Vulnerability Assessment for Livelihood Inclusion and Social Empowerment (VALISE) of farmers: a post flood analysis of Kerala state

by

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THESIS

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DECLARATION

I, hereby declare that this thesis entitled **"Vulnerability Assessment for Livelihood Inclusion and Social Empowerment (VALISE) of farmers: a post flood analysis of Kerala state"** is a bonafide record of research work done by me during the course of research and the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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LIST OF ABBREVIATIONS AND SYMBOLS USED

SVI^{FL}	Societal Vulnerability Index for Floods and Landslides
CSI^{FL}	Coping Strategies Index for Floods and Landslides
AD	Adimali
VT	Vellathooval
PM	Panamaram
MD	Meppadi
AP	Ambalappuzha
KK	Kainakari
KD	Kadapra
NM	Niranam
ALP	Alappuzha
PTM	Pathanamthitta
IDK	Idukki
WYD	Wayanad
PTSD	Post-Traumatic Stress Disorders
ANOVA	Analysis of Variance
PCA	Principal Component Analysis
EWS	Early Warning System
et al.,	Co- workers
%	Percentage

Introduction

1. INTRODUCTION

"*We cannot stop natural disasters, but we can arm ourselves with knowledge: so many lives wouldn't have to be lost if there was enough disaster preparedness*"

Petra Nemcova

Disasters are events of huge magnitude and negative impacts on society and environment. Disaster is also defined as a crisis situation causing wide spread damage which far exceeds our ability to recover (Van, 2006). Disaster can hit anywhere, at any time and take any form, be it natural disasters as we have seen too often in our recent past or manmade.

Over the years, both developed and developing nations have experienced fatalities, injuries, property damage, and disruption of economic and social structure due to the natural disasters. Moreover, the world has experienced a total of 6,457 weather related events in the past twenty years which claimed 6,06,000 lives, and left 4.10 billion people injured, homeless or in other desperate situations (WMO, 2015; UNISDR, 2016).

Among the natural disasters, floods and landslides have been the most devastating and recurring which accounted for 47% of all weather related disasters, and affecting 2.30 billion people worldwide (Diley *et al.*, 2005). Furthermore, the frequency of floods per year has unfortunately rose up from 127 to 171 within a 20 year time period. India, is one of the most flood affected regions that experiences a surge in frequency of floods, hence increased damages mainly due to its topography and socio-economic conditions (Singh and Kumar, 2017). The number of floods experienced by India has rose up from 67 to 90 in a ten year period from 2006 to 2015. As a result it has suffered crop losses, estimated at 0.18% of GDP, accounting to an annual loss of about 0.46 % of GDP (Parida, 2018). Therefore, frequent occurrence of floods is detrimental to a nation like India where 63% of the rural workforce and 47% of the total workforce still depends on agriculture for their source of livelihood.

Kerala, is prominently known as the gateway of summer monsoon rainfall mainly due to its tropical monsoon climate with seasonally excessive rainfall

(3000mm) and hot summers. However, the state has gained attention in the recent past due to significant alterations in the SW monsoon characteristics resulting in severe floods and landslides. The flood of 2018 was the worst of its kind in a century since the floods of the year 1924. It can be understood as a climate induced natural disaster, where it received an excess of 56% rainfall between July and August from multi-day extreme rainfall episodes.

Torrential rain of August 2018 in Kerala, was mainly due to the formation of very deep convective clouds developed as a result of a low-pressure system over south – east Arabian Sea off the state. Kerala, known for its high life expectancy, a high level of education and low population growth rate is more prone to natural hazards not only because of the increasing number of floods and landslides during the past few years but also due to the presence of Arabian Sea to the west, Western Ghats to the east and a geographically slanting terrain creating an asymmetrical topography. Furthermore, a weakening Western Ghats, unplanned construction on flood plains and mismanagement of dams and reservoirs further aggravated the state of affairs.

Kerala predominantly being an agrarian economy with agriculture as a key sector to attain the Sustainable Development Goals (SDG) of no poverty, zero hunger, better health and well-being any variability in the rainfall characteristics will have profound impact on the economy of the state as well as on the livelihoods of our farmer population. Moreover, the hilly tracts of the state also experienced flood associated landslides during the downpour in 2018 and 2019, where several landslides took a toll on people's lives, and livelihoods. These landslides are usually shallow seated debris flows which are triggered by hydrological mechanisms such as heavy precipitation.

Although farmers of Kerala experience frequent floods and multiple landslides with significant damage to livelihood and assets, studies on vulnerability of the farmers of these regions to floods and landslides with emphasis on socio economic aspects are less. Similarly, researches on landslides in Kerala are often limited to landslide susceptibility and risk mapping with the help of machine learning and satellite imaging, developing rainfall thresholds for early warning systems, identification of causative factors of flood induced landslides and construction of data inventory on landslides in Kerala

Moreover, small holder farmers of Kerala, are mostly poor, experience food insecurity and sometimes live in precarious conditions .These populations, who are already exposed to non-climatic stressors and multi-dimensional inequalities becomes more vulnerable as a result of climate change. Most of these farmers, experience the impacts of climate change in the form of droughts, unpredictable heavy rainfall, increased pest and disease incidence and wild animal attacks. As a result, majority of the farmer population in Kerala has been affected by loss of livelihood, leading to poverty and hunger as they lack access to technical or financial support that could help them invest in flood and landslide resilient technologies. Landslides and floods are one of the most important disasters today in Kerala with the frequency and intensity of floods increasing every year.

There are a number of factors predisposing people, infrastructure and institutions to the effects of landslides and floods. These include settling in high risk areas such as mountain slopes, lack of information on mitigation measures to reduce the effects of landslides; instability of slopes; the unstable nature of houses which makes them prone to collapsing in the event of a landslide; and low level of preparedness in the district· In the event of a disaster, personal characteristics of household members such as age, sex, health status and disability increase vulnerability to the disaster effects· Often, women, children, the sick and the elderly have been reported to be the most at risk groups affected by landslides and floods. In our society, particularly, it is the lack of social preparedness to disasters that is increasing the threat of farmers to landslides and floods.

In the flood prone regions of Alappuzha and Pathanamthitta, individuals, households and communities have come up with some local coping strategies. Coping strategies are a combination of all the strengths, attributes and resources available within a community, society or organization that can be used to avert some or all of the negative effects of a shock or stress· For instance, relocation to safer areas if the threats are too great to ignore, receipt of aid and relief, and resorting to subsistence and innovative farming practices such as homestead farming and adoption of farm diversification in order to overcome crop destruction following heavy rains. Therefore, in disaster prone areas, disaster preparedness and management authority should address some key coping issues such as resettlement of people living in high risk areas, applying appropriate farming technologies and prohibition of settlement in high risk areas. However, in order to increase household level resilience, there is an urgent need to formulate local specific coping mechanisms.

IPCC (2014) has defined adaptation as 'the process of adjustment to actual or expected climate and its effects'. In agriculture, the term adaptation refers to the changes or adjustments in farming activities or cropping patterns according to the changing climatic conditions in order to lessen the damages and losses. This approach of adaptation aims to reduce vulnerability and increase the adaptive capacity of farmers to reduce damages or cope with the impacts.

However, to mitigate the negative impacts of climate change, primarily, farmers must be willing to improve their capacity to adapt by adopting new strategies and they also must be willing to embrace new livelihood opportunities in the post flood situation. This depends upon the socio economical context of the farmers, support of the local authorities, and access to technologies. At the government level, policy makers often lack the necessary information on how farmers are being impacted by climate change, local adaptation initiatives and the factors which are influencing the selection of adaptation techniques. Absence of such critical information becomes a barrier for policy makers in addressing long term nature of climate change and in formulating effective adaptation framework at the local level. This emphasizes the importance of a climate adaptive approach for the farmers.

It is now widely accepted that building livelihood resilience to natural disasters like floods and landslides holds the key to sustained income generation and economic development in disaster-affected areas. However, for an extended period, disaster management authorities, have focused their attention on exploring what makes for a successful post-disaster recovery, ignoring the needs of the impacted people and the challenges they face in relation to their livelihood following a large-scale disaster. Here is where the post disaster livelihood analysis gains importance. Even though livelihood is not a new thing in the development domain, community's livelihood is one of the most important disaster recovery measures which will contribute to building the resilience of communities in a sustainable manner.

One major aspect that has immense importance in the rehabilitation phase of the disaster is the contribution by the Government. The Government efforts are mainly in the form of rehabilitation schemes and crop loss compensation programs. During recovery phase, the Kerala government conducted the first Post-Disaster Needs Assessment (PDNA) with the support of UN agencies to include community stakeholders. PDNA conducted by the government adopted a holistic approach and included substantive recommendations on environmental sustainability and gender inclusiveness. As a result of PDNA, Government formulated its reconstruction plans such as 'New Kerala -Nava Keralam', supported by the UN and the World Bank.

In the agricultural sector, the major scheme that was implemented soon after the disasters is known as Punarjani scheme. Punarjani Scheme was implemented for the revival of agricultural sector through social participation by adopting scientific and eco-friendly cultivation methods. It is a special programme for handholding and creating awareness among flood affected farmers, and was conducted in all the 14 districts. It was implemented with the help of Department officials, people's representatives, scientists from Kerala Agricultural University, NGOs and members of Agro service centres and Karshika Karma Sena. As part of this punarjani scheme, soil testing campaigns , removal of silt deposited by flood in farmers' fields, application of soil ameliorants, plant protection measures including rodent control, repair of farm machinery etc. were organized and demonstrated. Moreover, several policy initiatives were also taken to make relief readily available to farmers. However, the extent to which the Punarjani scheme benefitted the farmers is not known.

Therefore, in order to fill the gap in vulnerability assessment, coping strategy adoption, climate adaptive approaches, post flood livelihood alternatives and impact of the post disaster schemes, this study entitled 'Vulnerability Assessment for Livelihood Inclusion and Social Empowerment (VALISE) of farmers: a post flood analysis of Kerala state, was conducted with the following major objectives

1.1. The objectives of the study

The major objectives were:

- To establish a Societal Vulnerability Index for Floods and Landslides (SVI^{FL}) and map the vulnerability hotspots for the affected areas.
- Delineate the coping strategies adopted during various phases of the floods and study the impact of various post flood schemes and measures by the Government.
- To develop a Climate Adaptive Agricultural Extension Approach (CAAEA) to formulate mitigation strategies and suggest adaptation strategies for the farmers.

1.2. Need of the study

A number of studies related to flood vulnerability, coping mechanisms and adaptation strategies have been conducted across the world and India. However, very few studies have been performed in Kerala with regard to vulnerability of farmers, coping mechanisms to flood, post flood livelihood, impact of government programs and climate change adaptation strategies.

Moreover, there is little information on the individual level adaptation strategies of farmers and location specific adaption framework of the farmers.

For these reasons, a study that focuses on the vulnerability of farmers to floods and landslides considering the social dimension of the farmers along with their physical, environmental and economic dimension is considerably important to understand the interaction of the hazards with individuals and communities. Moreover, vulnerability assessment with emphasis on socio-economic dimension will help to formulate policies for reducing flood and landslide associated risks and ultimately improve the resilience capacity of farmers.

1.3. Scope of the study

The SVI^{FL} can be used as an effective tool for assessing farmers' vulnerability to floods and landslides. If the indicators are adapted to farmers' local circumstances and living conditions, the index can also be used to assess vulnerability to disasters other than floods and landslides. The results of this study may enable stakeholders to determine the vulnerability of their residential areas. For policy makers, the results may be useful in formulating disaster risk reduction strategies at the panchayath or community level.

As the adaptive behaviour for climate change, varies from region to region, it is imperative to understand the factors which regulate the choice of strategies at regional level for effective policy development. Therefore, an understanding of farmer's location specific strategies and their livelihood opportunities is essential in formulating effective adaptation framework at the local level

1.4. Limitations of the study

The sample selected for the study consisted of 520 farmers. The results obtained in this study may not be applicable to people outside of this designation. Moreover, abnormal field conditions at the time of survey hindered accessibility to several key informants at the time of survey questioning the reliability of the data collected. Furthermore, finite research resources (monetary and non – monetary) also affected the data collection process. Since this is a study conducted based on perception and expressed opinion this may not be free of personal bias and prejudices.

1.5. Presentation of the study

The report of the study has been presented under five chapters, the first chapter deals with the introduction which explains the topic, statement of problems, objectives, scope of the study and limitations of the research. The second chapter deals with review of literature which covers major studies related to the present study. The third chapter is the methodology which deals with process of investigation, method of data collection, sample size, sampling design, measurement of the dependent and independent variables. Fourth chapter deals with the results and discussions which explains the results of the study obtained and also the discussion of the results. The fifth and final chapter is the summary of the study and suggestions for future research. The references, appendixes and abstract of the thesis are given in the end.

Review of literature

2. REVIEW OF LITERATURE

The invoice for our climate-changing emissions will include more droughts, floods and other natural disasters. We need to 'climate proof' our farms, our infrastructure and our livelihoods in order to minimize our vulnerability to future disasters. **Steiner (2010)**

The main objective of this chapter is to develop a theoretical framework on the concept of "Vulnerability Assessment for Livelihood Inclusion and Social Empowerment of farmers (VALISE) of farmers- A post flood analysis of Kerala state". Definitions, ideas and concepts have been used in order to furnish this topic. Research findings of several studies were used in order to make relevant, each content discussed here.

The review of literature plays an important role in giving an orientation to the study and also provides an opportunity to evaluate our work by comparing it with others. According to Cooper (1989), a literature review uses as its database reports of primary or original scholarship, and does not report new primary scholarship itself. The types of scholarship may be empirical, theoretical, critical/analytic or methodological in nature. Second, a literature review seeks to describe, summarize, evaluate, clarify and/or integrate the content of primary reports. Thus, literature review delimits the study, relates the methods used by other researchers, recommendations of earlier works and provides the basis for the intended research task.

The reviews to be discussed are presented under the following heads:

2.1. Concept of vulnerability

2.2. Vulnerability to Floods

2.3. Factors influencing vulnerability

2.4. Vulnerability assessment

2.5. Types of vulnerability

2.6. Vulnerability Indices

2.7. Vulnerability Mapping

2.8. Coping strategies adopted by the farmers

2.9. Post flood inclusive activities of farmers

2.10. CAAEA (Climate Adaptive Agricultural Extension Approach)

2.11. Impact of various post flood schemes and programmes

2.12. Profile characteristics of respondents.

2.1. CONCEPT OF VULNERABILITY

Gabor and Griffith (1980) conceptualised vulnerability in the context of risk. It has been described as a threat to which people are exposed and may or may not result in losses. Vulnerability reduces the capacity of the individual and community to withstand the adverse effects of hazards (Pijawka and Radwan, 1985). As per Cutter (1996), vulnerability determines the potential for less and it is an important component of hazard mitigation strategies.

Liverman (1990) defined vulnerability as a bio physical condition and described it as the product of economic, social and political conditions of the society. He also reported that vulnerability deals with the characteristics of a person or a group to anticipate, cope, resist and recover from the impacts of a hazard. Dow and downing (1995) conceptualised vulnerability as a complex of biophysical, demographic, economic, social and technological factors that comes alive in times of hazard.

Adger (2006) spotlighted vulnerability as the state of susceptibility to harm from exposure to stresses associated with environmental and social change and from the absence of capacity to adapt. He argues that vulnerability includes both susceptibility to a disaster’s effects and a lack of maintenance of well-being.

Green (2004) and Gheorghe (2005) explains vulnerability as a function of susceptibility, resilience, and state of knowledge and which has a potential for a receptor to be harmed.

Wisner *et al*. (2004) has defined vulnerability as combination of factors that determine the degree to which someone’s life and livelihood is put at risk by a discrete and identifiable event in nature or society. Cannon (2006) has defined vulnerability in terms of five components that capture all aspects of the exposure to risk from natural hazards namely i) Livelihood strength and resilience ii) Wellbeing and base-line status iii) Self-protection iv) Social protection, and v) Governance. Cardona (2006) defined vulnerability as an internal risk factor of the subject or system that is exposed to a hazard and corresponds to its intrinsic predisposition to be affected, or to be susceptible to damage. In other words, vulnerability represents the physical, economic, political or social susceptibility or predisposition of a community to damage in the case of a destabilizing phenomenon of natural or anthropogenic origin.

Mitchell (2002) has expressed vulnerability as a function of exposure, resilience and resistance. Vulnerability is about people, their perceptions and knowledge. People's ideas about risk and their practices in relation to disaster constitute the sextant and compass with which they measure and chart the landscape of vulnerability (Hilhorst and Bankoff, 2006). Messner and Meyer (2006) and Merz *et al*. (2007) narrowed the definition of vulnerability to elements at risk, exposure (damage potential) and (loss) susceptibility. As per Birkmann and Fernado (2008), vulnerability is linked to deficits in risk communication, which may have an influence on the motivation and ability to or to adopt to climate change and environmental stressors.

Fekete (2010) considers vulnerability as the disadvantages of individuals, communities and countries in the face of natural disasters or any external stressor. Vulnerability changes in time and space and aims at identifying and explaining why the object of research is at risk and how risk can be mitigated.

Vulnerability refers to the propensity of exposed elements such as human beings, their livelihoods, and assets to suffer adverse effects when impacted by hazard events (Cardona *et al*. 2012). She has also opined that vulnerability of human settlements and ecosystems is intrinsically tied to different socio-cultural and environmental processes. Gangwar (2013) identified vulnerability in terms of three elements: system exposure to crises, stresses and shocks; inadequate system capacity to cope; and consequences and attendant risks of slow (or poor) system recovery. He has also defined vulnerability as "the characteristics of a person or group and their situation that influences their capacity to anticipate, cope with, resist, and recover from the impact of a hazardous event". Ding *et al*. (2015) has elaborated vulnerability as the population's capacity to anticipate, cope with, and recover from the impact of a hazardous event.

Testa *et al*. (2015) has represented vulnerability as the susceptibility of a given population to harmful effects from exposure to hazardous events. It directly affects disaster preparation, response, and recovery. As per Chakraborty and Joshi (2016), vulnerability must be considered as a function of three overlapping elements: (1) exposure (the shocks and stresses experienced by the system), (2) sensitivity (the response of the system), and (3) adaptive capacity. While increase in sensitivity and exposure increases the vulnerability, an increase in adaptive capacity will reduce the vulnerability of the system.

Vulnerability is an essential component of risk analysis, and understanding, analysing, quantifying and visualising vulnerabilities enable authorities and decision makers to manage and reduce existing risks (Kohle, 2019)

2.2 . VULNERABILITY TO FLOODS AND LANDSLIDES

Cutter *et al.* (1996) conducted a social vulnerability assessment to identify the social vulnerability of United States to environmental hazards including floods and found that vast majority of US States exhibit moderate levels of social vulnerability.

Scoones (1998) reported that flood vulnerability is influenced by personal or group characteristics in terms of their capacity to anticipate and cope with the impacts of flood.

Cardona (2003) conducted a systematic review on risk management and noted that individuals and communities are differently exposed and are vulnerable to floods because of the socio-economic factors, such as wealth, education, race, ethnicity, religion, gender, age, class, disability and health status. This is because flood vulnerability and adaptations are firmly related to the context of the natural environment and socio-economic factors of a specific area.

Kaynia *et al*. (2008) conducted a probabilistic assessment of vulnerability to landslides in Germany and found that other than the physical characters such as length of the slope and construction materials, other factors such as the high standard of living of the people, the accumulation of property, as well as high population density makes a society extremely vulnerable against disasters such as landslides.

Uzieli *et al*. (2008) proposed a model for the quantitative estimation of physical vulnerability to landslides and in this, vulnerability has been expressed as a function of Susceptibility (S) and Intensity (I), wherein *I* indicates landslide intensity and *S* indicates the susceptibility of elements at risk

Zuma *et al.* (2012) conducted a flood disaster management in South Africa, and reported that in South Africa, the annual risk of flooding is 83.3% and the level of vulnerability is high because of economic factors and geographical location.

According to Munyai *et al*. (2019), flood vulnerability is firmly rooted in how people or societies are likely to be affected by flood phenomena – that is, the sensitivity of the community or people to flooding considering the socio-economic, environmental and physical components. They, in their assessment of flood vulnerability and adaptation in Hamutsha-Muungamunwe village, Makhado municipality, South Africa, pointed out the major components of flood vulnerability as social, economic, environmental and physical components. The study also reported that Hamutsha-Muungamunwe community has a very high social vulnerability to flood mainly because of the high population density, lack of early warning systems for flood and poor or slow emergency services.

A study conducted by Jha and Gundimeda (2019), to assess the district level vulnerability of Bihar to floods, finds that North Bihar is highly vulnerable to floods due to relative differences in exposure, sensitivity, and adaptive capacities.

