VULNERABILITY AND ADAPTATION STUDY OF WOMEN EXPOSED TO EXTREME WEATHER EVENTS IN THRISSUR DISTRICT

by

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THESIS

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DECLARATION

I, hereby declare that the thesis entitled "VULNERABILITY AND ADAPTATION STUDY OF WOMEN EXPOSED TO EXTREME WEATHER EVENTS IN THRISSUR DISTRICT" is a bonafide record of research work done by me during the course of research and the thesis has not been previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

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ABBREVIATIONS

UNFCCC	United Nations Framework Convention on Climate Change
IMD	India Meteorological Department
GHG	Green House Gas
HIV	Human Immuno Deficiency Virus
AIDS	Acquired Immuno Deficiency Syndrome
FAO	Food and Agriculture Organisation
QOL	Quality Of Life
IPCC	Intergovernmental Panel on Climate Change
USAID	United States Agency for International Development
SLA	Sustainable Livelihood Approach
THVAF	Total Household Vulnerability Assessment Framework
LVI	Livelihood Vulnerability Index
GCM	Global Circulation Model
ICAR	Indian Council of Agricultural Research
BRAC	Bangladesh Rural Advancement Committee
WDP	Watershed Development Programme
CSV	Climate Smart Village
CGIAR	Consultative Group on International Agricultural Research
CCAFS	Climate Change, Agriculture and Food Security
CSA	Climate Smart Agriculture
ICT	Information and Communication Technology
ACCER	Academy of Climate Change Education and Research
KAU	Kerala Agricultural university
MHH	Male-headed household
FHH	Female-headed household
BPL	Below Poverty Line

LVI-IPCC	Livelihood Vulnerability Index-Intergovernmental Panel on Climate Change
UNDP	United Nations Development Programme
DHS	Domestic Household Survey
WHO	World Health Organisation
NDCV	Natural Disasters and Climate Variability
SDP	Socio-Demographic Profile
NGO	Non-Governmental Organisation
ASPIRES	Accelerating Strategies for Practical Innovation and Research in Economic Strengthening
GCA	Gross Cropped Area
NCA	Net Cropped Area
CI	Cropping Intensity
NBFC	Non-Banking Finance Companies

CHAPTER 1

INTRODUCTION

The world's temperature has already warmed up to almost 1.2° C since the pre-industrial levels and this warming impact is visible in the form of extreme weather events, sea level rise and diminishing Arctic sea ice. Heat waves and drought in Europe and China, forest fires in the U.S., dust storms and extreme rainfall in India (including the Kerala floods 2018) and high precipitation in Japan and other island nations are all examples of the disasters which have occurred within a single year, ie., 2018. With a further 0.5° C warming, these effects would be even more pronounced than the scientists' previous prediction. A 1.5° C warmer world will see higher temperatures, increase in frequency and intensity of precipitation, higher sea levels, and floods, droughts and heatwaves (Venkatesh, 2018).

Natural disasters are low-probability, high-consequence events that can result in significant human losses and economic shocks. Disaster induced economic damage has been increasing in the past few decades and is likely to continue growing because of population growth, urban development and changing land use pattern (IPCC, 2012). In an era where due to climate change the frequency and severity of extreme weather events are increasing, disasters will continue to be a regular phenomenon and we may have to learn to live with the disasters.

According to the study conducted by Hemmati and Rohr (2007), women constitute a disproportionate share among the poor and hence are likely to be extremely vulnerable to the effects of climate change. Around 70 per cent in the 1.3 billion people of developing countries living below the poverty threshold are women. Terry (2009) observed that since the beginning of the twenty-first century, womens' specific gendered vulnerability to disasters have been clearly demonstrated by several extreme climate events, including the Asian tsunami of 2004, the 2003 heat wave in Europe and Hurricane Katrina of 2005, which devastated New Orleans. In 1991, the cyclone which hit coastal Bangladesh killed more women than men (Röhr, 2006). Therefore, since 2012, the United Nations Framework Convention on Climate Change (UNFCCC) has considered gender and climate change as a stand-alone agenda item under the Conference of the Parties. This is because it has been already understood that climate

change has a greater impact on those population sections which are more reliant on natural resources for their livelihood or those who have the least capacity to respond to natural hazards. Women, who are often considered as the poorest of the poor are at a greater disadvantage as their income is mostly derived from informal sources.

Globally, more than 400 million women engage in farm work in more than 90 countries. Agriculture being a climate sensitive sector, climate change takes a huge toll on this area. Women are usually engaged in subsistence agriculture and labor-intensive works which worsens their susceptibility to climatic change (Lambrou and Piana, 2006). Hence during extreme weather events, women experience greater impacts and vulnerability than men. They also become economically insecure following a disaster.

In Africa, women and female-headed households tend to be more vulnerable and less resilient to climate change, risk and environmental degradation as they depend more on natural resources for their income. They are responsible for water and fuel wood collection. They have fewer assets and less access to financial services. Around 20-30 per cent women have lesser capacity than men to come up with emergency funds during disasters. Ebola epidemics, the fall army worm crisis and the drought caused by El Nino are common in Africa. Women also tend to sacrifice their meals and assets when there is an emergency (WBG, 2017).

According to Asian Development Bank, over 95 per cent of the female-headed households of Asia are below the poverty line. Hence women find it difficult to recover from the effects of disasters due to low levels of capital accumulation, and lesser access to information and credit (Rahman, 2013). The poorest people in South Asia will suffer the most from climate change due to unfavourable geography, limited assets and a heavy dependence on climate sensitive sources of income (World Bank, 2009). Mumbai floods (2005), Uttarakhand floods (2013), Chennai floods (2015) and Kerala floods (2018) are some of the most disastrous extreme weather events which took place in India in the 21st century. Roxy et al. (2017) has reported that each year, flooding in India from extreme rainfall results in a loss of around three billion dollars which constitutes about 10 per cent of global economic losses. Even though extreme weather events have become a new normal, studies relating to gender and climate change have not been undertaken so far in India. Hence, the study is being taken up.

Vulnerability is 'the characteristics of a person or a group that influence their capacity to anticipate, resist, cope with and recover from the impact of a natural hazard' (Blaikei et al., 2003). An understanding of vulnerability helps to inform program designing and targeting. Rahman (2013) remarked that the effects of extreme weather-related disasters are gender-biased and woman experience higher vulnerability and greater impacts than men. A substantial body of literature on gendered nature of vulnerability to past climate change induced disasters throws light on how women and men are differently affected.

Enarson (2000) has determined four types of disaster impacts which affect women's participation in economic life. First, women become economically insecure after a disaster. Second, women's working conditions deteriorate. Third, women's responsibility and workload increase. Fourth, women take more time to compensate for the economic losses caused by the disaster than men. Compared to men, women are poorer, have less ability to buy and own land and access financial resources like credit, savings or pensions. They have less access to developing entrepreneurial skills, and are paid less if at all paid. Hence, their income is less secure.

Despite its impressive achievements in human development, the state of Kerala is highly vulnerable to natural disasters. Its location along the sea coast with a steep gradient along the slopes of the Western Ghats renders the state highly vulnerable to natural disasters and changing climate dynamics. Seasonal extremes in rainfall causing water scarcity and floods, rising temperatures and accelerated coastal erosion together have led to crop failure, drop in fish catch, threat of sea level rise in coastal cities and increase in diseases. The vulnerability is further increased by the high population density (860 persons per square kilometres) leading to huge damages and losses on account of disasters.

According to Parida et al. (2018), floods are the most recurrent natural hazards in the state and Kerala stands fourth in the country in state-wise vulnerability to floods. The floods witnessed by Kerala in August 2018 which affected millions of people and caused 400 or more deaths is also an example of extreme weather event caused by climate variability. It was the worst flood experienced by Kerala in the last nine decades. Kerala received a rainfall of 2,346.6 mm against a normal of 1,649.5 mm since the beginning of June, which is excess by 42 per cent (IMD, 2019). In a span of 30

days, around 339 lives were lost, thousands of houses were damaged, 1.5 million people were shifted to relief camps and the total loss incurred by the state amounted to ₹20,000 crores. The crop loss due to the floods is estimated to be ₹3,558 crores (GOK, 2019). An assessment of the agricultural loss due to flood from farm households in the flood plains of Chalakudy river has been conducted by George (2020). Her results revealed that on an average a farm household in the flood plain has suffered a loss of ₹1,59,469 from seasonal crops, ₹1,52,358 from totally destroyed perennial crops and ₹32,854 from partially destroyed perennial crops. The food plain also had a loss of about ₹6.97 crores due to death of livestock and poultry.

About 16 per cent of families in Kerala, are female-headed as there is large outmigration from Kerala to Middle East countries not all of which are high-income groups. In such situations, women must manage the household and homestead matters single handedly. Hence women have to bear double work burden. The gender division of labour within the society and household makes women responsible for collecting fodder and fuel and securing water. Women do all the caring work inside the home, are responsible for family diet and food provision, ensure nutritional status of their families and have an important role in agricultural production (Buhaug et al., 2010). According to 2010-11 Agricultural Census, the total area of female operational holdings in Kerala is 2,29,426.75 hectare accounting to 12.7 per cent of the total operational holdings (GOK, 2019).

Hence, this study tries to relate gender and economic vulnerability of agricultural households on behalf of Kerala floods of 2018. It was carried out in the Mala and Vellangallur blocks of Chalakudy River Basin which was one of the most heavily flooded regions of Thrissur district. The specific objectives of this study are:

- To analyse the economic aspects of womens' vulnerability to extreme weather events and the components which contribute to the vulnerability.
- To study the adaptation strategies undertaken by the rural households.

1.1 Scope of the study

While women tend to be more vulnerable and to face greater challenges than men in adapting to climate change, they are also powerful agents of change. Their leadership

is critical in the efforts to adapt to climate change both at the household and community level. Hence, based on this study, adaptation strategies can be devised for women in the face of existing climate change impacts on agricultural productivity and food security. This study can help in building disaster mitigation and prevention plan for which is founded on the specific needs, roles and potential of women.

1.2 Limitations of the study

The study is based on the responses of farmers in the Mala and Vellangallur blocks of Thrissur district in Kerala and hence the generalisation need not be quite accurate. This study chiefly uses the primary data collected from farmers through a pre-tested interview schedule and the required information was collected from their memory. Hence could suffer from recall bias. However, the data was cross-checked to minimise the errors and misconception to the extent possible. The common limitations in statistical analysis might also have affected the study. As previous research studies in the area were less, the study also suffered from scant availability of published literature. Despite all these constraints, every care has been taken to make the study as unbiased as possible.

1.3 Presentation of the thesis

The thesis entitled 'Vulnerability and adaptation study of women exposed to extreme weather events in Thrissur district' is organised and presented in five chapters. The first chapter 'introduction' presents a brief outline on the theoretical background of the study, its relevance, objectives, scope and the major limitations. The second chapter 'review of literature' intends to provide theoretical background of the study by reviewing the previous studies related to the present research. Third chapter 'methodology' is comprised of an overview of the study area, nature and sources of data, details of design of the study and various methods adopted for carrying out research work and its analysis. The results and discussion based on the observations are presented in the fourth chapter 'results and discussion'. A brief summary of the overall results and the main findings of the study is presented in the fifth chapter 'summary and conclusions'.

CHAPTER 2

REVIEW OF LITERATURE

A crucial examination of the literature related to a research area is imperative for a researcher to arrive at a good approach for conducting the study. This chapter presents the review of literature relevant to the objectives of the study. The literature reviewed are presented under the following sub-headings:

2.1 Gendered impacts of climate change

2.2 Gender and extreme weather events

2.2.1 Global scenario

2.2.2 Indian scenario

2.2.3 Kerala scenario

2.3 Human vulnerability to climate change and its indices

2.4 Vulnerability of agricultural households to climate change

2.4.1 Global scenario

2.4.2 Indian scenario

2.4.3 Kerala scenario

2.5 Gendered roles in agricultural sector

2.6 Economic aspects of womens' vulnerability to extreme weather events

2.7 Climate change adaptation in agricultural sector

2.8 Women and climate change adaptation

2.1 GENDERED IMPACTS OF CLIMATE CHANGE

A change in the statistical distribution of weather over periods of time that range from decades to millions of years is known as climate change. It is now widely recognized that the consequence of 200 years of excessive greenhouse gas (GHG) emissions from combustion of fossil fuel for energy generation, industry and transport, deforestation and intensive agriculture is unavoidable (Adhikari et al., 2018). Terry (2009) observed that since the beginning of the twenty-first century, greater vulnerability of women, when compared with men, to disasters have been clearly demonstrated by several extreme climate events, including the Asian tsunami of 2004, the 2003 heat wave in Europe and Hurricane Katrina of 2005, which devastated New

Orleans. In 1991, a cyclone which hit coastal Bangladesh killed more women than men. Neumayer and Plumper (2007) have found that women tend to die in larger numbers than men during after disasters, and that these gender inequities in mortality are due to womens' low socio-economic status compared to men.

A reason why it is hard to separate the relations between climate change and gender-and-development issues is because climate change is not happening in a vacuum, but rather in the context of other threats like economic liberalisation, unpredictable government policies, globalisation, and health risks like HIV and AIDS etc. Although the effects of climate change intermingle with, and intensify, other types of stress, poor people themselves may not distinguish climate as the utmost important or urgent of their problems (Thomas and Twyman, 2005).

Nepal is ranked as the fourth most vulnerable country in the world, after Bangladesh, India, and Madagascar by the Maplecroft Climate Change Risk Atlas 2011 (a global risk analysis map). Due to their socially constructed roles and relatively poor social and economic positions, women of Nepal were found to be inexplicably susceptible to the consequences of climate change (Kunwar and Sharma, 2015). According to Connell and Messerschmidt (2005), globalisation, which quickens carbon emissions, is driven by a certain type of masculinity which values power and ruthlessness, and is creating a small number of super-wealthy people, mostly men, at the cost of millions of poor men and women who bear its negative effects.

Arora-Jonsson (2011) stated that the literature on gender and climate change predominate two views: men in North pollute more than women and that women in South are affected by climate change more than men in those countries. This is due to the different gender roles that has been set in different societies. Here "gender roles", fundamentally refer to the social roles played by men and women and power relations between them and not the biological differences between men and women. Because of gender roles in the developing nations, women suffer more due to unequal participation in decision making process, access to resources, limited mobility etc. However, depending on values, customs and norms of a particular society, we can find different types of gender roles in each individual society.

For example, in rural Piura, women typically have less access to education, healthcare, specialist technical assistance and control over the family's productive resources. This is an example of gender discrimination. These profound and widespread inequalities made poor women and their children more vulnerable to food insecurity particularly during El Nino. During El Nino, they were also disproportionately exposed to epidemics (acute respiratory and diarrhoeal infections, dengue, malaria, and cholera) due to widespread malnutrition. Pregnant women were particularly at the risk of malaria leading to serious complications during pregnancy and peri- and post-partum illnesses. The number of temporarily female-headed households were increased by the migration of men from Piura into cities and coastal valleys for employment. The resultant female-headed households faced many challenges during their attempts to survive the effects of El Nino. Most of the rural community organizations typically did not recognize female-headed households as such. In the absence of men, the increased burden of household and agricultural work fell on women posing serious limitation to their ability to seek paid employment. Nonetheless, women in Piura developed various survival strategies and capacities to tackle the problems caused by El Nino (Reyes, 2002).

The Bali Conference of 2007 was a breakthrough for gender advocates. Huge numbers of participants, including the United Nations Framework Convention on Climate Change (UNFCCC) itself, seems to agree with the need of mainstreaming gender issues into any future agreement. Additionally, Gender CC - Women for Climate Justice - Network, and Global Gender and Climate Alliance were launched during the conference. However, gender concerns can be considered in the climate protection system only if there is a basic change in system that puts the human rights of both men and women in centre-stage (Hemmati, 2008).

2.2 GENDER AND EXTREME WEATHER EVENTS

2.2.1 GLOBAL SCENARIO

Women outnumbered men in the deaths caused by cyclone of 1991 and 2007 in Bangladesh. More women died than men during the tsunami which struck the Indian Ocean coastlines in 2004. Also, in the European heat wave of 2003, elderly women died in more rates than older men. These examples substantiate the claim that climate change is unequal in terms of gender just as it unequally impacts the rich and poor. The statistics

of mortality rates point to a astounding disproportion and inconsistencies in terms of their impacts on the gender. The vulnerability of children and women to the disaster and post disaster casualties is 14 times higher than that of men (Rahman, 2013). A study of 4,605 natural disasters from around the world found that disasters reduced womens' life expectancy significantly more than men's. Such gender differences in death rates attributed to natural disasters have been linked directly to womens' social and economic rights.

Mehta and Awasthi (2019) observed that in almost all societies, both womens' engagement in homosociability and patriarchy offered men greater opportunities in headship, professional specialisations, and higher earning capacities. Reproductive work is done by women and it is usually hidden, non-monetised, and not recognised as real work (Delaney and Macdonald, 2018). In many low-income countries, women already work for more hours than men each day. A study from rural Cameroon found that women work for more than 64 hours a week, compared to men's 31 hours. According to the estimates of Food and Agriculture Organization of the United Nations (FAO) women produce 60 to 80 per cent of food grown in the developing world, mostly small scale crops critical to their family's sustenance (Rahman, 2013). In community activities, women mostly offer their time for hands-on manual activities, such as fundraising, visiting the sick people, cooking or cleaning, compared to men's community activities, which are mostly figure-heading and political (Moreno and Shaw, 2018). Altogether, the reproductive, productive, and community activities of women are undervalued and even can be hazardous to health and life. During times of war, poverty, natural disaster or disease outbreak, the power relations between men and women can be altered, increasing womens' vulnerabilities and additional burdens (McLaren et al., 2020).

Socially recognized characters and responsibilities of women, like collecting fuel and water, recurrently make them more directly dependent on natural resources and therefore highly vulnerable to the effects of climate change. Lack of assets, resources, shelter, and information access makes women more vulnerable than men in the time of natural disasters. Many women were vulnerable because of their low decision-making power in disaster prevention and preparedness programs as well as their lack of access to sources of emergency information (Rahman, 2013). They do not receive warning

information transmitted to men at the public spaces. They are also reluctant to go to safe shelters during disasters, because of the fear of losing their children and household assets. Rural women, due to their reliance on agriculture and natural resources as livelihood bases, are likely to become increasingly vulnerable to the effects of climate change on natural resources. They may be forced to migrate to urban centres, particularly to informal settlements. In such places, they may be exposed further to crime, conflict and violence and supportive social institutions may be absent (Mearns and Norton, 2009).

Gender discriminations also may be aggravated after disasters. There are data which suggests that women and girls are more expected to become victims of sexual and domestic violence after disasters. Such instances are more when families have been displaced and are living in overcrowded transitional or emergency housing where they lack privacy. Young girls complain particularly about increased levels of sexual abuse and harassment in the aftermath of disasters and they report of the lack of privacy they come across in emergency shelters. The rise in violence is mostly attributed to the stress caused by decreased economic opportunities in the period following a disaster. It is also compounded by threatened livelihoods or longer term unemployment (Demetriades and Esplen, 2010). Another issue in refugee camps is the absence of culturally suitable hygienic facilities for men and women. This worsens the health and security situation for women especially adolescent girls. Lack of privacy at latrines, unavailability of separate showers, toilets, and tents for men and women and adolescent girls are some unresolved problems (Rahman, 2013).

A key aspect of womens' reduced capacity to cope with the effects of a hazard is their poor nutritional status. Women of all ages groups are more calorie-deficient than men in Bangladesh. The prevalence of chronic energy deficiency among women is the highest in the world there (Del Ninno et al., 2001). Given the present dangerous nutritional state of large numbers of girls and women in Bangladesh any further rise in discrimination against females with respect to food consumption would have serious consequences. In comparison with men, women receive less and poorer-quality healthcare. Bangladesh is among the few countries in the world where the male population outnumbers the female, and where men live longer than women (Terry, 2009).

A study conducted in drought-affected communities of Tanzania and Kenya found that households whose members each specialised in different non-agricultural livelihood activities did reasonably well during climate stress. However, compared to men, womens' livelihood options were lesser. Their setbacks were lack of access to financial capital and reproductive burdens. These issues prevented them from investing in any type of income generation initiative. Some gender norms also excluded them from doing more profitable activities such as bee-keeping. Despite this, in order to maintain some degree of financial independence from their husbands, women tried their best to find income-generating activities which would compensate for their loss of income from agriculture (Terry, 2009). Development initiatives have recognised the burden of gender and have tried to implement mechanisms to support the empowerment of women (Nawaz and McLaren, 2016). Patti et al. (2007) had done a research on the quality of life (QOL) of men and women in Italy. He found that simply being female was a key predictor of lower QOL and the psychological indisposition of spousal carers in relation to disasters. McLaren et al. (2020) proved that gender inequality and the compounding gendered burdens on women worsened during disasters. This affected their capacity to cope with and recover from them.

2.2.2 INDIAN SCENARIO

Rural women and men in India are historically associated with its agrarian landscape, with which they have co-evolved over centuries. Today, exceptional challenges, comprising a growing population, the globalization of markets, and environmental hazards in the form of climate change and land degradation, are driving the need for fundamentally dissimilar social arrangements. Rural women have only few options, especially with the absence of land rights. Education, which could increase their opportunities and choices, remains limited or absent. In India, the female literacy rates are lower at 65.46 per cent than their male counterparts at 82.14 per cent (GOI, 2011). This lack of power extends beyond the family as women rarely participate in community-level decision making. Consequently, they are unable to act as agents of change to improve their condition (Roy and Venema, 2002).

The Asian Development Bank reported that around 95 per cent of female-headed households of Asian region are below the poverty line. Womens' income is mostly derived from the informal sector. These sectors are worst hit by the disasters and they

are least able to recover from the effects of disasters due to weaker access to credit and information and low levels of capital accumulation (Rahman, 2013). Four types of economic impacts of the disaster on the women were determined by Enarson. First, women become economically insecure after a disaster. Second, womens' workload and responsibility increase. Third, womens' working conditions worsen. Fourth, women take significantly more time to compensate for the economic losses created by disasters compared to that of men (Enarson, 2000).

2.2.3 KERALA SCENARIO

Owing to its location along the coast and steep slopes along the Western Ghats, the state of Kerala is specifically vulnerable to the changing climate dynamics. Sea level rise, extreme temperatures, erratic rainfall, droughts etc. are the climatic events currently felt at Kerala. Children and women make up 70 per cent of victims who are affected by any climate disaster. In Kerala, the Department of Economics and Statistics published a Report on Gender Statistics 2015-16. The report observed that the participation of women in decision making in the public sphere and the economic realm is low even though according to 2011 Census, 52.02 per cent of the total population in Kerala is women. They are facing negative consequences due to water stress and migration. Progress in women empowerment and gender equality can be accessed by three dimensions:

1. Enhanced participation and voice of women in formal and informal social, economic and political institutions,

2. Strengthened womens' access, ownership and control on resources and capabilities, and

3. Security and freedom from violence (Climate Resilient Kerala, 2017).

The floods of southwest season are evident examples of climate variability with very heavy rainfall over a short span of time as predicted by the Fifth Assessment Report brought by the Intergovernmental Panel for Climate Change (IPCC) in 2014 (Pachauri et al., 2014). The swirling, billowing, jostling monsoon rain is a part of the state every year. However, in 2018 the southwest monsoon had an unprecedented impact as it resulted in a disastrous flood. Three hundred and thirty-nine human lives

were lost, thousands of houses damaged, over a million and half people were shifted to relief camps, large stretches of major roads got washed away and many bridges collapsed all within a span of 30 days (Climate Resilient Kerala, 2017).

2.3 HUMAN VULNERABILITY TO CLIMATE CHANGE AND ITS INDICES

Climate change hot spots can be demarcated as the 'live labs' where the manifestation of the climate change impacts can be observed first. Globally, Southwest India is one among the twenty-four hot spot regions (Shyam et al., 2018).

According to IPCC (2001) vulnerability to climate change is the degree up to which a system is liable, or incapable of surviving under negative effects of climate change and variability. The extent of vulnerability of a system to climate change and variability depends on the character, rate, and degree of climate change and variation to which the system is exposed. It's sensitivity and adaptive capacity also plays major roles (IPCC, 2007). Climate change exposure is understood to be location specific. For example, coastal communities undergo higher exposure to sea level rise and cyclones whereas communities in semi-arid areas are most exposed to drought. Sensitivity is the extent to which a body is either beneficially or adversely, directly or indirectly affected by climate change and variability (IPCC, 2007). For example, a tropical ecosystem will be less sensitive to a decrease in rainfall compared to a semi-arid, arid or fragile one due to the successive influence on water flows. Similarly, a mining community is not highly sensitive to changing rainfall patterns compared to communities which depend on rain-fed agriculture for its livelihood (IPCC, 2007).

Terry (2009) indicates that vulnerability also varies according to the 'original conditions' of a person like how well-fed they are, their morale and capacity for self-reliance, and what their physical and mental health status and mobility are. It is also related to the resilience of their livelihood like how quickly and easily they can resume activities which provide food or money and other basics. The hazard itself must be identified, and the fact that vulnerability will be lesser if people are able to create proper 'self-protection' in place e.g. a house site that is raised above flood levels or the right type of building to resist high winds.

The poor suffer higher mortality and greater housing damage rates during disasters (Rygel et al., 2006). Poor people from developing countries tend to depend more directly on climate-sensitive sectors such as agriculture, fishing, and forestry for their livelihoods and hence are more exposed to climate change than the people from developed world. They often live in risky flood and drought prone rural or urban environments, would lack the insurance required to recover from losses, and have little influence on their governments to provide protective infrastructure, reconstruction support, or temporary relief. Indeed, even in the absence of climate stress, their everyday conditions are unacceptable. Climate stresses push such populations into much lower threshold of poverty and insecurity which violates their basic rights as humans (Ribot, 2013). They have the least ability to buffer themselves against from stress and rebound. They face many barriers in receiving financial access like distance from bank services, prohibitive costs, and the inability to submit formal documents. Only 20 per cent of households have accounts with financial institutions across sub Saharan Africa (Heltberg et al., 2010). Rahman (2013) found that poverty is a key factor which affects people's ability to provide adequate self-protection when disasters occur. For those in power, the weak or poor people within the society tend to be of lesser priority. Economically weak actors in marginal groups or urban slums far from the centers of power within semiarid or forest zones may be of little importance to people involved in big business or holding political power. They are likely to be a low priority even in matters of disaster planning. To counter the biases against the poor and marginalized, policies and vulnerability analyses must be deliberately pro-poor (Ribot, 2013).

Most vulnerable people include agro pastoralists living in the drylands of the world, inhabitants of low-lying island developing states, poor people living in highly populous cities and those living in rural communities and major cities which are located in the downstream of high-altitude Himalayan glaciers. Agro pastoralists are exposed to climate variability and changing precipitation and temperature. The inhabitants of low-lying and small-island developing states are highly exposed both to sea-level rise and the effects of coral bleaching on fishery and tourism sectors which are their important sources of income. Poor people who live in highly populous cities of coastal zones and low-lying deltas of developing countries are exposed both to sea-level rise and to flooding from storm surges. People living in rural communities

and major cities in the downstream of high-altitude glaciers in the Himalayas, Hindu-Kush, Andes, and other high-mountain regions are exposed to the loss of glacial water sources for drinking water and agriculture. Mearns and Norton (2009) found that indigenous people who account for just 5 per cent of the world's population, but protect an estimated 22 per cent of the Earth's surface, 90 per cent of cultural diversity, and 80 per cent of remaining biodiversity, on the planet are also among the most socially excluded and poorest people in the world and are disproportionately affected by climate change due to their heavy reliance on these ecosystems as a source of livelihood.

