	23.33	152.77	202.76	109.34	108.39	129.77	45.65	300.2	89.81	15
2013	0.1	19.89	44.23	96.56	114.88	312.74	240.33	182.28	213.59	230.59	135.5	5.61
2014	1.99	5.68	11.37	63.35	206.26	115.42	182.84	276.78	263.03	474	73.31	65.7
2015	0.3	2.43	27.42	67.41	182.91	90.13	10.88	35.98	59.34	51.56	104.73	29.9
2016	1	0.3	15.66	16.66	51.26	49.58	31.62	13	9.07	45.32	12	8.8
2017	9.8	0	41.8	37.3	78.3	39	24.5	79.3	110.2	104.5	74.3	65.9

Mean monthly rainfall of Wayanad from 2009-2017

Year	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
2009	23.92	1.4	226.43	318.59	606.68	388.15	446.79	468.29	821.38	531.82	806.46	438.23
2010	126.29	34.09	76.07	308.47	422.08	480.69	454.52	545.16	863.55	538.77	692.31	120.8
2011	33.23	116.2	109.91	446.5	504.33	306.55	238.58	274.57	225.53	730.72	389.25	32.03
2012	5.39	8.2	31.81	333.47	536.3	167.22	200.69	287.17	162.57	494.26	136.2	63.21
2013	1.6	78.77	124.66	269.15	416.03	249.03	243.42	404.48	426.85	477.69	256.82	16.39
2014	17.4	33.59	55.01	161.81	481.58	213.68	281.07	606.04	475.93	808.14	116.67	162.32
2015	8.94	34.08	150.77	380.03	923.78	341.71	278.41	341.79	645.15	383.85	762.05	231.57
2016	21.89	8	64.38	98.28	577.28	419.42	609.97	232.6	252.99	252.82	73.9	125.1
2017	77.7	0.5	295.6	233.6	694.5	357.8	300.4	768.6	866.3	733.2	443.2	227.2

Mainstreaming climate resilience into agricultural development: Readiness of the extension system in Kerala

By

T. P. ANSEERA

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ABSTRACT OF THE THESIS

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Kerala Agricultural University, Thrissur

Department of Agricultural Extension

COLLEGE OF HORTICULTURE
VELLANIKKARA, THRISSUR - 680 656
KERALA, INDIA

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Abstract

ABSTRACT

Mitigating the impact of climate change requires mainstreaming climate resilience into agricultural systems through research, awareness building, standardization of new cultivation practices and introduction of adaptation practices, all of which call for targeted extension delivery, special support packages, action research programmes and participatory problem solving. Reorientation of the extension delivery system by equipping the extension institutions with scientific content and action programmes to propagate the strategies to mitigate climate change is imminent.

Kerala, with its receding share of agriculture is under the pressure of climate change. The study attempted to appraise the readiness of the public extension system to face the challenge of climate change in Kerala in terms of the institutional and financial support available and find out the role played by various agencies. The study also assessed the extent of vulnerability at the farm level, delineated the dimensions of climate resilient agriculture and explored the level of awareness and adoption of climate resilient practices among the farming community.

The sample included 40 extension personnel of the Department of Agriculture and 100 farmers drawn from 30 Grama Panchayats in Palakkad and 10 Grama Panchayats in Wayanad. Data were collected by using structured interview schedules and focused group discussions.

The extent of climate change vulnerability at the farm level was assessed using Livelihood Vulnerability Index (LVI) and Palakkad was found to be more vulnerable (0.14) than Wayanad (0.12). Among the dimensions of climate change delineated it was found that there are three distinct dimensions of climate change and its impact, viz. ecological, economic and social resilience. Out of the different components of ecological resilience, agro-ecological features of farming was perceived to be the key component, whereas, integrated farming approach with weather based crop insurance, enhanced seed security and alternative livelihood options would enhance economic resilience of the farming community. Adequate infrastructure and community networks

to encounter climatic debacle and increased awareness on climate change would help build up social resilience.

Awareness of farmers on climate change was found to be higher with respect to crop related aspects and lower in the case of soil and water related components. However, significant difference could be observed between farmers and extension personnel with regard to overall awareness on climate change and its impacts.

Of the different climate resilient practices, rain water harvesting structures, integrated weed management practices and community seed bank were found to be adopted more. Farmers in Wayanad were found to have higher mean adoption index (82.83). Attributes like farm size, annual income, farming integration, access to climatological information, education, institutional support and innovativeness of the farmers were found to have significant positive correlation with awareness on climate resilient practices and adoption.

Readiness of the public extension system to mainstream climate resilience was explored by analyzing 16 programmes of the Department of Agriculture. Functional components of these programmes which would be instrumental in building climate resilience to the system were identified and financial support to each of them was assessed. 'Vegetable development programme' was found to have maximum functional components that could address climate resilience. However, financial outlay of these programmes from 2013-14 to 2017-18 showed higher compound growth rate for 'soil and root health management and productivity improvement' interventions. Considering both the outlay and number of programme components, extension support (4.88) and crop production (4.69) interventions were found to have more readiness to combat climate change.

In view of the positive and significant relationship between climate change awareness and adoption of resilient practices, it is important that the farming community is scientifically oriented towards building climate resilient agriculture. Shortfalls in institutional and financial support should be sealed with redesigning each development programme with adequate components to address climate change.