According to UNISDR (2015), floods are on average the greatest source of annual losses to disaster in India, costing an estimated $7 billion every year. During the 20th century, frequency of flood hazards increased across India, making the country highly vulnerable to floods.

According to Panda (2019), extreme rainfall and flooding in Kerala was caused by climate change. He also reported that more than 75 percent of the geographical area in Kerala is vulnerable to flooding and this vulnerability of the state got exacerbated due to unprecedented rainfall that led to extreme flooding. He described vulnerability as the degree of damage to certain objects at flood risk with specified amount and present in a scale from 0 to 1 (no damage to full damage)

Pollock and Wartman (2020) stated that analyzing human vulnerability to landslides is an essential predisposition to predict and prevent human loss of life. Further, they also conducted a literature review to assess the human vulnerability to landslides using binary logistic regression model to assess the impact of demographic, situational, and behavioral factors on human mortality to landslides. In this study, they found that, vulnerability to floods increases with increasing process intensity, and inundation depth. Moreover socio economic condition, gender, age, material of construction, hazard awareness, and emergency response were also found to have association with landslide vulnerability and morbidity

2.3. FACTORS INFLUENCING VULNERABILITY TO FLOODS

Oxfam America (2012) mapped the social vulnerability and climate change in Louisiana and identified the influencing factors as eonomic standing, percentage of people belonging to extreme age category, rural and urban population, special needs population and other factors such as race and ethnicity, gender, education and unemployment rates. Among them, economic standing is identified as the number one factor determining a community’s vulnerability to disaster.

According to Devkota *et al*. (2013), vulnerability is dependent on the economic wellbeing, awareness of the people living in a society, preparedness and recovery conditions of the community. It was reported as a result of their study entitled ‘Flood Vulnerability through the Eyes of Vulnerable People in Mid-Western Terai of Nepal’.

Praditha (2018) conducted a study to identify the factors affecting vulnerability to flood risk in Balikpapan city of Indonesia. He identified and publicized 15 major factors and they are as follows: adaptation to flood, participation in disaster management, housing locations, income, populations density, government grants, infrastructure, accessibility, critical facilities, topography, plans, early warning system, external support, private donors, friends, regional transport, and network infrastructure

According to the studies of Associated Programme of Flood Management, (2019), the major factors that influences the vulnerability of a society to floods are physical/material conditions (initial well-being, strength and resilience), constitutional/ organizational conditions (lack of leadership, initiative, or organizational structure) and motivational/ attitudinal conditions (lack of awareness of development issues, rights and obligations, certain beliefs and customs and fatalistic attitudes).

Munyayi *et al*. (2019) conducted a study titled 'an assessment of flood vulnerability and adaptation: A case study of Hamutsha-Muungamunwe village, Makhado municipality' in the country of South Africa. They identified the major factors of vulnerability as nature of soil, dwelling type, employment status, education and rainfall. Out of these, nature of the soil was ranked as the most important factor, followed by dwelling types.

Shah *et al.* (2020) conducted a study to identify the factors affecting flood-induced household vulnerability and health risks in Khyber Pakhtunkhwa (KP) Province of Pakisthan. The results reveal that respondents' socio-economic and demographic attributes, such as age, gender, education, income, the materials out of which their house is constructed, past experience of floods and social networks as the key factors influencing their flood vulnerability.

2.4. VULNERABILITY ASSESSMENT

The major construct in flood risk management is vulnerability. Establishment of a clear demarcation between theoretical conceptions of flood vulnerability and daily administrative process is the most important aim of vulnerability assessment. In the field of vulnerability assessment, a number of approaches has been introduced, tested and implemented. Widely used and commonly adopted methods can be discussed under the major groups of curve method, disaster loss data method, computer modeling methods and indicator based methods.

According to Gao (2007), measurement of vulnerability is a complex process, influenced by environmental, economic, social and political elements in local scale.

2.4.1. Vulnerability curve method

Fuchs (2009) in his study to analyze the paradigms of vulnerability to mountain hazards, reported that vulnerability curves do not provide any information concerning the drivers of vulnerability or potential ways of reducing it.

According to Mazzorana *et al.* (2009), who conducted a study on physical approach on flood risk vulnerability of buildings, commented that vulnerability curves, helps the practitioners to directly connect the intensity of a process with the corresponding degree of loss, providing the researchers with strong quantitative results, also enabling them to translate potential events into monetary damage.

Maria (2016) in her study on vulnerability curves and vulnerability indicators for debris flow hazards in Austria opined that, in the case of vulnerability curves, physical vulnerability is expressed as a function of the intensity of the process and the degree of loss, taking into account, only the structural characteristics of buildings.

However, she also reported that, vulnerability curves often fails to ignore the characteristics of the buildings, focusing only on the intensity of the process and the corresponding loss.

2.4.2. Disaster loss data method

This method progresses on the data collected from real flood hazard. It is a simple approach which can be used by the practitioners to direct and control the upcoming events. However, in many cases, unevenly recorded data makes this approach inaccurate and unreliable (Nasiri *et al*., 2019)

2.4.3. Modeling methods.

Computer models are used to evaluate, the depth, elevation and velocity of flood, using the frequency, magnitude and shape of the hydrograph. For computing flood inundation, one dimensional (1D) and two- dimensional (2D) models are used. For accurate measurement, these models depends on detailed data about topographic, hydrographic and economic information in the study region (Balica and wright, 2009).

According to Lein (2010), in GIS-based vulnerability modeling, variables are used as an input data which should be geo-referenced and converted to raster format for the tangible analysis. Even though this method of modelling, assesses vulnerability in local scale considering specific local factors, it could not establish a clear link between predicted map and the level of real flood damage.

2.4.4. Indicator based methods

According to Nasiri *et al.* (2019), indicator based methods measure those factors which may contribute to flood risk and vulnerability without measuring the flood risk directly. Even though indicator based vulnerability assessments are common, they are challenged by the complications related to standardization, weightage and aggregation, and Baptista (2014) defined an indicator as an estimate to depict a feature of the system in question.

2.5. TYPES OF VULNERABILITY TO FLOODS

Vulnerability expresses the attributes and circumstances of a community or society that makes it vulnerable or susceptible to disastrous effects of a hazard. The facets of vulnerability are numerous, which arises mostly from the physical, social, economic, and environmental factors of the system.

The major types of vulnerability can be discussed under the headings of social vulnerability, physical vulnerability, economic vulnerability, environmental vulnerability and biophysical vulnerability

2.5.1. Social Vulnerability

Adger (1999) defined social vulnerability as the exposure of individuals and society to different types of stress that arises as a result of social and environmental change. It also measures the stress in terms of unexpected events and livelihood disruption.

According to Cutter *et al*. (2003), who is the pioneer in assessing social vulnerability, he described social vulnerability as the social, economic, demographic, and built characteristics of a community that affect its ability to respond to, cope with, recover from, and adapt to environmental hazards.

The major factors or components of social vulnerability includes community's literacy level, employment status, income levels, ownership of dwelling, age and sex distributions, religious beliefs, kinship levels, and informal social support networks among the group (Haki, 2006)

Fakete (2010) described social vulnerability as the predisposition of a society towards a hazard or natural disaster. It is the potential to be wounded or to continue to be wounded. He also reported social vulnerability as one important aspect of disaster risk assessments, which provides crucial information for supplementing hazard assessments.

Social vulnerability focuses on the social characteristics that makes a society susceptible to adverse impacts. However, as per Rufat *et al*. (2015), social vulnerability is a function of the ability of the people to cope with flood impacts in the short term and adapt in the long run. .

2.5.2. Physical vulnerability

Kohle *et al* (2011) and Muller *et al*. (2011) in their studies on physical vulnerability reported that variables such as construction material for the roof, walls, and floor (building typology), the position of buildings in relation to the street level (plinth height), the age of household residence and availability of flood protection measures on building (building modifications) needs to be taken into account while measuring physical vulnerability

Kappes *et al*. (2012) in his study to assess the physical vulnerability for multi-hazards using an indicator-based methodology, opined that physical vulnerability deals with the physical structures and components of the built environment that expose people and elements to natural hazards such as floods. Moreover, higher the physical vulnerability, higher will be the losses and it will also influence, other facets of vulnerability.

In the case of floods, the physical vulnerability of buildings depends on proximity to rivers, elevation, and frequency of floods, duration, and depth of floods (Ciurean *et al*., 2013). He has described physical vulnerability as the structural and non-structural damage to buildings, building components and other infrastructure. These damages could be direct, in terms of gradual and consistent deterioration of buildings and other infrastructure.

2.5.3. Economic vulnerability

World Bank (2003) has introduced an ECLAC methodology wherein economic vulnerability is expressed in terms of direct and indirect damages. As per the above said methodology, direct damages refer to the damages to the stock of assets that are incurred at the time of the disaster and immediately after, while indirect loss refers to the reduction in the economic flows due the decrease in the production of goods and services, as a consequence of disasters and other macroeconomic effects. Briguglio (2004) conducted a study on economic vulnerability and posited that, economic vulnerability and economic resilience together determines a country's risk of being affected by external shocks. Precisely, economic vulnerability deals with the country's exposure to disaster shocks due to its innate economic characteristics such as the economic openness, export concentration, and the dependence on strategic imports of the country in question.

In the case of computation of economic vulnerability, the major components of emphasis includes, output (gross domestic product (GDP) or regional production), income, employment, inflation, consumption, expenditures, savings, domestic and international financial transfers, public finance, and trade (Leon *et al.*, 2006)

2.5.4. Environmental vulnerability

Kaly *et al*. (2004) reported that environmental vulnerability brings into light the risk of damage to the natural environment which underpins all human activities. It reflects the status of a society's/ country's environmental vulnerability, exposing the extent to which the natural environment is prone to damage and declination. The impacts of human activities on environment have caused increasing concern and several policy frameworks have been developed and implemented over the past few years to control and mitigate this impact. However, world presently faces environmental changes on a massive scale, that human activities must be changed not only to reduce the changes but also need to change the responses to the effects of that change. According to the Hyogo framework, environmental vulnerability contributes to disaster risk and makes a society vulnerable (UNEP, 2014)

2.5.5. Biophysical Vulnerability

It is a concept that contemplates, vulnerability as the potential impacts of climate change on a specific exposure unit (Kelly and Adger, 2000; Füssel, 2007; O'Brien *et al*., 2007).

It can be calculated, using only one single climate variable and one single response or many processes that are considered as being important in determining system responses. According to Fellman (2011), in any system, its ability to adapt to a stressor depends upon its biophysical components mainly soil, air, water and biodiversity.

2.6. VULNERABILITY INDICES

Fekete (2010) conducted a study on assessment of social vulnerability for river floods in Germany and developed a Social Susceptibility Index (SSI) to assess the population characteristics for countries in Germany. It has been developed on the basis of three main indicators namely fragility, socio economic conditions and regional conditions. Social Susceptibility Map based on Social Susceptibility Index indicates that, Eastern Germany is susceptible to floods in terms of fragility, socio economic conditions and regional conditions.

Perdikaris *et al.* (2011) created a vulnerability index using a combination of Monte Carlo Simulation techniques and multi-criteria analysis for assessing the vulnerability of communities to flooding. In their study titled, "A methodology for undertaking vulnerability assessments of flood susceptible communities", vulnerability index has been applied to the Credit River watershed, in Ontario, Canada, to assess the vulnerability of the 22 flood damage centres within the watershed. The major components of the vulnerability index developed for this study were monetary, social and critical vulnerabilities.

Roder *et al*. (2017) developed a Social Vulnerability Index (SoVI) based on 15 census variables as part of his study to analyse the extent of vulnerability of Northern Italy to floods. Analysis identified vulnerable groups, those that are likely to suffer the most from floods. With the help of SoVI, they also identified that the Piemonte and .Veneto regions of Northern Italy contain the main areas prone to flood ‘‘social’’ risk, highlighting the need for a comprehensive management approach at all levels.

Kumar and Bhattacharya (2020) to understand and analyze the impact of natural hazards, and vulnerability of a society to natural disasters, conducted a study in the Hilly region of Uttarakhand, India. They developed an Integrated Social

Vulnetability Index ($SoVI_{Int}$) considering various factors, such as physical, social, economic, and environmental. The social vulnerability indicator will support state, local, and traditional disaster management officials to determine areas of the most sensitive populations and to enable better mitigation performance in case of disaster.

2.7. VULNERABILITY MAPPING

Paul (2013) identified vulnerability mapping as a means to visualize how different elements (social groups, livestock, houses and so on) are exposed to a disaster at varying degrees and the reasons for their settlement in the disaster prone area.

Alade (2017) conducted a study to analyze the Application of Geographic Information Systems (GIS) to Climate Vulnerability Assessment and found that, vulnerability mapping using GIS helps to improve communication about risks and about the people who are threatened. As the results of the study indicate, mapping will also help us to reduce loss of life, injury and environmental consequences by identifying where to respond first and best evacuation routes.

Esterhuse *et al.* (2017) in their study titled ‘vulnerability mapping as a tool to manage the environmental impacts of oil and gas extraction’ has described vulnerability mapping as the one which entails the mapping of exposure, sensitivity and coping capacity indicators.

According to Handbook on culture and urban disaster (2019), social mapping in the disaster prone areas, will help us to understand, how people perceive their situation and their relationships with other stakeholders. This will also throw light upon the role of state, private sector, NGO and political bodies in disaster prevention and recovery.

2.8. FLOOD AND LANDSLIDE COPING MECHANISMS

Historically, all communities living in flood plains have always co-existed with floods and many studies identify such communities to have a traditional flood culture, characterized by adjustments to mitigate flood damage. Due to frequency of long history of flooding, it is possible to find collective action patterns and cognitive patterns which are adjusted to the hazard situation; through the elimination of doubt, thus making the situation predictable (Kates, 1978).

The major coping mechanisms include raising houses on stilts, construction of houses on plinths, livelihood diversification, and mobilization of community- based support networks (Chan and Parker, 1996).

In the northern valleys of Pakistan, according to David and Hall (1999), people practice traditional risk reduction measures such as tying ropes across fast-flowing rivers with bells attached to the ropes. This helps the people to get warned as the ropes break when flash floods cascade down the valleys.

Del Ninno *et al*. (2000) for example reports on how borrowing and selling belongings and reducing food consumption become short term economic coping mechanisms for poor families affected by the extreme Bangladesh flooding of 1998.

As far as the community based coping strategies, are concerned they are the source of first line of relief when disaster strikes (Nishat *et al*., 2001). Moreover, author also highlighted that, a community can help in the restoration of houses, sanitation facilities in each household, water supply facilities at community levels, commuter roads/ bridges/culverts/electric connections, educational activities, and health care facilities.

Few *et al*. (2003) elaborately described that health care and hygiene initiatives taken by communities included transferring of sick member to nearest health care center, and providing drinking water, fodder and animal feed to livestock and poultry, as needed.

Mandal and Sivaramakrishnan (2006) also commented that the local community is the main focus of community based flood preparedness programme as it is the community which is adversely affected by a flood and, more importantly, it is the first responder to the event.

Social capital e.g. reciprocal support among neighbours, support from immediate family members and wider kinship networks, is found to be a vital safe net for people in coping with recurrent flooding (ProVention, 2008). Moreover, Somkuwar and Das (2010), conducted a study in the flood prone areas of Assam and highlighted that the community based flood management approach with a view to preserving the crop and other agricultural resources at household levels communities also helps to reduce the financial loss by harvesting premature standing crops (viz., vegetables etc.) if there is a threat of such crops being inundated. Even though these grassroots mechanisms have remained neglected for a long time in disaster relief and rescue measures, it is now emerging as a major strategy for many disaster management agencies.

Pantoja (2002) reported that in most of the studies related to coping mechanisms, households are taken as the unit of analysis because the decision of choosing livelihood strategies is taken primarily at household level.

Few (2003) in his report entitled flooding, vulnerability and coping strategies: local responses to a global threat, commented that people's responses to floods include a variety of coping mechanisms starting from flood prediction to recovery. Their response to floods, are typically based on an intimate knowledge of hazard risks and viable coping strategies.

In a study conducted in the flood affected Northwestern Bangladesh, Rashid *et al*. (2006), reported that flood coping strategies of households falls under the three broad categories of i) current adjustment strategies of reducing the frequency of consumption and shifting to less preferred foods ii) unsecured borrowing and iii) secured borrowing where money is borrowed against assets owned by the household. People of Bangladesh have exhibited strong coping mechanisms in every phase of the disaster (i.e. at Pre, during and post disaster phases).

Considering the gender aspects of coping mechanisms, Nasreen (2009) presented a detailed picture of a disaster experienced by rural households in Bangaldesh based on sociological approach and reported that even though disaster affects both men and women, the burden of flood coping falls heavily on women. The author hence claimed that coping strategies of women are crucial in enabling rural people to cope with disaster as they demonstrate considerable fortitude and ingenuity in their attempts to maintain the livelihoods of their households.

Similarly Ahmad (2010), also conducted a study to reveal the adjustment practices of women with the adverse effects of flood in Ganges Dependent Area of Bangladesh. The study found that women apply multiple strategies like defense mechanisms, problem solving and stress handling to face sudden risks, crises and periodic stresses in the household. Moreover, adjustments by women before, during and after flood disaster in Ganges Dependent Area of Bangladesh can be classified under the broad areas of: i)Adjustments processes in small scale which includes collection of foods, collection of water, sale of women's ornaments, taking care of family health care by women, borrowing grain from kin by the social network of women ii)Adjustments processes in larger scale which includes sale of livestock, animals, agricultural tools and land (women's own land), female labor migration, use of credit and self-employment, repairing their houses permanently with brick and cement and finally; iii) Mass-migration.

Sheheli and Khan (2015) conducted a study to document the coping strategies of women in flood prone areas of Bangladesh and reported that the women respondents had low level of coping ability against floods and also found that they have only limited resources and meagre income opportunities as well as livelihood opportunities during and after floods. Moreover, the respondents also had less accessibility to communication facilities, training facilities, and educational facilities. Therefore, abject poverty, lack of resources, and appropriate income opportunities reduces one's coping ability against floods

Internal political/ economic organizations serve as point through which the government can provide assistance to the victims. Mutual aid groups such as agricultural cooperatives and labor unions provide leadership as well as some degree of financial support (Anders and Lioyd, 1984).

Alam and Collins (2010) conducted a study in the cyclone affected coastal areas of Bangladesh and reported that even though the people of the disaster prone area react passively to disaster before the disaster event, during and after the cyclone, they exhibit effective coping capabilities through social networking, group and individual initiatives, kinship ties and obligations.

Patnaik and Narayanan (2010) conducted a study in the flood prone regions of Uttar Pradesh and found that households adopt a wide variety of risk coping measures. The most commonly used measures include, receiving monetary transfers, relief, selling of livestock and borrowing. Out of the several coping strategies, receiving monetary transfers was found to be the most effective means of coping for households during floods. However, in the case of cyclone prone regions of Orissa, the households were seen to adopt a mix of post-disaster coping mechanisms.

Kamal (2012) conducted a study on coping and recovery strategies of a coastal community of Bangladesh in response to the cyclone Aila and revealed that households of Dumuria village of Bangladesh had low resource base and poor sections who were most vulnerable to disaster mostly relied on water and forests for their livelihood. The major coping strategies included fishing in the post flood phase, and reliance on informal support mechanisms such as kin and community networks. Livelihood diversification was also found to be an important coping strategy and people diversified their livelihood opportunities by engaging in different on and off farm activities.

Sakijege (2012) in a study conducted in a flood prone settlement found that the most common coping strategies at household level were use of sandbags and tree logs; raised pit latrines and doorsteps; provision of water outlet pipes above plinth level; construction of embankments, protection walls and elevation of house foundations; seasonal displacement; and boiling and chemical treatment of water.

Findings by Opondo (2013), in a study on loss and damage from flooding in Budalang'i, revealed that the most common coping strategies adopted by households included seeking support from organizations, temporary relocation, reduction of expenditure on household necessities, engagement in extra income-generating activities, and modification in the food consumed.

Mandal (2014) conducted a study to understand the coping mechanisms of farmers in the flood plains of Assam and reported that the ex – ante coping options include contract farming and crop insurance. However, diversified cropping pattern was also identified as a major coping strategy.

Singh and Singh (2015) in his study to understand the response of farmers to flood hazards documented the different coping strategies adopted by the farmers. They reported that indigenous coping strategies, agronomic adjustments, family budget adjustments, and support from social set-up and credit from financial institutions helped them to mitigate the adverse effects of the floods.

In the case of flood prone regions of Lower Nyando Basin, Kisumu County, Kenya, the major coping strategies include moving the family and valuable goods away from home briefly to safer places, constructing flood diversion trenches, and seeking relief from the Government and other agencies (Masese *et al*., 2016).