Vulnerability also differs with gender. Women especially never married mothers and divorced mothers are more likely to live in poverty. Also, women mostly have low-status jobs or jobs in the informal economy, which are often lost after a disaster. Women are also more vulnerable because of their roles as caregivers and mothers When a disaster strikes, their ability to stay safe is limited by their responsibilities to the young and the old, both of whom require help and supervision (Fothergill, 1998). Men and women perceive different risks as important and also express different levels of concern about the risk of floods or droughts. The same risk may have different meanings for men and women (Terry, 2009). Through the surveys carried out in the USA, Satterfield et al. (2004) have found a 'white male effect', where the white men tend to perceive environmental risks less seriously than black men, black women, or white women do.

Vulnerability assessment includes a large set of approaches used to integrate and examine interactions between humans and their social and physical surroundings systematically. Such assessments have been used in a variety of contexts including World Food Programme's Vulnerability Analysis and Mapping tool for targeting food aid (World Food Programme, 2007), the USAID Famine Early Warning System (FEWS-NET) (USAID, 2007a). It has also been used in a variety of geographic analyses combining data on poverty, biodiversity, health and globalization (UNEP, 2004). Attempts to quantify multidimensional issues using indicators as proxies are common. Vulnerability indicators are potentially beneficial tools to identify and monitor vulnerability over time and space, developing strategies to reduce vulnerability, and for determining the effectiveness of those strategies (Rygel et al.,

2006). In a study conducted by Antwi-Agyei et al. (2012) in the Ejura Sekyeredumasi district of Ashanti region and Bongo district of the Upper East region of Ghana which were formerly identified as the most resilient and vulnerable regions and districts respectively in Ghana, sustainable livelihoods approach (SLA) was used to assess poverty and builds on the entitlement approach. SLA assessed communities' capacities to withstand climate and non-climate stresses and other conflicts. SLA considers five livelihood capital assets i.e. human, financial, natural, physical and social and their links to an overall vulnerability context, institutions, processes, and policies which govern people's access to these capital assets. Similarly, in Junagadh district of Gujarat, Koya et al. (2017) had conducted a study to assess the vulnerability of 1500 fishermen households. It was carried out using PARS (parameter, attribute, resilient indicator, score) methodology. Environment, social attribute, fishery, development drivers and economy were the parameters used and it was found that 'economy' was the most impacted parameter consequent to climate change followed by the 'social' and 'environmental' parameters. Similarly, Jakpa, in 2015 carried out a study of household vulnerability to floods in the Tolon district of Northern Region of Ghana. The assessment of vulnerability was done using a total household vulnerability assessment framework (THVAF) in which the indices exposure, sensitivity and adaptive capacity were computed based on Hahn et al.'s (2009) livelihood vulnerability index (LVI). Indigenous knowledge of local farmers was used to select the indicators.

The field of assessment of climate vulnerability has evolved to address how communities will adapt to changing environmental conditions. Various researchers have tried to bring down the gap between the social, physical and natural sciences and added new methodologies which confront this challenge (Polsky et al., 2007). Many of the methodologies relied on the IPCC working definitions of vulnerability as a function of sensitivity, exposure, and adaptive capacity (IPCC, 2001). In this case, exposure is the duration and magnitude of the climate-related exposure like a change in precipitation or drought. Sensitivity is the degree to which the system is affected by exposure. Adaptive capacity is the system's ability to recover from or withstand the exposure (Ebi et al., 2006).

Among the studies previously conducted in vulnerability assessment, the scale, the methods used to select, group, and aggregate indicators, and the methods used to

display results were the key differences. Some common limitations were also there. For example, the studies relying on climate scenario projections taken from General Circulation Models (GCMs) are limited by the uncertainty associated with these models and how they are mapped (O'Brien et al., 2004; Thornton et al., 2006). Studies relying on secondary data have to build their analytical framework around available data, deal with missing or inconsistent data, and sometimes must combine data collected at different spatial or temporal scales (Sullivan et al., 2002; Vincent, 2004; Sullivan and Meigh, 2005). In secondary data sets, the information on sources of measurement error is often lacking making sensitivity analysis difficult. Methods relying on multiple international and national databases and sophisticated climate projections may be impractical for health and development planners working at the community level.

2.4 VULNERABILITY OF AGRICULTURAL HOUSEHOLDS TO CLIMATE CHANGE

2.4.1 GLOBAL SCENARIO

The 21st century has seen a 7 per cent shortage in the per capita global food production and the shortage is believed to be caused by climate change and variability and low soil productivity (Adu et al., 2018). A rapidly changing climate brings the largest short-term effects on economies dependent on exports or production of primary commodities which are renewable. Some societies will be better off, but the developing world will experience reduced agricultural yields. This would result in an increasing ingenuity gap between developing and developed countries. Hence, the former will have less to spend on such adaptive buffers like irrigation systems, desalinization plants for generation of freshwater, and resilient infrastructure (Buhaug et al., 2010).

Minia (2004) has forecasted that globally, the value of total annual rainfall would decline by 9 to 27 per cent while the value of mean daily temperatures would rise by 2.5 to 3.2°C by 2100. Adu et al. (2018) revealed that agricultural production and food security of many African countries and regions had the highest probability of being severely compromised by climate change and variability. Models and information on climate change and variability are only available at global, continental, and national levels. Models does not yet forecast the impacts at very small scales therefore the extension officers face the challenge of providing farmers

with ecological and location specific knowledge. Without being provided with adaptive measures or suitable policies, the smallholder farming households find it difficult to undertake sustainable crop production and rearing of animals in an environment with unpredictable climatic conditions.

Jakpa (2015) revealed that floods are among the most regular natural disasters in Northern Ghana, that affect livelihoods especially farming. Since agriculture is predominantly on a subsistence basis and mostly rain fed with about 90 per cent of farm holdings being less than 2 hectares in size, the occurrence of a flood event directly affects their agricultural output. The region is also noted for its underdevelopment as well as its high poverty levels ranging from 62 to 88 per cent. Chamberlin (2008) showed that in the Ghanaian economy, small-holder farming households dominate the agricultural sector with about 90 per cent being resource poor. Smallholder farmers mostly depend on family labour and also operate under rain fed conditions. This has contributed to the lack of ability of Ghana to produce more maize to feed its people leading to average shortfalls of 12 per cent in domestic supply. Attaher et al. (2009) concluded that in Nile Delta, sea level rise, water and soil degradation, undiversified cropping-pattern, pest and disease attack, yield reduction, and irrigation and drainage management were the main issues that increased vulnerability of the agriculture sector.

An attention-grabbing study of the small farmers in South Africa shows that men and women in the South, as well as in the North, perceive climate risk differently because of their gender (Thomas et al., 2007). Researchers found that gender identity influenced the kind of climate risk which the farmers were concerned about. Most of the women farmers recognised heavy rains as a distinctive risk. Conversely, more men than women saw drought as a typical risk. The difference appears to be linked to the gendered patterns of livelihood, and the various ways in which the activities of agriculture and livestock rearing are sensitive to climate change. Agriculture tends to be linked with women in the study area, and livestock rearing with men. It shows that poor women and men in developing countries may not share the same priorities with regard to climate risks (Terry, 2009). Institutional guidelines about information sharing even though informal sometimes often helps to reduce vulnerability by facilitating ex ante planning and action (Agrawal, 2010).

2.4.2 INDIAN SCENARIO

With 66 per cent of its total cropped area depending on rainfall for irrigation, India is first among the rain fed agricultural countries of the world. India is the second largest producer of wheat, rice, and staple food for millions of the world, while half of its production is rain fed. By negatively affecting food security, food stability, rural income, food prices and crop yields climate change would act as a hunger risk multiplier. Thus, in rain fed farming systems, climate change vulnerability assessment is an important tool for adaptation planning and decision-making to reduce the detrimental effects of climate change on the most vulnerable people (Raghavan et al., 2018). In a survey, conducted by Adhikari et al. (2018), about 27 per cent of the farmers feel that soil salinity has increased in their farm in Bellary district of Karnataka. This incident was due to reduced rainfall, which is attributed to climate change. However, farmers of other states have not experienced this.

2.4.3 KERALA SCENARIO

The agricultural sector in Kerala has been badly hit by the extreme rainfall of July-August 2018. The crop loss due to the floods is estimated to be ₹3,558 crores (GOK, 2019). In Southern India, a study found that at times of high climate risk, poor farmers reaped lower returns to assets than the better-off farmers, whereas the reverse was true in low risk settings. In brief, high climate risk and the nonexistence of effective risk management instruments constrains the escape from poverty and asset growth (Heltberg et al., 2010).

2.5 GENDERED ROLES IN AGRICULTURAL SECTOR

Agriculture comprises of nearly two-thirds of female labour force in developing countries. More than 90 per cent in many African countries, does agricultural work. In Nepal, agriculture forms the occupation of over 65 per cent of its population. About 70.5 per cent of women are employed in it and contributes 60.5 per cent to agriculture economy which is higher when compared with men's involvement and their contribution in agriculture sector (Gurung and Bisht, 2014). In Nepal, 90 per cent of women aged between 15 to 49 years' age do not own any land and 93 per cent of them do not own a house. Thus, women of rural areas who rely on natural resources for their livelihood are affected by unequal access to resources and to decision-making process

making them disproportionately affected by climate change (Kunwar and Sharm, 2015). In India, the farmers are mainly men, although women also play an important role in agricultural activities (Lal and Khurana, 2011). Around 89.5 per cent of the total Indian female work force works in rural India and extensively contributes to household income and welfare.

However, womens' experience, access to technical exposure, and training is inadequate, which limits their opportunities and affects their capacity to contribute to decision-making in farming. Rural women, in addition, have less access to and control over resources in comparison to men. Men have more access to credit, farm inputs (e.g., seed supply), extension market services, etc., (ICAR, 2011).

According to Kunwar and Sharm (2015), gender roles refer to behaviours which are considered masculine and feminine. They are manifested daily and determine level of responsibility and participation of men and women. Roy and Venema (2002) have noted that women, more and more, are sustaining their livelihoods as farm workers rather than as cultivators, with their labour and knowledge largely marginalized due to mechanisation and other technical interventions, which women are traditionally excluded from using. Additionally, their workload has increased. The shift to high-yielding varieties of grains has created fewer crops and animal wastes for animal fodder and household fuel, the provision of which is mainly the domain of tribal women and poor peasants. Terry (2009) pointed out that in most developing countries, rural women produce between 60 to 80 per cent of the food. So gender analysis has an evident relevance to adaptation and mitigation in this sector.

Within India, however there is some variation. For example, in both mountain and hilly regions and arid and semi-arid areas where forests have been wiped out and agriculture remains poor, women spend around six to ten hours daily collecting the resources they need to meet their basic survival needs. Whereas, those in the rich plains, where the agricultural biomass has replaced the forest biomass, spend less time on these tasks. The poor women in these areas who don't own land or whose landholdings are slight, find themselves at the mercy of major landowners to meet their fodder and fuel needs (Roy and Venema, 2002). Gurung and Bisht (2014) observed that in Nepal, the hardening of soil demanded additional breaking, even after ploughing, meaning additional physical labour for women. The emergence of new varieties of pests and

weeds increased womens' workload, as they are the ones responsible for weeding. Womens' form of personal income earned by selling small quantities of high value crops such as beans, lentils, and vegetables is being lost due to climate variability and low production. Decreasing agricultural production and resulting food security issues have fuelled already existing outmigration of men, which has increased womens' workload, mental stress, and risk of physical violence. The early ripening of vegetables and crops has created problems with pest infestation in stored crops and seeds, increasing womens' workload as they have to check, clean and dry the pests in the crops.

Land is the most important productive asset for the households dependent on agriculture. But customary or statutory laws confine womens' land rights in many parts of the world. This in turn can make it difficult for women farmers to access credit. Research from Africa suggests that women receive less than 10 per cent of the credit approved to small farmers (Nair et al., 2004). Without credit, they cannot purchase the crucial inputs needed to adapt to environmental stress like new varieties of animal breeds and plant types intended for higher heat or drought tolerance, and latest agricultural technologies. Gender biases in institutions further exacerbate these obstacles which form assumptions that men are the farmers. As a result, agricultural extension technologies and services are rarely available to female farmers (Lambrou and Piana, 2006). Without access to credit, land, and agricultural technologies, they experience major constraints in their capability to diversify into alternative livelihoods. For households which are headed by women who cannot rely on male household members to purchase crucial inputs these obstacles can be particularly problematic. Moreover, when livelihoods are in jeopardy and men out migrate for work, the number of female-headed households often increases (Demetriades and Esplen, 2010).

McLaren et al. (2020) suggested that while both women and men would have a preference for labour-saving mechanized farming, men are mainly responsible for irrigation and women are usually part of very labour-intensive, low-emission subsistence agriculture. Men are generally vested with water rights in societies where irrigation is important and men participate in both formal and informal decision making at field canal level and at the higher tiers. They are completely the ones to invest in and own their private equipment. Thus women are seen only as marginal stakeholders in

irrigation and not as directly needing irrigation water. Most of the times, women who manage their own farms still have to ask men to mediate in ensuring water for their plots, fulfilling labour obligations, and particularly in representing them in meetings. This leads to large transaction costs. In South East Asia, women have had some kind of access to water resources only through common property. The ability of women to fall back on such common resources has reduced significantly as the availability of these resources, has rapidly declined, especially in rural communities, as a result of their appropriation by the state.

2.6 ECONOMIC ASPECTS OF WOMENS' VULNERABILITY TO EXTREME WEATHER EVENTS

Generally, it is known that gender inequalities in societies throughout the world would give rise to higher rates of poverty among women than men. This is true for both female-headed households and for women and girls living within male-headed households due to unequal intra-household sharing of power and resources, such as property and food (Kabeer, 2008). Where women and girls have fewer capabilities than men, and less access to resources (financial, material, and human), their capacity to adapt to existing and predicted impacts of climate change will be undermined (Demetriades and Esplen, 2010).

Climate change is widely projected to affect all these areas of womens' lives unfavorably. For instance, increased climate variability makes agriculture unpredictable, and the ongoing desertification in some regions exacerbates the domestic fuel crisis. In urban areas, 'urban heat island' causes effects like shortage of clean water in cities like New Delhi, which are located in dry zones. There are chances of increased occurrence of vector-borne diseases like malaria due to changes in temperature and rainfall patterns etc. Poor women are likely to bear the brunt of all these (Terry, 2009). Balmori (2003) highlighted that so far, government-led financing schemes and adaptation strategies have not been subjected to scrutiny by gender-budget specialists. However, it is expected that more and more public funding in both developing and industrialised countries will be needed for taking public adaptation measures as the impact of climate change intensifies. A useful way of ensuring that poor womens' interests and priorities are not overlooked would be drawing on gender-budgeting

techniques to compare the gendered costs and benefits of alternative adaptation strategies.

There is no universally accepted definition for household economic vulnerability in the literature. However, Anderloni et al. (2012) argue that economic vulnerability occurs due to unsustainable or unsound borrowing practices which lead households to contract debt levels that are too high relative to their present and future earning capacity. Thus debt is an important components of economic vulnerability. The economic vulnerability may also be determined by factors other than debt, such as low income and wealth levels, lifestyle behaviour that may be driven by short-sightedness or irresponsibility which in turn may lead to non-optimal money management or unsustainable expenditure, adverse events including natural disasters that may negatively impact the household's financial situations, and/or absence of financial instruments (eg. Life, health or accident insurance policies) which enable the households to manage risk more commendably. This means that an inclusive household economic vulnerability function will contain financial, demographic, and socio-economic characteristics of the household.

2.7 CLIMATE CHANGE ADAPTATION IN AGRICULTURAL SECTOR

Adaptation and short-term coping are different. While people's coping strategies helps in immediate survival, they might fail to protect them in the long-term. This could even make the situation worse. On the other hand, effective adaptation decreases people's vulnerability to climate stresses and shocks in the future. The word 'adaptation' covers a wide range of responses. It ranges from big government projects such as sea-wall building, to the changes people bring on their own initiative, such as taking insurance, changing the crops they grow, or finding techniques to make a living which is less sensitive to the weather (Terry, 2009). It includes long-term scheduling for infrastructure (water storage, supply, and sanitation, transport, building codes), land use (flood management, conservation), agricultural diversification, research, and extension (for example, research on drought-resistant crop varieties), planning for disaster risk reduction, post disaster responses and recovery and social policy measures. It also includes the expansion of social protection systems, adaptation of public health priorities, and providing support to populations with special needs including migrants. These measures are to be mainstreamed into sector-based and national level economic

planning. Also, simultaneously aspirations of local communities must be recognised and they must be enabled to adapt. Current approaches to adaptation might lack the major opportunities to engage with local people creatively through institutional partnerships. It also lacks the diverse ways through which they can adapt to climate change autonomously (Mearns and Norton, 2009).

Across all three stages, pre-disaster risk limitation, instantaneous post-disaster response, and long term recovery from the risk event, common elements are the need to increase the capacity of communities to make demands on municipal government for providing protective infrastructure and services, and the need to increase the capacity of those local governments to react. Therefore, firming up the asset base of households and communities is a key means in building more accountable, competent local governments. The poor need to be educated of the risks posed by climate change. They should also be better equipped to deal with its impacts at the local level. People also should be trained to and have access to use social accountability instruments and tools for citizen monitoring and oversight, so that they can hold government accountable for delivering results (Mearns and Norton, 2009). Agrawal (2010) confirms that the choice of specific adaptation practices is dependent on economic and social endowments of households and communities, networks of social and institutional relationships. It is also based on their ecological location, institutional articulation and access, and the availability of power and resources.

The most common natural response to environmental risks is mobility. It is especially vital as an adaptation practice for agro pastoralists in West and South Asia, Sub-Saharan Africa, and most dry regions of the world (Agrawal, 2010). Storage pools can reduce risks across time. When they are combined with well-constructed infrastructure, high level of coordination across households and social groups, and low levels of perishability, it would be effective measure even during complete livelihood failures. Communal pooling is an adaptation practice that involves joint ownership of resources and assets, sharing of capital, incomes or labor from various activities across households. It also involves the mobilization and use of resources that are held collectively during times of scarcity. It groups the risks across households. This practice is most effective when the benefits from assets possessed by different livelihood benefit streams and households are uncorrelated. When a group is affected in the same manner

by adverse climate hazards, for example floods or drought, communal pooling is unlikely to be an effective response (Agrawal, 2010).

Some national governments in authority of dryland regions have taken a role in managing drought through public works programs. They have tried to create temporary employment, food relief, and subsidized distribution of feed for livestock. Such strategies have been carried out for decades by India and some countries in Western Asia and North Africa. Governments of developing countries mostly rely on emergency assistance from international donors. This is mostly provided only after long-lasting negotiations, protracted assessment, and logistics. Now, new technologies have been deployed like remote sensing of agricultural stages to give early warning of drought so that donors and national governments can take appropriate actions, including quick delivery of flood relief (Anderson et al., 2010).

Whether it be flooding, drought, heavier storms, or sea-level rise, the direct impacts of climate change are mostly associated with water in one form or another. Thus, for dryland regions, a robust focus on upgraded management of water at local, regional, and national levels will be key to building better resilience to disasters, damage to infrastructure, and crop failures. This requires a blend of micro investments at the field and village levels, with coordinated planning of major river basins and wider water catchment management such as those of the Niger, Zambezi, and Nile (Anderson et al., 2010).

International allocation of the burdens of adapting to climate change should go beyond development assistance. It will have to consist of migration and labour policies, water sharing, financial markets, food trade, and insurance systems. It should possibly include even peacekeeping when resource scarcities created by climate change trigger violent conflict. Providing microfinance ie., the delivery of loans, insurance, savings, and other financial facilities to low-income groups is a good measure during times of disaster. This would help them to engage in productive activities, protect themselves against risk, and build assets. In Bangladesh, the large non-governmental organization BRAC (Bangladesh Rural Advancement Committee) has initiated approaches to sequence safety net support, microfinance, and skills building through a program which aims to "graduate" the poorest people into microfinance clients (Heltberg, 2010).

In India, Watershed Development Programmes (WDPs) are potential tools in creating a significant aid to bring down vulnerability, build adaptive capacities and enhance resilience of rain fed farming communities to climate-induced shocks. Watershed development is a multi-sectoral interference which aims to enhance the socio-economic situation and potential of ecosystem resources of the community in a particular natural landscape unit. It includes regeneration, conservation, and the thoughtful use of all the resources, human and natural, within the watershed area. Different studies show that WDPs have the capacity to act as tools for disaster management and to reduce the risk associated with rain fed agriculture. Moreover, they are also valued as one of the best practices which back to mitigation and adaptation (Raghavan et al., 2018).

The fundamental goal of adaptation strategies is the lessening of vulnerability to climate-induced changes and at the same time enhancement and protection of one's livelihood. These, therefore include the means of production obtainable to a given group, household, or individual which can be used in their livelihood activities. The bigger and more varied the asset base the higher and more long-lasting will be the level of security and sustainability of households. The role played by the local knowledge organizations is of strategic importance in this circumstance. The application of local knowledge as a priceless source of information of natural resource management have been progressively acknowledged by a growing number of studies (Lambrou and Piana, 2006).

2.8 WOMEN AND CLIMATE CHANGE ADAPTATION

For poor countries, the most effective way to adapt would be through gender equitable sustainable development. This would give them the resources and flexibility they need to respond, which includes educated, skilled, and healthy women and men (Terry, 2009). Focusing on social justice and equity would help by giving voice to the vulnerable groups because, by design, human rights give attention to the most vulnerable people on the planet (Mearns and Norton, 2009). Women are not merely victims in the face of climate change. They are actively handle the common-pool and household resources. They are also powerful agents of change because of their "triple roles" in reproductive, productive, and community-handling activities. Women, however, so far, have not been provided equal opportunities to take part in decision

making concerned with climate mitigation and adaptation policies at the national and international levels. The policy debate fails to take into consideration the strategic and practical necessities of women. Harnessing women's leadership experience and skills in natural resource management and community revitalization should be a priority in designing and implementing risk-reduction strategies and climate change adaptation (Mearns and Norton, 2009). Women, especially have important role to play in adaptation, due to their gendered indigenous knowledge on matters of agriculture and water supplying (Agrawal, 2010).

Gender mainstreaming provides a focus to make sure that women's needs and rights are addressed and that unfair gender relations are challenged during and after climate disasters. Women does not lack agency in the environmental space. They are well-versed with traditional knowledge and practices. These will have the potential to add enormous worth to the development of new technologies and adaptations for addressing climate change. Yet getting into this expertise and knowledge is hampered by a lack of attention to gender equality. An often unquestioned acceptance of existing gender and power relations is also a reason for this (Alston, 2014).

In Tanzania's district of Kilombero, where a well built by a non-governmental organization dried up soon after it was created, it has been found that the well's location had been decided by a local committee of men alone. On talking with the local women, the development workers discovered that it is often the women's task to dig for water by hand, and therefore women knew the places which provide the best water yields. After the incident, women were asked to involve more in taking decisions regarding the locality of wells. Their help was also required to ensure that programmatic and policy responses to climate change take into account the diverse priorities and needs of both men and women (Demetriades and Esplen, 2010).

Women and girls play vital roles before, during and after disasters. Their active involvement augments the potential effectiveness of mitigation measures or disaster prevention. As they have diverse involvement in their surroundings and their household, they can contribute to the process of assessing capacities and vulnerabilities. To protect the elderly, the children, and other vulnerable groups, womens' participation is most effective and common. Women also play key roles in the planning and implementation of physical methods to mitigate disasters. Women preserve matches,

fuels, dry food (such as peas, rice, puffed rice, molasses, and flattened rice), ropes and medicine at home and prepare portable mud stoves for future use. They also stock fodder for domestic animals, blankets, seeds, valuables etc. They are the first to offer nursing care for the injured whether it is an earthquake, flood, or cyclone, before any official relief work begins. Womens' active role playing can be exploited during different phases of a disaster i.e., before, after and during the incident. In the first stage, they may be involved in organizing women members from various strata of a particular community. In the second stage, they can take lead by pursuing education and training, for their family, neighbourhood and community. During disaster, they can participate even in relief work, medicines, providing nursing, and caring for children and the aged. At that time women are most active and effective in making food and equal distribution among the victims. From the experiences of our daily lives, it can be said that women are most rational and generous in distributing anything. They are especially good in providing timely care and food including reproductive health services for females. In hazardous condition, this quality may be applied particularly to financial matters (Rahman, 2013).

Moser and Satterthwaite (2010) remarked that though the Asian tsunami of 2004 was not triggered by climate change, it exposed the extreme vulnerability of coastal populations to storm surges. The event made it clear why firm gender analysis should be included in rebuilding. Many women joined self-help groups, after the tsunami, to obtain microcredit, which they used to increase their productive activities and boost their assets. This reliance on self-help groups was started partly due to the gender blind nature of disaster relief which focused more on men's lost fishing boats, not on the assets controlled or managed by women. At the same time, it identified the crucial responsibilities and roles of households, individuals, and communities in their personal adaptation processes, independent of government. For climate change adaptation to move beyond its identification as a technical domain toward acknowledgement of the essential importance of its social dimensions, supporting such communities and their collaboration through local institutions, such as municipal governments will be essential.

Another thing to be noted is that millions of poor men and women in affected regions is adapting to climate risk with their own resources and their own initiatives,

with little or no help from governments (Terry, 2009). Jat (2017) has showed that in the Haryana and Bihar states of India, climate-smart villages (CSVs) have been developed and piloted by the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). It aims to test and validate several climate-smart agriculture (CSA) options for promoting gender equality and managing climate-related risks in agricultural production. This approach adopted a wide range of interventions that covered the full spectrum of farm activities in the category of "water-smart" technologies. They included direct seeded rice, bunding, precision land leveling, micro-irrigation; "nutrition smart" e.g., Nutrient Expert decision support tool, legume integration Green Seeker; "carbon and energy smart" e.g., residue management, no-tillage; and "weather and knowledge smart" e.g., index-based insurance, weather forecast, ICT-based agro services. The interventions were customised according to the local needs of villages and farmers. The objective of such interventions was to engender adaptive capability in households and enable them to mitigate the risk of climate change. Climate change disproportionately affects socially marginalized and poor groups such as women due to their lower adaptive capacity. Therefore, understanding how the CSV approach helped in addressing the varying challenges that women faced in adapting to climate change was an important facet. It was also found that the practices and technologies for climate change adaptation would be successfully adopted if women in the farming households are equally aware, empowered, and participate, to adopt the technologies (Hariharan et al., 2018).

CHAPTER 3

MATERIALS AND METHODS

For doing a systematic analysis of the research problem and arriving at meaningful conclusions, an appropriately designed research methodology is essential. It also helps the readers to assess the study conducted and replicate it if needed. This chapter deals with the materials and methods used in the research work. It is given under the following headings:

3.1 Study area

3.2 Sampling design

3.3 Types of data

3.4 Data sources and period of the study

3.5 Analyses of data

3.1 STUDY AREA

The study was undertaken in the Thrissur district of Kerala as it was one among the seven worst affected districts during the Kerala floods of 2018 with 67 per cent departure from normal rainfall. The whole district was notified as flood affected by the Kerala State Disaster Management Authority. The district also recorded the highest number of human fatalities ie., 72 deaths and a crop loss of 3569.25 ha which accounted for greater than 33 per cent of the total cultivated area (GOK, 2018).

3.1.1 Thrissur District

Thrissur is a revenue district of Kerala. It is situated in the Central part of the state, spanning across an area of about 3,032 km^2. It was formed on July 1, 1949 with the headquarters at Thrissur city. The name Thrissur is a shortened version of the Malayalam/Tamil word *'Thiru-Shiva-Per-Ur'* which means a place having three places of worship of Lord Shiva. Thrissur is also known as the cultural capital of Kerala due to it's cultural, religious and spiritual inclination all over history. The largest temple festival of India, *Thrissur Pooram* is the most spectacular festival of this cultural capital.