The most preferred ways of coping included selling of household assets and livestock, the use of credit or borrowing and receiving remittances from migrant members (Patnaik, 2017).

Shah *et al.* (2017) on the basis of their study on Khyber Pakhtunkhwa (KP) province, Pakistan, reported that elevated ground floor, foundation strengthening, construction of house with reinforced material and precautionary savings were the main adaptation measures adopted at household level. Moreover, the study also reported that adoption of mitigation strategies at household level is limited by several factors such as financial constraint, lack of early warning system, lack of land use planning and inadequate resources.

2.9. POST FLOOD LIVELIHOOD INCLUSIVE ACTIVITIES

Livelihood refers to a set of actions taken by families, within their capacity to make a living by maintaining various types of activities. This section therefore deals with the various post flood livelihood inclusive activities taken by the farmers.

In the case of tsunami affected coastal areas of Sri Lanka, the most commonly adopted livelihood strategies include, petty trade, casual waged labour and illegal mining of corals, especially in the tourism belt (Shanmugharatnam, 2005).

Regnier *et al*. (2008) conducted a post tsunami livelihood analysis in India and Indonesia and reported the major post disaster livelihood inclusive activities as post-fishing marketing and transportation to end markets, bulk purchase of rice for resale in small quantities, production of fish pickles, soap and other small items and goat rearing.

Climate-induced extreme events are increasing affecting livelihoods all over the world (Reed *et al*., 2013; Singh and Nair, 2014). Extreme events such as floods, drought, cyclone and heat waves worsen the livelihood vulnerabilities of the resource – poor or disadvantaged communities like farmers, fishermen, coastal communities, and urban poor (Paul, 2015; Khayyati and Aazami,2016).

Fajarwati *et al*. (2015) conducted a post disaster analysis in the volcano prone areas of Indonesia and reported that, there has been a considerable change in the productive and livelihood activities of respondents especially women. Women members who were mostly housewives, took up jobs such as selling groceries, babysitting, selling fries and meals, and laundry service to meet the needs of the family in the post disaster phase.

In the earthquake prone migrant villages of Nanbao township of China, a study was conducted to analyze the changes in livelihood of migrant tea labourers. As a result Chen *et al.* (2016) reported that in the post disaster phase, resettled households largely relied on wage employment and state subsidies as their major income sources. Many of the households also leased out tea tree orchards to obtain an additional income.

Whereas when Daly *et al*. (2020), conducted a study to analyze the post flood livelihood activities during the post tsunami phase in Indonesia reported the following findings. In the agricultural sector, the major livelihood alternatives introduced were tree crop plantation, and home stead vegetable gardens. Fish and prawn pond cultivation were taken up in the case of aquaculture and clothes making, cake baking, textile weaving, brick making etc were introduced in the micro enterprise sector.

Naithani and Saha (2020) conducted a study in the flood prone areas of Kedarnath and reported that there is negligible post flood livelihood strategies adopted among the respondents. As a result, introduction of diversification activities with relatively less direct influences of weather or climate like livestock rearing, silkworm rearing and commercial bee farming were suggested in the study along with handicraft or handloom making. In the cyclone prone areas of Orissa, the alternative livelihood options were agricultural wage labour, outward migration of youth to neighboring states, and prawn cultivation. The study also reported that few local alternative employment opportunities existed in the study sites and private entrepreneurship was practically absent.

2.10. IMPACT ASSESSMENT OF POST FLOOD SCHEMES AND MEASURES BY THE GOVERNMENT

Wodon and Yitzhaki (2002) performed an evaluation to assess the impact of government programs on social welfare in three Latin American countries and found that, most of the programs are upper bound neglecting the needs of the poor.

Impact evaluations answer some important questions about the effectiveness of program interventions and assesses under what conditions a program or intervention should be evaluated. It depends on a combination of factors, including an assessment of the raw policy value of the exercise and the political economy associated with the policy environment (Blomquist, 2003).

An impact assessment study of socio-economic development programmes in Himachal Pradesh, sponsored by the Planning Commission, Government of India has been conducted from December 1999 to February 2000 (Asia pacific Socio-Economic Research Institute, 2003). The study hence found that, during the reference period the socio-economic programmes have improved the social living standard of the beneficiaries and assistance given for improvement of land and farming activities has contributed to improving their standard of living.

Similarly, National Productivity Council (2017) conducted an impact assessment of Seekho aur Kamao (Learn and Earn) Scheme and submitted the report to Ministry of Minority Affairs, Government of India. As per the assessment, the Scheme has been well accepted by the targeted beneficiaries and has been able to generate gainful employment besides improving the economic condition of minority communities.

Sehgal and Mir (2014) conducted an impact analysis of developmental schemes in Jammu and Kashmir and reported that there must be full empowerment to beneficiaries to build up their capacity to enhance competitiveness of their products and services at domestic as well as at global market in a sustainable manner. Pandey and Parthasarathy (2019) in their impact analysis of welfare schemes of women’s empowerment with reference to RMK, STEP and E-HAAT found that participation of women through such schemes develops “communities for women" that provide social identity to all its members. Some programs also enables women to acquire the preliminary social abilities of negotiation and decision-making while they are engaged in community level actions.

Dash and Hota (2020) conducted an impact assessment of Govt. Sponsored Schemes for the upliftment of the rural people in Sundargarh District of Orissa. The study found that, even though the objectives of the study were specific and effective, implementation is not as per the real objectives. Due to the political interference, kith and kin relationship, the sponsored schemes did not reach the needy people who lead substandard lives.

2.11. CLIMATE ADAPTIVE AGRICULTURAL EXTENSION APPROACH (CAAEA)

Speranza *et al*. (2009) analysed the adaptiveness of Public Agricultural Extension Services (PAES) to climate change in Kenya and found that hierarchical structure of the PAES does not augur well for self-organisation at local levels of extension provision, especially under conditions of abrupt change which climate change might trigger. Hence a different framework, incorporating other means of extension services. It also includes incorporation of research extension-farmer linkage and also up scaling of adaptive research to come up with farmer friendly least cost technologies.

Meera *et al.* (2011) in their study on ICT (Information and Communication Technology) and climate change, reported that as the linkages between agriculture and climate are pronounced and often complex, agricultural extension is bound to face increased challenges of addressing vulnerability. As a result, they developed a comprehensive ICT enabled extension framework involving various components of climate change and extension methodologies to promote the same.

Agarwal *et al*. (2021) assessed climate-smart village approach for scaling up adaptation options in agriculture. The study has further presented a scalable approach that integrates agronomic interventions, climate information services, and farmers’ traditional knowledge at local scales. The components contribute to both resilience and mitigation. The CSV approach so developed can be scaled out horizontally and locally through farmer participatory processes and farmer-to farmer communication.

2.12. PROFILE CHARACTERISTICS OF THE RESPONDENTS

2.12.1. Neighborhood cohesion

Chou and Wu (2013) in their study to analyze the success factors of enhanced disaster resilience in urban community in Taiwan, revealed that strengthening neighborhood cohesion contributes to the rational development of disaster prevention and rescue work.

Wei *et al*. (2019) conducted a household preparedness study in the disaster prone areas of Taiwan, and reported that households with a higher degree of confidence in authorities and high in neighborhood cohesion are more likely to adopt more preparedness activities, (e.g., purchase disaster insurance).

Fan *et al*. (2020) investigated the phenomena of neighborhood cohesion, which is characterized by extensive social ties with the goal of sharing and receiving information regarding a particular event influencing a community. In the context of disasters, neighborhood cohesion, enabled by social media usage, could play a significant role in improving the ability of communities to cope with disruptions in recent disasters.

Robinette *et al*. (2021) performed a study in United States to understand the relation between neighborhood cohesion and COVID-19 impacts on mental health and concluded that perceiving one's neighborhood as more cohesive was associated with fewer depressive symptoms. Moreover, it also attenuated the relationship between spending more time at home during the pandemic and depressive symptoms.

2.12.2. Self-Efficacy

Marceron and Rohrbeck (2018) analysed the role of self-efficacy in disaster preparedness measures of disabled people in United States and the results suggest that self-efficacy and perceived threat operate jointly to motivate individuals with physical disabilities to take precautionary steps to reduce adverse effects of natural and human-made disasters.

Kilic (2019) conducted a study to assess the effect of psychological first aid training on disaster preparedness perception and self-efficacy and reported that, psychological first aid education increased their perception of general self-efficacy, which in turn further increased the rate of adoption of disaster preparedness.

In the study performed by Yu *et al*. (2020) in the disaster prone rural north western China, a moderated mediation model was used to analyze the relationship between self -efficacy and individual disaster preparedness measures. The results indicated that those with a higher level of self-efficacy were more likely to prepare for disasters after receiving disaster risk-reduction information with village officials. Furthermore, Wang *et al*. (2021) also conducted a similar study in the eastern province of China and reported that self-efficacy is correlated with higher degrees of overall preparedness and all three types of individual preparedness. Moreover, self-efficacy plays a mediating role between place attachment and disaster preparedness.

Recently, Yu *et al*. (2022) conducted a study in the drought prone areas of China to analyse the perceived role of collective efficacy and self-efficacy in individual disaster preparedness and found that self-efficacy greatly influenced the coping behaviour of people in the post disaster phase.

2.12.3. Altruism

Altruism is thought to be a major contributor to the development of large-scale human societies. Dynes (1994) performed a study on the situational altruism in United States and stated that altruism produces a massive response of human and material resources to cope effectively with disaster.

Tomasello (2009) and Yiyuan *et al.* (2013) conducted a study among the disaster impacted inmates of Sichuan province of China and found that altruism can increase group cooperation, thus strengthening society’s fitness for survival and indirectly improving individuals’ odds of survival.

Ultramari and Szuchman (2017) conducted a study to understand the relation between altruism and disaster preparedness and found that as the altruism among individuals increased the number of people assisted with livelihood opportunities also increased. They also investigated the altruism level of an earthquake prone community in Japan through a psychometric index. The study assessed the influence of altruism on food with donation attributes and found that donation attributes varies by the types of food. The results of the study indicate that tuna demonstrates the most influence from the respondent's altruism level on their purchase preference and pork also reveals a similar impact when the probit model is controlled with the demographic variables such as age, gender, and income.

2.12.4. Optimism

Atwood and Major (2000) studied the role of optimism, pessimism, and communication behaviour in response to an earthquake prediction in Java, Indonesia. The study however produced interesting results as it was found that pessimistic respondents were more likely to believe the prediction as they believed that they were at greater risk than others. On the other hand, optimistic respondents were less likely than pessimists to seek information, and their lack of information about the risk have led to denial of the threat and therefore greater injuries.

Spittal *et al*. (2005) in their study to analyze the optimistic bias in relation to a disaster found that participants with higher optimistic orientation were better prepared for a major earthquake than others and they also judged that they were personally less likely than others to suffer injury in a major earthquake.

Trumbo *et al*. (2014) performed a study to understand the influence of optimism on the disaster preparedness measures to Hurricanes among Gulf coast residents. The results reported that a phenomenon known as unrealistic optimism exists among the respondents, wherein individuals believe themselves to be less likely harmed by negative events as compared to others. This has however hindered the evacuation process before and during the disaster.

Cherry *et al.* (2016) examined the role of optimism in a sample of disaster survivors who were exposed to Hurricanes Katrina and Rita in 2005 and found that optimism and hope are protective factors that may positively impact mental health after multiple disasters.

Liu and Sun (2021) conducted a study to assess the impact of fatalism, belief and optimism orientation on seismic preparedness in earthquake prone regions of China and found that optimism orientation has dual effects. On the one side, it influences the individual's intention to prepare for the disaster and on the other hand it makes people underestimate their perceptions of the aftermath of earthquakes, which indirectly reduces their willingness to materially prepare for the disaster.

2.12.5. Risk Propensity

Cameron and Shah (2015) in their study on risk-taking behaviour in the wake of natural disasters reported that individuals who recently suffered a flood or earthquake exhibit more risk-aversion nature. Experiencing a natural disaster caused people to perceive that they faced a greater risk of a future disaster.

Ejeta *et al*. (2015) concluded that higher the risk propensity, higher will be the need of disaster preparedness in their study on application of behavioral theories to disaster and emergency health preparedness.

Nurjunah and Rezza (2021) conducted a study in the flood and volcano prone regions of Bandung and reported that risk propensity variable directly affects disaster preparedness behavior.

Ng (2022) conducted a study in the Typhoon affected areas of Hong Kong and reported that risk propensity influences intention of preparedness and disaster preparedness behavior *via* two types of channels. The first type is the ''direct'' channel, as indicated by the significant correlations between risk propensity, intention, and disaster preparedness behavior. The second type is the ''indirect'' channel via subjective norms and rules.

Methodology

3. METHODOLOGY

This chapter deals with the description of the methods and procedures adopted in conducting the present research study. The various aspects of the methodology adopted for each variable are furnished in this chapter under the following subheadings.

3.1 Locale of the study

3.2 Selection of sample

3.3 Operationalization and measurement of the dependent variables

3.4 Operationalization and measurement of the independent variables

3.5 Climate Adaptive Agricultural Extension Approach (CAAEA)

3.6 Statistical tools used for the study

3.1. LOCALE OF THE STUDY

Kerala located between 10.8505° N and 76.2711° E can be physiographically divided into high lands (above 75m + MSL), midlands (7.5 to 75 + MSL) and lowlands (less than 7.5m + MSL). The lowlands or coastal area located on the shore of Arabian Sea, is made up of river deltas and covers an area of almost 4000 sq.km. This makes it a land of coconuts, rice and home to major fisheries and coir industries (GOK, 2011). Fig.1. shows the Locale of the study.

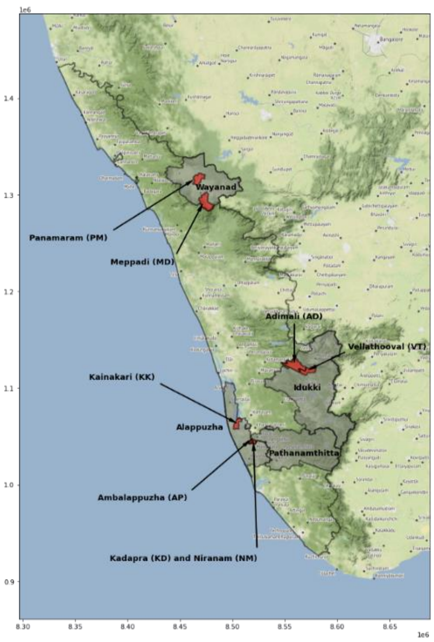


Fig.1. Locale of the study

Among the 14 districts of Kerala, 10 districts belong to high, low and mid lands, Alappuzha belongs to low and mid lands, Palakkad and Idukki districts belongs to mid and highlands, whereas Wayanad belongs completely to the highlands. For the study, lowlands of Alappuzha (ALP) and Pathanamthitta (PTM) has been purposively selected for flood vulnerability assessment as all the villages of both the districts has been declared disaster affected in the floods of 2018. To study the vulnerability of farmers to flood associated landslides, Wayanad (WYD) and Idukki (IDK) districts has been selected from the landslide prone highland regions. Therefore, for the vulnerability assessment to floods and flood associated landslides, four districts has been purposively selected which includes 2 districts from the lowlands and two districts from the highlands.

Alappuzha(ALP), a southern district of Kerala with an area of 46.2 km^2 lying between Arabian Sea and Vembanad lake is one among the most severely flood affected districts of the state. Kuttanad, the place in Alappuzha, famous for The Kuttanad below Sea Level Farming System (KBSFS) is hugely influenced by floods (Santhi and Veerakumaran, 2019). Moreover, more than 50% of the area identified as flood prone in Alappuzha district belongs to the Kuttanad region. Kainakari (KK) is a small panchayath (Local self-Government at the village level) in Kuttanad Taluk (a group of several villages organised for revenue purposes) most damaged by the flood where more than 90% of the houses and crops have been damaged in the sudden heavy rainfall (Sooryalekshmi, 2019). Similarly, Ambalappuzha (AP) is a small town belonging to the Ambalappuzha taluk which also suffered the grievous impacts of flooding. Therefore, from the district of Alappuzha, two panchayaths Kainakari (KK) and Ambalappuzha (AP) has been selected for the research.

Pathanamthitta (PTM), with an area of only 23.5 km^2, is a true tropical diversity with an equal share of Western Ghats, forest stretches and rivers. However, anomalous rainfall (almost 117% more than the normal rainfall) along with lack of communication about the opening of reservoirs resulted in loss of lives (3), and thousands of hectares of crop damage (12085.05 ha) during the floods of 2018. Kadapra (KD) and Niranam (NM) are two low lying panchayaths of

Thiruvalla taluk of Pathanamthitta, where floods occur almost every year and people are often housed in relief camps. Accordingly research in Pathanamthitta district was conducted in the two above mentioned panchayaths of Kadapra (KD) and Niranam (NM).

Idukki (IDK), a hilly state with an area of 4358 km^2 is one among the worst-hit district during 2018 disaster, with 143 major landslides as a result of high intensity rainfall over a short period of time. Hence, for vulnerability assessment Adimali (AD) and Vellathooval (VT) panchayats has been selected for landslide vulnerability assessment in Idukki district. Wayanad district also belongs to high land regions which has suffered serious setbacks both in terms of human fatalities and crop damage from the landslides of 2018 and 2019. Therefore, panchayats *viz*. Panamaram (PM) and Meppadi (MD) has been selected for landslide vulnerability assessment in Wayanad district.

Hence, the study has been conducted in the eight panchayaths purposively selected for the research.

3.2. SELECTION OF SAMPLE

A multi stage sampling method was adopted for data collection purpose in this study. At the first level, districts of Alappuzha and Pathanamthitta, Idukki and Wayanad were purposively selected as they were severely affected by the flood and flood associated landslides. At the second level, two acutely damaged panchayaths (both in terms of crop damage and area affected) were selected from each district with the help of officials from Kerala State Disaster Management Authority (KSDMA). Furthermore, farmer population data of the eight selected panchayaths were obtained from the respective Agricultural offices and farmer respondents were selected. Third, using the proportionate sampling method, a total sample size of 520 was calculated. At the final level, farmer list was prepared, and data was collected through simple random sampling method.

The requisite data were collected through an interview schedule consisting of both open ended and close ended questions. The data collection period was from September 2021 to December 2021 and the interviews were conducted in local language. The interview schedule had seven broad sections which included (i)

General information about the farmer households; (ii) Place of residence (iii) Health status of the family; (iv) Agriculture and Animal husbandry; (v) Accessibility, communication and emergency response during floods; (vi) Water and sanitation; and (vii) Transportation facilities. To bring about simplicity in questions and to improve understanding, the interview schedule was pilot tested among 30 respondents who were not part of the sample and necessary changes were brought about.

Along with the household survey, Soil and water samples were also collected from the selected panchayaths to determine soil and water quality. For the collection of samples, grid sampling method was used which involved sample collection at regular intervals across an area. In this study ten soil samples and five water samples were collected from each panchayath at an equal distance of 5 kilometres. Hence, 80 soil samples and 40 water samples were analysed from the districts of Alappuzha, Pathanamthitta, Wayanad and Idukki. In addition, secondary data necessary for the study were also collected from Government organizations such as Agricultural office, State pollution control board, and State Disaster Management Authority (SDMA).

3.3. OPERATIONALIZATION AND MEASUREMENT OF DEPENDENT VARIABLES

Dependent variable is the variable that depends on other factors that are measured. These variables are expected to change as a result of an experimental manipulation of the independent variable or variables. Based on the objectives, review of literature, discussions with experts and observations made by the researchers, the following dependent variables were selected for the study.

3.3.1. Dependent variables

The dependent variables for the study, is studied under the three major headings of vulnerability assessment, livelihood inclusion and social empowerment. Under vulnerability assessment, the major observations include establishment of a Societal Vulnerability Index for Floods and Landslides (SVI^{FL}) and development of vulnerability maps to denote the vulnerability hotspots. In the case of livelihood inclusion, coping strategies adopted by the farmers and post flood livelihood inclusive activities has been identified as the dependent variables. Finally, under social empowerment, impact of punarjani scheme has been studied as dependent variable.

3.3.1.1. Societal Vulnerability Index for Floods and Landslides (SVI^{FL})

SVI^{FL} is operationalized as an indicator based localized approach to assess the vulnerability of farmers to disasters mainly floods and flood associated landslides.

For the construction of SVI^{F} in this study, well-established flood vulnerability assessment approaches of Balica and Wright (2010) and Sathyan *et al*. (2018) has been modified for estimating vulnerability according to the local situation. The SVI^{FL} developed for this study consists of four major components namely social, economical, physical and environmental which were estimated with regard to the three factors namely exposure, sensitivity and resilience. The three factors and four components are discussed in the following sections.