Thrissur has a population of 31,20,000 which accounts for 9 per cent of the population of Kerala. The district is divided into two revenue divisions, seven taluks, sixteen blocks and 255 villages. Literacy rate is 95.32 per cent. The economy of Thrissur is largely dependent on industries, retailing and financing. The district also accounts for 6.6 per cent of the total area under cultivation in Kerala.

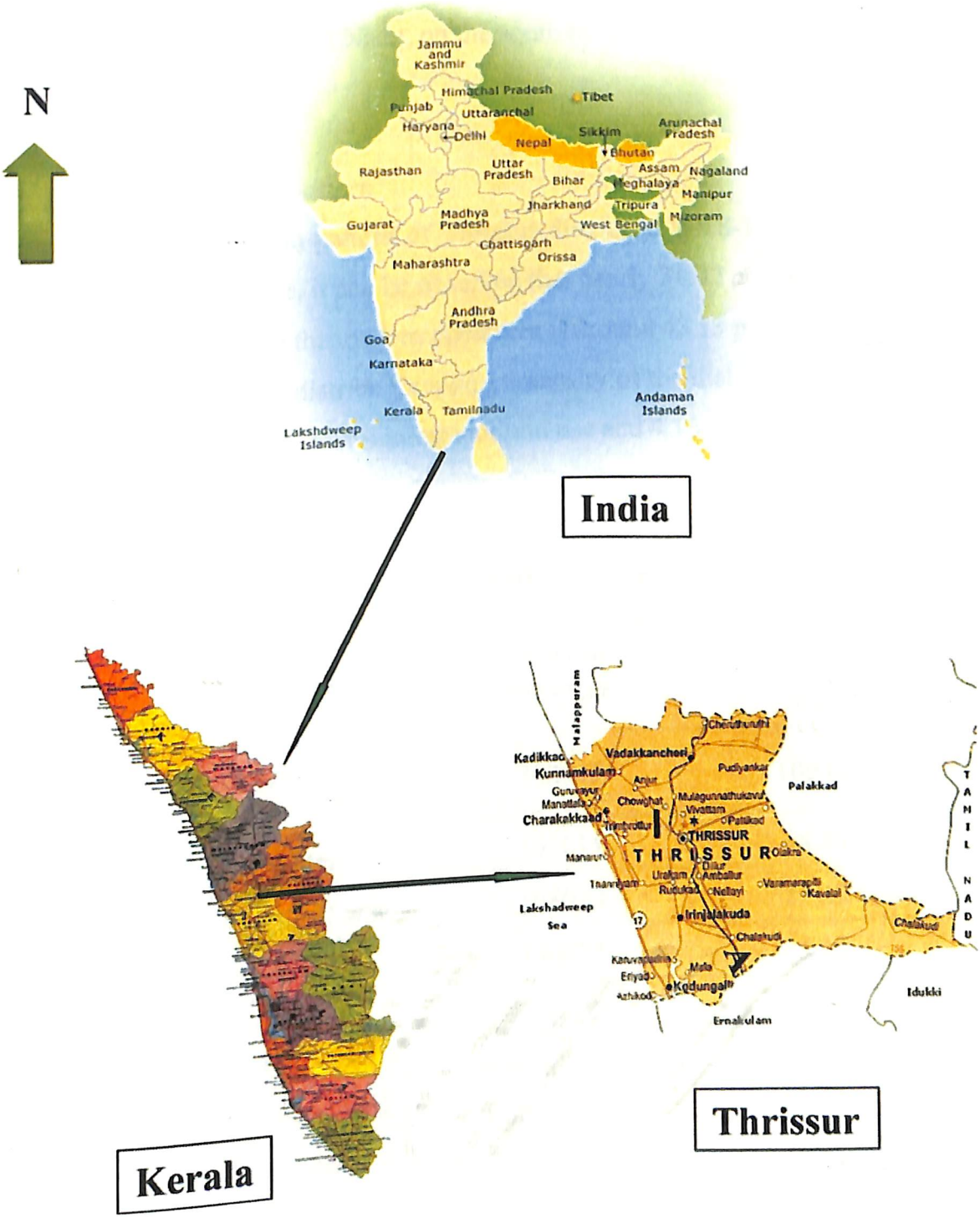


Plate 1 Map of the study area

3.1.1.1 Location

Thrissur is located in South-Western India and is in the Central part of Kerala between the northern latitudes $10^0$10'22" and $10^0$46'54", and the eastern longitudes $75^0$57'20" and $76^0$54'23". The district is located at sea level altitude and occupies an area of 3032 sq. km. It is circumscribed in the north by some parts of Malappuram district, on the northeast by Palakkad district, on the east by parts of Coimbatore district of Tamil Nadu, on the south by Ernakulam district, and on the west by the Arabian sea.

3.1.1.2 Land utilisation pattern

The land utilisation pattern of Thrissur district in 2018-19 is given in the Table 3.1. From the table, it can be observed that nearly 34.02 per cent of the land is under forest cover and the total cropped area is around 43.13 per cent of the total geographical area of the district. Cropping intensity of the district is 129. Around 13.36 per cent of land is under non-agricultural use and 4.15 per cent of the land is left fallow.

Table 3.1 Land utilization pattern of Thrissur district in 2018-19

Sl. No.	Particulars	Area in hectares	Percentage to the total geographical area
1	Total geographical area of the district	302919	100.00
2	Forest area	103619	34.20
3	Gross cropped area	168020	55.46
4	Net cropped area	130674	43.13
5	Land put to non-agricultural use	40472	13.36
6	Current fallow (up to 1 yr)	7732	2.55
7	Other fallow land (1 to 5 yr)	4869	1.60
8	Cultivable waste	9812	3.23

Source: Department of Economics and Statistics, Kerala

3.1.1.3 Topography and climate

The Arabian Sea lies to the west of Thrissur district and Western Ghats stretches towards the east. Sliding from the heights of the Western Ghats in the east, the land slopes towards the west forming three different natural divisions– the highlands, the plains and the seaboard. The highest point of Thrissur is Karimala Gopuram. It is situated in the border of Parambikulam Wildlife Sanctuary of Palakkad. The Periyar, the Karuvannur, the Chalakudy, the Kurumali (main tributary of the Karuvannur River) and the Bharathappuzha are the main river systems in the district. They originate from the mountains on the east, then flows westward and discharge into the Arabian Sea. Also, there are a number of tributaries joining these main rivers. There are waterfalls such as Athirappilly Falls. This is the only district in Kerala with the existence of both Periyar and Bharathappuzha, though they flow only through a small distance through the district. The district has a tropical humid climate. It has an oppressive hot season and plentiful and seasonal rainfall. Annual rainfall is about 3,000 mm (120 in). The hot season from March to May is followed by the southwest monsoon season from June to September. The period from December to February is the northeast monsoon season. However, the rain halts by the end of December and the rest of the period is generally dry.

3.1.1.4 Demographic features

As per the census of 2011, the population of the district was 31,21,200 which contributes to about 9 per cent of the state's population. This gives it the 113th rank in India (out of a total of 640). The district has a population density of 1,026. Its population growth rate over the decade 2001–2011 was 4.58%. Thrissur has a sex ratio of 1109 females for every 1000 males, and a literacy rate of 95.32%. Further social demography and gender data are given in the tables below.

Table 3.2 Demographics of Thrissur

Sl No.	District	Thrissur
1	Area (ha)	3,027
2	Population	31,21,200
3	Males	14,80,763
4	Females	16,40,437
5	Sex ratio : Females/1000	1,092
6	Density of population (per square km)	1031
7	Per Capita Income (in Rs)	21,362
8	Literacy rate	95.08% (Male 96.78%; Female 93.56%)
9	Coastal line in km.	54
10	Water bodied area in ha.	5,573
11	Forest area in ha.	103619

Source: Official Statistics 2012 (http://www.tsr.kerala.gov.in/barefacts.htm)

Table 3.3 Population of Thrissur district as per 2011 census

Category	Male	Female	Total
Total population	1480763	1640437	3121200
SC population	156480	167870	324350
ST population	4362	5068	9430
Literates (No.)	1282261	1396287	2678548
Literacy Rate (%)	97	94	95
Total population of workers	789511	306216	1095727
Main workers	706277	223229	929506
Main cultivators	28697	6094	34791
Main Agricultural labourers	35788	18750	54538
Main household industry workers	15727	6156	21883
Marginal workers	83234	82987	166221
Marginal cultivators	3920	3075	6995
Marginal Agricultural labourers	9534	9869	19403
Marginal household industry workers	2356	3644	6000
Non workers	691252	1334221	2025473
Work participation (%)	53	19	35

Source: Department of Economics and Statistics, Kerala.

3.1.2 Description of the Selected Blocks

Two blocks of Thrissur district, Mala and Vellangallur which are located in the Chalakudy river basin and that were heavily flooded during the Kerala floods of 2018 were selected for the study. Chalakudy Puzha or Chalakudy River is the fifth longest river in Kerala, India. The river flows through three districts namely

Palakkad, Thrissur and Ernakulam. The river's total drainage area is 1704 km². Out of this, 1404 km² lies in Kerala and the remaining 300 km² in Tamil Nadu. Around 12 lakh people from Pariyaram, Chalakudy, Mala, Puthenvelikkara up to Kodungalloor and the Eriyad coastal belt depend on the Chalakudy river for drinking water and irrigation. There are 30 drinking water projects and 600 lift irrigation projects in the river. As per the flood maps of Chalakudy river basin (Figure 2) prepared by the Academy of Climate Change Education and Research (ACCER), Kerala Agricultural University under a project funded by the Kerala State Biodiversity Board, the worst flood affected block panchayats were Mala, Vellangallur and Parakkadavu.

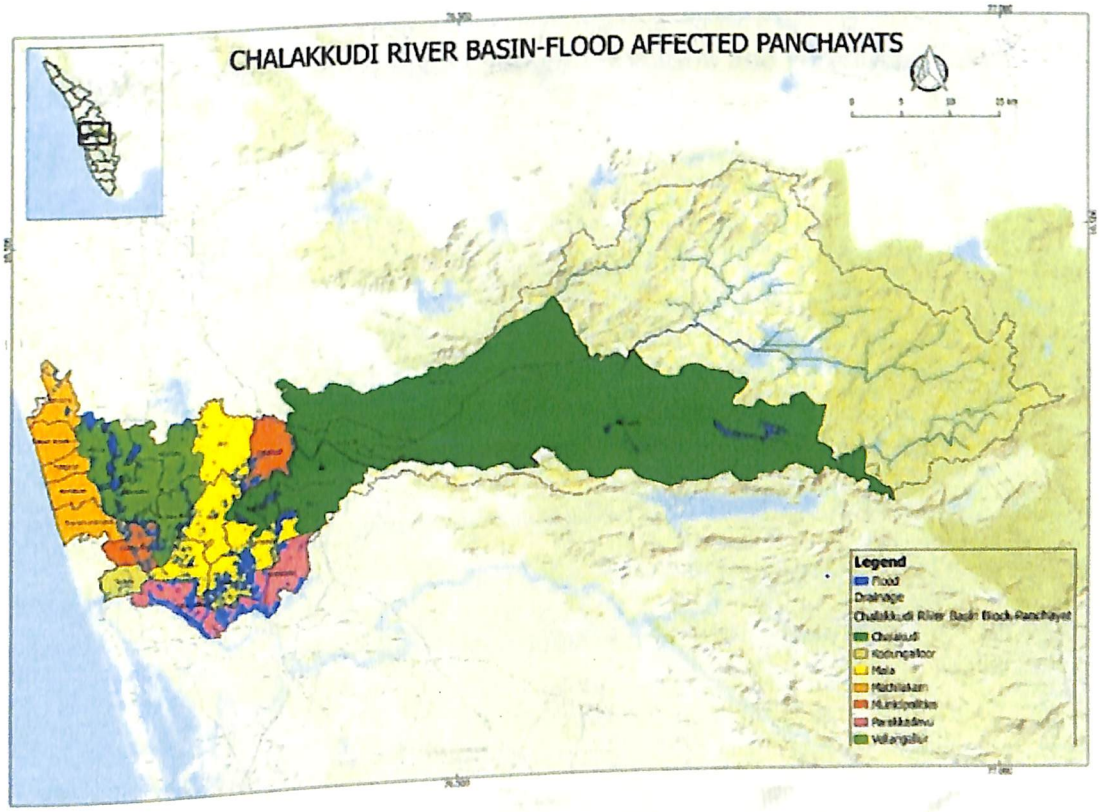
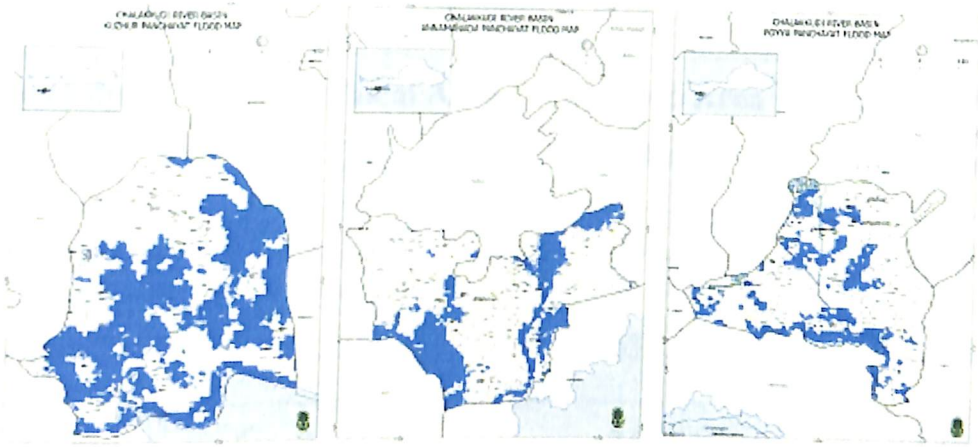


Plate 2 Flood map of Chalakudy river basin (Source: Flood Map of Chalakudy River Basin, Academy of Climate Change Education and Research, KAU)

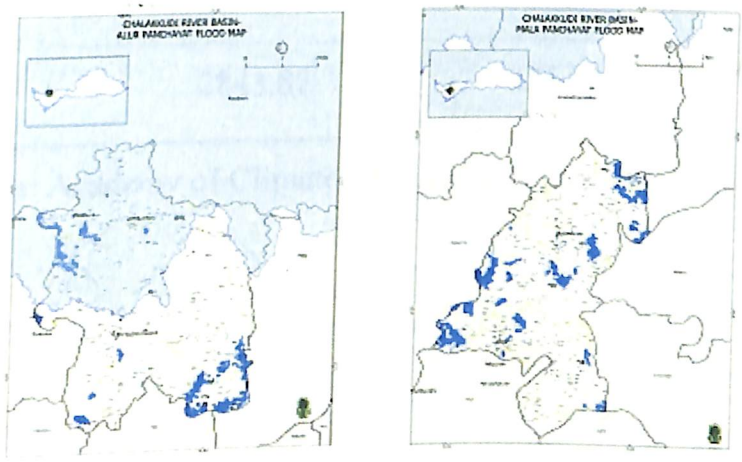
Table 3.4 List of major areas flooded (2018) Panchayat-wise of Mala block

Name of the Panchayat	Geographical Area (ha)	Flooded Area (ha)	Class wise percentage (%)
Kuzhur	2009.52	840.62	41.83
Annamanada	2521.17	578.52	22.95
Poyya	1973.12	326.11	16.53
Mala	2862.28	227.84	7.96
Alur	3673.72	189.62	5.16

Source: Academy of Climate Change Education and Research, KAU.



(a) (b) (c)



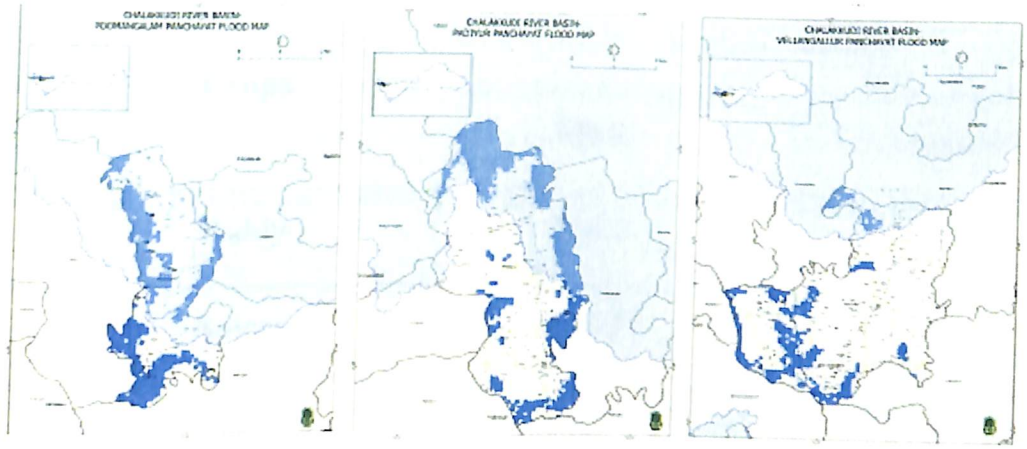
(d) (e)

Plate 3 Maps showing flood affected grama panchayats of Mala block (a) Kuzhur (b) Annamanada (c) Poyya (d) Alur (e) Mala (Source: Academy of Climate Change Education and Research, KAU)

Table 3.5 List of major areas flooded (2018) floods Panchayat-wise of Vellangallur block

Name of the Panchayat	Geographical Area (ha)	Flooded Area (ha)	Class wise percentage (%)
Poomangalam	1218.78	459.42	37.70
Padiyur	1828.69	631.95	34.56
Vellangallur	2392.55	349.64	14.61
Puthenchira	2442.51	315.87	12.93
Velukkara	2843.87	254.59	8.95

Source: Academy of Climate Change Education and Research, KAU.



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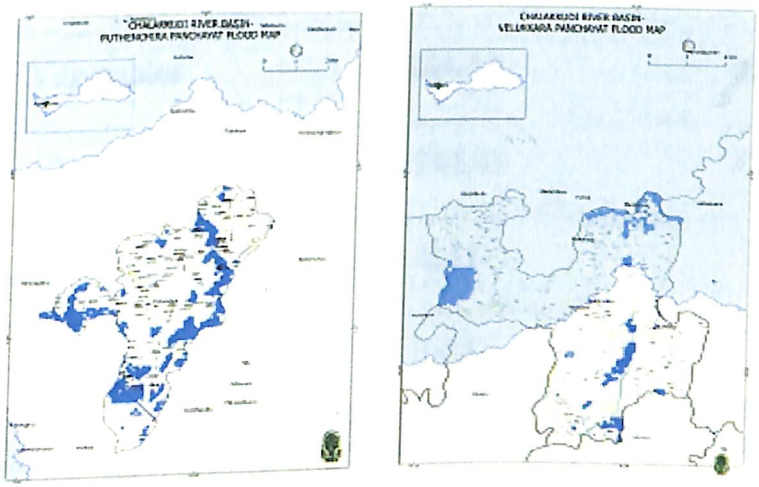

(d) (e)

Plate 4 Maps showing flood affected grama panchayats of Vellangallur block (a) Poomangalam (b) Padiyur (c) Vellangallur (d) Puthenchira (e) Velukkara

(Source: Academy of Climate Change Education and Research, KAU)

Table 3.6 Block wise area of crops 2016-17

Sl No.	Crops	Area in hectares	
		Mala	Vellangallur
1	Paddy	868.5	540.2
2	Spices	2116.53	1065.84
3	Jack	1663.71	977.11
4	Tubers	389.5	76.71
5	Vegetables	164.38	128.86
6	Coconut	4544.03	4202.8
7	Betel leaves	0.44	0.16
8	Cocoa	1.34	1.12
9	Fodder grass	6.02	5.54
10	Green manure plants	63.63	60.67
11	Teak	79.38	54.36
12	Medicinal plants	1.87	2.92

3.2 SAMPLING DESIGN

3.2.1 Criteria for selection of samples

The study was conducted among agricultural households which were relatively poor ie, BPL card holders. It was required that at least 20 per cent of their total income was from agriculture and allied sectors.

3.2.2 Distribution of samples

The extent of agricultural losses due to floods were found for each panchayat of the selected blocks from the respective Krishi Bhavans and accordingly the number of agricultural households to be surveyed from each panchayat was decided. The distribution of samples is given in the table 3.7.

Table 3.7 Distribution of samples

Block	Panchayat	No. of households	Total
Mala	Annamanada	20	75
	Mala	15	
	Alur	15	
	Kuzhur	15	
	Poyya	10	
Vellangallur	Padiyur	40	75
	Vellangallur	15	
	Puthenchira	10	
	Poomangalam	8	
	Velukkara	2	
TOTAL SAMPLE SIZE			**150**

The sample size of the survey was 150 with 75 households each from the two blocks. The households were selected through simple random sampling method from the lists provided from the Krishi Bhavan and the Panchayat.

Those samples in which men were involved in agriculture and were the head of the household were taken as ***male-headed households*** **(MHH)**. Those samples in which men were away or bedridden or the women were either a widow or separated, were considered as ***female-headed households*** **(FHH)**.

3.3 TYPES OF DATA

The study was conducted using primary and secondary data. Primary data was collected through survey of the households. It involved data on the vulnerability of households during extreme weather and the adaptation strategies undertaken by them. Secondary data included data on climate parameters of the past 10 years in the study area, list of below poverty line agricultural households of Mala and Vellangallur blocks and data on gender and agricultural production of the area.

3.4 DATA SOURCES AND PERIOD OF THE STUDY

The primary data was collected by a household survey. The head of the agricultural households was interviewed using a well-structured and pre-tested interview schedule. Information regarding the socio-demographic profile of the household, economic status, health, social network, food, water, natural disasters and climate variability were collected from the households. The general perception of the respondents on climate change and the adaptation strategies employed by them were also recorded.

The secondary data was collected from different sources. The climate parameters required for the study i.e. monthly average precipitation, monthly average maximum temperature and monthly average minimum temperature for the past 10 years i.e., 2010 to 2019 were collected from the weather station of Kerala Agricultural University. The list of male and female-headed BPL agricultural households of Mala and Vellangallur blocks were obtained from the Panchayats and Krishi Bhavans of the blocks. Further secondary level socio-economic statistical information was collected from the websites- Indiastat.com, Directorate of Economics and Statistics (Ministry of Agriculture and Farmers' Welfare, Govt. of India) and Department of Economics and Statistics (Govt. of Kerala).

The study was undertaken over a time span of one year, ie., August 2019-2020.

3.5 ANALYSES OF DATA

3.5.1 Conventional analysis

3.5.2 Climate variability and natural disasters

3.5.3 Livelihood vulnerability of male and female-headed households to extreme weather events

3.5.4 Economic vulnerability

3.5.5 Determinants of economic vulnerability

3.5.6 Adaptation strategies undertaken by the rural households

3.5.1 Conventional analysis

Tabular method using averages and percentages were adopted to interpret the responses of the households towards aspects related to the socio-demographic profile, economic status, social networks, health, food, water and natural disasters and climate variability. This was done to obtain a picture about the lives of the sample respondents and their area.

3.5.2 Climate variability and natural disasters

The weather data for 10 years, ie., 2010 to 2019, were analysed in excel to understand the interannual variability in precipitation of the study area.

3.5.3 Livelihood vulnerability of male and female-headed households to extreme weather events

3.5.3.2 The Livelihood Vulnerability Index

Hahn et al. (2009) combined the previous vulnerability assessment techniques to build a Livelihood Vulnerability Index (LVI). With this, it was aimed to estimate the differential impacts of climate change on communities in two districts of Mozambique. The LVI uses multiple indicators to assess exposure to natural disasters and climate variability, social and economic characteristics of households which affect their adaptive capacity, and current health, food, and water resource characteristics which determine their sensitivity to the impacts of climate change. Two approaches were presented by Hahn: the first one expresses Livelihood Vulnerability Index (LVI) as a composite index comprising of seven major components while the second aggregates these components into IPCC's three contributing factors to vulnerability- exposure, sensitivity, and adaptive capacity giving the LVI-IPCC. In this study, both these approaches have been used to find the climate change vulnerability of male and female-headed agricultural households of Thrissur district. Similarly, Sathyan et al. (2018) has

modified these approaches according to the local situation to address the climate vulnerability in rain fed farming areas of Kerala. Also, Gentle et al. (2014) has used Hahn's LVI approach to study the differential impacts of climate change on communities in the middle hills region of Nepal.

Hahn's approach varies from preceding methods. It uses only the primary data from household surveys to construct the index. It also offers a framework for grouping and aggregating indicators on the district level. This can be crucial for development and adaptation planning. As this approach uses primary household data, the pitfalls that can happen while using secondary data can be avoided. Another advantage is the limited reliance on climate models. The models regardless of the recent advances are still presented at too large a scale. Hence providing accurate projections at levels beneficial for community development planning is not possible (Patz et al., 2005). The focus of LVI approach is on quantifying the strength of current livelihood and health systems as well as the capacity of communities to alter them in response to climate-related exposures.

The LVI is intended to provide policy makers, development organizations, and public health practitioners with a practical tool to comprehend social, demographic, and health factors contributing to climate vulnerability at the community or district level. LVI is flexible so that development planners can refine and focus their analyses to suit the needs of each geographical area. In addition to the overall composite index, sectoral vulnerability scores can be separated to identify the potential areas of intervention.

3.5.3.3 Calculating LVI: The composite index approach

The LVI comprises of seven major components. They are Socio-Demographic Profile, Economic status, Social Networks, Health, Food, Water, and Natural Disasters and Climate Variability. Each one includes several indicators or sub-components which were developed by Hahn based on a review of the literature on each major component. The survey-questions used to collect the data, the original source of the survey-question and the potential sources of bias are provided in Appendix II.

The LVI uses a balanced weighted average approach (Sullivan et al., 2002) where even though each major component is comprised of varied number of sub-components, each sub-component contributes equally to the overall index. Hahn et al.

(2009) intended to develop an assessment tool handy to a diverse set of users from resource-poor settings. Hence the LVI formula uses a simple approach of applying equal weights to all major components. This weighting scheme could be accustomed as per the requirement of the user.

Each of the sub-components is measured on a different scale. Therefore, it was first required to standardize each as an index. For this conversion, an equation was adopted from the Human Development Index which was used to calculate the life expectancy index (UNDP, 2007).

$$index_{S_g} = \frac{S_g - S_{min}}{S_{max} - S_{min}} \quad (1)$$

where S_g is the original sub-component for gender g and S_{min} and S_{max} are the minimum and maximum values, respectively, for each sub-component determined using data from both male and female-headed households. For example, the sub-component 'number of times natural disasters have affected the household area between 2014 and 2019' ranged from 1 to 5 in the households where we conducted the survey. These minimum value and maximum value were used to convert this indicator into a standardized index. After that, it was incorporated into the natural disasters and climate variability component of the LVI. For variables that measure frequencies such as the 'Percentage of households that does not manage to get nutritious food', the minimum value was set at 0 and the maximum at 100. Some sub-components such as the 'average agricultural livelihood diversity index' were formed because an increase in the number of livelihood activities carried out by a household, was assumed to decrease vulnerability. In other words, we assumed that a household who raises animals along with farming is less vulnerable than a household who only farms. By taking the inverse of this indicator, we generated a number which allots higher values to households with a lower number of livelihood activities. The maximum and minimum values were also transformed according to this logic. Eq. (1) was used to standardize these sub-components. After standardizing, the sub-components were averaged using Eq. (2) to calculate the value of each major component:

$$M_d = \frac{\sum_{i=1}^{n} index_{S_g}{}^{i}}{n} \quad (2)$$

where M_d = one of the seven major components for gender g [Socio-Demographic Profile (SDP), Economic Status (ES), Social Networks (SN), Health (H), Food (F), Water (W), or Natural Disasters and Climate Variability (NDCV)], $index_{S_g i}$ represents the sub-components, indexed by i, which make up each major component, and n is the number of sub-components in each major component. Once the values for each of the seven major components for male-headed households (or female-headed households) were calculated, they were averaged using Eq. (3) to obtain the LVI for each gender:

$$LVI_g = \frac{\sum_{i=1}^{7} w_{M_i} M_{gi}}{\sum_{i=1}^{7} w_{M_i}} \tag{3}$$

which can also be expressed as-

$$LVI_g = \frac{w_{SDP}SDP_g + w_{ES}ES_g + w_{SN}SN_g + w_H H_g + w_F F_g + w_W W_g + w_{NDC}NDCV_g}{w_{SDP} + w_{LS} + w_{HSN} + w_H + w_F + w_W + w_{NDC}}$$

where LVI_g, the Livelihood Vulnerability Index for gender g, equals the weighted average of seven major components. The weights of each major component, w_{M_i} are determined by its number of sub-components. Weights are included to ensure that all sub-components equally contribute to the overall LVI (Sullivan et al., 2002). In this study, the LVI ranges from 0 (least vulnerable) to 0.5 (most vulnerable).