In this study, exposure refers to the alteration of the operational system, operating out of its normality operation. Judy *et al.* (2011), stated that it is the state and change in external stresses that a system is exposed to. Susceptibility is the potential or the likelihood of a hazard to have impacts in the system. It is the probability of negative consequences of floods and landslides to the environment and society. Both socio-economic and the natural environments might be susceptible to a hazard. It is also defined as the elements exposed within the system, which influence the probabilities of being harmed at times of hazardous floods. The term 'elements exposed' includes all elements of the human system, the built environment and the natural environment that are exposed to flooding in a given area. Resilience is the capacity of a community to adapt to changes in a hazardous area by modifying itself to achieve an acceptable structural and functional level. This means that the system must bounce back after disturbances, that is, the ability to retain the operation and function of the system is resilient. In this study, resilience is defined as the capacity of a system to suffer any perturbation, like floods, by maintaining significant levels of efficiency in its social, economic, environmental and physical components.

As already mentioned, the four major components selected for the study includes (1) Social (2) Physical (3) Environmental and (4) Economical. Here, social component addresses the vulnerability of people residing in an area. Indicators such as gender, age, disabilities, education, livelihood etc. enable us to understand, the impact of floods on the day to day lives of the people.

Physical component deals with the natural (indicators such as topography, proximity to the river, amount and duration of rainfall etc.) and artificial (indicators such as infrastructure, reservoirs, and dams) physical conditions, which makes a society vulnerable to floods. Regarding environmental component, it has indicators such as industrialization, deforestation and similar interventions which raises the vulnerability of the environment. Finally, economic component includes issues such as low per capita income, low life expectancy, and poor infrastructure which reduces the capability of a system to regain normalcy after a disaster. In this method, all components that are most likely to be affected by the disaster are taken into account.

The methodology of SVI^{FL} in this research was built up on the reciprocity between the four components and the factors of the system. The components and factors were further assessed by various indicators to understand the vulnerability of the social system to floods. Indicators are specific quantifiable variables, which can provide adequate information regarding the characteristics of a system. Selection of indicators is an important step in an indicator- based vulnerability assessment as it reflects the status of a region's flood and landslide vulnerability. In this study, 82 potential indicators have been identified to represent the determinants of vulnerability based on expert opinions, literature and local situation.

The framework upon which the SVI^{FL} was developed is as shown in Figure 2. The general SVI^{FL} Eq. (1) (IPCC, 2014; Sathyan *et al.*, 2018) which links the values of indicators to vulnerability components and factors was used for the computation of component wise vulnerability and subsequently the overall index.

FVI = Exposure + Susceptibility + Resilience (Eq. 1)

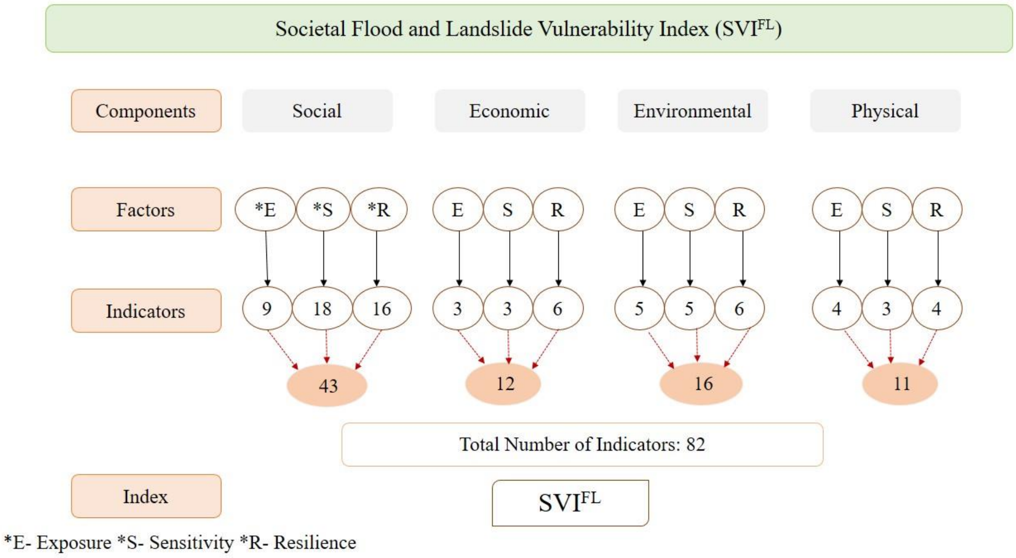


Fig. 2. Framework of SVI^{FL}

The procedure for calculating the SVI^{FL} comprises of four steps namely:

(1) Considering the assumed relationship to vulnerability;

(2) Normalization of data for reasons of comparison and

(3) Aggregating the indicators across each component and

(4) Computation of final index

1. The functional relationship of each of the 82 indicators to vulnerability was considered in terms of whether it increases or decreases the overall vulnerability. For indicators that were assumed to reduce vulnerability (see Appendix I), the values were transformed by multiplying them by minus one before normalizing the indicator value.

2. To make the data comparable across the eight panchayats, a methodology similar to constructing the SDG index proposed by Lafortune *et al*. (2018) was used. Each of the 82 indicators were transformed linearly to have an identical range [0, 1] using the following min-max normalization formula:

$$I_{ip} = \frac{x_{ip} - min_p(x_p)}{max_p(x_p) - min_p(x_p)}, \quad (1)$$

where $x_{ip}$is the original value of indicator *i* for panchayat p, $min_p(x_p)$ and $max_p(x_p)$ are the minimum and maximum value of x_{ip} across all panchayat *p*. Equation (1) ensures that all rescaled indicators are expressed as ascending variables, where higher values denote a higher vulnerability. This allows for an intuitive interpretation across all panchayats.

3. Each of the four components (social, physical, environmental or economical) were then calculated as the weighted sum of the three dimensions of vulnerability

$$M_{ip} = \frac{w_e\, Exposure_p + w_s Susceptibility_p + w_r Resilience_p}{w_e + w_s + w_r}, \qquad (2)$$

where M_{ip} is the major component for panchayat p, w_e, w_s, and w_r were the number of indicators related to the three dimensions of vulnerability and $Exposure_p$, $Susceptibility_p$, and $Resilience_p$ were calculated as the mean value of all related indicators in each panchayat p (number of indicators under each component are given in Appendix I). The results of our study are similar to the studies conducted by Rana and Routray (2018) and Ullah *et al.* (2021) in which they found significant difference among their study areas in terms of multidimensional vulnerability to disasters.

4. For calculating the SVI^{FL}, each major component contributes equally to the final index:

$$SVI_p^{FL} = \frac{\sum_{i=1}^{4} M_{ip}}{4}. \qquad (3)$$

The final index value varies between 0 and 1, where a higher value indicates greater vulnerability.

3.3.1.2. Delineation of coping strategies at individual, community and administrative (Government) level

Coping strategies in this study is operationalized as the process through which households attempt to smooth the consequences of the disaster. It includes recovery, restoration, and improvements where appropriate, of facilities, livelihood and living conditions of disaster affected communities, including efforts to reduce risk factors. For the development of index, methodology developed by Sheheli and Khan (2015), has been followed and minor modifications has been made to make it appropriate to the nature of disaster and socio economic conditions of the farmers. The focus variable in this section includes coping strategies practiced by farmers, at individual, community and administrative (government) level in the highlands and lowlands of Kerala. For the study, location specific coping strategies were selected and arranged (Appendix III- Interview schedule), based on experience gained in pre-testing of interview schedule, literature review and consultation with a number of key-informants. The coping strategies were arranged in a 4-point scale in order to reveal a respondent's extent of practice of the strategies. Each respondent was asked to indicate their frequency of practice of a specific coping strategy (actions and measures) before, during and post flood by selecting one of the four possible responses.

The responses were categorized into "frequently", "less frequently", "occasionally" and "not at all" headings, while scores were assigned as 4, 3, 2, and 1, respectively for the coping strategies against flood. On the basis of real situation in the disaster prone areas, the identified flood coping strategies for all the three levels were classified into categories such as food security, housing and shelter, crop production, protection and livestock, health and sanitation and means of livelihoods.

To ascertain the comparison among the practices, Coping Strategies Index for Floods and Landslides (CSI^{FL}) was computed by using the following formula: Coping Strategies Index for Floods and Landslides (CSI^{FL}) = C4×4 + C3×3 + C2×2 + C1×1 Where, C4 C = frequency of practice 'frequently'; C3 = frequency of practice 'less frequently'; C2 = frequency of practice 'occasionally'; and C1= frequency of least practice. Following is the scoring procedure to compute the CSI^{FL}

Statements	Coping Strategies Index for Floods and Landslides (CSI^{FL})			
	C4 (frequently)	C3 (less frequently)	C2 (Occasionally)	C1 (least frequently)

3.3.1.3. Documentation of post flood livelihood inclusive activities of farmers

In addition to suffering physical losses (losses to housing, infrastructure, transportation, water supply and sanitation systems), livelihoods of the affected farmers are also severely impaired. In most of the disaster management programs, disaster policy and recovery often side-lines the intangible issue of livelihood security. Documentation of post flood livelihood inclusive activities, helps us to understand the extent to which the farmers have been affected by the disaster and the different livelihood options adopted by the farmers after the disaster. Efforts have been taken to identify the areas, where post flood livelihood activities can be adopted individually or with the support of government or allied organizations. For the ease of the study, livelihood activities have been categorized under the four major headings of cropping pattern, livestock and fishery, non-farm livelihood options and post-harvest technology. Under each component, areas where livelihood options have been and could have been adopted are enlisted and they are further analyzed through a scoring procedure where Yes indicates **(2)** and No indicates **(1).** Following dimensions indicates the different areas and post flood livelihood inclusive activities that have been and could have been adopted by the farmer in the post flood scenario.

Dimension	**Livelihood activities**	**Scoring**	
		Yes (2)	**No (1)**
Changes in cropping pattern	Cultivation of short duration crops and vegetables		
	Farm diversification		
	Cultivation of new crop varieties		
Poultry and Fisheries	Cage farming		
	Poultry farming		
Non-farm sources of livelihood	Non-farm based livelihoods		
	Performance of wage labour		

	Migration of male youth		
New enterprises	Ecotourism		
	Development of value added products		

3.3.1.4. Impact analysis of post flood schemes and measures by the government

Impact assessment is operationalized as the analysis of the significant changes that has occurred due to an action or series of actions (intervention). This involves what has changed, for whom, how vital the change was, how long the change will last and in what ways our actions have contributed to that change. Here, impact study also aims to assess, the impact of Punarjani scheme among the farmers in the flood affected panchayaths of Idukki, Wayanad, Alappuzha and Pathanamthitta.

The study aimed to assess the impact of Punarjani scheme in the areas of economic, production, human capital and socio- psychological aspects. One question under each component has been identified, to assess the impact the programme has created on the above mentioned aspects of the life of farmers.

The statements have been scored on a binary scale where Yes is indicated by a score of 2 and No is indicated by a score of 1. Following components indicates the scoring procedure and the various statements under each component identified.

Component	**Questions**	**Scoring**	
		Yes (2)	**No (1)**
Economic impact	Did you receive financial support soon after the floods?		
Socio psychological impact	Did the scheme restore motivation to pursue		

	farming after the receding of flood waters?		
Impact on human capital	Did the scheme increase your knowledge on post flood land management practices through trainings?		
Impact on crop production	Did the scheme provide inputs for crop production		

3.4. OPERATIONALIZATION AND MEASUREMENT OF INDEPENDENT VARIABLES

Independent variables are those variables which are stable and which unaffected by the other variables in the study. It refers to the condition of an experiment that is systematically manipulated by the investigator. Based on the objectives, review of literature, discussions with experts and observations made by the researcher, the following independent variables were selected for the study.

3.4.1. Independent Variables

1. Neighbourhood cohesion
2. Self – efficacy
3. Optimism
4. Altruism
5. Risk propensity

3.4.1.1. Neighbourhood cohesion

A scale derived from Buckner (1988), and followed by Mare *et al*. (2012), has been used to measure neighbourhood cohesion. It is operationally defined as the sense of community felt by a respondent about his/her neighbourhood. Certain questions were asked to respondents to describe their relationship with neighbours as well as their feelings about their neighbourhood. The following are the various statements selected under neighbourhood cohesion and the scoring procedure followed is also given below

Sl. No	Statements	1	2	3	4	5
1	I feel like I am part of this neighborhood/community					
2	I visit with my neighbors in their homes.					
3	The friendships and associations I have with other people in this neighborhood mean a lot to me.					
4	If I needed advice about something I could go to someone in my neighborhood.					
5	I regularly stop and talk with people in my neighborhood.					
6	I feel like I have a voice in the neighborhood (community) decisions.					
7	I believe my neighbors would help me in an emergency.					
8	I would help my neighbors in an emergency.					
9	I borrow things and exchange favors with my neighbors.					
10	I would be willing to work together on something (project or program) to improve neighborhood/community					
11	If I can, I plan to remain a resident of this neighborhood for a number of years.					
12	I rarely have neighbors over to my house to visit.					

13	Given the opportunity, I would like to move out of this neighborhood					

Scoring procedure ranges from five to one, where (5) indicates strongly agree, (4) indicates agree, (3) indicates neutral, (2) indicates disagree and (1) indicates strongly disagree.

3.4.1.2. Self-Efficacy

It is operationalized as the belief that individuals have regarding their ability to organize and perform actions required to handle a wide range of challenging situations including those in the future, in an effective manner, that is, achieving specific goals proposed. Scale developed by Schwarzer (1992), has been used for the study.

The following are the various statements selected under self-efficacy along with their range of scores.

Sl. No	**Statements**	**1**	**2**	**3**	**4**
1	I can always manage to solve difficult problems if I try hard enough.				
2	If someone opposes me, I can find the means and ways to get what I want.				
3	It is easy for me to stick to my aims and accomplish my goals.				
4	I am confident that I could deal efficiently with unexpected events.				
5	Thanks to my resourcefulness, I know how to handle unforeseen situations.				
6	I can solve most problems if I invest the necessary effort.				
7	I can remain calm when facing difficulties because I can rely on my coping abilities.				

8	When I am confronted with a problem, I can usually find several solutions.				
9	If I am in trouble, I can usually think of a solution.				
10	I can usually handle whatever comes my way.				

For this variable, scoring procedure ranges from four to one, where (4) indicates exactly true, (3) indicates moderately true, (2) indicates hardly true, and (1) indicates not at all true.

3.4.1.3. Optimism

It is operationally defined as a form of positive thinking that includes the belief that you are responsible for your own happiness and that more good things will continue to happen to you in the future. It was measured using Life Orientation Test (LOT) developed by Scheier *et al.* (1994). Respondents were asked to rate each item on a 4-point scale, where 1 indicates strongly disagree, 2 indicates disagree, 3 indicates neutral, 4 indicates agree, and 5 indicates strongly agree. The following are the various statements selected under the variable

Sl. No	Statements
1	In uncertain times, I usually expect the best.
2	It's easy for me to relax.
3	If something can go wrong for me, it will.
4	I'm always optimistic about my future.
5	It's important for me to keep busy.
6	I hardly ever expect things to go my way. (R)
7	I don't get upset too easily.
8	I rarely count on good things happening to me. (R)
9	Overall, I expect more good things to happen to me than bad

3.4.1.4. Altruism

The attribute altruism is operationalized as the value one places upon the welfare of another in relation to his own. The altruistic scale developed by Rushton *et al*. (1987), and followed by Eisenberg (2002), was modified for the purpose of the study. The following indicates the various statements selected under altruism.

Sl. No	Statements
1	I have helped push a stranger's car that was broken down or out of gas.
2	I have given directions to a stranger.
3	I have made change for a stranger.
4	I have given money to a charity.
5	I have given money to a stranger who needed it (or asked me for it).
6	I have done volunteer work for a charity.
7	I have donated blood.
8	I have let a neighbor whom I didn't know too well borrow an item of some value to me (eg, a dish, tools, etc).
9	I have offered to help a handicapped or elderly stranger across a street.
10	I have offered my seat on a bus or train to a stranger who was standing.
11	I have helped an acquaintance to move households.

Scoring procedure ranges from five to one, where (5) indicates very often, (4) indicates often, (3) indicates often (2) indicates once and (1) indicates never

3.4.1.5. Risk Propensity

Risk propensity may be operationally defined as an individual's willingness to take or avoid risks which may have a significant impact on his decision-making under conditions of risk and uncertainty.

It was measured using **General Risk Propensity Scale (GRiPS)** developed by Zhang *et al*. (2018).

The following indicates the various statements selected under risk propensity and their scoring procedure

Sl. No	Statements
1	Taking risks makes life more fun
2	My friends would say that I'm a risk taker
3	I enjoy taking risks in most aspects of my life
4	I would take a risk even if it meant I might get hurt
5	Taking risks is an important part of my life

6	I commonly make risky decisions
7	I am a believer of taking chances

Scoring procedure ranges from five to one, where (5) indicates strongly agree, (4) indicates agree, (3) indicates neutral, (2) indicates disagree and (1) indicates strongly disagree.

3.5. CLIMATE ADAPTIVE AGRICULTURAL EXTENSION APPROACHES (CAAEA)

On the basis of information regarding vulnerability derived from Societal Flood Vulnerability Index of high land and low land areas and the various coping mechanisms devised and implemented by the farmers, a Climate Adaptive Agricultural Extension Approach was developed.

This approach aims to provide suggestions on the site specific climate adaptive agricultural practices and methods to implement them in their fields. For the development of the framework, the different problems, related to climate risk were enlisted. The problems so identified were included in the interview schedule and is given below.

The problems so identified were then scored and ranked using a scoring procedure. After scoring, the location specific problems were further correlated with the total climate risk values to understand the extent of relation.

Based on the results of the correlation, a climate adaptation strategy has been developed. The following details indicates the individual problems related to climate risks and their scoring procedures in highlands and lowlands. The scoring procedure for the statements/ problems ranged from highly important (1) to least important (4). The problems identified for scoring are given below for both highlands and low lands.

i) Highlands

Major climate risks	Scoring			
	1 (Highly Important)	2 (Important)	3 (Not important)	4 (Least important)
Landslide				
Excessive rain				

Wild animal attack / Crop scouting				
Increased incidence of pests and diseases				
Drought				

ii) Lowlands

Major climate risks	Scoring			
	1 (Highly Important)	2 (Important)	3 (Not important)	4 (Least important)
Flooding				
Pest and disease infestation				
Poultry and livestock diseases				
Salt water intrusion				
Scarcity of drinking water				
Drought				

3.6. STATISTICAL TOOLS USED FOR THE STUDY

Frequency distribution, percentage analysis, average, ANOVA, t- test, simple correlations, R software and PCA were employed in the analysis and interpretation

3.6.1. Frequency and Percentage analysis

The selected variables were subjected to and interpreted in terms of frequency and Percentage, to make simple comparisons and classify the respondents wherever necessary. Percentage was calculated by finding the frequency of particular cell multiplied by 100 and then further divided by the total number of respondents.

3.6.2. Correlation analysis

To explain the relationship between the variables simple correlational analysis was done. In order to measure the degree of relationship the correlation coefficient was worked out. The computed 'r' value were tested for their significance using table values for 'n-2'degrees of freedom.

3.6.3 Analysis of Variance (ANOVA)

ANOVA was employed to test whether there is any significant difference within the categories of respondents with regard to the different coping strategies and post flood livelihood inclusive activities of the farmers. Critical values were worked out to compare the factors with significant 'F' values and 'P' values.

3.6.4. T- Test

T- Test was conducted to analyze the existence of any significant difference between the different coping strategies adopted between highlands and lowlands

3.6.5. Principal Component Analysis (PCA)

Principal component analysis (PCA) was conducted to reduce the dimensionality of large datasets during index construction to ensure interpretability but at the same time to minimize information loss. It does so by creating new uncorrelated variables that successively maximize variance.

Results and Discussion

4. RESULTS AND DISCUSSION

"We learn from every natural disaster, whether it is a fire or a flood, we learn something from it so we can respond to the next one better"

Malcolm Turnbull

This chapter on results and discussions deal with the results obtained in this study in relation with the objectives so laid down and also the discussions. Keeping the objectives in consideration, the observations and the discussions based on the study are presented under the following categories.

4.1. Establishment of Societal Vulnerability Index for Floods and Landslides (SVI$^{FL)}$

4.2. Vulnerability maps denoting vulnerability hotspots

4.3. Coping strategies at individual, community and administrative levels.

4.4. Documentation of post flood livelihood inclusive activities of farmers

4.5. Impact analysis of Punarjani scheme

4.6. Profile characteristics of farmers

4.7. Climate Adaptive Agricultural Extension Approaches (CAAEA)

4.8. Conclusion

4.9. Recommendations for further research

4.1. SOCIETAL VULNERABILITY INDEX FOR FLOODS AND LANDSLIDES (SVI^{FL})

Human population worldwide is vulnerable to natural disasters. In recent years the impacts of floods have gained importance because of the increasing number of people who are getting exposed to its adverse effects. The aim of vulnerability studies is to recognize correct actions that can be taken to reduce vulnerability before the possible harm is realized.