3.5.3.4 Calculating the LVI–IPCC: IPCC framework approach

Hahn et al. (2009) developed an unconventional method for calculating the LVI. It incorporates the IPCC vulnerability definition. Table 3.8 shows the organization of seven major components in the LVI-IPCC framework. Climate variability was measured by the average standard deviation of the maximum and minimum monthly temperatures and monthly precipitation over a period of 6 years (2014-19). Exposure of the study population was obtained by taking the number of natural disasters that have occurred in these years. Adaptive capacity was quantified by taking the inverse of the sub-components of socio-demographic profile of the households (e.g., inverse of dependency ratio), their economic status (e.g., proportion of total income to agricultural income of the household) and the strength of social networks (e.g., inverse of the number of helps received in the past 12 months). Finally, sensitivity was measured by

weighing the existing state of food and water security and health status of the households. The same sub-components outlined in Appendix II as well as Eqs. (1) – (3) were used to calculate the LVI–IPCC. The LVI–IPCC deviates from the LVI when the major components are combined. Rather than merging the major components into the LVI in one step, they were first combined according to the categorization scheme in Table 3.8 using the following equation:

$$CF_g = \frac{\sum_{i=1}^{n} w_{M_i} M_{gi}}{\sum_{i=1}^{n} w_{M_i}}$$

where CF_g is an IPCC-defined contributing factor (exposure, sensitivity, or adaptive capacity) for gender g, M_{gi} is the major component indexed by i, w_{M_i} is the weight of each major component, and n is the number of major components in each contributing factor.

Table 3.8 Values of the sub-components of Adaptive Capacity

Major Component	Question
Socio-Demographic Profile	1.Percentage of households where the head has high school education 2.Inverse of dependency ratio
Economic Status	1.Percentage of households not dependent solely on agriculture 2.Proportion on non-agri income to total income 3.Agricultural livelihood diversification index 4.Household's ability to meet its basic needs 5.Household's ability to cope with financial stress 6.Liquid assets 7.Savings 8.Household's perception of their economic status 9.Productive assets
Social Networks	1.No. of helps received in the past 12 months 2.Percentage of households who have gone to the local government in the past 12 months

Table 3.9 Major contributing factors of LVI-IPCC.

Contributing factors	Major components
Exposure	Natural disasters and climate variability
Adaptive capacity	Socio-demographic profile (inverse of each sub-component)
	Economic status (inverse of each sub-component)
	Social networks (inverse of each sub-component)
Sensitivity	Health
	Food
	Water

Once exposure, sensitivity, and adaptive capacity were calculated, they were combined using the following equation:

$$LVI - IPCC_g = (e_g - a_g) * S_g$$

where $LVI - IPCC_g$ is the LVI for gender g expressed by means of the IPCC vulnerability framework, e is the calculated exposure value for district d (equivalent to the Natural Disaster and Climate Variability major component), a is the calculated adaptive capacity value for district d (weighted average of the Socio-Demographic, Economic Status, and Social Networks major components), and s is the calculated sensitivity value for district d (weighted average of the Heath, Food, and Water major components). The LVI–IPCC value ranges from -1 (least vulnerable) to 1 (most vulnerable).

3.5.4 Economic vulnerability

In this study, the economic vulnerability of the households was estimated by modifying the ASPIRES Economic Vulnerability Tool which was developed by an NGO from the United States of America. The components used in the tool are given in detail in the Table 3.10.

Table 3.10 Components of Economic Vulnerability

Sl No	Questions	Source	Units	Value Range
1.	Households with agriculture as the only source of income	Modified from LVI of Hahn et al (2009)	Binary digits	0,1
2.	Average agricultural livelihood diversification index	Modified from LVI of Hahn et al (2009)	1/1+no. of agricultural activities	0.5-0.167
3.	Proportion of agricultural income to annual income	Modified from LVI of Hahn et al (2009)	Ratio	
4.	Household's ability to meet its basic needs (a)We struggle for food and shelter (0.4) (b)We can afford food and shelter, but it is difficult to make huge payments for health and education expenses (0.3) (c)We can always afford food, shelter, and education and health care expenses. Although we have to struggle at times, we do make lump sum payments when necessary (0.2) (d)We can always afford to pay for food, shelter, education, and health care without difficulty (0.1)	ASPIRES economic vulnerability tool	**Range	0.1-0.4

Sl No	Questions	Source	Units	Value Range
5.	Sources of income of the household (Income diversity) (a)Salaries/wages/commission (b)Income from a business (c)Remittances (money received from people living elsewhere) (d)Pensions (e)Grants (f)Selling of farm products and services (g)Other sources of income e.g. rental income, interest (e)No income (Each of the option (from above),suggested by the household was given a value of 0.1and the inverse of its sum was taken)	ASPIRES economic vulnerability tool	Count	0.1*(no. of sources)
6.	Frequency of income availability throughout the year (a)Unpredictable (0.4) (b)Predictable, but it may change vividly depending on the season (0.3) (c) Predictable, but changes slightly with the season (0.2) (d) Predictable all round the year (0.1)	ASPIRES economic vulnerability tool	**Range	0.1-0.4

Sl No	Questions	Source	Units	Value Range
7.	Ability to handle financial stress (a)Find a new job (0.1) (b)Rely more on additional income generating activity within the household (0.2) (c)Rely on family members for backing (0.3) (d)Depend on charity (0.4) (e)I don't have a livelihood (0.5)	ASPIRES economic vulnerability tool	**Range	0.1-0.5
8.	Liquid assets (a)We never have many liquid assets (0.4) (b)We have some liquid assets, but it fluctuates a lot within the year (0.3) (c)We always have some liquid assets, and the amount changes a little during the year (0.2) (d)We constantly have many liquid assets (0.1)	ASPIRES economic vulnerability tool	**Range	0.1-0.4
9.	Savings (a)Nothing or nearly nothing (0.4) (b)Some, but the amount fluctuates within the year (0.3) (c)Some, but the amount changes a little during the year (0.2) (d)We constantly have a lot of savings (0.1)	ASPIRES economic vulnerability tool	**Range	0.1-0.4

Sl No	Questions	Source	Units	Value Range
10.	Economic status of the household (a)Destitute: we are barely surviving (0.4) (b)Struggle to make ends meet: we are just surviving with an unstable economic status (0.3) (c)Prepared to grow: our status is mostly steady and we are investing in new opportunities, though we sometimes struggle (0.2) (d)Not vulnerable: we are secure and stable (0.1)	ASPIRES economic vulnerability tool	**Range	0.1-0.4
11.	Productive assets (a)We don't have any productive assets (0.3) (b)We have some productive assets (0.2) (c)We have plenty of productive assets (0.1)	ASPIRES economic vulnerability tool	**Range	0.1-0.3
12.	Last time the household experienced a shock (a)No shocks have occurred (0.1) (b)More than 10yrs. Ago (0.2) (c)5-10yrs. Ago (0.3) (d)In the last yr (0.4)	ASPIRES economic vulnerability tool	**Range	0.1-0.5

Sl No	Questions	Source	Units	Value Range
13.	What was the shock (a)Family conflict (b)Death of a wage earner/grant recipient (c)Major job loss (d)Taking in new dependents (e)Drought or natural disaster (f) Failure of business (g)Other (Each of the option (from above),suggested by the household was given a value of 0.1and its sum was taken)	ASPIRES economic vulnerability tool	Count	0.1*(no. of shocks)
14.	Household recovery status with regard to shock experienced (a)Household never recovered (0.4) (b)Household is still recovering (0.3) (c)Household recovered over time (0.2) (d)Household recovered immediately (0.1)	ASPIRES economic vulnerability tool	**Range	0.1-0.4
15.	Overall debt of the household	Anderloni et al. (2012)	Amount in rupees divided by one lakh	

3.5.5 Determinants of economic vulnerability

The factors contributing to the economic vulnerability of male and female-headed households were found using logit model. Logistic Regression (logit) analysis is a uni/multivariate technique which estimates the probability that an event occurs or not, by predicting a binary dependent from a set of independent variables. The prediction is based on the use of one or several predictors which may be numerical or categorical. The equation of the model is explained below-

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

Where,

$P_i \rightarrow$ probability

$X_i \rightarrow$ vector of independent variables

$\beta_I s \rightarrow$ coefficients to be estimated

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

Where,

$Z_i \rightarrow \alpha + \beta_i X_i$

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

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

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

Taking logarithm on both sides,

$$Li = \ln (P_i/1 - P_i) = Z_i$$
$$= \alpha + \beta_i X_i$$

L is called the logit.

In the present study, the model is

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6$$

Where,

$\alpha \rightarrow$ the intercept

$\beta \rightarrow$ coefficient of subsequent variables

Table 3.11 provides the dependent and independent variables used in the model and their units.

Table 3.11 Variables used in the logit model

Sl No.	Variables	Unit
1	High school education (X_1)	1-Head has at least high school education 0-Head doesn't even have high school education
2	Dependency ratio (X_2)	Range: 0-3
3	Local govt. assistance (X_3)	1-The household has received help from the local govt. at least once in the past 12 months 0-The household has not received any help from the local govt. in the past 12 months
4	No. of family members (X_4)	Number
5	Households solely dependent on agricultural income for livelihood (X_5)	1-Solely dependent 0-Not solely dependent
6	Average agricultural livelihood diversification index (X_6)	Range: 0.2-0.5
7	Number of natural disasters that have occurred in the area in the past 6 years (X_7)	Number
8	Economic vulnerability (Y)	1-High vulnerability 0-Low vulnerability

The analysis was done in R 3.6.3 package.

3.5.6 Adaptation strategies undertaken by the rural households

The adaptation strategies undertaken by rural households were decided from the primary data collected through survey questionnaire. A comprehensive literature review was also done to acquire more information related to the household level adaptation strategies. The agreement among the households on these adaptation strategies were tested through Kendall's concordance test. Kendall's concordance test

is a non-parametric statistical technique employed to measure the level of agreement between multiple variables. Kendall's coefficient of concordance W, known as Kendall's W is the agreement among m raters who assess a given set of n objects by assigning ranks. In this study, this method is used to analyse the adaptation strategies (m) taken by the agricultural households (n) to address the difficulties posed by climate variability and extreme weather events. The test statistic is explained as:

$$R_i = \sum_{j=1}^{m} r_{i,j}$$

Where,

$R_i \rightarrow$ total rank given to an adaptation strategy

$r_{i,j} \rightarrow$ rank assigned to an adaptation strategy i by the household j

$m \rightarrow$ total number of adaptation strategies selected

$n \rightarrow$ the total number of households selected

The mean value of these total ranks is given as:

$$\bar{R} = \frac{1}{n}\sum_{i=1}^{n} R_i$$

The sum of the squared deviations, S, is found as:

$$S = \sum_{i=1}^{n} (R_i - \bar{R})^2$$

The Kendall's coefficient of concordance is defined as

$$W = \frac{12S}{m^2(n^3 - n)}$$

If two or more objects (here adaptation categories) are assigned with the same rank, the value of Kendall's W has to be corrected for ties using the correction factor, which is calculated as

$$T_h = \sum_{i=1}^{g_h} (t_i^3 - t_i)$$

Where,

t_i → number of tied ranks in the i^{th} group (set of values with constant rank) of tied ranks

g^h → number of groups of ties in the set of ranks ranging from 1 to n for the household h

T_h → correction factor required for the set of ranks for household h, i.e. the h^{th} set of ranks

Kendall's W, after correction of ties is as follows:

$$\frac{12\sum_{i=1}^{n}(R_i^2) - 3m^2\, n(n+1)^2}{m^2 n(n^2-1) - m\sum_{h=1}^{m}(T_h)}$$

Where,

R_i → sum of ranks for the adaptation category i

$\sum_{h=1}^{m}(T_h)$ → sum of values of T_h for all m set of ranks

The value of Kendall' W ranges between 0 to 1. Zero indicates no agreement and one indicate complete agreement among the variables selected.

CHAPTER 4

RESULTS AND DISCUSSION

The household survey yielded 110 male-headed households (MHH) and 40 female-headed households (FHH). The data of MHH and FHH were analysed using Mann Whitney U-test to ensure that there is significant difference between the data. Hence all the analyses were carried out separately for MHH and FHH. Results of the analyses and their discussion are presented in this chapter under the following major headings-

4.1 Conventional Analysis

4.2 Climate variability and natural disasters

4.3 Livelihood vulnerability of male and female-headed households to extreme weather events

4.4 Economic vulnerability

4.5 Determinants of economic vulnerability

4.6 Adaptation strategies undertaken by the rural households

4.1 Conventional Analysis

In this section, the socio-economic features of the sample respondents are discussed.

4.1.1 Age of the respondents

Table 4.1 Age

Age	MHH	FHH	Total
Below 40	5 (4.5)	3 (7.5)	8 (5.3)
40-49	31 (28.2)	9 (22.5)	40 (26.67)
50-59	41 (37.3)	17 (42.5)	58 (38.6)
60 and above	33 (30)	11 (27.5)	44 (29.3)
Total	110 (100)	40 (100)	150 (100)

Note: Figures in parentheses show percentages to the total

Majority of the respondents were of the age group fifty to fifty-nine. However, only a small per cent of them were below 40 years.

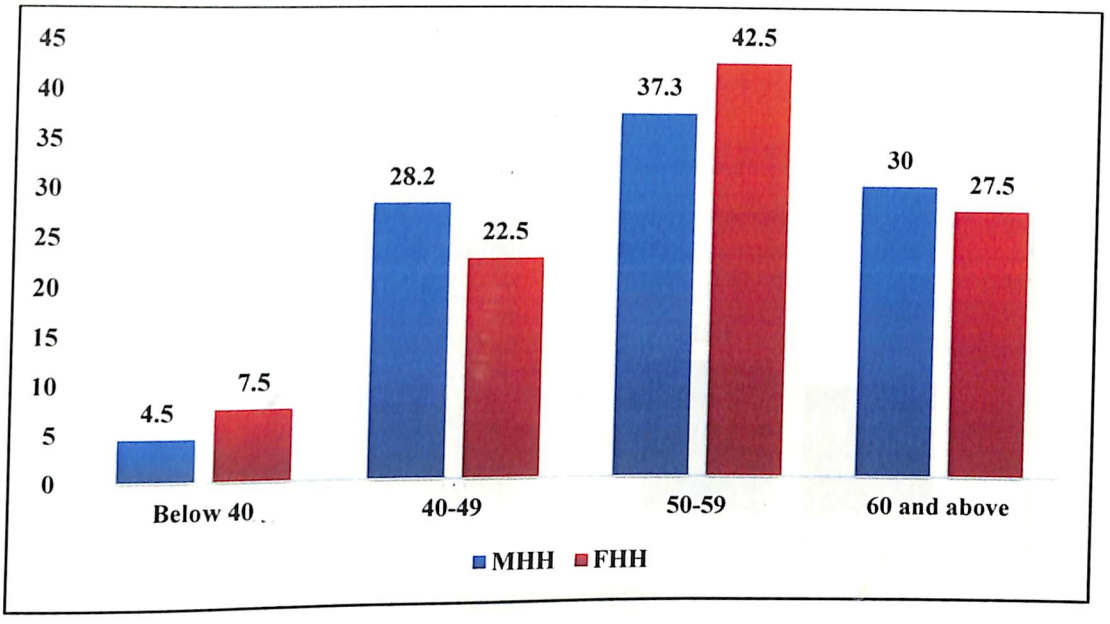

Fig.1 Age

4.1.2 Family size of the respondents

Table 4.2 Family size

Family size	MHH	FHH	Total
2-4	84 (76.3)	32 (80)	116 (77.3)
5-10	26 (23.6)	8 (20)	34 (22.6)
Total	110 (100)	40 (100)	150 (100)
Average family size	3.8	3.35	3.58

Note: Figures in parentheses show percentages to the total

The average family size of the respondents was 3.6 reflecting the general trend of nuclear family system. More than 70 per cent of the respondents from both the groups had only two to four members in their family. Due to smaller family size, the scope of family labour employment in agriculture was low among these households.

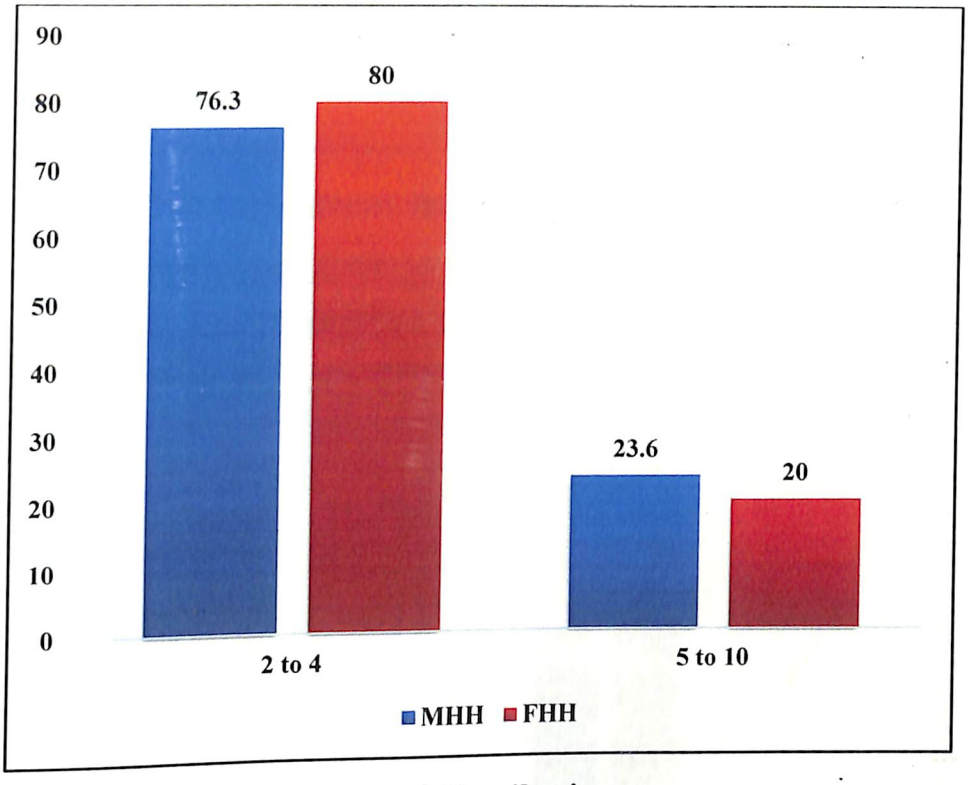

Fig.2 Family size

4.1.3 Dependency ratio

Table 4.3 Dependency ratio among the respondents

Dependency ratio	MHH	FHH	Total
0 to 0.49	49 (44.5)	18 (45)	67 (44.6)
0.5 to 0.99	20 (18.1)	5 (12.5)	25 (16.6)
1 to 1.99	34 (30.9)	14 (35)	48 (32)
2 to 3	7 (6.3)	3 (7.5)	10 (6.6)
Total	110 (100)	40 (100)	150 (100)
Average dependency ratio	0.63	0.62	0.62

Note: Figures in parentheses show percentages to the total

Dependency ratio gives an idea about the dependent population in the household. It is the ratio between the number of members in the household of the age group below 15 and above 65 years and those between 15 to 65 years. The average dependency ratio among MHH and FHH were almost the same but among the highest category of dependency ratio, females were found to have a greater percentage compared males. The presence of widows and bed-ridden husbands in the FHH may be the reason for this.

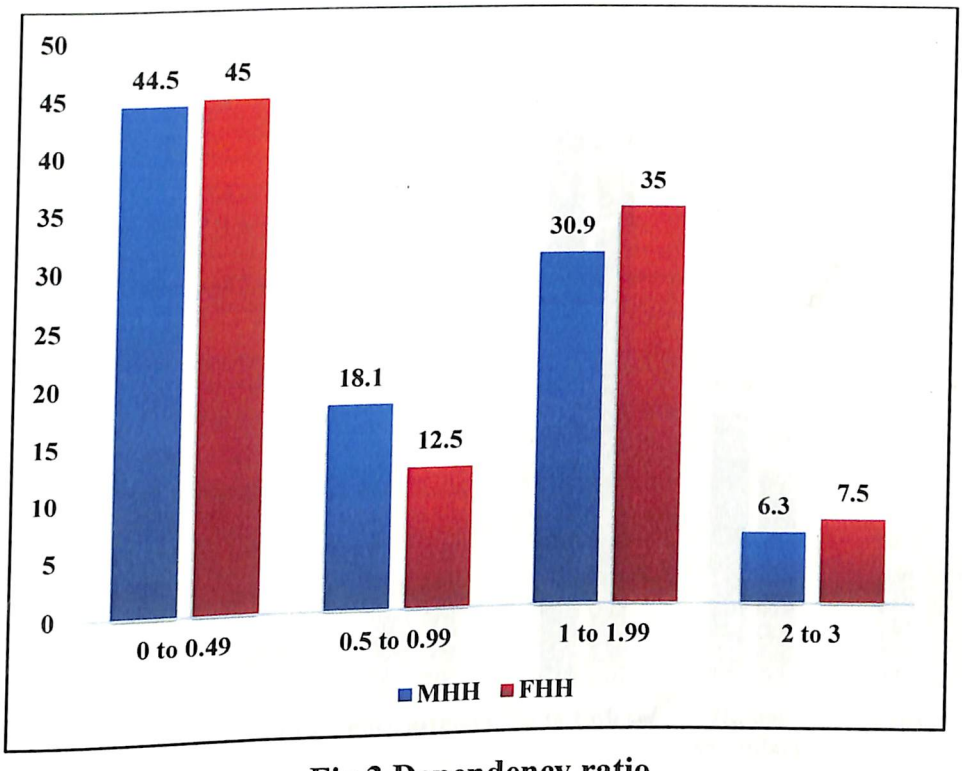

Fig.3 Dependency ratio

4.1.4 Educational status of the respondents

Table 4.4 Educational status

Educational status	MHH	FHH	Total
Illiterate	2 (1.8)	2 (5)	4 (2.6)
Primary (up to 4th std)	3 (2.7)	2 (5)	5 (3.3)
Upper primary (5th to 7th std)	8 (7.2)	4 (10)	12 (8)
Up to 10th std	57 (51.8)	19 (47.5)	76 (50.67)
Higher secondary	28 (25.4)	8 (20)	36 (24)
Graduate	12 (10.9)	5 (12.5)	17 (11.3)
Total	110 (100)	40 (100)	150 (100)

Note: Figures in parentheses show percentages to the total

More than 90 per cent of respondents from both the groups have attended at least upper primary school. This is in accordance with the high literacy rate of Kerala. Majority of them have studied up to 10th standard (50.67%). Around 24 per cent of respondents have studied up to higher secondary school and around 11.3 per cent had University level education. The college level education was more among females (12.5). This can be attributed to the fact that females were relatively younger than male farmers in age.

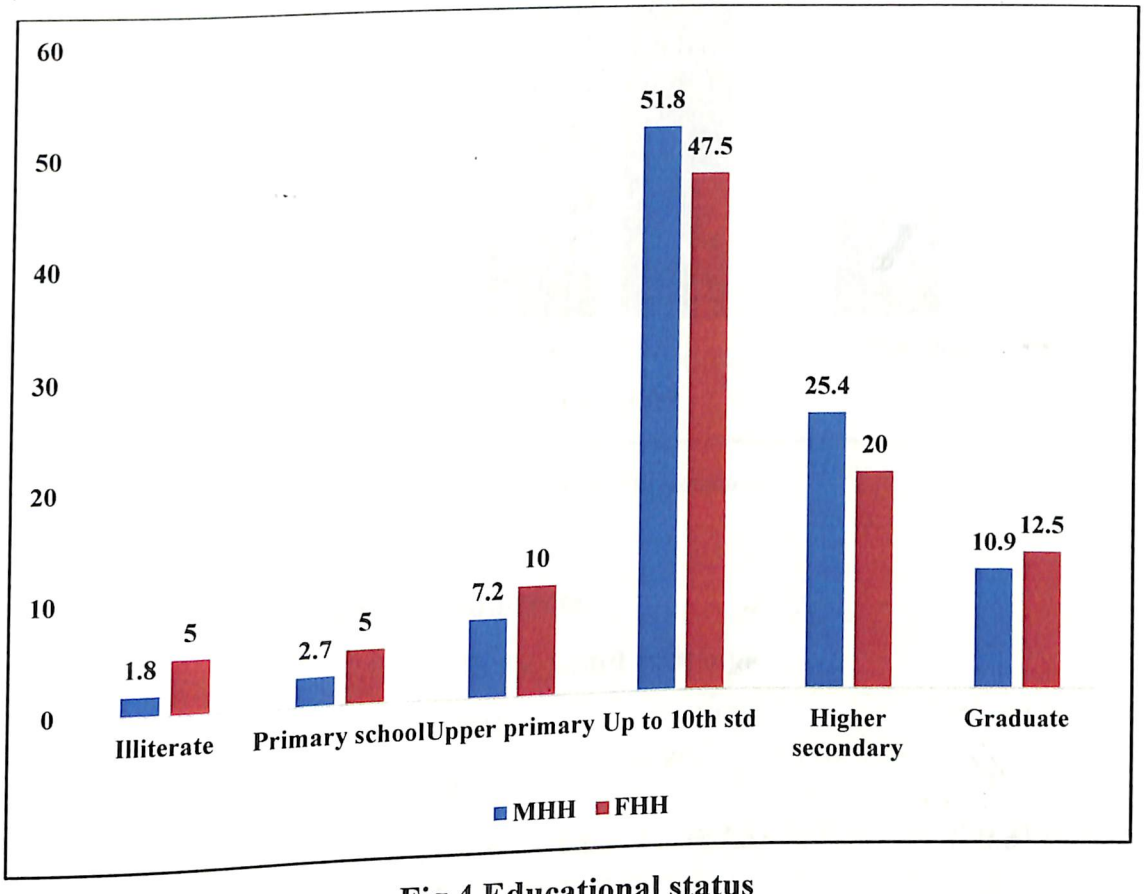

Fig.4 Educational status

4.1.5 Farming experience of the respondents

Table 4.5 Farming experience

Farming experience	MHH	FHH	Total
<10 yrs.	29 (26.3)	14 (35)	43 (28.6)
10 to 25 yrs.	62 (56.3)	26 (65)	88 (58.6)
>25 yrs.	19 (17.2)	0	19 (12.6)
Total	110 (100)	40 (100)	150 (100)

Note: Figures in parentheses show percentages to the total

Among the respondents, males were found to have a greater farming experience with around 17.2 per cent of them being farmers for more than 25 years. Sixty-five per cent of the female farmers had an experience of between 10 to 25 years whereas 35 per cent of them were recent practitioners (<10 years).

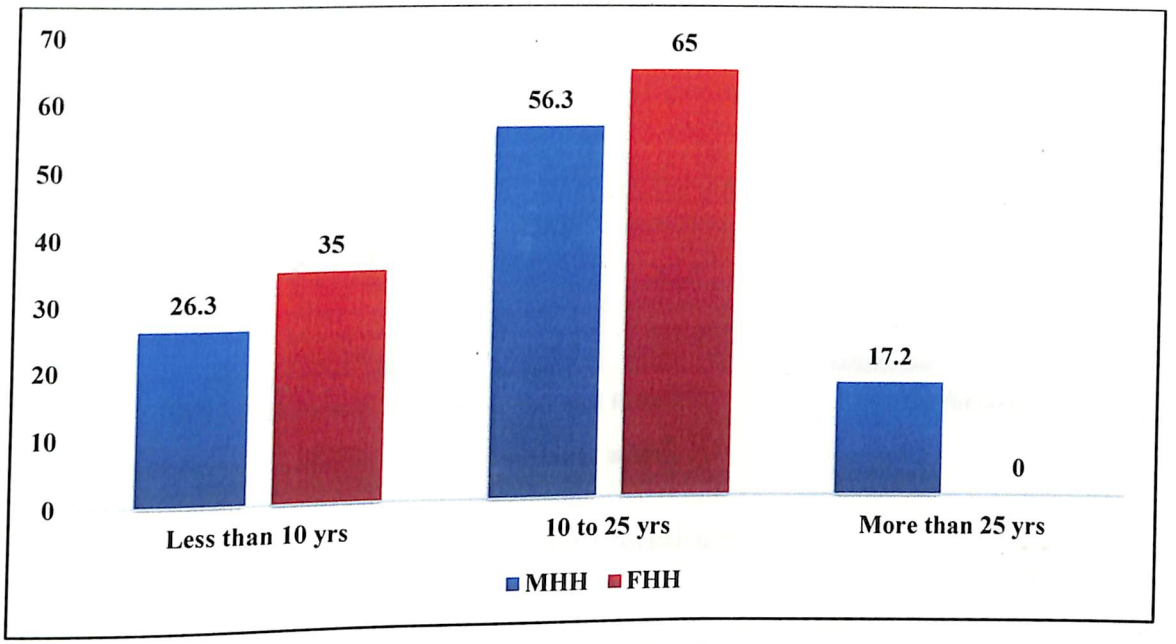

Fig.5 Farming experience

4.1.6 Land holdings of the respondents

Table 4.6 Land holdings

Land holdings (ha)	MHH	FHH	Total
Marginal farmer (<1 ha)	84 (76.3)	35 (87.5)	119 (79.3)
Small farmer (1 to 2 ha)	23 (20.9)	5 (12.5)	28 (18.67)
Large farmer (>2 ha)	3 (2.7)	0	3 (2)
Total	110 (100)	40 (100)	150 (150)

Note: Figures in parentheses show percentages to the total

Male-headed households also had larger land holdings with 2.7 per cent of them being large farmers (land holding >2 ha). However, most of the women were marginal farmers. Among most of the FHH, the land ownership went to the male of the household.

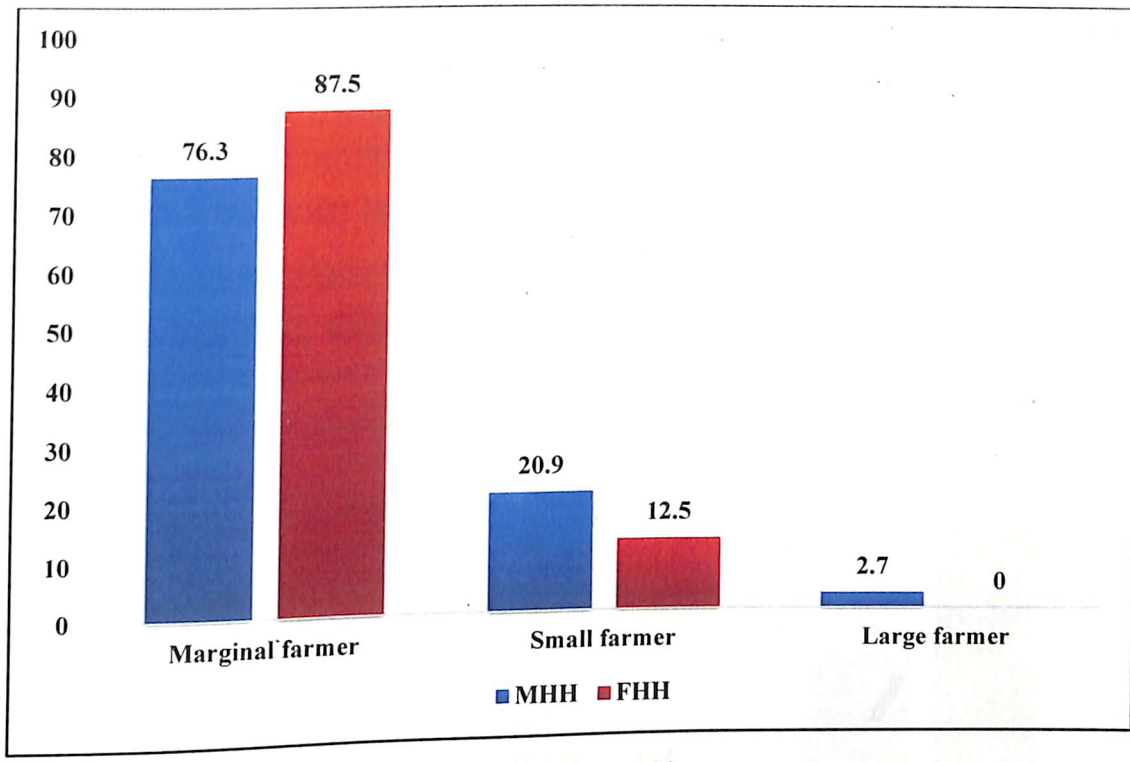

Fig.6 Land holdings

4.1.7 Occupation pattern of the respondents

Table 4.7 Occupation pattern

Main occupation		MHH	FHH	Total
Agriculture only		37 (33.6)	6 (15)	43 (28.6)
Agriculture as main occupation		27 (24.5)	7 (17.5)	34 (22.6)
Agriculture as subsidiary occupation	Govt. service	4 (3.6)	0	4 (2.6)
	Private service	8 (7.2)	11 (27.5)	19 (12.6)
	Self employed	18 (16.3)	8 (20)	26 (17.3)
	Agricultural labourers	8 (7.2)	5 (12.5)	13 (8.6)
	Non-agricultural labourers	8 (9.2)	3 (7.5)	11 (7.3)
	Sub total	46 (41.8)	27 (67.5)	73 (48.7)
Grand total		110 (100)	40 (100)	150 (100)

Note: Figures in parentheses show percentages to the total

Being large farmers, a good per cent of the male farmers depended solely on the income from agriculture for their livelihood (33.6 per cent). Agriculture was carried out as a subsidiary source of income by 48.7 per cent of the respondents (41.8% males and 67.5% females). Their main source of income was salary from govt./private services and self-employed jobs. Various kinds of entrepreneurial activities were carried out by both the groups especially women.

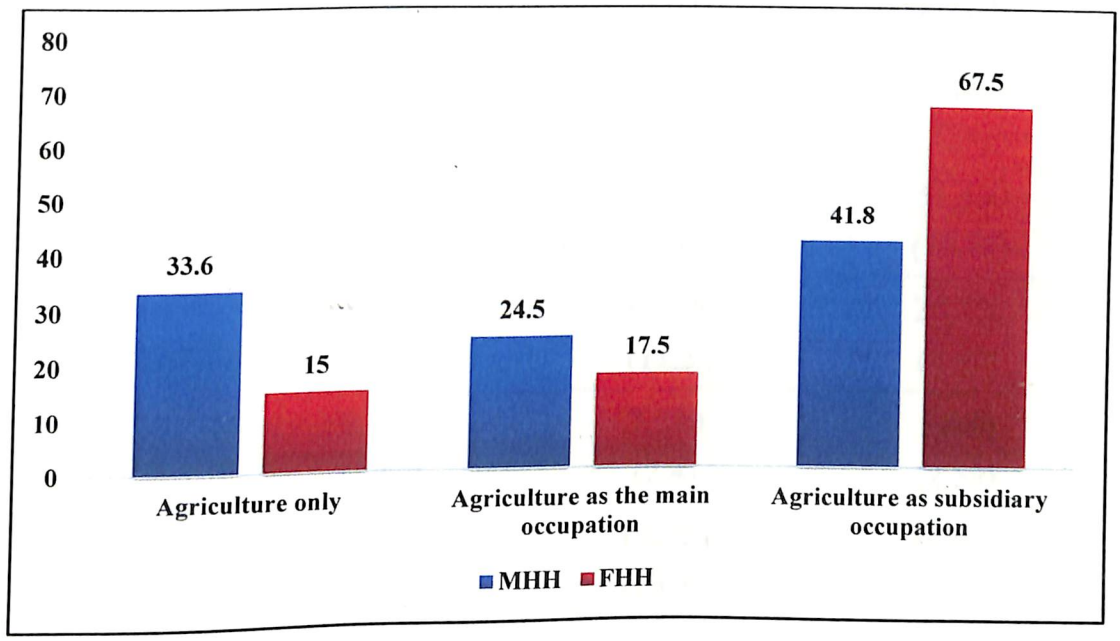

Fig.7 Occupation

4.1.8 Annual income of the respondents

Table 4.8 Annual income

Annual Income	MHH	FHH
Total household income (farm income + non-farm income)	2,37,949.36	1,93,806.25
Average agricultural income	1,49,085.27	1,06,206.25
% share of agricultural income to total income	62.65	54.8

Total income of the household includes both farm income and non-farm income. Non-farm income included income from salaried jobs, self-employment and from agricultural and non-agricultural labour. Income of other family members were also considered in estimating the total income. The average annual household income from farm and non-farm sources amount to 4.32 lakhs, ranging from 2.38 lakhs in MHH to

1.94 lakhs in FHH. The percentage share of farm income was comparatively high (62.65%) in male-headed households and almost 54.8 per cent in female-headed households.

4.1.8 Consumption pattern among the respondents

Table 4.9 Consumption pattern

Particulars (Rs/household/yr)	MHH	FHH	Aggregate
Food	45,600 (33.78)	31,400 (33.5)	77,000 (34)
Education	30,000 (22.2)	21,600 (23)	51,600 (22.76)
Health	11,400 (8.4)	10,800 (11.5)	20,350 (8.97)
Travel	3,600 (2.67)	2,280 (2.4)	5,880 (2.59)
Loan repayment	21,600 (16)	13,000 (13.8)	34,000 (15.26)
Other utilities (electricity, telephone, fuel, newspaper, water connection)	22,800 (16.89)	14,500 (15.5)	37,300 (16.45)
Total	1,35,000 (100)	93,580 (100)	2,26,730 (100)
% share of consumption expenses to total income	56.73	48.3	52.51

Note: Figures in parentheses show percentages to the total

The average annual consumption expense was found to be ₹ 2,26,730 which was about 52.51 per cent of the total household income. The proportion of consumption expenses to the total household income was found to be higher among MHH (56.73%) compared to 48.3 per cent in FHH. The highest share of expenses was for food followed by education, utility and loan repayment.

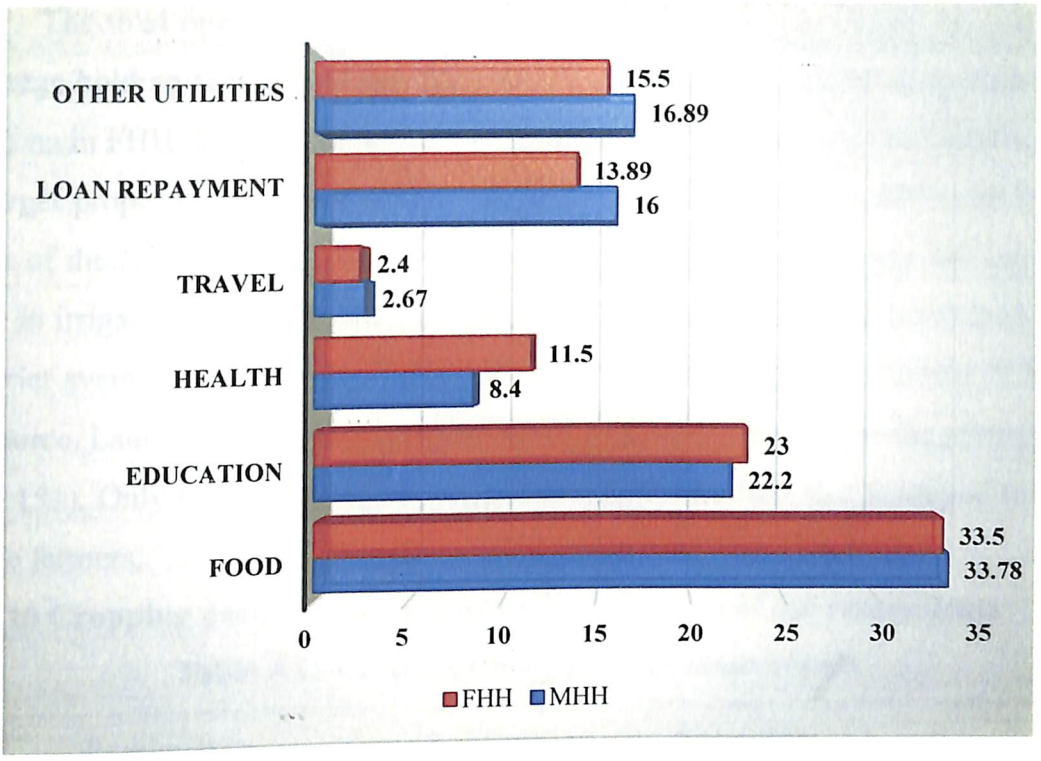

Fig.8 Consumption pattern

4.1.9 Land use pattern

Table 4.10 Land use pattern

Sl No.	Particulars			MHH (ha)	FHH (ha)	Aggregate (ha)
1	Operational holding size	Owned	Wetland	14.57 (50.15)	2.79 (29.7)	17.36 (45.15)
			Dryland	14.48 (49.8)	6.61 (70.3)	21.09 (54.85)
			Total	29.05 (100)	9.4 (100)	38.45 (100)
		Leased	Wetland	29.14 (50.15)	5.59 (81.13)	34.72 (53.41)
			Dryland	28.97 (49.85)	1.3 (18.87)	30.27 (46.57)
			Total	58.11 (100)	6.89 (100)	65 (100)
2	Total operational holding			87.16	16.29	103.45
3	Average holding size			0.79	0.41	0.69
4	Rain fed area			119.09	22.2	141.3
5	Irrigated area			11.78	2.47	14.25
6	Gross Cropped Area (GCA)			130.87	24.67	155.54
7	Net Cropped Area (NCA)			87.16	16.29	103.45
8	Cropping Intensity (CI)			150	151	151
9	Current fallow			0.72	-	0.72

Note: Figures in parentheses show percentages to the total

The total operational holding size of the respondents is 103.45 ha and the average holding size is 0.69 ha. The holding size of MHH is 0.79 ha against that 0.41 ha in FHH. More than half of the cultivated land is leased in land. MHH had a larger proportion of leased in land compared to FHH (42.29%). About 86.2 per cent of the Net Cropped Area among the sample respondents is rain fed and the rest is irrigated. Cropping intensity of the study area was higher (151) than the district average (134) and state average (122) implying proper utilisation of land resource. Land utilisation efficiency of MHH and FHH were almost the same (150 and 151). Only 0.72 ha of land remained as fallow land and that belonged to the male farmers.

4.1.10 Cropping pattern and agricultural production of the respondents

Table 4.11 Crops cultivated by the respondents

Particulars	Aggregate
Paddy	104.2 (66.98)
Tree crops	44.2 (28.4)
Vegetables	3.8 (2.44)
Spices	2.32 (1.49)
Tuber crops	1 (0.64)
Total	155.5 (100)

Note: Figures in parentheses show percentages to the total

Paddy was the main crop cultivated among the respondent farmers accounting for about 66.98 per cent of the Gross Cropped Area. It was followed by banana (10.6%) and nutmeg (9.95%). These three crops together constituted 87.53 per cent of the Gross Cropped Area. The cropping pattern among the sample respondents was similar to the general cropping pattern of Thrissur district. Paddy

is the most widely cultivated crop in Thrissur. The district also stands first in nutmeg production with its cultivation in 6897 ha. Besides, coconut, vegetables, pepper, arecanut, turmeric, tapioca, elephant foot yam, ginger, betel vine etc. were also cultivated by the respondents.

4.1.11 Other agricultural activities undertaken by the households

Apart from crop cultivation, a good percentage of respondents also relied on other allied sectors of agriculture like livestock rearing, poultry farming and Pisciculture. The details are given in Table 4.12. Out of the respondent farmers, a total of 69.3 per cent households were involved in these activities. Most of them were MHH which shows their better livelihood diversification compared to FHH.

Table 4.12 Other agricultural activities undertaken by the respondents

	Activity	MHH	FHH	Total
Livestock rearing	Cow	28	9	37
	Goat	41	16	57
	Buffalo	36	8	44
	TOTAL			63 (42)
Poultry	Hen	1350	109	1,459
	Duck	140	-	140
	TOTAL			39 (26)
Pisciculture	Sword fish (*vaala meen*)	600	-	600
	Tilapia (*karimeen*)	200	-	200
	TOTAL			2 (1.3)
	TOTAL NO. OF HOUSEHOLDS			104 (69.3)

Note: Figures in parentheses show percentages to the total

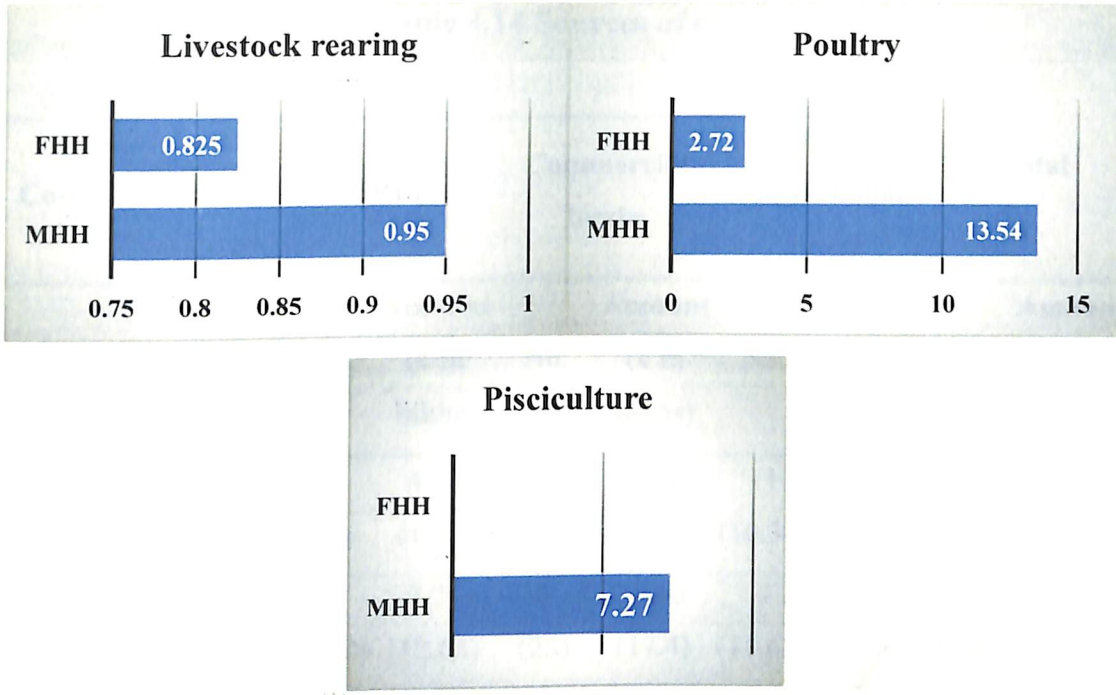

Fig.9 Agricultural diversification

4.1.12 Credit facilities

Around 86 per cent of MHH and 75 per cent of FHH had taken loans.

Table 4.13 Indebtedness

Group	Average credit (in lakhs)	Average credit per ha of GCA (Rs)
MHH	2.67	193636
FHH	2.04	248104
Aggregate	4.71	441740

The level of indebtedness among MHH (86.4%) was greater than that among FHH (75%). Irrespective of the holding size, 90.58 per cent of the debtors relied on organised sector ie., Co-operatives (68%), Regional Rural Banks (3.6%) and Commercial Banks (18.1%) for their credit requirements. Only 9.42 per cent of debtors relied on unorganised sectors. Greater reliance on institutional organisations may be due to their low interest rate and flexible approach compared to non-institutional organisations. Greater level of education among the farmers may also be a reason for this.

Table 4.14 Sources of credit

House-holds	Organised Sector						Unorganised		Total	
	Co-operatives		RRBs		Commercial banks		Non-institutional credit			
	No.	Amount (₹ in lakhs)	No.	Amount (₹ in lakhs)	No.	Amount (₹ in lakhs)	No.	Amount (₹ in lakhs)	No.	Amount (₹ in lakhs)
MHH	68 (64.15)	140.3 (55.37)	4 (3.8)	4.78 (1.89)	23 (21.7)	89.2 (35.2)	11 (10.38)	19.13 (7.55)	106 (100)	253.4 (100)
FHH	14 (43.75)	33.25 (54.3)	5 (15.62)	7.74 (12.65)	8 (25)	10.65 (17.4)	5 (15.62)	9.56 (15.6)	32 (100)	61.2 (100)
Total	82 (59.42)	173.55 (55.16)	9 (6.52)	12.52 (3.98)	31 (22.46)	99.85 (31.74)	16 (11.6)	28.69 (9.12)	138 (100)	314.6 (100)

Note: Figures in parentheses show percentages to the total

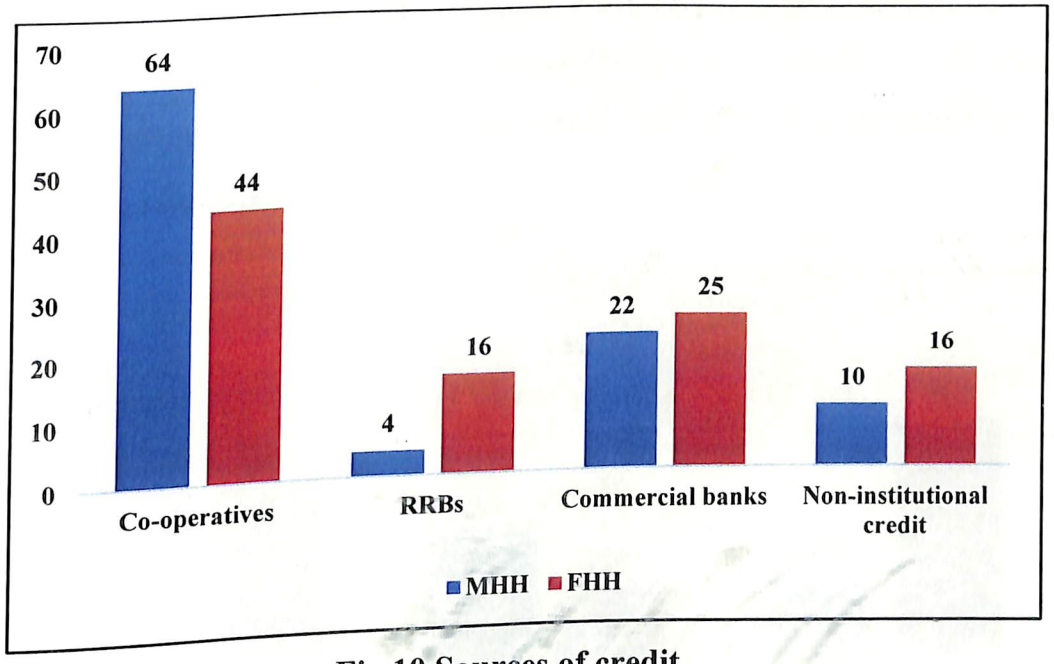

Fig.10 Sources of credit

The total capital borrowed by the respondents amount to ₹ 314.62 lakhs. Of this, 69.15 per cent was credited by Co-operatives, 18.39 per cent by Commercial banks and the rest by RRBs (Table 4.15). Co-operatives supplied major share of the total credit flow. Apart from the organised sectors, a 9.4 per cent of the respondents

have relied on credit from unorganised sectors including relatives and friends, moneylenders and NBFCs (Non-Banking Finance Companies).

Table 4.15 Purpose wise classification of liabilities

Group	Farming purposes	Farming and household purposes	Household purposes	Total
MHH	61 (57.5)	28 (26.4)	17 (16.04)	106 (100)
FHH	12 (37.5)	5 (15.6)	15 (46.8)	32 (100)
Total	73 (52.9)	33 (23.9)	32 (23.2)	138 (100)

Note: Figures in parentheses show percentages to the total

The average credit per respondent was around 2.28 lakhs, with MHH having an average of 2.3 lakhs and FHH 1.9 lakhs. Of the total loanee farmers, 76.09 per cent took credit for a single purpose (either farming or non-farming activity) and 23.91 per cent had availed more than one type of loan (ie., for farming and household consumption purposes).

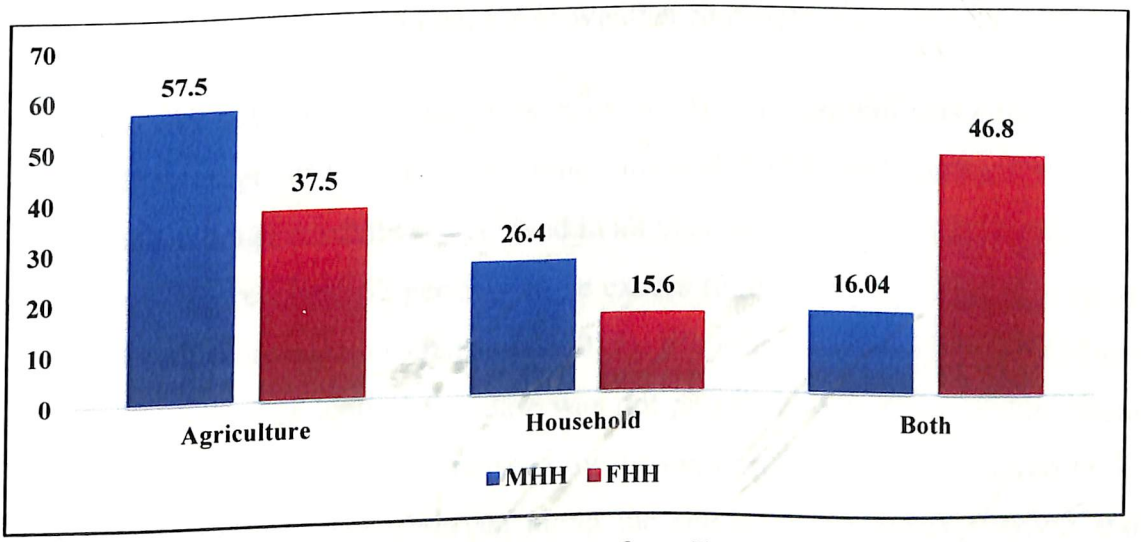

Fig.11 Purpose of credit

4.2 Climate variability and natural disasters

4.2.1 Rainfall variability over the study area

The graphs show the precipitation received during southwest monsoon over the district for the past 10 years.