SVI^{FL} is a powerful tool for policy and decision-makers to prioritize investments and makes the decision making process more transparent. Identifying areas with high flood vulnerability may guide the decision making process towards a better way of dealing with floods by societies.

4.1.1. Major Components and indices

SVI^{FL} in this study consists of four major components such as social, economic, environmental and physical components. Major results under each component are given in the following sections.

4.1.1. a. Social Vulnerability Index for Floods and Landslides (SoVI)

Social Vulnerability Index (SoVI) in this study provides information, on the potential characteristics of the population that makes it exposed, sensitive as well as adaptive to the impacts of floods and landslides (Fig.3). The factor wise results of Social Vulnerability is given in Table.1.

Table 1. Factor wise results of Social Vulnerability Index

Region	**Exposure**	**Sensitivity**	**Resilience**	**SoVI**
AD	0.469	0.366	0.571	0.442
KK	0.400	0.273	0.367	0.335
KD	0.304	0.261	0.38	0.314
NM	0.443	0.267	0.424	0.363
AD	0.384	0.368	0.597	0.456
VT	0.475	0.387	0.599	0.485
PM	0.413	0.304	0.567	0.424
MD	0.517	0.375	0.668	0.514

In the exposure assessment, it can be found that, Meppadi (MD) (0.517) (see Appendix II) of Wayanad district has the highest exposure followed by Vellathooval (VT) (0.475) of Idukki district. Both these regions belong to the highlands of Kerala which experiences intense landslides during the monsoons. The major indicators which makes MD, socially exposed to flood associated landslides are high population growth (0.888), (see Appendix II) a large number of respondents in temporary houses (0.808) without enough facilities, and a higher percentage (0.580) of population belonging to the older age group (60 and above). Moreover, most of the interviewed households reported that they have suffered from injuries in the past disaster and a majority of them (0.991) still suffers from some form of Post-Traumatic Stress Disorder (PTSD) where they live in a continuous fear that the event could happen again. However, the region has scored low values in the areas of population density (0.066), residence near polluted water bodies (0.062) and in the number of households who did not receive warnings during the landslides in the last two years. In the case of VT of Idukki district, a landslide prone region, the major indicators which makes its population exposed to landslides are a high percentage of rural population (0.994), respondents without permanent secure homes, and a large elderly population (0.796). Contrast to MD, in VT, most of the households reported that they have not received any disaster warnings in the last two years. However, VT has scored less in the areas of population density (0.082), households who has suffered injuries (0.382), residence near polluted water bodies (0.062) and PTSD. Panamaram (PM) (0.413) of Wayanad (WYD) and Adimali (AD) (0.384) of Idukki (IDK) has scored lower values among the highlands in exposure assessment.

The common indicators which reduces their exposure to landslides are mainly low population density, lower incidences of PTSD, a few number of temporary houses and residences near polluted bodies. However, the regions still have high exposure in the areas of elderly population, rural population, and households without warnings. Among the flood prone low lands under study, Ambalappuzha (AP) (0.469) of Alappuzha (ALP) has the highest social exposure to floods followed by Niranam (NM) (0.443) of Pathanamthitta (PTM). A high population density, large percentage of elderly population, higher cases of PTSD and a higher number of temporary residences (0.961) makes the population of AP exposed during flooding seasons. The region has however scored lower values in the indicators such as rural population, households without warnings and injuries and lesser number of residences near the polluted water bodies (0.258). In the case of NM, rural population, PTSD, and temporary residences accounts for the higher exposure and indicators such as population density (0.386), elderly population (0.279), households without warnings and injuries scored the lowest values. Kainakari (KK) of ALP also had moderate exposure (0.469) without much prominent difference in values when compared to AP. However, Kadapra (KD) (0.304) of PTM scored the lowest value in exposure assessment. The major indicators which reduces their exposure to floods are a lower elderly population, lower number of people residing in temporary homes and near polluted water bodies. Furthermore, most of the respondents reported that they have received timely warnings in the last two years and the number of people who suffers from injuries and PTSD are also low.

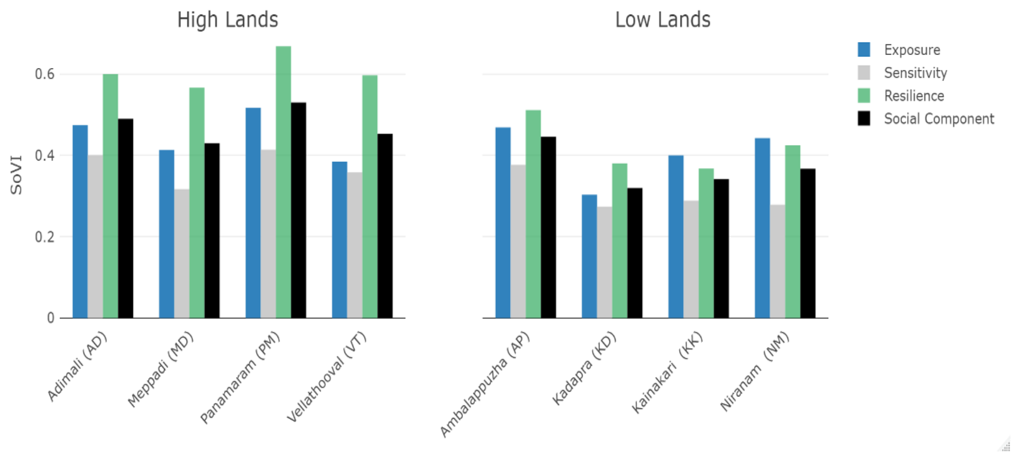


Fig.3. Factor and panchayat wise results of social component of vulnerability

Pertaining to the sensitivity assessment, VT (0.387) and MD (0.375) had the highest sensitivity to disasters particularly landslides similar to the case of exposure factor. VT had the highest sensitivity particularly due to the indicators such as higher dependent population (population in the age group of 0- 6 years), large number of households depending on natural water sources, natural input sources, untreated water and a number of female headed households (0.776) where they reported their husbands to be either dead or not in a healthy condition to look after the family. The region also reported a high population growth (0.824) and a higher number of people suffering from chronic diseases (0.574). However, the region expressed moderate sensitivity in the areas of disabled population (0.136), households depending entirely on agriculture for food and livelihood, smaller household size, and lesser time to water source. Furthermore, most of the households practiced homestead farming and they reported to save the seeds for the next season for cultivation, apparently ensuring food security. Whereas, indicators such as high disabled population, dependent population, larger household size (0.595), and population growth along with a higher number of people suffering from chronic illnesses (0.696) and receiving treatment at hospitals made MD sensitive to floods. Some factors which may help to reduce its vulnerability includes lesser number of female headed households, and lesser number of people depending on natural sources for inputs and drinking water (0.210). AD of Idukki (0.368) and PM (0.304) of WYD scored lower in sensitivity with PM having the lowest sensitivity among the highlands. The indicators which contributed to their lower sensitivity are a lower disabled population (0.143), households entirely dependent on agriculture and natural water sources, household size, and households with members suffering from chronic illnesses. However, dependent population (0.791, 0.716), female headed households (0.544, 1.00), and population growth (0.993, 0.850) scored higher in PM and AD respectively. Besides, the number of people suffering from chronic illnesses were higher in AD when compared to PM. In the case of lowlands, AP (0.366) and KK (0.273) of Alappuzha (ALP) had the highest sensitivity to floods with considerably lower values when compared to the highlands.

It is high dependent population (0.777), female headed households (0.642), agriculture dependent population (0.911), population growth (0.794), and a higher number of fish farmers that makes AP more sensitive to floods, whereas in the case of KK, a high disabled population (0.806), dependent population, population growth, and chronic illnesses contribute to higher sensitivity. Moreover, the average loan amount borrowed by the respondents is high in the case of KK. Both AP and KK scored lower in the areas of people consuming water from untreated sources, and household size. Pertaining to KD (0.261) and NM (0.267) which showed the lowest sensitivity to floods, the common contributing indicators are a lower agriculture dependent population and lesser number of people with chronic diseases. In addition, KD performed better in the areas of preserving seeds, consumption of purified water (0.021), and smaller household size (0.244). However the percentage of fish farmers and disabled members was higher along with a higher population growth. NM additionally performed better in the areas of lesser population growth, dependence on natural sources and people suffering from chronic illnesses. However number of female headed households (0.361), dependent population, percentage of fish farmers and average amount of money borrowed by the farmers were higher in NM.

While assessing the resilience factor, it is found that, MD (0.668) and VT (0.599) had the lowest resilience among the eight regions. As both these regions belong to the highlands, it is evident that farmer communities of highlands of Kerala have comparatively lower social resilience to disasters particularly flood associated landslides in the case of social component. The major indicators which led to the low resilience of MD were lower awareness to disaster, lower rate of adoption of early maturing varieties, lower crop and livestock diversification (0.646), lower membership in organizations, lesser number of health care facilities per lakh population and lesser number of people with higher education (graduate and above degree). The only indicators that contributed to the resilience of the community were a better access to communication media, income diversification as number of members worked outside the community and long term residency in the area.

As evident from the table 1. AD (0.597) and VT (0.599) does not have considerable difference in the resilience factor. Both, AD and VT had lower awareness, less exposure to coping mechanisms and past experiences to landslides. Moreover, they had lowest access to communication, lower rate of adoption of early maturing varieties, less income diversification, and lowest number of people with higher education. However, they had better strength in crop and livestock diversification and emergency services. Furthermore, AD had higher number of members who have been residing in the area for more than 40 years. Similarly, PM (0.567) also have lower resilience capacity mainly due to their lower awareness to disasters, lower membership in farmer organizations (0.751), less income diversification (0.755), a weak emergency and health services and less number of people with higher education. However, most of the respondents were long term residents of the area and had better crop and livestock diversification in their farming practices (0.264).

The resilience showed considerable changes in both highlands and lowlands ranging from 0.668 to 0.367. In the case of highlands AP had the lowest resilience followed by NM (0.424). The lowest resilience capacity of AP is mainly due to their weak emergency and health services, lesser number of people with higher education (0.908), and lower number of farmers adopting flood tolerant or early maturing rice varieties (0.588) even though they had higher awareness to disasters (0.339). In the case of NM, which had better resilience in the areas of awareness to disaster, access to communication media, adoption of early maturing varieties, emergency services, higher education, and income diversification (0.324), lower performance in the areas of membership in farmer's organizations, and lower crop and livestock diversification decreased the resilience capacity of the region. KK (0.367) and KD (0.380) had the highest resilience to floods among all the eight regions. The indicators which contributed to their better resilience capacity are higher awareness to disaster and coping mechanisms (0.080, 0.292), higher access to communication media, higher adoption of early maturing varieties, higher membership in organizations and better income diversification(0.252 and 0.379). Moreover KD has the highest number of members with a graduate degree. However both these regions had lower number of farmers with crop and livestock diversification, which in turn decreased their resilience capacity.

Therefore, in the case of social (SoVI), component (Table 2), MD of WYD has the highest (0.514) social vulnerability to disasters specifically flood associated landslides, followed by VT (0.485) of IDK which is also a highly landslide prone region. Moreover, AD (0.456) and PM (0.424) of highlands also shows higher social vulnerability. Lowest social vulnerability was recorded for KD (0.314) and KK (0.335) which belongs to the flood prone low lands of Kerala. Among the lowlands, AP of ALP showed the highest social vulnerability (0.442) followed by NM (0.363) of Pathanamthitta. However, from the Table 2, it can be inferred that social vulnerability is certainly high for the landslide prone highlands of Kerala when compared to the flood prone lowlands of the state.

According to the results, in case of social component, highlands have recorded the highest social vulnerability. MD of highlands had the highest vulnerability to disasters mainly landslides. Looking into the factors of vulnerability of MD, it can be found that, MD had higher social exposure and lowest resilience to landslides. The most important characteristic that made the population of MD exposed to landslides were higher number of causalities and PTSD. About 8% of the 62 households surveyed in MD, reported that they have suffered serious injuries or deaths in the past disaster. Higher number of injuries and deaths is an indirect indication of the vulnerability of the community. Moreover, about 71% of the respondents reported that, even after a year of disaster, they do experience PTSD symptoms (APA, 2019) such as trouble falling asleep, irritability or anger without reason, exhaustion and feeling of hopelessness. This is challenging the psycho social resilience of the even the hardiest people to overcome the impact of disaster and lead a normal life (Stanke *et al*., 2012; Benevolenza *et al*., 2018). In the case of resilience factor, MD had the lowest preparedness to disaster, which is true for the four highland regions under study. Lower preparedness to landslides resonates with the negligible number of trainings received by respondents regarding disaster coping mechanisms and post disaster farming. This finding is in line with the results of Rana and Routray (2018), who reported that ineffective coping mechanisms and lack of awareness, plague the disaster risk management in Pakistan. Moreover, except VT of IDK, most of the respondents in the three other regions reported that even though they have received warnings, they disregarded the instructions as they did not expect the disaster to be severe.

Other social characteristics of highlands which makes it vulnerable to landslides are higher rural population, elderly population, medically frail population higher population growth, and debts. Rural population with a large majority depending on agriculture for their source of livelihood are more vulnerable to the effects of a disaster. This is similar to the findings of Silwa and Kawasaki (2018), who conducted a socio economic vulnerability assessment to the disasters among the rural Sri Lankan community. Elderly population and medically frail population who are suffering from chronic diseases makes a community vulnerable to disaster, as they disproportionately experience higher morbidity and mortality during a disaster (Heagele and Pacquiao,2018). Moreover, chronic diseases widely found among the population of highlands include cardiac diseases (17%), chronic diabetes (13%), hypertension (16%) and cancer (16%). This also indicates the number of members who cannot work making the household more vulnerable (Panthi *et al*., 2014). Highlands also reported to have a high population growth which makes it vulnerable to disasters as it leads to congestion and competition for limited resources during disasters (Donner and Rodriguez, 2011).

Moreover, about 36% of the respondents resort to borrowing money from institutional and non-institutional sources, to cope with the financial insecurity. However, what makes a society more vulnerable is the dependence of farmers more on non-institutional or private money lending agencies for support. About 15% of the farmer respondents depended on private money lenders at exorbitant interest rates or from relatives and friends. Hence, these small holder farmers, always at the losing end, even before disasters, falls into a 'debt trap' (Dacles, 2019) when they lose all their crop and livelihood in disasters, and becomes unable to repay the loans and moreover they may be forced to borrow more to adapt to the post flood situation. However, except VT, respondents of all the other regions reported that they have access to at least one source of communication which is either TV or mobile phone.

In the case of lowlands, AP of ALP had the highest social vulnerability to floods mainly due to their high exposure, high sensitivity and low resilience to floods. Apart from similar features of considerable number of farmers suffering from PTSD, large dependent population, rural population, and higher debts, the characteristic attributes that makes the vulnerability of lowlands different from high lands is the pollution of water bodies, high percentage of agriculture dependent population, population of fish farmers, and less crop and livestock diversification. About 30% of the respondents in lowlands reported that they have their residence near to a polluted water body. Especially, in the KK and AP regions, disposal of wastes by households and discharges from small fisheries industries, prawn bleaching industries and district medical college is blamed to pollute the water network. At the time of floods, the water overflows and mixes up with the drinking water sources making it a source of several water borne diseases and during summers, foul smell is being produced which creates a sense of nausea and dizziness in children and elder residents. A prominent example is the extremely polluted '*Kappithodu*' water network in AP which is the source of irrigation water for more than ten paddy fields and drinking water source of nearly 100 households. Water pollution that results from flooding is particularly detrimental to a society where the traditional sources of water include rivers, lakes and wells, making them more vulnerable to floods (Sholihah, 2020).

Of the farmers surveyed, fish farmers constituted about 26%, who pursues fish farming for their livelihood and reported that they suffer huge losses during floods. Furthermore, as they do not receive any kind of compensation from fisheries department, many farmers do not wish to continue this practice as a source of income. This result is similar to the findings of Oyebola *et al.* (2021) who conducted a study among the fish farmers of climate hotspots of Uganda and reported that vulnerability and impact of floods is relatively high among fish farmers.

Even though farmers of low lands of Kerala, experience frequent floods, and experience crop loss, they are still hesitant to adopt crop and livestock diversification in their practices wherein only 29 and 11% of the farmers have adopted crop and livestock diversification respectively. This is in line with the findings of Sathyan *et al.* (2018) who claimed that crop diversification was lower among farmers even though they had problems of soil erosion. Rice farmers, still cultivate regular varieties such as Uma, Jyothi and Athira as most of the farmers are unaware of high yielding short duration rice varieties such as 'Manuratna' which can be harvested in 100 days when other varieties takes more than 115 days to harvest. Adoption of early maturing varieties can help the farmers to harvest their crop before the flooding season.

However, there exists some interesting characteristics for both highlands and lowlands which makes Kerala stand out when compared to other regions. All the 520 households surveyed had electricity and sanitation facilities and the household head had received some form of school education and knows to read, write and speak at least one language. This result is in par with the results of Census

(2011) which reported Kerala to be the highest literate state with 96.2% literacy rate.

4.1.1.b. Economic Vulnerability Index (EVI^{FL}) for Floods and Landslides

Economic vulnerability in this study provides knowledge on the wealth status, poverty level and its ability to distribute goods and services. The factor and region wise results of economic component are given in Table 2 and Fig.4.

Table 2. Economic Vulnerability Index for floods and Landslides

Region	**Exposure**	**Sensitivity**	**Resilience**	**EVI^{FL}**
AD	0.373	0.131	0.442	0.337
KK	1	0.212	0.516	0.561
KD	0.167	0.061	0.422	0.268
NM	0.281	0.280	0.857	0.568
AD	0.277	0.879	0.601	0.59
VT	0.429	0.773	0.542	0.571
PM	0.594	0.537	0.688	0.626
MD	0.664	0.845	0.675	0.715

As per Table 2, pertaining to the exposure assessment, KK of ALP has the highest exposure (1.00) among the eight regions under study followed by MD (0.664) of WYD. There is a considerable difference in the exposure values of eight regions ranging from 1.00 (highest) to 0.167 (lowest). As far as KK and MD is concerned, the major indicators which makes it the most exposed to floods and landslides respectively are their higher proximity to river or a steep slope (1.00,0.885), presence of higher number of small and medium scale industries (1.00, 0.476) and a lower Life Expectancy Index (LEI).

When KK is primarily exposed to floods, MD has higher exposure to landslides. Looking into details of lowlands, AP, NM and KD has exposure values of 0.373, 0.281 and 0.167 respectively. In the case of AP, even though it had a lower number of respondents in the near proximity to a river, it had higher number of industries functioning in its area (0.607) and a comparatively lower life expectancy

(0.513). NM had the highest life expectancy among the eight regions, moreover number of small and medium industries operating in the area was comparatively less (0.132). KD of PTM district scored the lowest exposure to economic vulnerability mainly due to the lower proximity of the households to the water sources (0.038), lower number of small and medium scale industries (0.330) and also a good life expectancy (0.333). As opposed to lowlands, almost all the highland regions under study showed higher exposure to economic vulnerability with values 0.594, 0.429 and 0.277 for PM, VT and AD respectively.

PM had number of respondents living in close proximity to a cutting or a steep slope, higher number of small scale industries (0.537) and a lower life expectancy (0.667). Similarly, in VT, exposure of households to landslide prone areas was high (0.997). However, they had a better life expectancy and fewer number of industries functioning. AD with the lowest exposure value among the highlands had fewer households near a water source or sloping areas (0.102), along with fewer industries and better life expectancy. Therefore in the exposure assessment, highlands showed higher exposure to economic vulnerability along with KK of lowlands, (Table 3).

In the case of sensitivity assessment, AD showed highest (0.879) sensitivity followed by MD (0.845). Both AD and MD respectively showed similar trends in the areas of high unemployment rates (0.765, 0.804), high urban growth rate and high number of households Below Poverty Line (BPL) (GoK, 2011).Comparably, VT(0.773) also had a high unemployment rate (1.00) and poverty rate (1.00). Whereas, PM, have scored the lowest (0.537) in sensitivity, mainly because of lower unemployment rates (0.339), and lower urban growth rate (0.320).

However, number of households under BPL was higher as in the case of other high lands. With respect to lowlands, NM of PTM, showed highest sensitivity (0.280) followed by KK (0.212) of ALP, with values significantly lower than that of highlands. For NM and KK, it is the high unemployment rate that added to the sensitivity. Urban growth rate and households under BPL were lower for the areas. In case of KD which showed the lowest sensitivity (0.061) to floods, had the lowest unemployment rate (0.104), lowest urban growth rate (0.080) and lowest number of households under BPL. Hence, similar to the results of exposure assessment, highlands have higher economic sensitivity to landslides.

When we analyse the resilience component, it can be found that, NM of PTM have the lowest resilience capacity (0.857) followed by PM (0.688) of WYD. NM is the only region among the lowlands which has showcased such lower resilience capacity. This is mainly due to the indicators such as lower number of farmers with either crop, livestock or life insurance (0.860), lower number of Institutional Organizations (IO) and Veterinary Institutions (VI).Moreover, majority of respondents (1.00) also reported that, after the floods, the basic services such as electricity and water supply were disrupted for more than 2 weeks and their recovery time after the disaster was also very high (1.00).

Pertaining to PM, lesser number of IO, VI, and lesser savings (0.865) for the respondents to respond to flood decreased their resilience capacity. However, the respondents reported that, supply of basic services were restored soon. When we look into the other regions under lowlands, KK have the lowest resilience (0.516) capacity after NM, which was mainly due to their lesser number of IO, higher recovery time (0.520), lesser savings (0.529) to cope with the damage and also failure at the end of authorities to restore the basic services after the floods, thereby increasing their recovery time. However, KK had the largest number of farmers enrolled in either crop or livestock insurance schemes.

AP and KD have identical values (0.422) under resilience capacity. However, the reasons for their resilience are not comparable. When AP showed higher resilience in areas of number of farmers with insurance schemes, and number of IO, KD had better resilience in the areas of increased savings of the farmers to cope with floods, lesser recovery time and lesser number of days without basic services restored (0.241). However, number of farmers enrolled in insurance schemes and number of IO's were less decreasing their resilience capacity.

Whereas in the case of AP, it is the higher recovery time (0.696), lower savings of the farmers (0.971), and delay in restoring the basic services that reduces its resilience. Furthermore, in the case of highlands, after PM, MD, AD and VT have resilience values of 0.675, 0.601 and 0.542 respectively.

With respect to MD, lower number of farmers with insurance (0.951), lower number of IO, higher recovery time (0.718), and the lowest savings are the major factors decreasing the resilience to landslides. AD and VT, the low lying regions of IDK, also had the problems of low insurance rate among the farmers, low savings and higher number of days with services interrupted.

However, individually, number of IO is higher in AD when compared to VT. Similarly, when AD had a higher recovery time, it was quite negligible for VT and number of VO were the same for both the regions.

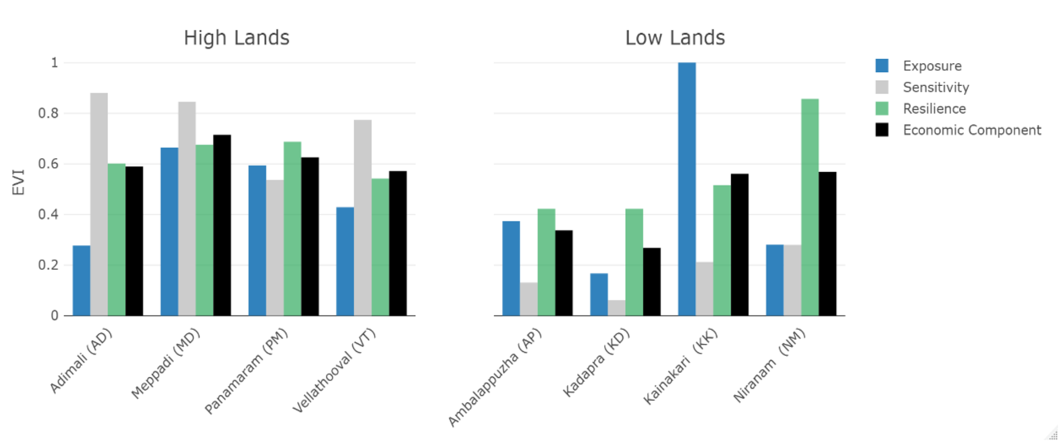


Fig.4. Factor and panchayat wise results of the economic component of vulnerability

Accordingly, as per table 2, MD (0.715) and PM (0.626) of WYD are the regions with the highest economic vulnerability to flood associated landslides. AD (0.590) and VT (0.571) of IDK also exhibit high vulnerability to landslides. On the contrary, in the case of lowlands, highest economic vulnerability is expressed by NM (0.568) followed by KK (0.561). Lowest economic vulnerability among all the eight regions is exhibited by KD (0.268). Therefore, it can be concluded that, highlands of Kerala has the highest economic vulnerability to natural disasters specifically landslides.

With respect to economic component, same as in the case of Social component, MD of highlands has the highest economic vulnerability to floods and associated landslides. Moreover, there is a significant difference between the economic vulnerability of highlands and lowlands as depicted in table 2. About 12 indicators were used to measure the economic vulnerability of regions. The major characteristics that makes the highlands highly vulnerable to landslides are mainly, higher proximity of residence and agricultural areas to steep slopes, higher rates of unemployment, higher number of people below poverty line, lower enrolment in insurance schemes, higher recovery time, and low savings to adapt to the changes. As per the survey results, more than 50% of the respondents have either their homes, or agricultural fields near unstable steep slopes which are highly susceptible to landslides when there is heavy and prolonged rainfall (Diana *et al*., 2021).

When MD, AD and VT had large number of number of buildings near to landslide prone sites, PM had the residences near to the rivers or active streams. The distance of the buildings from steep slopes and flood plains ranges from 5m (min) to 2000m (max). This finding is in line with the results of Wadhawan *et al*. (2020) who conducted a study on the causative factors of floods and landslides in Malappuram and Wayanad district and reported that the indiscriminate construction of houses across the active first order channel courses and slopes were vulnerable to natural processes of erosion and destruction. High unemployment is often considered as an impediment for the family for capital procurement and rebuilding after disaster (Fraser, 2020). In this study unemployment represents the number of households with at least one unemployed educated member who is in the age group of 21 – 35 years, willing to work but couldn't find a job. In this context, unemployment rate was almost double in highlands (30%) when compared to the lowlands (15%). This finding supports the low number of households (38%) with another earning member in highlands as compared to lowlands (68%). Similarly, number of people in the BPL category (GoK, 2011) and lower savings for post disaster adaptation was high in highlands. Higher number of members involving in meagre daily wage jobs for livelihood indicates their economic vulnerability and higher number of households under BPL. Moreover, disasters deprive these daily wage labourers of their source of income intensifying their economic situation (Ullah *et al*., 2020). In addition, among the 14 districts of Kerala, WYD and IDK has the highest poverty percentage of 3.48% and 1.6% respectively whereas, ALP and PTM belongs to the districts with less than 1% poverty (GoK, 2017). Higher recovery time of households of highlands is therefore a reflection of intensified economic vulnerability of disadvantaged households. About 80% of the respondents of MD, AD and PM reported that they couldn’t return to their normal life till date even after three years of unfortunate incident.

Crop loss due to floods and landslides is inevitable which further weakens the financial security of farmers who are already in huge debts and losses (Rozaki *et al*., 2021). Therefore crop insurance can be used by the farmers as a pre disaster risk management tool to compensate for the losses (Islam *et al*., 2021).

However, number of farmers enrolled in crop and livestock insurance programs are lower in highlands, wherein only 31 % of the framers had enrolled in highlands when compared to 69% farmers in Lowlands. High insurance premium is the major problem reported by the farmers of AD, VT and PM who are predominantly farmers of spice crops such as Cardamom and pepper. According to them, for the perennial crops they have to pay a premium of Rs. 2000/acre/year which is costly for them. This finding holds true as most of the farmer households under study belonged to BPL category.

Moreover, the enrolled farmers reported that they did not get compensatory relief for crop loss on time. According to them both agricultural offices and insurance companies do not proactively addresses the concerns of farmers enrolled in the scheme. Higher number of insurance enrolment in lowlands point towards the group insurance programs prevailing for the paddy farmers where they only have to pay Rs.100/acre/season. However, percentage of farmers who insured other crops such as vegetables, tuber and plantation crops are less in both regions.

Even though lowlands have low economic vulnerability than highlands, there are indeed some traits which makes the farmer community vulnerable such as proximity of the residence or agricultural fields near to a river or water source, recovery time and higher number of days the basic services was interrupted. Almost all the respondents under study have either their homes or agricultural fields near a lake or river. The range of proximity to the river varied from 10m (min) in KK to

3000m (max) in NM. Deepak *et al*. (2020) who assessed the flood vulnerability of local self-governments using Geo spatial approach reported proximity from river and elevation as the major contributors of vulnerability. Recovery time indicates the amount of time needed by the community to recover to a functional operation after floods (Hashim *et al*., 2018) and among the lowlands, highest recovery time was shown by KK and NM. This indicates their low resilience to floods even though both regions are the most flood prone regions which floods almost every year (KSDMA, 2019). Allaire *et al*. (2018) claimed that disruption of basic services (transportation, electricity, water and health services) as one of the major impacts of flood and one the most important factor which delays the recovery of the people from the disasters.

Higher the number of days the basic services were interrupted, slower had been the recovery of the people to normal life which decreased their resilience to floods. In this study, disruption of two basic services such as water and electricity supply were studied and about 57% of the respondents reported that the services were disrupted for less than 5 days after the flood water subsided, and about 10% reported that the services were restored after about 10-15 days. Revival of services was longest in KK mainly due to their physiography and paucity in road network (GoK, 2017, Survey data).

4.1.1.c. Environmental Vulnerability Index ($EnVI^{FL}$) for Floods and Landslides

Environmental vulnerability deals with environmental conditions, and biophysical endowments that makes a region vulnerable to floods or landslides (Munyayi *et al*., 2019). Table 3 and Fig.5 shows the results of environmental vulnerability at the factor and regional level. (n=520)

Table 3. Environmental Vulnerability Index

Region	**Exposure**	**Sensitivity**	**Resilience**	$EnVI^{FL}$
AD	0.451	0.519	0.47	0.479
KK	0.354	0.498	0.557	0.475
KD	0.36	0.413	0.557	0.45
NM	0.474	0.435	0.62	0.517

AD	0.645	0.368	0.445	0.484
VT	0.648	0.342	0.639	0.549
PM	0.532	0.548	0.484	0.519
MD	0.766	0.605	0.26	0.526

As per exposure assessment, MD (0.766) of WYD has the highest exposure (see Appendix II) to environmental component followed by VT (0.648) of IDK. However, there is no considerable difference in the exposure values of AD (0.645) and VT (0.648). For MD, higher average rainfall amount (0.855), higher pollutant concentration (0.923), considerable decrease in area under wetlands (0.553), are the major reasons for its high exposure to flood associated landslides. With respect to AD and VT, the important indicators which increased their environmental exposure to landslides are high rainfall amount (0.982, 1.00), and higher pollutant concentration (1.00, 0.990). However, the average number of drought events experienced and area decreased under wetlands were lower for AD and VT. Panamaram (0.532), have the lowest exposure values among the highlands, and this is influenced by the low pollutant concentration, and lower decrease in area under wetlands over the years.

However. The region still experienced higher average rainfall and drought events. Moving to the lowlands, it can be found that there is a considerable difference in the exposure values of both low and high lands. NM (0.474) expressed the highest exposure followed by AP (0.451). Higher rates of paddy land conversion and higher number of drought events during summers are major reasons which makes it exposed. However, for KK (0.354) and KD (0.360) which has scored the lowest and alike values in exposure assessment. When lower decrease in area under paddy fields and wetlands and lower air pollutant concentration are the exposure inducing factors in KK, in KD, they were mainly due to the lower average annual rainfall and lower number of drought events in the past five years. Therefore, under exposure assessment to environmental component, it can be found that, highlands have higher exposure in comparison to lowlands.

In terms of sensitivity assessment, MD (0.605) and PM (0.548) of WYD showcases the highest sensitivity to landslides, mostly due to the nature of soil, and wild animal attack faced by the farmers. Moreover, average monthly temperature of MD (0.880) and PM (1.00) has also increased over the years. AD (0.342) and VT (0.342) of IDK however expresses lower sensitivity to landslides due to the regions lowest change in maximum temperature and nature of soil. The region however experiences wild animal attack and higher temperature during the flooding season. The highest sensitivity in lowlands was recorded by AP (0.519) and KK (0.498) of ALP, which was mainly due to the presence of a number of rivers, their nature of soil, and higher temperature during the flooding season. However, the regions did not report any sort of wild animal attack, and moreover, the average maximum temperature of the region also did not fluctuate much over the years. KD (0.413) and NM (0.435) has the lowest sensitivity to floods among the lowlands under study. Even though the regions also has a higher network of rivers, and impermeable nature of soil, the average maximum temperature has not deviated at a higher rate and incidences of wild animal attack were also less in KD and NM.

Pertaining to resilience, VT of IDK has the lowest resilience to landslides (0.639) among highlands followed by PM (0.484) of WYD. The lowest resilience of VT point towards the decrease in area under forests (0.635), lower adoption of homestead farming (0.761) and soil conservation measures (0.948). Whereas in PM, quality of the soil (0.538), reduction in area under forests (0.794) and non-adoption of soil conservation measures (0.948) has led to the lower resilience capacity. AD and MD has higher resilience to landslides among the high lands with MD scoring the highest (0.260). The highest environmental resilience of MD projects the higher area under forests (0.349), a higher water quality, higher crop land density, higher adoption of homestead farming and soil conservation measures.

In the case of lowlands, NM (0.620) has the lowest resilience to floods followed by KD and KK with similar values. AP showed the higher resilience to floods (0.470) among the lowlands. Lower resilience of NM, is mainly due to their lower area under forests, lower soil quality (1.00), and lower homestead farming (0.761). The same reasons applies for KK and KD. However, KK and AP has a higher rate of adoption of soil conservation measures. When quality of drinking water was the best in KD, AP had the worst, followed by KK and NM with moderate quality. Hence, for environmental component, VT (0.549) of IDK has the highest environmental vulnerability to disasters followed by MD (0.526) of WYD. This shows the higher environmental vulnerability of highlands when compared to lowlands. Among the lowlands, NM (0.517) of PTM is highly vulnerable to floods followed by AP (0.479) of ALP. However, both KK and AP is equally vulnerable to floods as there is no considerable difference in their vulnerability values (0.475 and 0.479 respectively). KD (0.450) of PTM and AD (0.484) of IDK has the highest environmental resilience for lowlands and highlands respectively.

In the context of environmental vulnerability, vulnerability of highlands is more when compared to that of lowlands. The key characteristics, which makes the highlands vulnerable to floods and associated landslides are, higher rainfall over a short period of time, decrease in area under wetlands, nature of soil, quality of soil, less adoption of soil conservation measures and wild animal attack. The average amount of rainfall received by the highlands has increased from 698mm in 2011 to 800mm in 2020 and the highest amount of rainfall in the last 10 years was recorded in 2018 (1340 mm) and 2019 (1125 mm) when floods and landslides occurred. Moreover, according to the respondents, the heavy rainfall continued for 7 days which ultimately resulted in landslides. Nuryanto *et al*. (2021), who conducted a study in Indonesia on soil moisture and rainfall induced landslides reported that continuous rainfall over a long period triggered landslides in Java islands of Indonesia.

According to the data from concerned Agricultural Offices, area under wetlands in highlands has undergone a 9% decrease, the highest reduction being recorded in MD (19%) from 2011 to 2020 mainly because of urban expansion and encroachment. Palomar (2020) in his study on the role of urban wetlands in flood risk reduction, Columbia revealed that Wetlands have an important role in hydrological regulation and flood abatement and decrease in area under wetlands have resulted in frequent floods in Columbia including the extreme flood events of 2010-2011.Lowland regions have also undergone reduction in the area under wetlands even though at lower rate (0.2%) when compared to highlands. This makes the region more vulnerable to floods and landslides.

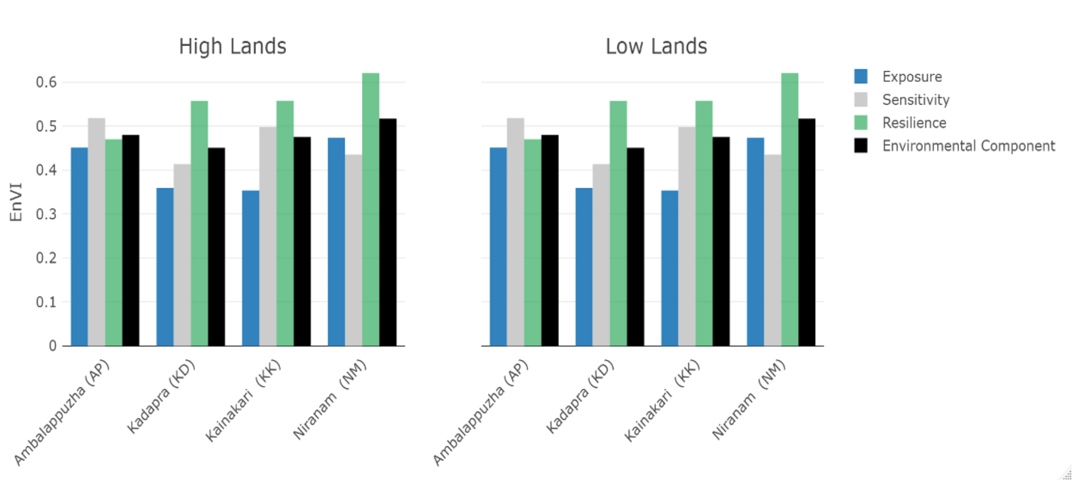
Nature and quality of the soil is a major determinant of flood and landslide vulnerability (Munyayi *et al.,* 2019). In order to determine soil and water quality, soil and water samples were collected from each panchayath. For the collection of samples, grid sampling method was used which involved sample collection at regular intervals across an area (Ackerson, 2018). In this study ten soil samples and five water samples were collected from each panchayath at an equal distance of 5 kilometres. Hence, 80 soil samples and 40 water samples were analysed for the study. Nature of the soil was determined on the basis of texture and soil quality was determined and interpreted using additive soil quality index method (Mukherjee and Lal, 2014) and was assessed on the basis of five parameters such as ph, EC, OC, P and K. From the results obtained, it is found that sandy clay, and clayey loam soils are the major soil profiles found in the highlands which exhibits moderate (AD and VT) to low permeability (MD and PM) (Chandel and Kumar, 2016). In the case of low lands too, permeability of the soil ranged from low permeability in the case of AP and KK to moderate permeability in KD and NM. More permeable soil has more infiltration capacity and therefore reduces surface run-off, whereas less permeable soil has less infiltration capacity and is more prone to water logging (Muyayi *et al*., 2019). The findings of this study revealed similarities with the study conducted by Karmaka *et al*. (2010), where the nature of the soil was found as one of the major factors determining vulnerability to floods. A small downpour of rain can cause floods and cut slope failures because of the nature of soil in this area. In the instance of Soil quality, the highest soil quality was found in AP and the lowest in NM in the lowlands and in highlands, soil quality was the worst in MD and best in VT. The high soil quality in AP may be due to excessive use of fertilizers in their paddy fields. This is convincible, as 75% of the farmers recognised them to be inorganic farmers who use chemical fertilizers and pesticides in their field and 25 % of the farmers who incorporates integrated methods to improve fertility. Whereas in the case of MD, about 50% of the respondents claimed themselves to be organic farmers who use cow dung and other easily available organic manures for fertilizers. This is also an indirect indication of the higher number of organic farmers in highlands when compared to lowlands.

As soil is an important factor in crop production, low soil quality can adversely impact the adaptive capacity of the farmers increasing their vulnerability to floods and landslides (Prayoga *et al*., 2021). Similar to soil, water also plays an important role in the adaptive capacity of the farmers, wherein water insecurity is considered as a major component of disaster risk reduction (Ho *et al*., 2019). In this study, water quality was determined on the basis of parameters such as ph., EC, hardness, Ca, Mg, Carbonate, Bicarbonate, Na, and K. Furthermore, water quality index was computed and interpreted using the WQI method given by Brown *et al*. (1970), and followed by Kochrund *et al.* (2019). As per the results of the index, water quality was the lowest in AP and highest in KD. In the case of highlands, all the four regions had moderate to good quality of water. Low water quality of AP is justifiable as the region has many polluted water bodies as discussed in the section earlier.

In highlands, which is prone to landslides and cut slope failures, it is unfortunate to know that only 22% of the total respondents were adopting some soil conservation measures. Major soil conservation measures adopted by the farmer includes mulching (10%), bunding (8%) and tree planting (3%). However, in the case of lowlands, about 48% of the farmers adopts soil conservation measures in their fields and homesteads. The commonly adopted measures include mulching (36%), creation of bunds (17%), and use of geo textiles (6%). Caldas *et al*. (2018) conducted a flood vulnerability study among farmer communities of Brazil and found that, even when frequency of floods and intensity of crop losses were increasing every year, the percentage of farmers who were willing to adopt soil conservation measures in their fields were negligible, making them more vulnerable to the impacts.