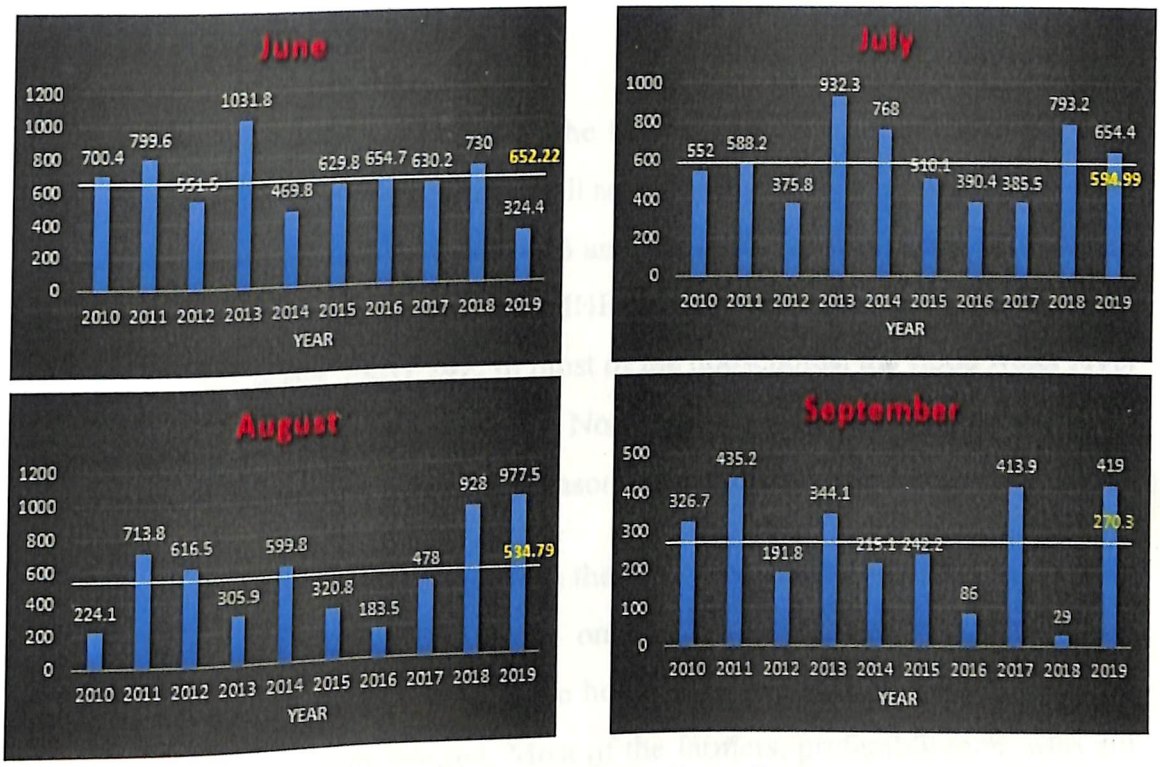

Fig.12 Average monthly precipitation from June-September over Thrissur district

(Source: KAU Weather Station)

It can be noted that for the years 2015 to 2017, the rainfall was considerably lower than average for the months of June, July and August and suddenly in 2018, greater than average rainfall was received in all the three months resulting in floods. Thrissur district received 67 per cent large excess rainfall in the month of August, 2018 (India Meteorological Department, 2019). After three consecutive years of low rainfall, the district as well as the state was not prepared for a flood of this extent which has been one of the many reasons for the largescale destruction caused by it. Maximum destruction was observed along the rivers of Chalakudy, Periyar and Pamba, all having multiple dams on their tributaries.

After the downpour of the third week of August, there was an abrupt break in the monsoon. The rainfall received in September 2018 was a mere 29 mm. Hence

the state had to face an exceptionally long (20 or more days) dry spell. This unexpected long dry spell has led to further receding groundwater levels, opening up of deep cracks both in the hills and floodplains, continued reduction in river water flows. Open wells, which are a major source of drinking water in the study area showed sudden drawdowns.

4.2.2 Losses from Kerala floods 2018

The total economic losses due to the floods of 2018 comprising of physical losses from household and the farm as well as losses due to injuries or diseases from the floods is given in detail in Table 4.16 and Table 4.17 respectively. The overall economic loss was greater among the MHH summing up to ₹ 2,27,76,392 while among the FHH it was ₹ 73,57,242. In most of the households, the flood water level raised at least to the height of first storey. None of the households were prepared for a flood of this extent which was also a reason for such largescale losses.

Almost all the households received the basic compensation of ₹ 10,000 from the government and further depending on the level of damage of the house, compensation amount varied. Among the household area, except for vehicles in a few cases, nothing else was insured. Most of the farmers, preferably men, who did farming on their own land had insured their crops whereas those who did farming on leased land were either not allowed to insure the crops by the land owners or they did not take crop insurance as the claim goes to the land owner. The number of farmers cultivating on leased land were considerably high among the respondents which was a reason for large economic losses from the farm area. Most of the FHH, did agriculture on smaller areas of land and therefore had not insured crops.

Table 4.16 Value of losses from Kerala floods (Male-headed households)

Sl No.	Losses due to floods	Particulars		Area/ No.s	Amount (A)	No. of households who have insured	Claim got from the company (B)	Rebuilding cost (C)	Compensation from govt. (D)	Net loss (A+C-B-D)
1	Physical losses incurred from the household area	Damage to house building	Complete damage	2 no.s	-	-	-	25,00,000	13,20,000	11,80,000
			Partial damage	83 no.s	-	-	-	79,00,000	8,30,000	70,70,000
		Vehicles	Car	5 no.s	3,00,000	1	50,000	90,000	-	3,40,000
			Bike	7 no.s	2,40,000	3	1,20,000	1,80,000	-	3,00,000
		Furniture set		330 no.s	18,50,000	-	-	43,000	-	18,93,000
		Electronic appliances	TV	66 no.s	6,55,000	-	-	25,000	-	6,80,000
			Refrigerator	38 no.s	1,90,000	-	-	30,000	-	2,20,000
			Washing Machine	8 no.s	35,000	-	-	24,000	-	59,000
			Computer	5 no.s	60,000	-	-	20,000	-	80,000
			Others		30,000	-	-	-	-	30,000
		Others (food items, utensils, clothes, books)			6,88,200	-	-	-	-	6,88,200
		TOTAL								**1,25,40,200**

Sl No.	Losses due to floods	Particulars		Area/ No.s	Amount (A)	No. of households who have insured	Claim got from the company (B)	Rebuilding cost (C)	Compensation from govt. (D)	Net loss (A+C-B-D)
2	Physical losses incurred from the farming area	Major crop loss	Paddy	43.7 ha (95)	68,49,342	25	20,09,500	-	3,20,000	45,19,842
			Banana	27,495 no.s (90)	41,24,250	27	8,37,000	-	-	32,87,250
			Nutmeg	1424 no.s (63)	15,80,640	-	-	-	-	15,80,640
			Others		5,05,460	-	-	-	-	5,05,460
		Damage to cattle shed		6 no.s	2,40,000	-	-	-	-	2,40,000
		Water pump motor		17 no.s	25,000	-	-	23,000	-	47,000
		Farm implements		7 no.s	6000	-	-	-	-	6,000
		TOTAL								**1,01,86,192**
3	Losses due to injuries/ diseases/ death	Injuries		2	20,000	-	-	-	-	20,000
		Diseases		7	30,000	-	-	-	-	30,000
		Death		-	-	-	-	-	-	-
		TOTAL								**50,000**
		GRAND TOTAL								**2,27,76,392**

Table 4.17 Value of losses from Kerala floods (Female-headed households)

Sl No.	Losses due to floods	Particulars		Area/ No.s	Amount (A)	No. of households who have insured	Claim got from the company (B)	Rebuilding cost(C)	Compensation from govt. (D)	Net loss (A+C-B-D)
1	Physical losses incurred from the household area	Damage to house building	Complete damage	-	-	-	-	-	-	-
			Partial damage	23 no.s	46,25,000	-	-	-	9,80,000	36,45,000
		Vehicles	Car	2 no.s	1,50,000	-	-	35,00000	-	1,85,000
			Bike	1 no.s	-	-	-	7,500	-	7,500
		Furniture set		80 no.s	5,00,000	-	-	-	-	5,00,000
		Electronic appliances	TV	18 no.s	1,40,000	-	-	30,000	-	1,70,000
			Refrigerator	3 no.s	24,000	-	-	-	-	24,000
			Washing Machine	2 no.s	10,000	-	-	-	-	10,000
			Computer	2 no.s	30,000	-	-	-	-	30,000
			Others		18,000	-	-	-	-	18,000
		Others (food items, utensils, clothes, books)			3,94,000	-	-	-	-	3,94,000
		TOTAL								**49,83,500**
2	Physical losses	Major crop loss	Paddy	8.21 ha (98)	12,72,242	2	70,000	-	1,80,000	10,22,242

Sl No.	Losses due to floods	Particulars	Area/ No.s	Amount (A)	No. of households who have insured	Claim got from the company (B)	Rebuilding cost(C)	Compensation from govt. (D)	Net loss (A+C-B-D)
	incurred from the farming area	Banana	7031 no.s (79)	10,54,650	3	1,50,000	-	-	9,04,650
		Nutmeg	104 no.s (60)	1,15,440	-	-	-	-	1,15,440
		Others		2,18,910	-	-	-	-	2,18,910
		Damage to cattle shed	2	80,000	-	-	-	-	80,000
		Water pump motor	3	4,500	-	-	-	-	4,500
		Farm implements	-	-	-	-	-	-	-
		TOTAL							**23,45,742**
3	Losses due to injuries/ diseases/ death	Injuries	-	-	-	-	-	-	-
		Diseases	4	28,000	-	-	-	-	28,000
		Death	-	-	-	-	-	-	-
		TOTAL							**28,000**
		GRAND TOTAL							**73,57,242**

Note: Figures in parentheses show percentages to the total Net Cropped Area of that particular crop

4.2.3 Farmers' perception on climate change

Table 4.18 Farmers' perception on climate change

Sl No.	Impact	Farmers responded (%)
1	**Temperature**	
a)	Increase in temperature	100
2	**Rainfall**	
a)	No change in annual rainfall	11.7
b)	Decline in annual rainfall	88.3
c)	Delay in monsoon onset	15.3
d)	Most of the rainfall concentrated over months of July-August	92
e)	Heavy rainfall in rainy season followed by drought in summer	64.2
f)	Decline in water availability	8
3	**Pest/disease incidence in crops**	
a)	Increase in pest attack	76.3
b)	Increase in disease incidence	70.3
c)	Minor pests becoming major pests	33
d)	Decreased crop yield	95.58

All the respondents (100%) were of the opinion that there is an increase in temperature and rainfall pattern over the years. About 11.7 per cent of the farmers were of the view that there is a steady decline in annual rainfall whereas the rest believed that there is not much change in the total amount of rainfall received, but only the pattern has changed. Around 92% of the respondents agreed that most of the rainfall were concentrated over the months of July and August which was the main reason for floods. About three-fourth of the respondents have perceived the increased incidence of pest and diseases as due to the changing climate. Nearly 33 per cent of them reported about the emergence of minor pests as major, whereas 70.3 per cent pointed out that diseases have become uncontrollable over the years. Majority of the farmers (95.58%) told that there was considerable reduction in the crop yield in recent years. According to them, climate change and crop yield were inversely related.

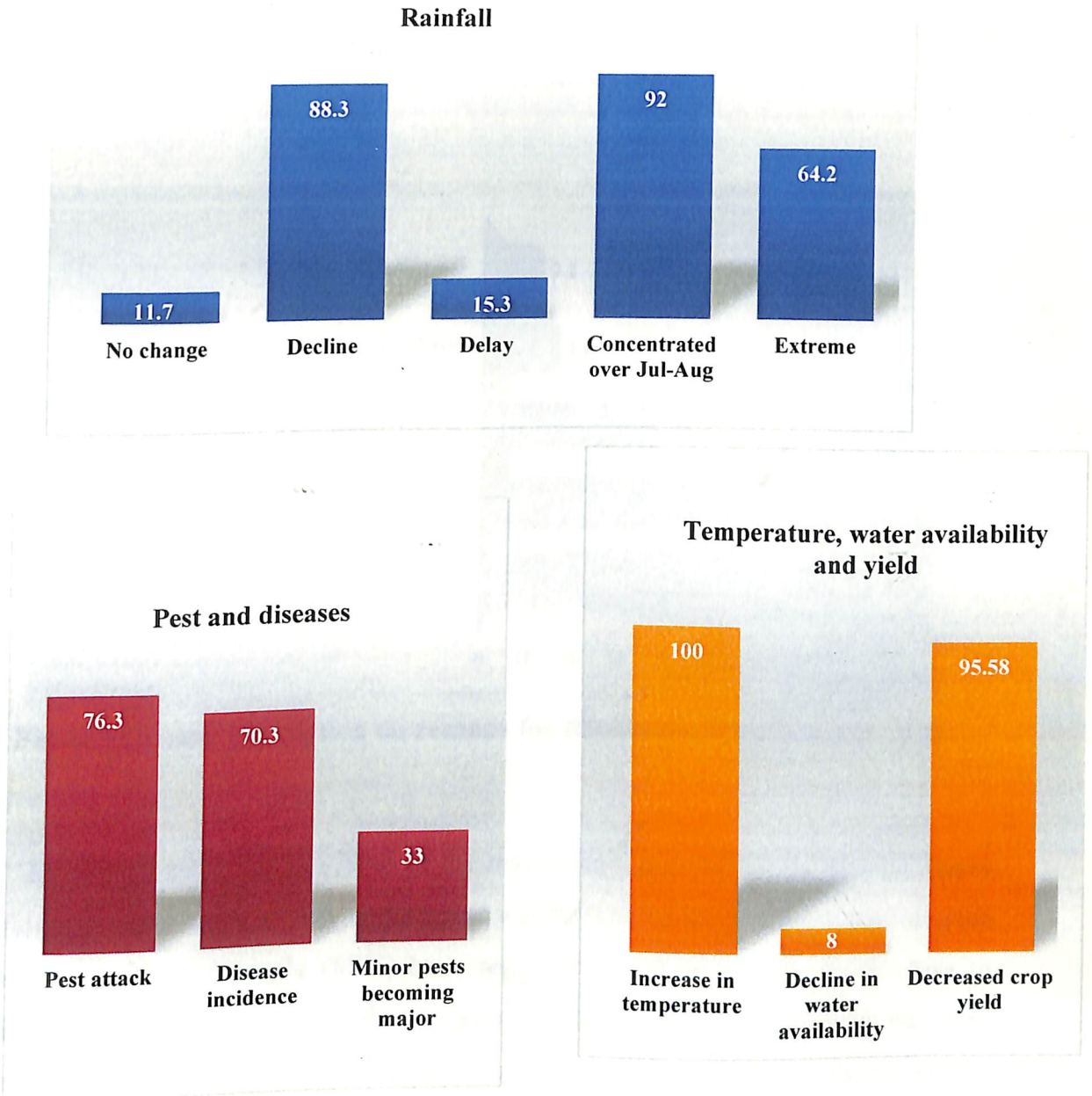

Fig.13 Farmers' perception on climate change

The farmers' perception on the reasons for flooding in their areas in 2018 is given in Table 4.19.

Table 4.19 Farmers' perception on reasons for flooding in their areas in 2018

Sl No.	Reasons	Farmers responded (%)
1	Continuous heavy rainfall over months of July-August	79

2	Closeness to river	88
3	Home close to paddy farm	38
4	Poor drainage system	13.5
5	Settling of debris in river	9.2

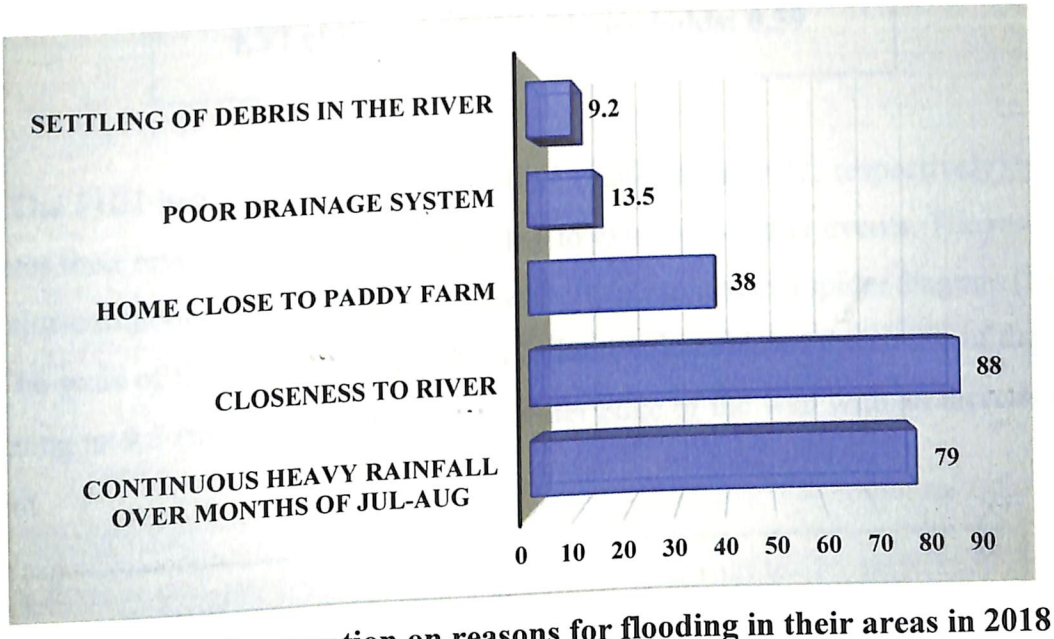

Fig.14 Farmers' perception on reasons for flooding in their areas in 2018

More than three-fourth (79%) of the respondents opined that continuous heavy rainfall over the months of July and August was the reason for flood whereas an even higher percentage of people (88%) have reported that their locality being close to Chalakudy river, which had overflown when the dam waters were released, has been the sole reason for flooding in their area. Closeness to paddy farms was the reason for 38 per cent of the people A lower percentage of the respondents were of the view that poor drainage system of their locality (13.5%) and settling of debris in Chalakudy river (9.2%), leading to the overflowing of river also contributed to flooding of their area.

4.3 Livelihood vulnerability of male and female-headed households to extreme weather events

4.3.1 LVI: Male versus female-headed households

Appendix V represents the values of sub-components of LVI for both male and female-headed households as well as the maximum and minimum values for both combined.

Overall LVI

LVI of Male-headed households: 0.32

LVI of Female-headed households: 0.39

The FHH had a higher LVI than MHH (0.39 versus 0.32, respectively), which indicates their relatively greater vulnerability to extreme weather events. The results of the major-component calculations are collectively presented in a spider diagram (Figure 19). The scale of the diagram ranges from 0 (least vulnerable) at the centre of the web, increasing to 0.5 (more vulnerable) at the outer edge of the web with an increment of 0.1 unit.

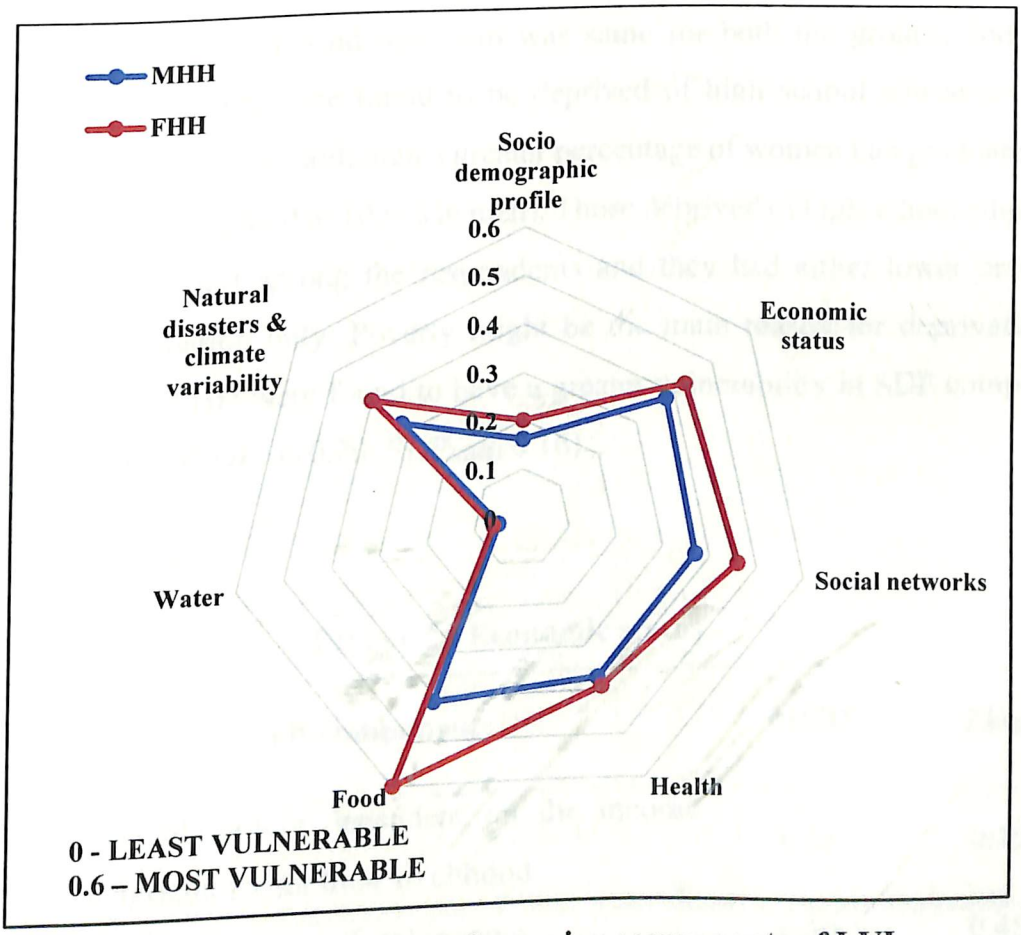

Fig.15 Spider diagram for major components of LVI

Figure 19 shows that FHH are more vulnerable than MHH in all the seven major components, although there are variations within the sub-components. The difference in vulnerability among MHH and FHH were largest among the Food major component and the difference was least among the Water major component. The reasons for greater vulnerability of FHH in each of the major components is explained below in detail.

1.Socio demographic profile

Table 4.20 Socio demographic profile

Sl No.	Sub-components	MHH	FHH
1	Dependency ratio	0.21	0.21
2	High school education	0.12	0.20
	Overall	**0.16**	**0.20**

SDP consists of two sub-components, dependency ratio and high school education. The average dependency ratio was same for both the groups. But more number of female-heads were found to be deprived of high school education (20% compared to 11.8% in men) although a greater percentage of women had graduate level education (12.5% compared to 10.9% in men). Those deprived of high school education were mostly the oldest among the respondents and they had either lower or upper primary level education only. Poverty might be the main reason for deprivation of education. Hence, FHH were found to have a greater vulnerability in SDP component compared to MHH (SDP_{FHH} 0.20; SDP_{MHH} 0.16).

2.Economic status

Table 4.21 Economic status

Sl No.	Sub-components	MHH	FHH
1	Households solely dependent on the income from agriculture for their livelihood	0.24	0.18
2	Agricultural income : Total income	0.59	0.48
3	Agricultural diversification index	0.46	0.48
4	Household's ability to meet its basic needs	0.17	0.27

5	Ability to handle financial stress	0.30	0.44
6	Liquid assets	0.49	0.55
7	Savings	0.34	0.42
8	Economic status of the household	0.51	0.55
9	Productive assets	0.30	0.54
	Overall	**0.38**	**0.43**

Economic status consists of 8 sub-components. Male-headed households were more vulnerable in two sub-components as there were some male members who were completely dependent on the income from agriculture for their livelihood and the proportion of agricultural income was also higher among them. Since agricultural sector is sensitive to climate change, their income level may vary according to changes in monsoon pattern or occurrences of extreme weather events. However, in all the remaining sub-components, FHH were found to be more vulnerable.

Women were mostly marginal farmers (holding size <1 ha) who mostly practised agriculture as a subsidiary source of income (67.5%). They had a lower agricultural diversification (0.48) compared to MHH (0.46) which makes them more vulnerable in a changing climatic scenario. In most cases, women were only involved in two activities ie., agriculture and livestock rearing or poultry on small scales whereas in MHH, many of them carried out multiple allied sector activities along with agriculture. Fish rearing and growing chickens in large numbers on contract basis were found in some of the MHH.

When asked about their own perception of their ability to meet basic needs and handle financial stress, most of the FHH told that they were only able to pay for food and shelter and struggled to make lump sum payments for health and education expenses. FHH also responded that if they lost their primary livelihood source, they had no other option than relying on family or relatives for support. This is mainly because of the social obligations that the concept of gender has placed on women, which in turn has brought down their roles into house-keeping eventually making them less self-sufficient. Therefore, women find it really difficult to realize their financial requirements after a disaster. Whereas most of the MHH reported that they would rely more on other existing income-generating activity or find a new informal job. For

example, a male farmer has switched-on to supplying snacks to a bakery as the income from paddy farms have significantly reduced after the floods.

Availability of liquid assets and savings which indicates the household's capacity to cope with shocks were lower or almost absent among the FHH. They also had lower productive assets like land and diversification within agriculture etc. Due to lower land entitlements, women found it difficult to receive agricultural loans which once again contributed to their greater vulnerability. Altogether, FHH were more vulnerable than MHH (0.54 versus 0.30 in MHH) in the Economic status component.

3.Social networks

Table 4.22 Social networks

Sl No.	Sub-components	MHH	FHH
1	No. of helps received in the past 12 months	0.32	0.41
2	Assistance from local government	0.40	0.52
	Overall	**0.37**	**0.46**

In the social networks component, FHH were found to be more vulnerable (0.46) than MHH (0.37). The number of helps received in the past 12 months were higher among FHH indicating their more vulnerable situation. These helps were either in the form of money or in the form of medicines, clothes or food during times of disasters. Help was received only in cases of emergency. Most of the respondents tried their best not to borrow money in any cases as that would only increase their financial burden. Also, for some respondents, their relatives or friends were also poor or in even worse situations which prevented them from receiving helps. Around 52.5 per cent of FHH reported that they haven't approached their local government for any assistance in the past 12 months but in the case of MHH, around 60 per cent of them have made visit to the panchayat at least once during this time. These are due to several reasons. In some cases, women were a bit reluctant in consulting authorities and some also reported that the ward member or panchayat were biased towards some households, acting in their

favour especially during allotting compensation funds to the households after floods. However, most of the women were members of at least one social group like Kudumbashree or Joint Liability Group (JLG) which helped them financially during times of stress.

4.Health

Table 4.23 Health

Sl No.	Sub-components	MHH	FHH
1	Chronically ill members	0.26	0.40
2	Whether a member of the household missed work or school due to illness	0.07	0.08
3	Lifestyle diseases	0.53	0.45
4	Health insurance	0.89	1
5	Whether some new disease have become common in the past 5 yrs.	0.09	0
	Overall	**0.37**	**0.39**

Female-headed households were found to be slightly more vulnerable in the Health component than MHH (0.39 versus 0.37 in MHH). This may be because mostly women are generally less physically strong. Moreover, they have the additional burden of doing the household chores and taking care of the children, elderly and sick at home. Out of the respondents, FHH had a greater percentage of chronically bedridden people at home (20% compared to 13.2% in MHH). Many women revealed that they were not spared from household chores even when they themselves fell sick. One women reported that increase in back pain due to ageing has deprived her from carrying out most of the farm activities that she herself used to do earlier, like turning the soil and providing props for banana. Now such tasks have to be carried out by hiring labour which reduces the profit from the farm.

Percentage of households where a member missed work or school due to illness yielded only small values and was almost similar in MHH and FHH. This can be attributed to the better sanitation and health facilities of Kerala. This was also reflected in the study area where almost all the respondents reported that they had at least one Primary Health Centre within three kilometers distance from their home.

Lifestyle diseases were reported more among MHH (52.73%) compared to FHH (45%). However most of the farmers did not have diabetes or cholesterol owing to the physical demands of agriculture. Lifestyle diseases were reported mostly from the women at home or others. Among FHH, it was found that many of them were taking medicines for hypertension. These have put them at disadvantage during times of flood and crop loss. Women were really worried not just about the farm alone, but also about everything at home.

None of the FHH had a health insurance whereas 10.9 per cent of MHH reported to have health insurance. Most of them were insured under the RSBY Scheme (Rashtriya Swasthya Bhima Yojana) under Government of India which aims to provide financial security for hospitalization-related expenses to BPL families.

Finally, only one male-headed household (0.009%) has reported about skin allergies that have occurred frequently among them after the floods of 2018. None of the female-headed households have experienced any diseases becoming common in the past 5 years.

5.Food

Table 4.24 Food

Sl No.	Sub-components	MHH	FHH
1	Households dependent on family farm for food	0.17	0.30
2	Households that do not manage to get nutritious food	0.32	0.52
3	Average crop diversity index	0.33	0.66
4	Households that does not save crops to eat during a different time of the year	0.62	0.75

5	Households that does not save seeds to grow in the next season	0.63	0.80
	Overall	**0.41**	**0.60**

The major component Food has five sub components and female-headed households were found to be more vulnerable in all of them. This is because some of them were dependent on the family farm for their food. Many of them also couldn't afford nutritious food. They had a low crop diversity compared to men and also couldn't save crops or seeds for future use.

6.Water

Table 4.25 Water

Sl No.	Sub-components	MHH	FHH
1	Consistent water supply	0	0
2	Water shortage	0.13	0.13
3	Households that depend on natural source of water for their household water needs	0	0
4	Average no. of litres of water stored	0.09	0.10
	Overall	**0.04**	**0.06**

Most of the respondents (MHH and FHH) had a consistent supply of drinking water in the whole year and there were no big issues of water shortage. Most of the households took drinking water from well. Many of them also had Jalanidhi water connection to aid them if at all some disruption occurred with the groundwater supply during summer season. None of the respondents had to rely on any natural resources like pond or lake for household water needs. However, some of the FHH reported that they couldn't store water in large volumes due to the absence of water tanks which has made them more vulnerable in the Water component.

7.Natural disasters and climate variability

Table 4.26 Natural disasters and climate variability

Sl No.	Sub-components	MHH	FHH
1	Disaster prone area	0.60	1
2	No. of natural disasters between 2014-19	0.13	0.17
3	Disaster warning	0.13	0.20
4	Injury/death from disasters in the past 6 yrs.	0.16	0.25
5	No. of months with altered/no income after the floods	0.37	0.52
6	Economic loss in 2018 floods	0.30	0.27
7	Whether the 2018 floods helped the household to stay prepared thereafter	0.04	0.13
8	Standard deviation of max. temperature for the past 6 yrs.	0.47	0.47
9	Standard deviation of min. temperature for the past 6 yrs.	0.66	0.66
10	Standard deviation of precipitation for the past 6 yrs.	0.32	0.32
	Overall	**0.32**	**0.40**

From the study area, it was found that FHH were more vulnerable (0.40) to Natural Disasters and Climate Variability compared to MHH (0.32). When asked about whether they believed that they live in a disaster-prone area, 100 per cent of the FHH responded that they did whereas only 60 per cent of MHH agreed to it. The reason might be because most of the male-heads were born and brought up in the same area and most of them are not ready to accept or were afraid of the recent flood situations. In such houses, these men were the ones who were most reluctant to evacuate their homes and were equally ready to take risks when floodwaters were on a rise in the area. While in the case of women, they were even more worried thinking about the shifting of things, disruption of children's education and cleaning the house after the floods.

Percentage of households that did not receive a warning about the pending disaster were higher among FHH (0.13 versus 0.20 in MHH). For example, a female household head, whose husband works abroad, responded that she had been attentively

noting the alerts and warnings given by the government even on the day before which flood waters entered their home, but that was not at all expected and she concluded that getting to know the rainfall alerts will be helpful only if they were more region-specific. Having had to evacuate home suddenly with the children was an unmanageable task for her being the only elderly person at home. Some of the male respondents also told that they did not care the rainfall alerts and claimed that they knew their place better. Quite a large number of respondents lost the electricity connection in their area and thereafter could not receive any warnings. The panchayats in most of the areas under study had done a remarkable job in reaching out to people beforehand and evacuating them to safer places, especially the elderly and sick members of the family. A Church and a Government Higher Secondary School were the major relief camps in the study area.

No deaths were reported due to the 2018 floods from the study area but there were cases of injuries and diseases. A male-head was reported to have developed Arthritis after floods which has prohibited him from cultivating crops requiring huge labour during different stages. He has switched on to cultivation of bitter gourd and *pottuvellari* from the last year. Whereas among FHH, some households have reported cases of fever and cold for every member immediately after they returned from the relief camps. However, almost all the respondents whose households were flooded have received the vaccination and medicines provided by the government which have prevented disease outbreak among them.

In most of the households, the electricity connection was not restored at least for one month after the floods which have largely contributed to the increased workload of women during those times. Most of the households also could not afford to repair the damaged electrical appliances or purchase new ones, for example, washing machine, which also have contributed to women's increased workload in the months following a disaster. However, this is expected to be settled after few months.

The household income of almost all the respondents were severely disrupted in the months immediately after the floods (average range- 3 to 5 months). Most of the households did not have any income during this time as their farms were inundated in the floods. Most of crops which were ready to be harvested were damaged in the flood waters and those that remained were given to relief camps. Other employment opportunities did not resume soon after the floods. Altogether, many of the BPL

families barely survived with the food kits and clothes provided by the government. Some of the MHH reported that the men started going for non-farm employment after two to three months after the disaster which helped them to come out of the grim situation, reducing their vulnerability, compared to that of FHH.

In the floods, both MHH and FHH incurred losses from household as well as the farms, but the total economic loss was particularly high among MHH (0.30 versus 0.27 in FHH) which could be attributed to their larger land holding size and assets.

When asked about whether the 2018 flood experience helped them to stay prepared for the future, most of the respondents were desperate and told that nothing can prevent damage when floods of this magnitude occurs and that all they can do is to save their lives. However, some of the FHH reported that during the month of August in the following year (2019), most of them kept emergency kits containing clothes, medicines, torch lights and important documents ready beforehand. Most of the households also shifted their household objects to upper storeys.

4.3.2 LVI-IPCC- Male versus female-headed households

Table 4.27 provides the values of the three contributing factors of LVI-IPCC ie., exposure, adaptive capacity and sensitivity.

Table 4.27 LVI-IPCC Index for male and female-headed households

IPCC contributing factors to vulnerability	Major components coming under each factor	MHH	FHH
Exposure (e)	1.Natural disasters and climate variability	0.32	0.40
Adaptive Capacity (a)	2.Socio-demographic profile 3.Economic status 4.Social networks	0.60	0.51
Sensitivity (s)	5.Health 6.Food 7.Water	0.28	0.39
LVI-IPCC [(e-a)*s]		**-0.0752** Less vulnerable	**-0.0433** More vulnerable

The LVI-IPCC analysis yielded similar results as LVI ie., FHH were more vulnerable to climate change compared to MHH [LVI-IPCC FHH: **-0.0433** (more vulnerable) ; LVI-IPCC MHH: **-0.0752** (less vulnerable)]. The vulnerability triangle in figure 16 plots the contributing factor scores for exposure, adaptive capacity, and sensitivity.

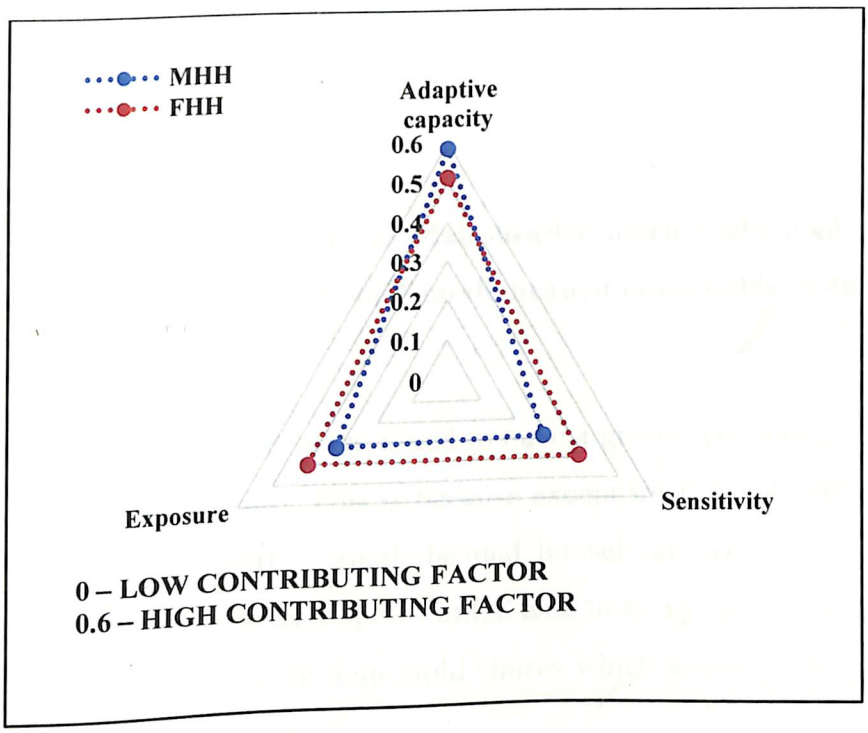

Fig.16 Triangle diagram for contributing factors of LVI-IPCC

The triangle illustrates that FHH had a higher sensitivity (0.39 versus 0.28 in MHH) and exposure (0.40 versus to 0.32 in MHH) to extreme weather events. They also showed a lower adaptive capacity (0.512 versus 0.58 in MHH) than MHH.

However, various initiatives under Kudumbashree have really helped the female respondents in terms of social empowerment as well as in gaining income. Initiatives like Collective Farming, Mahila Kisan Sashakthikaran Pariyojana (MKSP) and Polivu are some examples. Collective Farming aims at encouraging cultivation among neighborhood groups. This initiative can bring significant changes in the lives of the poor and also help in increasing agricultural production by converting fallow and cultivable waste land into agricultural use. It also has significance as a food security measure. Women participate in this programme as cultivators and not just agricultural labourers. They also get a control over the means of production and access to formal

credit which helps in increasing the returns from farming. There were some women from the study area who were part of collective farming through Joint Liability groups (JLGs). These JLGs are structured according to NABARD (National Bank for Agriculture and Rural Development) guidelines. It also provides an open bank account in the name of the JLGs which is also brought under the purview of Interest Subsidy Scheme (ISS) of Kudumbashree. All such initiatives support women to achieve financial security.

4.4 Economic vulnerability

Economic Vulnerability of Male-headed households: 0.40
Economic Vulnerability of Female-headed households: 0.46

Female-headed households were found to have a greater economic vulnerability (0.46) compared to MHH (0.40). This is because except for two sub components, all others were in favour of MHH. Female-headed households had lower agricultural diversification which is attributed to their limited land holding size and lack of time to handle multiple sectors along with household chores which would prevent them from ensuring a fixed income all the time.

When asked about the household's ability to meet their basic needs and handle financial stress, most of the FHH responded that they were only able to pay for food and shelter and struggled to make lump sum payments for health and education expenses whereas it was better among the MHH. Also, the income diversity among FHH were lesser than in MHH. This was because many of the male heads had alternative job too and most of them possessed larger assets compared to female-heads whose livelihood activities were mostly restricted to farming alone.

While both MHH and FHH admitted that their farm income changed dramatically depending on the season, FHH were found to be more vulnerable in their frequency of income availability because of less diversified agriculture. It was also found that the ability of FHH to handle financial stress was lower compared to their male counterparts. Many of them reported that if their primary source of living was lost, they had to rely on family for support.

Liquid assets in FHH were much lower compared to MHH which has also contributed to their greater economic vulnerability. Most of the households also lost their major liquid assets during the floods. When asked about their cash savings, most of the respondents told that they were struggling to make ends meet and hence could not afford to save money. Some MHH told about savings in chit funds. Most of the FHH had lower land holding size and lesser diversification in agriculture and therefore their productive assets were also lower compared to that of their male counterparts.

For most of the households, the floods of 2018 was the last major shock that they experienced which resulted in largescale economic losses. Some households even experienced floods in 2019 but it wasn't as severe as the previous one. However, among FHH, there were widows and also women looking after ill or bedridden husbands and they narrated those incidents as the major shock that have ever happened in their life. The current crisis caused by Covid-19 (Coronavirus disease 2019), in job sectors and economy has also created uneasiness in the livelihood of most of the respondents. MHH complained about their inability to sell products in local markets during times of country-wide lockdown. One female head reported about her son loosing job from abroad (a Gulf country) due to the economic crisis brought by the pandemic. Such cases severely affected FHH as they were their main sources of economic support during times of extreme weather events. Hence, with respect to this component too. FHH were found to be more vulnerable contributing to their greater economic vulnerability.

However, MHH showed greater vulnerability on the debt component. While only 75 per cent of the FHH had loans, it was 86.4 per cent among MHH. Average credit per farmer was 2.67 lakhs in MHH compared to 2.04 lakhs in FHH. Most of the male heads also took possible loans in their wife's name from their social groups like Kudumbashree for general household purposes. For example, in a household truss work was done on the upper storey after the 2018 floods, by availing loan from Kudumbashree. On the other hand, FHH were found to be hesitant to take loans of large sums.

Altogether, FHH were found to be having a greater economic vulnerability compared to MHH due to the reasons discussed above.

4.5 Determinants of economic vulnerability

The results of logit analysis are presented in detail in Table 4.28 and Table 4.29 respectively.

Table 4.28 Logit estimates for economic vulnerability in male-headed households

Variable	Coefficient	Standard error	Wald statistic	Odds ratio
Constant	-5.95	5.15	-1.16	0.003
High school education	1.93*	0.94	2.05	6.92
Dependency ratio	0.53	0.48	1.10	1.70
Assistance from local government	-1.60*	0.82	-1.94	0.20
Family size	-0.32	0.42	-0.76	0.73
Agriculture as the sole source of income	4.58*	2.07	2.22	97.48
Agricultural diversification index	-0.07	3.88	-0.02	0.94
Natural disasters	2.48**	0.80	3.10	11.91
McFadden's Pseudo R-square			**0.52**	

***Significance at 1% level, **Significance at 5% level, *Significance at 10% level

In MHH, 'high school education' was found to negatively influence the economic vulnerability ie., those farmers who had at least high school education were less economically vulnerable compared to those without high school education. 'Assistance from local government' was also found to influence the economic vulnerability negatively which means that help from the local government during times of a natural disaster can reduce the economic vulnerability. 'Agricultural as the sole source of income' was also significant. This is because, agriculture being a climate sensitive

sector, greater reliance on it will increase the economic vulnerability of the household. 'Natural disasters' also influenced the economic vulnerability of the household positively which means greater the number of natural disasters, greater the economic vulnerability.

Table 4.29 Logit estimates for economic vulnerability in female-headed households

Variable	Coefficient	Standard error	Wald statistic	Odds ratio
Constant	-18.58	11343.60	-0.002	0.001
High school education	3.60*	1.77	2.04	9.98
Dependency ratio	1.46*	0.80	1.81	4.30
Local government	-3.21*	1.43	-2.25	4.04
Family size	-1.35*	0.57	-2.37	2.60
Agriculture as the sole source of income	37.37	9147.50	0.004	1.70
Agricultural diversification index	-14.28*	7.36	-1.94	6.28
Natural disasters	2.52**	0.89	2.84	1.24
McFadden's Pseudo R-square			**0.66**	

***Significance at 1% level, **Significance at 5% level, *Significance at 10% level

Apart from 'high school education', 'assistance from local government' and 'natural disasters', the other determinants of economic vulnerability of FHH are 'dependency ratio', 'family size' and 'agricultural diversification index'. Dependency ratio may be significant because of the presence of some widows among the FHH. It was found to positively influence the economic vulnerability of FHH which means greater the dependency ratio of the household, greater is their economic vulnerability. 'Family size' was found to negatively influence the economic vulnerability of FHH. It can be interpreted that a larger family size means larger number of earning members

for the family which would reduce their economic vulnerability. 'Agricultural diversification index' also negatively influenced the economic vulnerability of FHH owing to their lower agricultural diversification.

4.5 Adaptation strategies undertaken by the rural households

Kendall's coefficient, $W = 0.94$

A value of 0.9436 indicates a good level of agreement among the respondents on the preference of adaptation strategies. The following are those adaptation strategies:

1. Livelihood Diversification - Finding other sources of income as agriculture sector has become more vulnerable to climate change and the income from the sector has reduced significantly. Examples:

- Engaging in labour works in the village or urban areas
- Van, rickshaw, tempo driving
- Business
- Relying on income (rent) from properties (moveable/immovable)
- Livestock, poultry or fish rearing
- Fetching employment outside agriculture

2. Agronomic and plant protection measures - Bringing small changes to the existing farming practices so that it becomes more adapted to the changing climate and pest and disease outbreak. Examples:

- Applying inorganic fertilizers
- Crop rotation
- Fallowing
- Growing vegetables during off-season
- Mixed cropping
- Growing short duration varieties of crops

3. Adoption of new crops and modern agricultural technology - Adopting new farming methods to ensure income from the farm. Examples:

- Adjusting the planting/sowing time

- Crop selection
- Crop diversification
- Adopting new agronomic measures
- Applying different feed techniques

4. Preparation for climate change - Physical actions done proactively in or around the house to protect one's family members or possessions and to minimise the losses. Examples:

Preparation of household

- Relocating objects
- Preparing emergency kits consisting of important documents, ID cards, valuables, medicines and few pairs of clothes
- Attention to alerts and warnings given by the govt., following farmer's weather bulletin
- Keeping the telephone numbers of responsible departments ready for use
- Moving equipments to upper floors
- Raising floor heights

Evacuation

- Shifting to relatives' home or relief camps
- Shifting the elderlies from home earlier
- Relocating livestock or other pet animals to safer places

Self-protection

- Drinking water, adjusting work time and wearing light clothes during a heat wave
- Agreeing to evacuate home during times of a flood or cyclone threat

Preparation of farm area

- Propping of crops. Ex. banana
- Creating temporary flood barriers around the farm

- Insuring the crops

5. Institutional support by government or concerned authorities - Measures to protect the households from disasters (floods) as well as to help them cope with the effects later. Examples:

- Constructing efficient drainage systems
- Removing the debris that have settled in the river
- Prompt warning systems or alerts
- Ensuring that the households are informed about the disaster risk or the need for immediate evacuation- region specific alerts
- Technological support/incentives/subsidies for alternate livelihood options in small scale enterprises/marketing of value added products
- Access to institutional credit from banks, cooperative societies, Kudumbasree, Kisan Credit Card scheme
- Compensation/financial assistance for relocation/rehabilitation
- Insurance schemes

6. Resilience through social networks - Actions to develop or support climate change adaptation measures, environment protection or other community adaptation goals. Examples:

- Volunteering/joining with a community organization for working towards climate change adaptation
- Building canals/channels for effective drainage in flood-prone areas
- Collective farming

7. Promoting sustainable-livelihood by reducing carbon emissions or environmental pollution - Carrying out an eco-friendly lifestyle by reducing consumption, purchasing eco-friendly products or using things in a way that it won't harm the environment. Examples:

- Reducing energy consumption
- Reducing expenses by changing consumption pattern
- Growing one's own food (homestead gardening)
- Purchasing green products
- Using public transport instead of driving
- Water conservation

8. Psychological coping - Managing the mental stress associated with the impacts of climate change. Examples:

- Seeking support from others
- Using coping strategies like mental reframing, counselling or adjusting expectations

9. Building climate knowledge - Building an understanding about how to adapt to climate change or minimise the risks. Examples:

- Information seeking or sharing
- Agreeing to change the misbeliefs
- Social learning, applying ITKs
- Reading information leaflets about the subject
- Capacity building in climate knowledge through awareness training or formation of climate clubs

10. Migration - Permanently leaving one's original home in response to the increased risks due to extreme weather events. Examples:

- Changing house type or location (within the same city or region)
- Temporary migration for work
- Moving to a new city or region

CHAPTER 6
SUMMARY AND CONCLUSIONS

Kerala encountered the most disastrous floods in its history since 1924, between June 1st and August 19th of 2018. As the torrential rainfall and associated storm thrashed the state, the entire state got buried under water with only few areas remaining above water. The combined precipitation received by the state during this period was 42 per cent in excess of the typical normal. The exceptional spell of rainfall inflicted heavy damage on the life and properties of thousands of people in the state.

A large number of agriculture dependent rural households, most of which are involved in subsistence agriculture, were found to have borne the brunt of the unprecedented deluge as it vandalised the agricultural fields. It is in this context that the present study entitled 'Vulnerability and adaptation study of women exposed to extreme weather events in Thrissur district' was undertaken. It was carried out in the BPL agricultural households of Mala and Vellangallur blocks in Thrissur district. The objectives of the study were to analyse the economic aspects of womens' vulnerability to extreme weather events and the components which contribute to the vulnerability as well as to study the adaptation strategies undertaken by the rural households.

Both primary as well as secondary data were used for the study, however, the study was based mostly on primary data. Primary data was collected from the respondents using pretested structured interview schedule through personal interview method for studying the economic vulnerability of male and female-headed households as well as the adaptation strategies undertaken by them. The secondary data regarding the list of BPL farmers in the selected panchayats were obtained from the respective Panchayats and Krishi bhavans. A Mann-Whitney U test was done to find out whether there is significant difference between the male and female-headed households.

Prior to estimating the economic vulnerability of the male and female-headed households, their livelihood vulnerability was found using two approaches designed by Hahn et al. (2009) ie., LVI (Livelihood Vulnerability Index) and LVI-IPCC (Livelihood Vulnerability Index-Intergovernmental Panel on Climate Change). LVI was estimated using seven major components ie., Socio-Demographic Profile, Economic Status,

Social Networks, Health, Food, Water and Natural Disasters and Climate Variability. The LVI values for male and female-headed households were found to be 0.32 and 0.39. Hence the study showed that female-headed households were more vulnerable to extreme weather events compared to male-headed households. They were more vulnerable with respect to all the seven major components. LVI-IPCC also yielded a similar result. Female-headed households were more vulnerable in terms of all the three contributing factors ie., Adaptive capacity, exposure and sensitivity. Female-headed households had a lower adaptive capacity and higher exposure as well as sensitivity.

The economic vulnerability of male and female-headed households were estimated by slightly modifying the ASPIRES Economic Vulnerability tool. The results showed that female-headed households were more economically vulnerable with a value of 0.46 compared to 0.40 in male-headed households.

Logistic regression analysis was carried out to study the determinants of economic vulnerability. High school education, dependency ratio, assistance from local government, family size, agriculture as the sole source of income, agricultural diversification index and natural disasters were found to have significant influence on the male and female-headed households becoming economically vulnerable. The results suggested that while natural disasters and dependency ratio positively influenced the economic vulnerability of female-headed households, high school education, assistance from local government, family size and agricultural diversification index were found to negatively influence the vulnerability.

Mann Kendall's Concordance test was carried out to study the level of agreement among the respondents on the preference of climate change adaptation strategies. The results showed that there was a high level of agreement among the respondents with the value of Kendall's coefficient 0.94. The most preferred adaptation strategies were livelihood diversification, preparation, institutional support, agronomic and plant protection measures, psychological coping, building climate knowledge, adaptation of new crops and modern agricultural technology, resilience through social networks, promoting sustainable livelihood and migration.

To conclude, from the study, it was found that female-headed households were more vulnerable than male-headed households in terms of livelihood vulnerability as

well as economic vulnerability to extreme weather events. They had a lower adaptive capacity and higher sensitivity and exposure to natural disasters. Natural disasters and dependency ratio positively influenced the economic vulnerability of female-headed households. Livelihood diversification was the most preferred adaptation strategy among them.





Plate 5 Field survey

CHAPTER-7
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VULNERABILITY AND ADAPTATION STUDY OF WOMEN EXPOSED TO EXTREME WEATHER EVENTS IN THRISSUR DISTRICT

by

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(2015 – 20 - 003)

ABSTRACT

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ABSTRACT

Economic damage due to extreme weather events have been increasing in the past few decades and is likely to continue growing due to increase in population, urbanisation and changing land use pattern. Women constitute a disproportionate share of the poor and hence are likely to be extremely vulnerable to the effects of climate change. Their income is mostly derived from informal sources like agriculture which are climate sensitive. Therefore, more intensive research is needed to illuminate the interaction between climate change and gender inequalities. The state of Kerala with its geographical features and location is highly vulnerable to natural disasters. It stands fourth in the country in state-wise vulnerability to floods. Kerala encountered the most disastrous floods in its history since 1924, between June 1st and August 19th of 2018. The exceptional spell of rainfall inflicted heavy damage on the life and properties of thousands of people in the state. The cultivated area of a large number of rural households, who did subsistence agriculture, were vandalised in the floods. Around 16 per cent of the families in Kerala are female-headed and female operational holdings accounts to 12.7 per cent. It is in this context that the study entitled 'Vulnerability and adaptation study of women exposed to extreme weather events in Thrissur district' was undertaken. The study aims to analyse the economic vulnerability of women to extreme weather events, its determinants as well as the adaptation strategies undertaken by them. The study was conducted in the agricultural households of Mala and Vellangallur blocks of Thrissur district. These blocks are located in the Chalakudy River Basin which was heavily flooded during Kerala floods of 2018. BPL households with atleast 20 per cent of their income from agriculture or allied sectors were randomly chosen for the study. The study was undertaken to compare the vulnerability of male and female-headed households separately. Both primary as well as secondary data were used for the study, however, the study was based mostly on primary data which was collected using household survey. Two approaches (1) LVI (Livelihood Vulnerability Index) and (2) LVI-IPCC (Livelihood Vulnerability Index-Intergovernmental Panel on Climate Change) proposed by Hahn et al. (2012) were used to study the livelihood vulnerability of male and female-headed households to extreme weather events. Economic vulnerability of male and female-headed households were estimated by modifying the ASPIRES Economic Vulnerability Tool. It was found that female-headed households were more vulnerable than male-headed households in terms of both livelihood vulnerability and economic vulnerability. Logistic regression analysis was carried out

to study the determinants of economic vulnerability. The results suggested that while natural disasters and dependency ratio positively influenced the economic vulnerability of female-headed households, high school education, assistance from local government, family size and agricultural diversification index were found to negatively influence the vulnerability. Mann Kendall's Concordance test was carried out to study the level of agreement among the respondents on the preference of climate change adaptation strategies. The results showed that there was a high level of agreement among the respondents with the value of Kendall's coefficient 0.94. The most preferred adaptation strategies were livelihood diversification, preparation, institutional support, agronomic and plant protection measures, psychological coping, building climate knowledge, adaptation of new crops and modern agricultural technology, resilience through social networks, promoting sustainable livelihood and migration.

APPENDIX I

KERALA AGRICULTURAL UNIVERSITY

VULNERABILITY AND ADAPTATION STUDY OF WOMEN EXPOSED TO EXTREME WEATHER EVENTS IN THRISSUR DISTRICT

ACCER

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SURVEY QUESTIONNAIRE

Date: Panchayat: Block:

BASIC DETAILS

1. Name & address of the head of the household:

2. Gender : Male/Female
3. Age : 20-30/30-40/40-50/>50 yrs
4. Religion : Hindu/Muslim/Christian/Others
5. Caste : General/SC/ST/OBC/OEC/Others
6. Marital Status : Single/Married/Widower/Widow/Divorced
7. Economic Status : BPL/APL

MAJOR COMPONENTS OF LIVELIHOOD VULNERABILITY INDEX

A. SOCIO-DEMOGRAPHIC PROFILE

1. Family Details

Sl. No	Name of the member	Relationship with the head of the household	M/F	Age	Designation
1.		Head			
2.					
3.					
4.					
5.					
6.					
7.					
8.					

B. LIVELIHOOD

1. Sources of income of the household (agriculture, livestock, govt. job, wages, rent, others)

Sl no.	Sources of income (major to minor)	Member/members of the family involved	Place of work	No.of days of work	Earnings		
					Daily	Monthly	Yearly
1.							
2.							
3.							
4.							
5.							
6.							