One characteristic attribute which makes the highlands highly vulnerable to landslide vulnerability is the man animal conflict or intense wild animal attack. Instances of wild animal attack reported in lowlands were negligible. IDK and WYD are centres of wild animal attacks (Raman, 2021). Almost all the respondents interviewed complained of wild animals such as Elephants, pigs and monkeys causing widespread destruction to standing crops as well as lives of the people. One respondent from IDK suffering from lung cancer reported that even during health emergencies they fear to get out of their homes after 6 in the evening due to the scouting of wild elephants once it's dark. Even though they have tried several measures including low voltage fencing to keep the animals at bay, none was successful. This finding is in line with the results of Datta and Behera (2022), who described the plight of farmers of Eastern Himalayan foothills of West Bengal, India as a result of their continuous conflict with animals. In this study, Human-wild animal conflict is considered as a result of habitat loss of the animals due to climate change. According to them, crop scouting is a major factor which can reduce the capability of the farmer to return to normalcy post disaster. Contrarily, negligible cases of wild animal attack were reported in lowlands. This might be due to the lower forest area found in the lowlands when compared to the highlands, where more than 55% of the respondents have their homes in close proximity to a forest area (Survey results).

Fig.5. Factor and panchayat wise results of environmental component of vulnerability



4.1.1d. Physical Vulnerability Index (PVI^{FL}) for floods and landslides

Physical component of vulnerability assessment in this study represents, the physical condition of the region, which can further influence its vulnerability (Balica and Wright, 2011). Table 4 and Fig. 6 gives a detailed analysis of the physical component as per the factors under consideration in the study.

Table 4. Physical Vulnerability Index (PVI)

Region	**Exposure**	**Sensitivity**	**Resilience**	PVI^{FL}
AD	0.755	0.431	0.677	0.626
KK	0.803	0.239	0.886	0.667
KD	0.487	0.470	0.386	0.442
NM	0.851	0.470	0.191	0.473
AD	0.643	0.285	0.47	0.466
VT	0	0.601	0.481	0.373
PM	0.412	0.254	0.095	0.238
MD	0.269	0.667	0. 46	0.465

As per the results in Table 4 the exposure assessment shows some interesting results, wherein the values ranged from as low as 0 for VT to as high as 0.851 for NM. The results shall be assessed in detail in the following sections. As already mentioned, NM of PTM has the highest (0.851) exposure in terms of physical component to floods, followed by KK (0.803), also belonging to the lowlands. The characteristic physical features which make NM and KK exposed to floods are higher probability for flood occurrence in a year (0.621, 0.659), higher number of days with heavy rainfall (0.955, 0.858) and higher water level rise (0.979, 0.901). AP and KD, the other low lying regions, with values 0.755 and 0.487 also show higher exposure to floods. Higher probability for disaster occurrence (1.00), and higher rise of water during floods (0.967) makes AP exposed to floods. While, in KD, the region with lowest exposure to floods among the lowlands have higher number of heavy rainfall days and height of water level as the exposing characters to floods. When we compare, highlands have relatively low physical exposure to floods or flood associated landslides (Table 4). However, among the highlands AD has the highest exposure (0.643) followed by PM (0.412).When higher number of heavy rainfall days (1.00) and increased height of water level led to the high exposure of AD, in PM it was mainly due to the moderately higher disaster frequency (0.382) and increased height of water level (0.584). MD and VT have lower physical exposure to landslides with VT achieving the lowest value. As far as VT is concerned, disaster frequency, number of heavy rainfall days and height of water level in the residence score the lowest values. Whereas in MD, number of heavy rainfall days were higher (0.10) with the other two indicators scoring lower values. Hence, lowlands have high physical exposure in terms of indicators such as disaster frequency, heavy days and height of water level when compared to the low lands.

In the case of sensitivity assessment, MD (0.667) of WYD is revealed to have high physical sensitivity to landslides, followed by VT (0.601) of IDK. The prime factors which make MD sensitive to landslides are a higher percentage of dilapidated houses (1.00) and buildings that are older than 20 years. While, in VT, it was the housing type and higher number of dilapidated houses that makes it sensitive to landslides. Remaining regions of highlands, AD (0.431) and PM (0.254) showed moderate to low sensitivity to landslides respectively. For AD, type of housing was the most sensitive factor and in case of PM, age of the buildings was the only sensitive factor as the other two indicators showed low sensitivity. With respect to low lands, KD and NM has the highest sensitivity to floods with similar values (0.470). The characteristics of residence which makes these regions sensitive to floods are the housing type (0.781, 0.875) and buildings that are more than 20 years old (0.475,0.368) for KD and NM respectively. However the number of dilapidated houses is lower in both in these regions. KK (0.239) and AP (0.431) have the lowest sensitivity with KK showcasing the lowest. Type of housing is the concerning factor in AP, which increases its sensitivity. KK however has better sensitivity in all the three areas of type of housing (0.314), number of dilapidated houses (0.204) and age of the buildings (0.199).

Pertaining to the resilience assessment, lowest resilience is denoted by KK (0.886) followed by AP (0.677). Both these regions belong to the flood prone lowlands of ALP district. The major elements which reduce the resilience of KK are lower road network connecting the villages with towns (0.832), and small number of hospitals to meet the needs of the people. However, the region reported to have the highest number of water harvesting structures and least number of reservoirs such as dams. In the case of AP, even though the region had a better road network connecting villages, number of hospitals, number of reservoirs and water harvesting structures appeared to be less. Pertaining to other regions of lowlands, KD had a moderately high (0.386) resilience capacity and NM (0.191) had the highest resilience capacity among the highlands. KD and NM villages respectively has a better road network, reservoirs for storage of excess water, and a relatively higher number of health institutions increasing their resilience capacity. Meanwhile, for highlands, VT (0.481) has the lowest and PM (0.095) has the highest resilience capacity. Whereas, AD and MD has reliance values, 0.470 and 0.460 respectively. VT has small number of villages connected with roads, relatively less number of hospitals per lakh population and less number of water harvesting structures, reducing their ability to recover. Similarly, lower number of villages connected with metalled roads, lower number of hospitals per lakh population and water harvesting structures leads to low resilience for AD. However, for MD, it is lower number of hospitals per lakh population and absence of water harvesting structures that reduces its resilience. PM with the highest resilience capacity among all the eight regions had a good road network connecting villages, and higher number of health institutions. However, in terms of storage capacity of dams and reservoirs, dams of AD and VT has higher storage capacity (0.014) when compared to that in PM and MD (0.285). Therefore, as per Table 4, KK (0.667) followed by AP (0.626) is the most vulnerable regions in terms of physical component to disasters such as floods. Moreover, KD and NM of PTM also exhibits high vulnerability to floods. As both ALP and PTM belong to the lowlands of

Kerala, it can be concluded that physical vulnerability to floods is more among the regions of Lowlands. Pertaining to highlands, AD and MD shows the most vulnerability with almost similar values (0.465, 0.466) followed by VT and PM. Here PM of WYD has the least physical vulnerability.

Physical component is the only area, where the lowlands had higher vulnerability than lowlands. This is primarily because of attributes such as increased frequency of disasters in a year, increasing level of water in the residence during floods, housing type, and less number of water harvesting structures. More than 90% of the respondents in lowlands, indicated that they have experienced at least one disaster almost every year since 2010. Even though floods are the main threats faced by the region, about 13% also reported droughts to be a major problem. In the case of highlands, about 32% of the respondents reported they have started experiencing frequent floods since 2015. However, along with floods, they do face threats such as heavy winds (23%) which causes huge financial losses to Banana farmers which constitutes 37% of the total respondents in highlands.

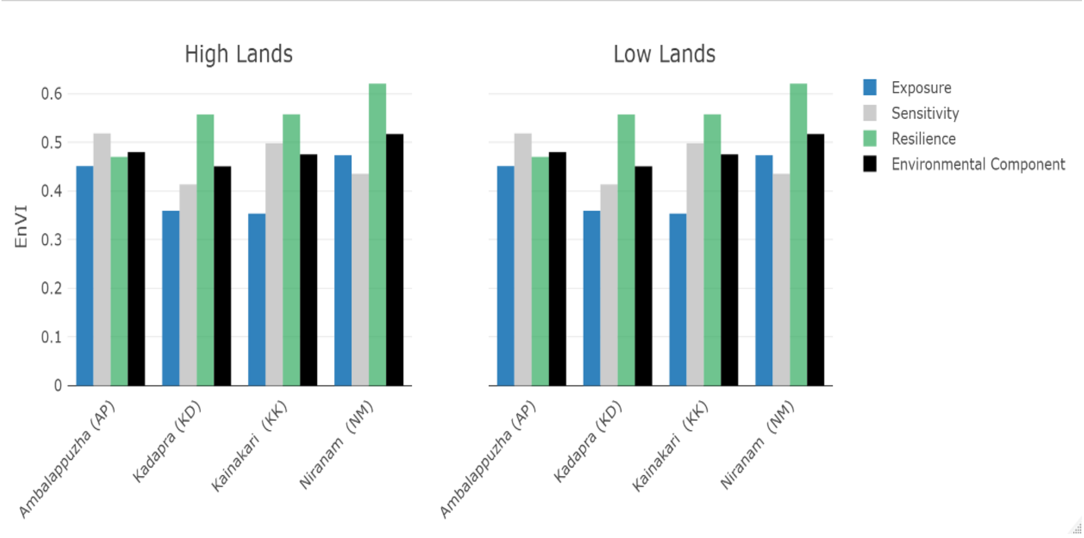


Fig. 6. Factor and panchayat wise results of the physical component of vulnerability

Silva and Kawasaki (2018) administered a socio economic vulnerability assessment among the rural communities of Sri Lanka and concluded that rural households who suffered from frequent floods and cyclones, found it harder to recover from losses when compared to others. In the case of housing of members, 21% of the respondents lived in houses which are fired or unfired brick or laterite walled but roofed with sheet such as asbestos. About 33% of the respondents resides in traditional Kerala homes which are made of clay, bricks and roofed with tiles. Such homes however have an age of more than 40 years.

Furthermore, 36% of the respondents lives in small concrete homes and age of such homes ranged from 5 to 15 years. Moreover, 73% of the respondents lives in homes which has only one floor. In highlands, 38% of the respondents have tiled roof homes with fired or unbricks walls. Age of such buildings were also more than 20 years. However, 36% of respondents lives in 2- room concrete houses and majority of the respondents received their houses through Pradhan Mantri Awas Yojana which is an initiative by the Government of India in which affordable housing is provided to the poor with a target of building 2 crore affordable houses by 31 March 2022 (GoI, 2015).Solin (2012) who conducted spatial flood variability assessment of urban areas in the headwater basins of Slovakia reported that even though earthen houses are considered to be more susceptible to floods, single storey houses and those which are older than 20 years are expected to be experience more damage.

In addition to the type of housing, height or depth of flood water is also an indication of vulnerability (Solin, 2021). Average height of water level in residence in lowlands was about 3 ft and in highlands it was about 1.3 ft. Higher flood water level in residences of lowlands indicates that majority of the people of lowlands have not elevated their homes above the expected flood water level (Botzen *et al*., 2019). This is indeed true, because the number of houses with increased plinth level or the number of houses built on poles is low. Win *et al* (2018) explained the relation between the height of water level and vulnerability to floods in his study on flood damages in the Bago river basin of Myanmar. According to them, houses with plinth level below the average flood water level suffer higher in- house damage, which further reduces their adaptive capacity.

Rainwater harvesting (RWH) systems represents a valuable solution to reduce the dependence on natural drinking water sources at the time of disasters. It also has additional benefits such as greater retention of rain water and reduction in the flood volume and peak (Freni and Liuzzo, 2019). In lowlands, when 35% of the households had installed a water harvesting structure, in highlands, only 18% of households has a similar structure.

Commonly used water harvesting structures are plastic or concrete tanks (19%) and ponds (13%). Freni and Liuzzo (2019) conducted a study to assess the role of RWH in flood reduction and two scenarios (with and without RWH) was taken into consideration. According to their results, RHS has been able to reduce the number of failures of drainage system and flood volume. Therefore, lower number of RWH systems reduce the resilience of the system to floods.

4.1.2. Comparison of major components under study

The major components for the SVI^{FL} are compared in Table 5. We found that there is a considerable difference in the vulnerability values obtained by the regions for each component under study. Looking into the component wise average vulnerability values, it is found that, economic component has the highest vulnerability (0.530), followed by environmental vulnerability (0.500) and physical vulnerability (0.469). Surprisingly, social component has exhibited the lowest vulnerability to natural disasters in Kerala.

Moreover, among the eight regions significant difference among the highest and lowest vulnerability values is found in the economic component (0.447), followed by physical component (0.429) and social component (0.2). Environmental component showcased the least significant difference among the eight regions with only a negligible difference of 0.09 (Table 5)

Table 5. Comparison of vulnerability among the components under study

Region	**Social**	**Economic**	**Environmental**
AD	0.442	0.337	0.479
KK	0.335	0.561	0.475
KD	0.314	0.268	0.450
NM	0.363	0.568	0.517

AD	0.456	0.590	0.484
VT	0.485	0.571	0.549
PM	0.424	0.626	0.519
MD	0.514	0.715	0.526
Mean	0.417	0.530	0.500

4.1.3. Societal Flood and Landslide Vulnerability Index (SVI^{FL})

4.1.3. a. Overall comparison of SVI^{FL}

In the previous section, the four components of vulnerability has been discussed in detail. The regions has their characteristic topographical differences which further influences their vulnerability. For instance, when low lands of Kerala which includes AP, KK, KD and NM is prone to riverine and flash floods, high lands which includes AD, VT, PM and MD is prone to landslides. Therefore there is a clear difference in the forms of disaster faced by each study region. The Societal Flood and Landslide Vulnerability Index (SVI^{FL}) is obtained by measuring all four components of vulnerability as mentioned below that is social, economic, environmental and physical (Table 6). The methodology explained in the previous section has been used to compute the SVI^{FL}.

Table 6. Computation of SVI^{FL} a measure of four individual indices

Region	**Social**	**Economic**	**Environmental**	**Physical**	SVI^{FL}
AP	0.442	0.337	0.479	0.626	0.471
KK	0.335	0.561	0.475	0.667	0.509
KD	0.314	0.268	0.450	0.442	0.369
NM	0.363	0.568	0.517	0.473	0.480
AD	0.456	0.59	0.484	0.466	0.499

VT	0.485	0.571	0.549	0.373	0.494
PM	0.424	0.626	0.519	0.238	0.452
MD	0.514	0.715	0.526	0.465	0.555

The SVI^{FL} results of the study are given in Table 7 and Fig.7 along with the interpretation of the results.

Table 7. Computed Total SVI^{FL} value

Region	**SVI^{FL} values**
AP	0.471
KK	0.509
KD	0.369
NM	0.480
AD	0.499
VT	0.494
PM	0.452
MD	0.555
Total SVI^{FL}	**0.479**

As per Table 7, there is significant difference in the values of vulnerability across the eight regions under study. The SVI^{FL} values varies from 0.369 (low vulnerability) to 0.555 (high vulnerability). The findings of our study are similar to the studies conducted by Rana and Routray (2018), and Ullah *et al* (2021) where they found significant difference among their study areas regarding multidimensional vulnerability to disasters.

According to the SVI^{FL} values, MD in WYD appears to be the most vulnerable region among the study areas with a SFLVI index value of 0.555. MD which experiences frequent landslides during the monsoons (Sajinkumar *et al.,* 2014; Jain *et al*., 2021) is specifically vulnerable to disasters predominantly due to a very high economic vulnerability along with high social, environmental, and physical vulnerability (Table 7).

The next highest vulnerability was recorded for KK (0.509), the low lying flood prone region of ALP. The higher vulnerability of KK which floods almost every year was mainly due to their very high physical vulnerability along with high social, economic and environmental vulnerability (Table 7).

The lowest vulnerability when compared with other regions was found for KD (0.369) of PTM. KD has comparatively low social, economic, environmental and physical vulnerability (Table 7).

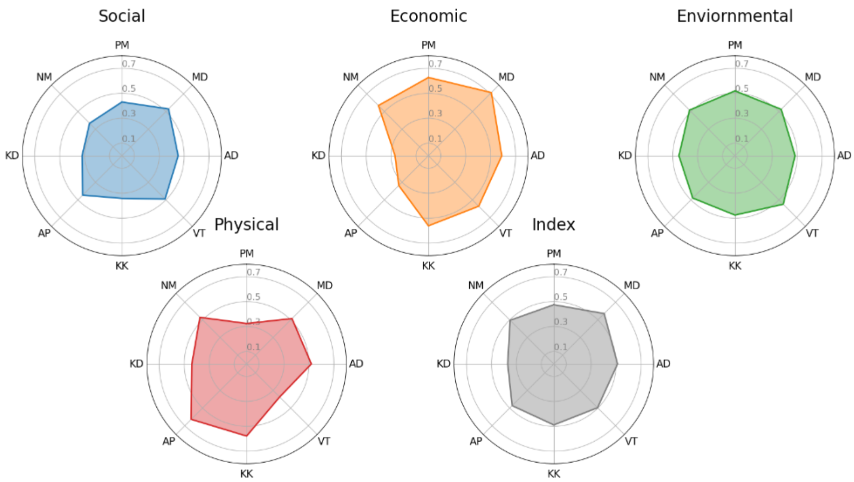


Fig.7. Overall comparison of vulnerability among the eight panchayats under study.

4.1.3. b. Comparison of SVI^{FL} between highlands and lowlands

When we compare the highlands and lowlands under study, (Table 8 and Fig.8) it can be found that vulnerability values in the lowlands varied from 0.369 (Min) to 0.509 (Max). Whereas in the case of highlands, the SVI^{FL} values varied from 0.452 (Min) to 0.555 (Max). The degree of SVI^{FL} was higher in highlands (Mean = 0.457) compared to lowlands (Mean = 0.500).

Table 8. Comparison of SVI^{FL} between highlands and lowlands

Lowlands	**SVI^{FL}**	**Highlands**	**SVI^{FL}**
AP	0.471	AD	0.499
KK	0.509	VT	0.494
KD	0.369	PM	0.452
NM	0.480	MD	0.555
Mean	**0.457**	**Mean**	**0.500**

Individually, social (mean=0.470), economic (mean=0.626) and environmental (0.520) vulnerabilities were found to be higher in highlands compared to lowlands; social (mean=0.363), economic (mean=0.433), and environmental (mean =0.480) respectively. However, the physical vulnerability, was higher in lowlands (mean=0.552) compared to highlands (mean = 0.386). Table 9 shows the comparison of components between highlands and lowlands

Table 9. Comparison of components between highlands and lowlands

Lowlands	**Social**	**Economic**	**Environmental**	**Physical**
AP	0.442	0.337	0.479	0.626
KK	0.335	0.561	0.475	0.667
KD	0.314	0.268	0.45	0.442
NM	0.363	0.568	0.517	0.473
Mean	**0.363**	**0.433**	**0.480**	**0.552**
Highlands	**Social**	**Economic**	**Environmental**	**Physical**
AD	0.456	0.59	0.484	0.466
VT	0.485	0.571	0.549	0.373
PM	0.424	0.626	0.519	0.238
MD	0.514	0.715	0.526	0.465
Mean	**0.470**	**0.626**	**0.520**	**0.386**

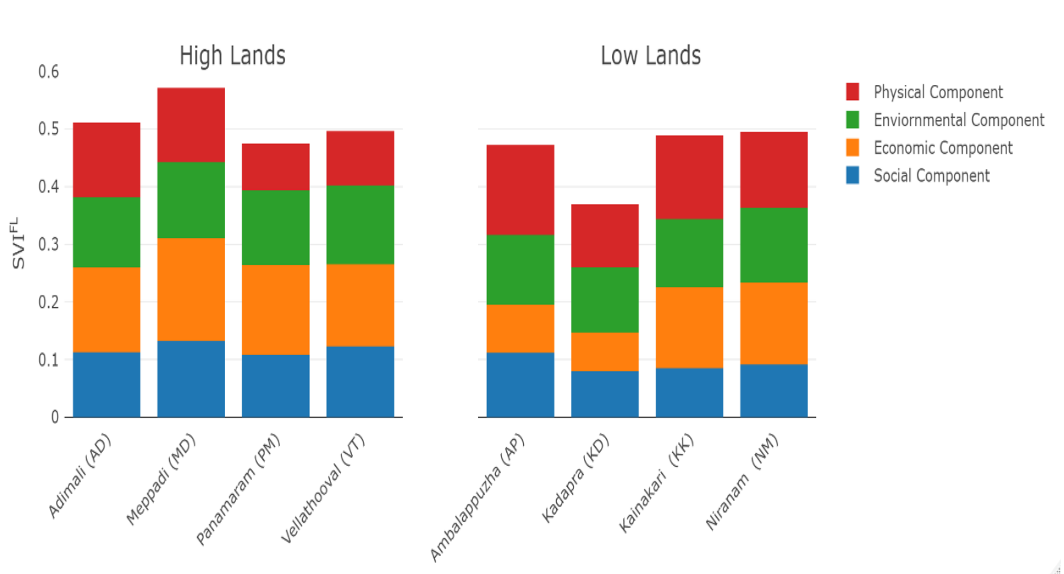


Fig. 8. Differences in values of components of the dimensionless Societal Vulnerability Index for Floods and Landslides (SVI^{FL}) across panchayats

4.1.4. Implications of the study

From the results of the study, it is clear that the vulnerability of farmers in Kerala cannot be reduced with a one-size-fits-all solution. Therefore, an integrated approach in the pre-disaster phase (risk reduction), emergency response phase and post-disaster phase (response) is essential. During the pre-disaster phase, disaster mitigation actions should be employed to strengthen the capacity and resilience of farming households to protect their lives, land and livelihoods. During the disaster phase, the focus should be on the most vulnerable population and the elimination of immediate hazards. In the post-disaster phase, efforts need to focus on recovery and reconstruction, and enabling farmers to make a living to get back to better than before (Mitchell and Garibay, 2011). Therefore, an attempt has been made to document the most vulnerable areas that require attention during three phases of disaster risk reduction. Figure 9 denotes the disaster risk reduction framework for the four components studied for the farmers of lowland and highland panchayats.