2. Details of assets owned

Total land area owned-
Household area: _____ Farming area: _____ Barren land: _____
No. of houses owned: _____

a. Farm assets

Sl no.	Particulars	Assets	Number	Purchase value	Present value
1.	Farm buildings	Farm house			
		Cattle shed			
		Pump house			
		Poultry shed			
2.	Farm machinery & equipments	Tractor			
		Submersible Pump set			

		Power tiller			
		Cultivator			
		Disc plough			
		Bullock cart			
		M.B plough			
		Harvester			
3.	Intercultural implements	Spade			
		Sickle			

b. Livestock enterprises

Enterprises	Number	Purchase value	Present value	Maintenance cost	Income
1. Bullock					
2. Cow					
3. Buffalo					
4. sheep					
5. goat					
6. poultry					
7. others					
Total					

c. Household assets

Particulars	Number	Purchase value	Present value	Source of funding
1. T.V				
2. Refrigerator				
3.Fan				
4. Furniture				
5. Gold				
5.Transport vehicles				
a. Two-wheeler				
b. Car				
c.others				

d. Financial status

Sl no.	Particulars	Amount	Remarks
1.	Cash on hand		
2.	Savings in bank		
3.	Chit funds		
4.	Advances made to others		
5.	Others(specify)		

3. Average Monthly Family Expenditure (Amount in rupees)

Description	Weekly	Monthly	Yearly
Food (W)			
Clothing (Y)			
Education (Y)			
Medical (Y)			
Entertainment (M)			
Fuel (M)			
Electricity (M)			
Phone (M)			
Donation (Y)			
Loan repayment (M)			
Liquor/Tobacco (M)			
Travel (M)			
Newspaper (M)			
Rent (M)			
Internet (M)			
Other (M)			
Total			

4. Details on crops

Sl no.	Crop (along with variety)	Area cultivated	Material cost	Labour cost	Yield (kg)	Price (Rs)	By product yield (kg)	Price (Rs)	Total Price(Rs ``)

5. Were you cultivating the same crops for years or have you changed the crops for some reasons? If yes, why?

6. Marketing of products

Sl no.	Sector	Products	Processing involved (if any)	Price per unit	Qty	Volume sold (Retail/wholesale)
1.	Agriculture					
2.	Livestock					
3.	Poultry					
4.						

7. Details of Credit

Type of loan	Source	Amount	When was it taken	Interest	Any delay in repayment after the floods
1.Agricultural loan					
2.Gold loan					
3.Personal loan					
4.Educational loan					

Total amount of debt _____

8. Have you availed any loan personally available for agriculture or any other purposes via some schemes? If yes, which one?

9. Details of Insurance

Type of insurance	Company	Is the premium payment up to date	Claim sought

10. Do you know to carry out all the operations involved in your farm? Can you do them alone if necessary?

C. HEALTH

Sl no.	Question	Response
1.	How long does it take you to reach a health centre?	
2.	Is anybody in your family chronically ill (they get sick very often)?	
3.	Has anyone in your family been so sick in the past 2 weeks that they had to miss work or school?	
4.	Does anyone in the family suffer from lifestyle diseases?	
5.	Do you have a health insurance?	
6.	Details on any other disease that has become common in the past 5 years and how equipped the household is to cope with it?	

D. SOCIAL NETWORKS

Sl no.	Question	Yes/No	Reason
1.	In the past month, did your relatives or friends help you and family: (e.g., get medical care or medicines, sell animal products or other goods produced by family, take care of children). If so, how many times have to received help from others?		
2.	In the past 12 months, have you or someone in your family gone to your community leader/panchayat for help?		

E. FOOD

Sl no.	Question	Response
1.	Do you cultivate your own food?	
2.	Does your family manage to get nutritious food? (protein-rich, vitamin A, calcium supplements etc.)	
3.	Does your family save some of the crops you harvest to eat during a different time of the year?	
4.	Does your family save seeds to grow in the next year?	

F. WATER

Sl no.	Question	Response
1.	Where do you collect drinking water from?	
2.	In the past years, have you heard about any water shortage/water quality related issues in your area?	
3.	How long does it take to reach your water source?	
4.	Is this water available every day?	
5.	What containers do you usually store water in? How many? What are their capacities?	

G. NATURAL DISASTERS AND CLIMATE VARIABILITY

Sl no.	Question	Response
1.	Do you think that you live in a disaster prone area?	
2.	What do you think makes your family more vulnerable to any disaster? (poverty, agriculture as the main source of livelihood, proximity to river or paddy fields etc.)	

3.	How many times have natural disasters affected your area between 2015 and 2019? Which were they?	
4.	When did flood affect your area for the first time?	
5.	Did you notice the early warnings and alerts given by the government during 2018 floods?	
6.	Was any one in your family injured in the flood?	
7.	Was your monthly average income altered due to the effects of floods?	If yes, from which all sources and for how long?

Physical losses incurred from the household area

Item	Qty	Value	Total rebuilding cost	Insured or not?	From which insurance company/scheme	Was premium payment up to date?	Amount of claim from the company	Compensation from govt.

Physical losses incurred from the farming area

Crop/farming implement	Acres/ Nos	Value	Total loss/ rebuilding cost	Insured or not?	From which insurance company/scheme	Was premium payment up to date?	Amount of claim from the company	Compensation from govt.

Health impacts

Impacts on health (physical/ mental) due to the floods	Name of the victim	Expenditure

Total Economic Loss = Rebuilding cost from physical losses + Expenditure due to health impacts =

What additional burdens of work were there during the time of disaster?

Activity	Time taken	Did it have a negative effect on your other income generating activities?

1.	Does the 2018 experience help you to stay prepared in a better manner in future?	If yes, what steps have you taken for the same?
2.	Now, can you identify the situation of an approaching flood?	If yes, what will be the immediate steps that you take?
3.	Did some notable changes occur in your farm land after the floods?	If yes, which all? What were the remedies taken?
4.	Have you changed your crops after the floods?	If yes, which are the new crops and why were they selected?

5.	Was the crop insurance beneficial? Would you recommend it?	
6.	Do you notice the early warnings and alerts given by the government now?	If no, why?
7.	Do you know what different colours signify? Which mode of communication is most accessible for you?	

Indigenous technical knowledge that can be included in adaptation strategies.

ITK	Use	Reason	How can they be put to use in adaptation strategies?

Sl No.	Question	Options (Tick the most appropriate answer)
1.	Which response most accurately describes your household's ability to meet its basic needs, including food, shelter, education, and health care?	a) We struggle to pay for food and shelter
		b) We can usually pay for food and shelter, but we struggle to make lump sum payments for health and education expenses.
		c) We can usually pay for food, shelter, and education and health care expenses. Sometimes we struggle, but we usually make lump sum payments.
		d) We are always able to pay for food, shelter, education, and health care without struggle.
2.	What are the sources of income for this household? (Income diversity)	a) Salaries/wages/commission
		b) Income from a business
		c) Remittances (money received from people living elsewhere)
		d) Pensions
		e) Grants (include old age grant here)
		f) Sales of farming products and services
		g) Other income sources e.g. rental income, interest

		h) No income
3.	How frequently is this income available throughout the year?	a) Unpredictable
		b) Predictable, but changes dramatically depending on the season
		c) Predictable, but changes slightly depending on the season
		d) Predictable throughout the year
4.	If something bad happened and you could no longer earn money through your primary livelihood, what would you do?	a) Find a new job
		b) Rely more on other existing income generating activity
		c) Rely on family for support
		d) Rely on charity
		e) I don't have a livelihood
5.	Is there anything your household owns that can be turned into cash quickly, such as livestock, food stores, or personal belongings. These are called liquid assets. What describes your household best?	a) We never have many liquid assets
		b) We have some liquid assets, but the amount changes a lot during the year
		c) We have some liquid assets, and the amount changes a little during the year
		d) We always have many liquid assets
6.	How much money do you have in savings?	a) Nothing or nearly nothing
		b) Some, but the amount changes a lot during the year
		c) Some, but the amount changes a little during the year
		d) We always have a lot of savings
7.	Which best describes your household's economic status.	a) Destitute: we are barely surviving
		b) Struggling to make ends meet: we are surviving, but our economic status is not stable
		c) Prepared to grow: our status is mostly stable and we are investing in new opportunities, though we sometimes struggle
		d) Not vulnerable: we are stable and secure
8.	Productive assets are the resources used to generate income, like livestock, land for agriculture, tools, or equipment for a business. How would you describe your household's productive assets?	a) We don't have any productive assets
		b) We have some productive assets
		c) We have a lot of productive assets
9.		a) No shocks have occurred

	When was the last time the household experienced a shock or emergency that had a major effect on your household finances, such as taking in new dependents, losing a wage earner, natural disaster, or losing a business?	b)	More than 10 yrs. ago
		c)	5-10 yrs. ago
		d)	1-5 yrs. ago
		e)	In the last yr
10.	What was the shock?	a)	Family conflict
		b)	Death of a wage earner/grant recipient
		c)	Major job loss
		d)	Taking in new dependents
		e)	Drought or natural disaster
		f)	Business failure
		g)	Other
11.	Of the following options, which best describes what happened?	a)	Household never recovered
		b)	Household is still recovering
		c)	Household recovered over time
		d)	Household recovered immediately

APPENDIX II

Table 8 Major components and sub-components comprising the Livelihood Vulnerability Index (LVI) developed for male and female-headed households of Thrissur district

Major components	Sub components	Explanation of the sub-components	Survey question	Source	Potential limitations
Socio-demographic profile	Percentage of households where head does not have high school education	Percentage of households where the head of the household reports that they have only primary education.	Do you have high school education?	Adapted from Domestic Household Survey (DHS) (2006)	Difficult to trace whether the respondent is a drop out from high school.
	Dependency ratio	Ratio of the population under 15 and over 65 years of age to the population between 19 and 64 years of age.	Could you please list the ages and sexes of every person who eats and sleeps in this house?	Adapted from DHS (2006)	It does not consider the sick/chronically ill people of the age between 19 and 64 years.
Economic status	Percentage of households dependent solely on agriculture as the main source of income	Percentage of households that report only agriculture as a source of income.	What are the different sources of income for the family?	Adapted from World Bank (1997)	People may sometimes not reveal all the sources of income.
	Proportion of agricultural income to total	Proportion of the income from various agricultural activities (farming,	Can you please mention the income received from each source in a year?	Adapted from Booth (2002)	Due to lack of trust, people may not reveal the

Major components	Sub components	Explanation of the sub-components	Survey question	Source	Potential limitations
	household income	livestock rearing, poultry, fish rearing etc.) to the total annual income (comprising of income from other sources as well) of the household.			exact income.
	Average agricultural livelihood diversification (range: 0.20-1)	The inverse of (the number of agricultural livelihood activities + 1) reported by a household, eg., A household that farms, raises animals, and collects natural resources will have a Livelihood Diversification Index = 1/(3+1) = 0.25	Same as above	Adapted from DHS (2006)	People may not carry out all of them throughout the year.
	Household's ability to meet its basic needs	How well the household is able to meet its basic needs like food, shelter, education and health care.	Which response most accurately describes your household's ability to meet its basic needs, including food, shelter, education, and health care? 1.We struggle to pay for food and shelter. 2.We can usually pay for food and shelter, but we struggle to	Adapted from household economic vulnerability tool indicator guide, PEPFAR (President's Emergency Plan for AIDS Relief, U.S), USAID	Tendency of people to project themselves as poor.

Major components	Sub components	Explanation of the sub-components	Survey question	Source	Potential limitations
			make lump sum payments for health and education expenses. 3.We can usually pay for food, shelter, and education and health care expenses. Sometimes we struggle, but we usually make lump sum payments. 4.We are always able to pay for food, shelter, education, and health care without struggle.		
	Ability to handle financial stress	The steps taken by the household when something bad happens and earning from the primary source of livelihood stops.	If something bad happened and you could no longer earn money through your primary livelihood, what would you do? 1.Find a new job 2.Rely more on other existing income generating activity 3.Rely on family for support or loans 4.Rely on charity, I don't	Adapted from household economic vulnerability tool indicator guide, PEPFAR, USAID	Confusion among the options regarding which one to follow.

Major components	Sub components	Explanation of the sub-components	Survey question	Source	Potential limitations
			have a livelihood		
	Liquid assets	Is there anything your household owns that can be turned into cash quickly, such as livestock, food stores, or personal belongings. These are called liquid assets.	What describes your household best? 1.We never have many liquid assets 2.We have some liquid assets, but the amount changes a lot during the year 3.We have some liquid assets, and the amount changes a little during the year 4.We always have many liquid assets	Adapted from household economic vulnerability tool indicator guide, PEPFAR, USAID	Confused whether some are liquid assets or not.
	Savings	The difference between a household's disposable income and its consumption on goods and services.	How much money do you have in savings? 1.Nothing or nearly nothing 2. Some, but the amount changes a lot during the year. 3.Some, but the amount changes a little during the year 4.We always have a lot of savings	Adapted from household economic vulnerability tool indicator guide, PEPFAR, USAID	Variability in the amount of savings.

Major components	Sub components	Explanation of the sub-components	Survey question	Source	Potential limitations
	Economic status of the household	Household's perception about their economic status	Which best describes your household's economic status? 1.Destitute: we are barely surviving 2.Struggling to make ends meet: we are surviving, but our economic status is not stable 3.Prepared to grow: our status is mostly stable and we are investing in new opportunities, though we sometimes struggle 4.Not vulnerable: we are stable and secure	Adapted from household economic vulnerability tool indicator guide, PEPFAR, USAID	Tendency of people to project themselves as poor.
	Productive assets	Productive assets are the resources used to generate income, like livestock, land for agriculture, tools, or equipment for a business.	How would you describe your household's productive assets? 1.We don't have any productive assets 2.We have some productive assets 3.We have a lot of productive assets	Adapted from household economic vulnerability tool indicator guide, PEPFAR, USAID	Confused whether some are productive assets or not.

Major components	Sub components	Explanation of the sub-components	Survey question	Source	Potential limitations
Health	Percentage of households where a member is chronically ill	Percentage of households that report at least 1 family member with chronic illness. Chronic illness was defined subjectively by the respondent.	Is anybody in your family chronically ill? (they get sick very often)	Adapted from DHS (2006)	_
	Percentage of households where a member missed work or school due to illness	Percentage of households that report at least 1 family member who had to miss school or work due to illness in the last 2 weeks.	Has anyone in your family been so sick in the past 2 weeks that they had to miss work or school?	Adapted from World Health Organisation (2003)	_
	Percentage of households where at least one member suffers from a lifestyle disease	Percentage of households where at least one member suffers from diabetes, hypertension, blood pressure, cholesterol etc.	Does anyone in the family suffer from lifestyle diseases?	Developed for the purposes of this questionnaire	_
	Percentage of households that do not have a health insurance	*Health insurance* is a type of insurance coverage that pays for medical and surgical expenses that are incurred by the insured.	Do you have a health insurance?	Developed for the purposes of this questionnaire	_

Major components	Sub components	Explanation of the sub-components	Survey question	Source	Potential limitations
	Percentage of households in which a disease has become common in the past 5 years	Households in which a disease (previously not so common) has occurred more than once in the past 5 years.	Details on any other disease that has become common in the past 5 years and how equipped the household is to cope with it?	Developed for the purposes of this questionnaire	Recollection bias towards past two years
Social networks	Number of helps received by the household	The number of helps received by the household in the past 12 months	In the past month, did relatives or friends help you and your family; (eg., Get medical care or medicines, sell animal products or other goods produced by the family, take care of children).	Adapted from DHS (2006)	The perception of 'help' varies with respondents. Greater tendency to report self-perceived helps.
	Percentage of households that have not gone to their local government for help in the past 12 months	Percentage of households that have reported that they have not asked their local government for any assistance in the past 12 months.	In the past 12 months, have you or someone in your family gone to your community leader for help?	Adapted from WHO (2003)	Reliance on self-reported visit to government; recall bias(more likely to remember going to government for dire issues.
Food	Percentage of households dependen	Percentage of households that get their food primarily from	Where does your family get most of its food?	Developed for the purposes of this	Subjective definition of 'most'

Major components	Sub components	Explanation of the sub-components	Survey question	Source	Potential limitations
	t on family farm for food	their personal farms.		questionnaire	
	Percentage of households that do not manage to get nutritious food	Percentage of households that cannot afford to buy protein-rich food, vitamin-A, calcium supplements etc.	Does your family manage to get nutritious food?	Developed for the purposes of this questionnaire	Confusion regarding the frequency of availability of protein rich food.
	Average crop diversity index (range: >0-1)	The inverse of (the number of crops grown by a household +1) eg., A household that grows paddy, banana, nutmeg, and cassava will have a Crop Diversity Index = 1/(4+1) = 0.20.	What kind of crops does your household grow?	Adapted from World Bank (1997)	No specification regarding the seasonality of crops
	Percentage of households that do not save crops	Percentage of households that do not save crops from each harvest.	Does your family save some of the crops you harvest to eat during a different time of the year?	Developed for the purposes of this questionnaire	Does not count families that sell crops and save money
	Percentage of households that do not save seeds	Percentage of households that do not have seeds from year to year.	Does your family save seeds to grow in the next year?	Developed for the purposes of this questionnaire	No specification regarding the year in the question
Water	Percentage of households that do not have a	Percentage of households that report that water is not available at their primary	Is drinking water available every day?	Adapted from World Bank (1997)	Confusion regarding availability throughout the day.

Major components	Sub components	Explanation of the sub-components	Survey question	Source	Potential limitations
	consistent water supply	water source every day.			
	Percentage of households who have reported water shortage in their area in the past years	Percentage of households that have reported that ground water level has significantly decreased in their area.	In the past years, have you heard about any water shortage/water quality related issues in your area?	Adapted from World Bank (1997)	Recall bias; most likely to remember incidents of the recent past
	Percentage of households that depend on natural source of water for their household water needs	Percentage of households that report a creek, river, lake, pool, or hole as their primary water source.	Where do you collect your water from?	Adapted from DHS (2006)	Confusion where families have multiple water sources
	Inverse of the average number of litres of water stored per household (range: 0-1)	The inverse of (the average number of litres of water stored by each household + 1)	What containers do you usually store water in? How many? How many litres are they of?	Developed for the purposes of this questionnaire	Perception differences among the respondents on the quantity of one litre
Natural disasters and climate variability	Percentage of households which believe that they live in a disaster	Household's perception of the risk involved in the area that they live in	Do you think you live in a disaster prone area?	Developed for the purposes of this questionnaire	Confusion regarding disaster prone area

Major components	Sub components	Explanation of the sub-components	Survey question	Source	Potential limitations
	prone area				
	No. of times natural disasters have affected the household area between 2014 and 2019	Total number of floods, droughts, and cyclones that were reported by households in the past 6 years.	How many times has this area been affected by a flood/cyclone/drought in 2001-2007?	Adapted from Williamsburg Emergency Mgmt. (2004). Household Natural Hazards Preparedness Questionnaire.	Recall bias (most severe disasters are most likely to be remembered)
	Percentage of households that did not receive a warning about the pending natural disaster	Percentage of households that did not receive a warning about the most severe flood, drought, and cyclone event in the past 6 years.	Did you receive a warning about the flood/cyclone/drought before it happened?	Adapted from Williamsburg Emergency Mgmt. (2004).	Subjective definition of 'warning'
	Percentage of households with an injury or death as a result of the most severe natural disaster in the past 6 years	Percentage of households that reported either an injury to or death of one of their family members as a result of the most severe flood, drought, or cyclone in the past 6 years.	Was anyone in your family injured in the flood/cyclone/drought? Did anyone in your family die during the flood/cyclone/drought?	Developed for the purposes of this questionnaire	Recall bias (severe injuries are most likely to be ··· remembered)
	No. of months for which the income	No. of months for which the household had very less/ nearly no income after	Was your monthly average income altered due to the effects of	Developed for the purposes of this	Tendency to include the whole month even if

Major components	Sub components	Explanation of the sub-components	Survey question	Source	Potential limitations
	of the household was reduced after the disaster	the floods of 2018.	floods? If yes, from which all sources and for how long?	questionnaire	they returned to normal condition in the midway.
	Total economic loss during the 2018 floods	Sum of physical losses and rebuilding cost from both the household and agricultural area	How much did the physical losses from the household and agricultural land and the rebuilding cost you?	Developed for the purposes of this questionnaire	Tendency to round off the lost amount to the nearest ten-thousand.
	Households in which the 2018 experience has not helped them to stay prepared in a better manner in future	Whether or not the experience of 2018 floods helped the households to stay prepared during the summer monsoon of 2019 in order to reduce the physical losses and danger.	Does the 2018 experience help you to stay prepared in a better manner in future?	Developed for the purposes of this questionnaire	Subjective definition of 'experience'.
	Mean standard deviation of the daily average maximum temperature by month	Standard deviation of the average daily maximum temperature by month between 2014-19 was averaged for the place.	2014-2019: district weather data from KAU weather station		Reliance on average data; Short time period.
	Mean standard deviation of the daily average minimum temperat	Standard deviation of the average daily minimum temperature by month between 2014-19 was	2014-2019: district weather data from KAU weather station		Reliance on average data; Short time period.

Major components	Sub components	Explanation of the sub-components	Survey question	Source	Potential limitations
	ure by month	averaged for the place.			
	Mean standard deviation of the average precipitation by month	Standard deviation of the average monthly precipitation between 2014-19 was averaged for the place.	2014-2019: district weather data from KAU weather station		Reliance on average data; Short time period.

APPENDIX III

Calculating the food major component for the LVI for female-headed households (FHH):

Sub components for food major component	Sub component values for FHH	Maximum sub-component value for the study population	Minimum sub-component value for the study population	Index value for FHH	Food major component value for FHH
1.Percentage of households dependent on family farm for food (F1)	30	100	0	0.30	0.60
2.Percentage of households that do not manage to get nutritious food (F2)	52.5	100	0	0.52	
3.Average crop diversity index (F3)	0.376	0.5	0.14	0.66	
4.Percentage of households that does not save crops to eat during a different time of the year (F4)	0.75	100	0	0.75	
5.Percentage of households that does not save seeds to grow in the next season (F5)	80	100	0	0.80	

Step 1 (repeat for all the sub-components): $\text{index}_{F1} = \frac{30-0}{100-0} = 0.30$

Step 2 (repeat for all the major components): $\text{Food}_{FHH} = \frac{\sum_{n=1}^{5} \text{index Fi}}{n} = \frac{F1+F2+F3+F4+F5}{5} = \frac{0.30+0.52+0.66+0.75+0.80}{5} = 0.60$

Step 3 (repeat for both the groups): $\frac{\sum_{i=1}^{7} w_{M_i} M_{gi}}{\sum_{i=1}^{7} w_{M_i}} = \frac{(2)(0.20)+(9)(0.43)+(2)(0.46)+(5)(0.39)+(5)(0.60)+(4)(0.06)+(10)(0.40)}{2+9+2+5+4+10} = 0.39$

APPENDIX IV

Calculating LVI-IPCC for female-headed households (FHH):

Contributing factors	Major components	Major component values for FHH	No. of sub-components per major component	Contributing factor values	LVI-IPCC value for FHH
Adaptive capacity	Socio-demographic profile (inverse)	1.12	2	0.50	-0.04
	Economic status (inverse)	5.06	9		
	Social networks (inverse)	1	2		
Sensitivity	Health	0.39	5	0.40	
	Food	0.60	5		
	Water	0.05	4		
Exposure	Natural disasters & climate variability	0.4	10	0.40	

Step 1 (calculate indexed sub-components and major components as shown in Appendix III, taking the inverse of the adaptive capacity sub-components: Socio demographic profile, Economic status and Social networks)

Step 2 (repeat for all contributing factors: exposure, sensitivity, and adaptive capacity): Adaptive capacity$_{FHH}$ $= \frac{\sum_{i=1}^{3} w_{M_i} M_{gi}}{\sum_{i=1}^{3} w_{M_i}}$

$= \frac{(2)(1.12)+(9)(5.06)+(2)(1)}{2+9+2}$

$=0.5$

Step 3 (repeat for all study areas): LVI-IPCC$_{FHH}$ = $(e_{fhh} - a_{fhh}) * s_{fhh} = (0.4-0.5) * 0.4 = -0.04$

APPENDIX V

Table 4.20 Sub-component values of LVI

Major component	Sub-component	Units	MHH	FHH	Max value	Min value
Socio demographic profile	1. Percentage of households where the head does not have high school education	Percent	11.8	20	100	0
	2. Dependency ratio	Ratio	0.628	0.621	3	0
Economic status	1. Percentage of households dependent solely on agriculture as the main source of income.	Percent	23.6	17.5	1	0
	2. Proportion of agriculture income to total household income	Ratio	0.65	0.55	1	0.13
	3. Average agriculture livelihood diversification	1/1+no. of agricultural activities	0.413	0.42	0.66	0.2
	4. Household's ability to meet its basic needs	(0.1-0.4)	0.152	0.18	0.4	0.1
	5. Ability to handle financial stress	(0.1-0.4)	0.218	0.275	0.5	0.1
	6. Liquid assets	(0.1-0.4)	0.248	0.265	0.4	0.1
	7. Savings	(0.1-0.4)	0.269	0.285	0.4	0.2
	8. Economic status of the household	(0.1-0.4)	0.254	0.265	0.4	0.1
	9. Productive assets	(0.1-0.3)	0.24	0.262	0.4	0.1
Social networks	1. No. of helps received in the past 12 months	Number	0.96	1.2	3	0
	2. Percentage of households that have not gone to their local government for help in the past 12 months	Percent	40	52.5	100	0

Health	1. Percentage of households where a member is chronically ill	Percent	26.3	40	100	0
	2. Percentage of households where a member missed work or school due to illness	Percent	7.3	7.5	100	0
	3. Percentage of households where at least one member suffers from a lifestyle disease	Percent	52.7	45	100	0
	4. Percentage of households that do not have a health insurance or similar government health card.	Percent	89.1	100	100	0
	5. Percentage of households where a disease have become common in the past five years.	Percent	0.9	0	100	0
Food	1.Percentage of households dependent on family farm for food	Percent	17.3	30	100	0
	2.Percentage of households that do not manage to get nutritious food	Percent	31.8	52.5	100	0
	3.Average crop diversity index	Ratio	0.326	0.376	0.5	0.14
	4. Percentage of households that does not save crops to eat during a different time of the year	Percent	61.8	75	100	0
	5. Percentage of households that does not save seeds to grow in the next season	Percent	62.7	80	100	0
Water	1.Percentage of households that do	Percent	0	0	100	0

	not have a consistent water supply					
	2.Percentage of households who have reported water shortage in their area in the past years	Percent	12.7	12.5	100	0
	3.Percentage of households that depend on natural source of water for their household water needs	Percent	3.6	7.5	100	0
	4.Inverse of the average number of litres of water stored per household (range: 0-1)	Ratio	0.01	0.005	0.2	0.001
Natural disasters and climate variability	1.Percentage of households which believe that they live in a disaster prone area	Percent	60	100	100	0
	2.No. of times natural disasters have affected the household area between 2014 and 2019	Average	1.53	1.675	5	1
	3.Percentage of households that did not receive a warning about the pending natural disaster	Percent	12.7	20	100	0
	4.Percentage of households with an injury or death as a result of the most severe natural disaster in the past 6 years	Percent	16.4	25	100	0
	5.No. of months for which the income of the household was reduced after the disaster	Average	0.221	0.31	0.6	0

6.Total economic loss during the 2018 floods	Amount/1 lakh	1.96	2	6	0.2
7.Households in which the 2018 experience has not helped them to stay prepared in a better manner in future	Average	0.036	0.125	1	0
8. Mean standard deviation of the daily average maximum temperature by month (2014-19)	Celsius	0.563	0.563	0.82	0.32
9. Mean standard deviation of the daily average minimum temperature by month (2014-19)	Celsius	0.692	0.692	0.88	0.33
10. Mean standard deviation of the average precipitation by month (2014-19)	Millimeters	99.03	99.03	292.7	8.87