At the policy level, the disaster risk reduction framework should focus on strengthening individual and institutional capacity. Regarding the social component, there are some main areas that need to be considered when building individual capacity for disaster risk reduction. Prior to the disaster phase, the mental health of farmers needs to be strengthened so that they can effectively survive a disaster. To reduce the incidence of post-traumatic stress disorders among farmers, a team of mental health experts should be formed to identify and treat the psychological impact of floods at an early stage. To reduce the psychological and financial impact of flooding, farmers should be educated on the various coping mechanisms and farming practices that can be adopted before the disaster strikes. Since flooding in polluted water bodies has the potential to make groundwater unsafe for human use such polluted water sources need to be cleaned before the onset of the monsoon or flood season.

For an effective rescue operation, local authorities must follow a standard operating procedure to minimize flood-related damages. The standard operating procedures must be prepared at the panchayat level with the aim of rescuing all flood victims, especially vulnerable community groups (GOI, 2016). At the institutional level, emergency response and expert medical teams need to be strengthened to meet the needs of victims. In addition, early flood warning systems, which include risk knowledge, monitoring and forecasting, warning dissemination, and communication and response capabilities should be recognized and invested in to reduce risks and damages.

As for the economic component, a flood and landslide vulnerability map need to be prepared at the household level to identify the most vulnerable population. They also need to be evacuated to safer locations as soon as the occurrence of a disaster is foreseeable. As mentioned earlier, insurance is an important risk transfer tool that can make an important contribution to the financial management of flood risk Therefore, policies and programs need to be formulated to include farmers in insurance coverage.

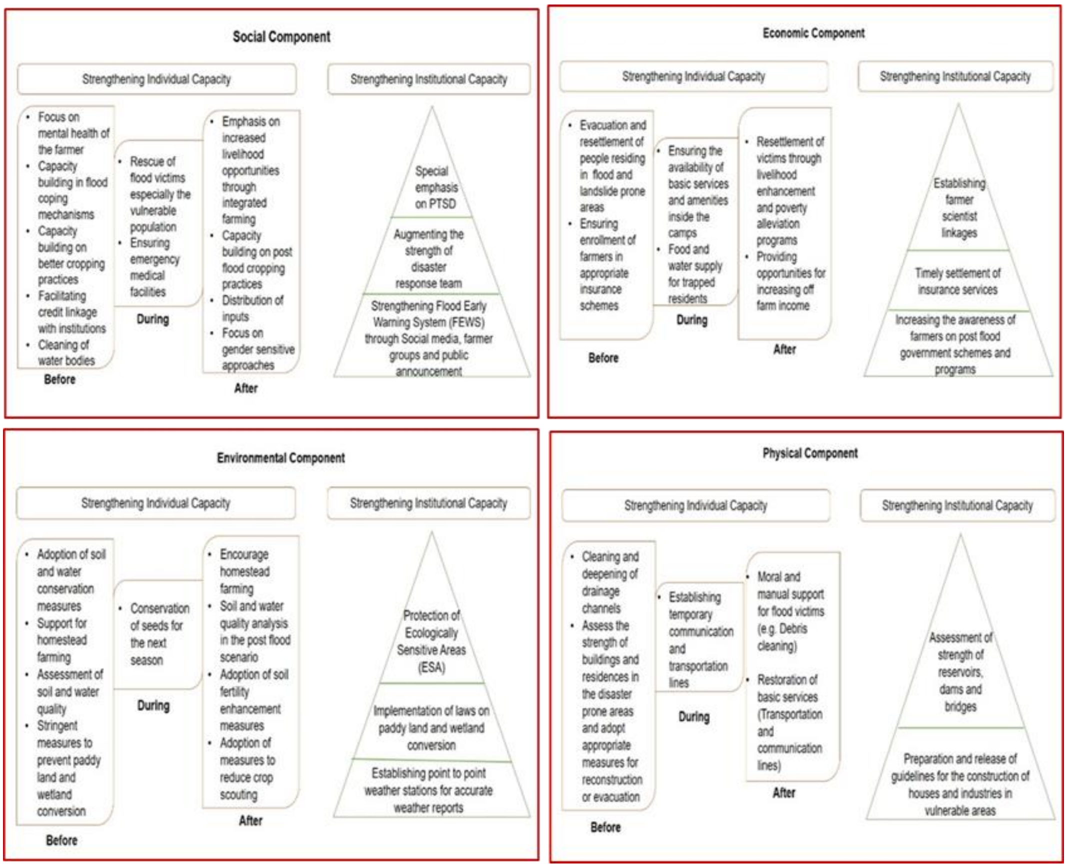


Fig 9. Component wise disaster risk reduction (DRR) framework developed on the basis of (SVI^{FL})

The environmental component is an important area that requires attention, especially in the Pre-disaster phase. Measures to conserve soil and water, protect wetlands and environmentally vulnerable areas, and prevent the conversion of rice cultivation areas will help reduce the impact of flooding. In addition, homestead farming can also be promoted to ensure food and nutrition security. As floodwaters recede, soil and water testing can be conducted to assess the fertility of soil and water for crop production. Soil conservation measures such as mulching, contour bunding, and tree planting should be conducted at highlands and in lowlands, measures such as construction of embankments and geotextiles should also be adopted.

As for the physical component, dilapidated buildings, bridges and houses should be identified and appropriate measures taken in the pre-disaster phase. Drainage channels and natural waterways should be cleaned and deepened in time before the onset of the monsoon to ensure unobstructed rainwater runoff. In the post-disaster phase, timely restoration of transport, communication and other basic services is of great importance as it can accelerate or hinder farmers' recovery. At the institutional level, guidelines should be issued for the construction of ouses and buildings in flood-prone and landslide-prone areas, clearly specifying the type of construction materials to be used and the location of construction.

4.2. VULNERABILITY MAPS DENOTING VULNERABILITY HOTSPOTS

Vulnerability maps are used to direct attention to geographic areas where impacts of disaster on society are expected to be greatest and that may therefore require urgent adaptation interventions (Sherbinin *et al.*, 2019). Vulnerability Mapping is not only a tool to develop the action plan but it capacitates the people to identify their vulnerability and help them to find out the opportunities. It is not constant and it can be changed through the empowerment of community to take the effort by themselves to address their vulnerability. In this study, maps has been created with the help of ArcGIS software.

4.2.1. Vulnerability map of Adimali panchayath

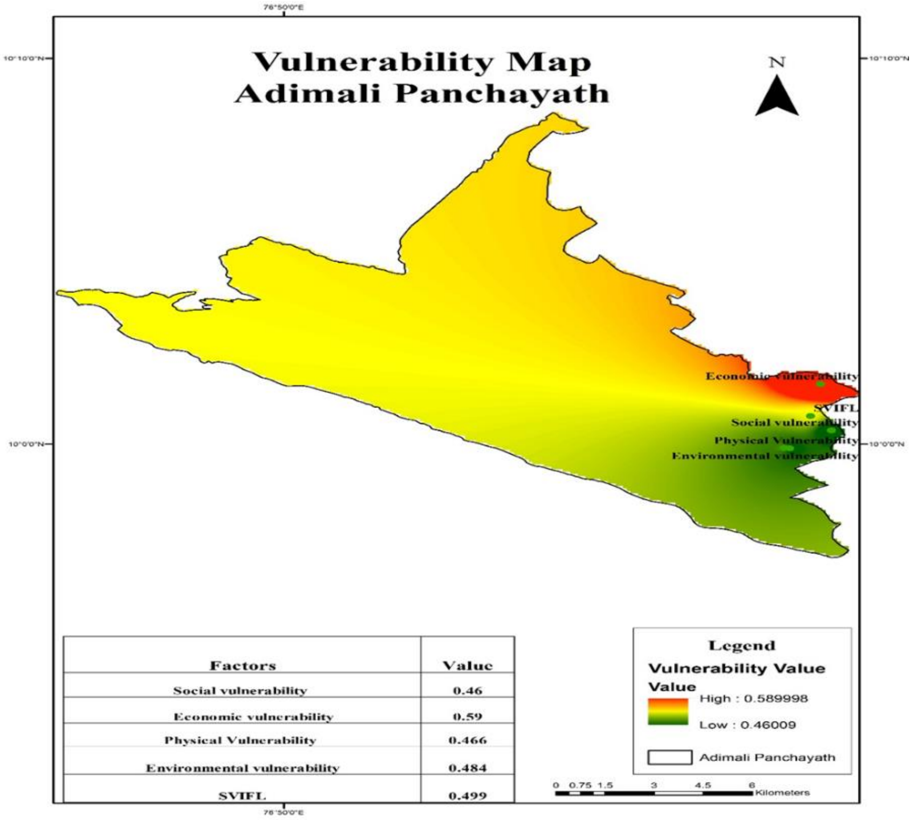


Fig.10. Vulnerability map of Adimali panchayath

In the vulnerability maps constructed for the study, areas marked in red indicates very high vulnerability, the shades of yellow indicates moderate vulnerability and green denotes low vulnerability. From the vulnerability map of Adimali, it is clear that the region is highly vulnerable to economic component (0.59) mainly due to high sensitivity to indicators such as unemployment (0.765), urban growth rate (1.00) and households below poverty line (0.873) (see Appendix II)Low resilience capacity also contributed to the high vulnerability of Adimali panchayath.

Low resilience is mainly because of indicators such as lower enrolment in insurance schemes (1.00), higher recovery time (0.909) and low savings (0.616) to recover in the post flood phase. Figure 10 indicates the extent of vulnerability of each component and overall vulnerability of Adimali panchayath

4.2.2. Vulnerability map of Vellathooval panchayath

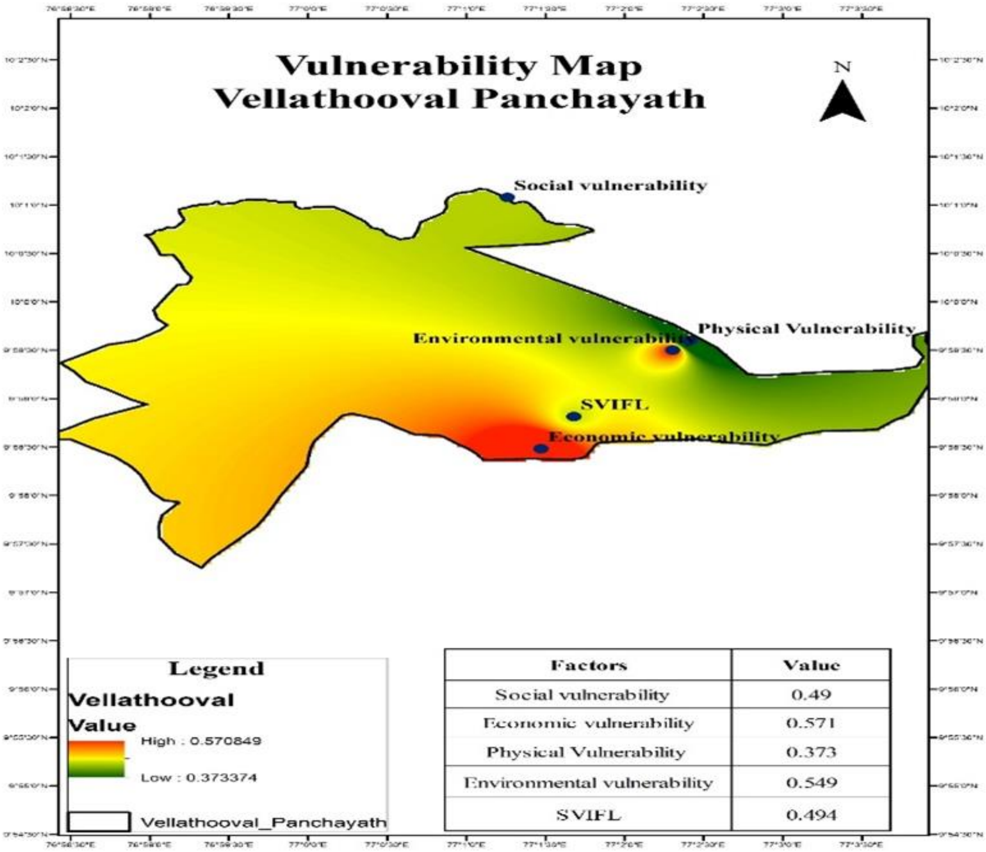


Fig. 11. The vulnerability map of Vellathooval.

Vellathooval panchayath of Idukki district is also vulnerable to economic component. The major factors which contributed to the economic vulnerability were higher sensitivity to flood associated landslides and lower resilience to return to normalcy in the post flood phase. The major indicators that contributed to high sensitivity were an increasing urban growth rate (1.00) and higher number of households below poverty line (0.873). The major indicators that influenced the low resilience capacity of Vellathooval farmers were lower number of farmers enrolled in insurance schemes (0.921), lower number of Institutional Organizations, and low savings to sustain in the post flood situation.

4.2.3. Vulnerability map of Panamaram pachayath

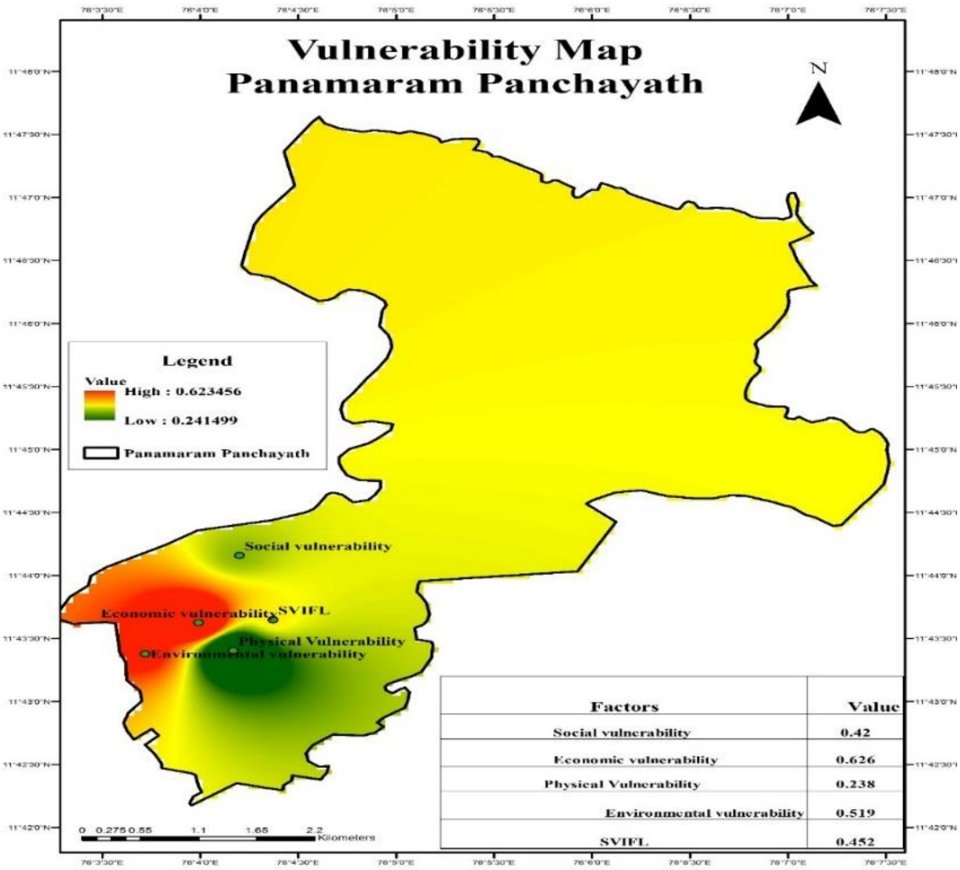


Fig. 12. The vulnerability map of Panamaram panchayath

Figure 12 shows the vulnerability map of Panamaram panchayath. In the case of Panamaram panchayath too, it is the economic vulnerability that has scored the highest. In this region, it is the lower resilience factor that has contributed to the overall vulnerability. The major indicators that has led to the decreased resilience capacity were lower number of institutions related to disaster management (1.00), higher recovery time to normalcy (0.718) and meagre savings (0.865) to sustain their livelihood when the flood water recedes

4.2.4. Vulnerability map of Meppadi panchayath

Meppadi panchayath of Idukki district of highlands is highly vulnerable, especially to economic component same as that of other regions in the highlands. Higher economic vulnerability of Meppadi panchayath is also due to higher sensitivity and low resilience. Higher sensitivity is due to higher unemployment rate (0.804), higher number of households under below poverty line (1.00) and an increased urban growth rate (0.731). Figure 13 shows the vulnerability map of Meppadi panchayath**.**

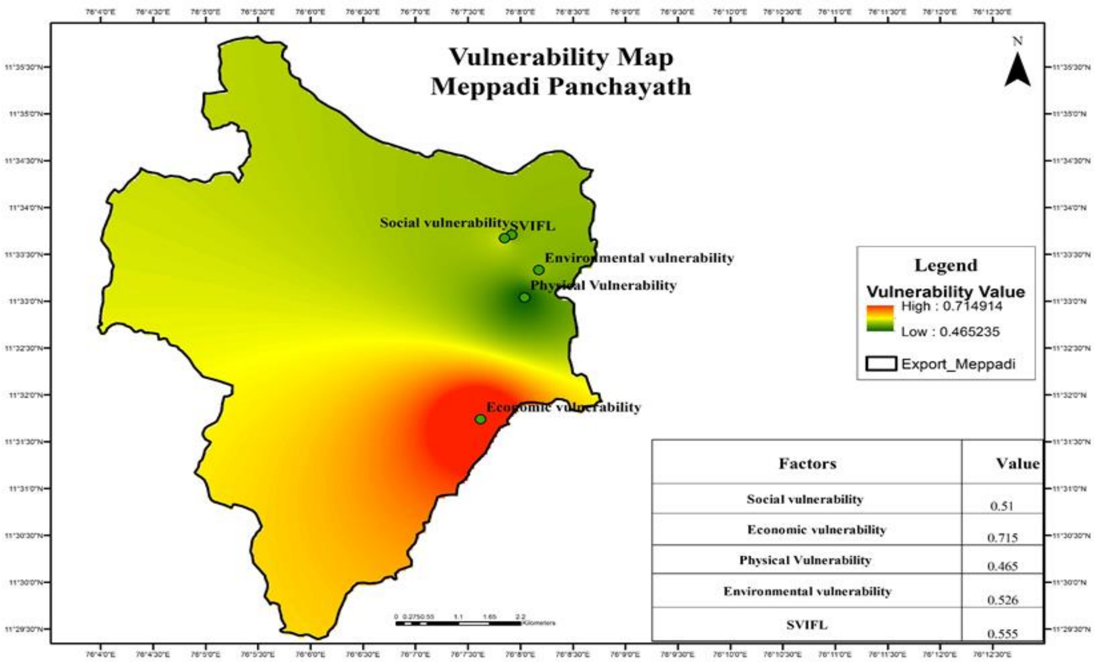


Fig. 13. The vulnerability map of Meppadi panchayath

4.2.5. Vulnerability map of Ambalappuzha panchayath

Ambalappuzha panchayath in the Alappuzha district (lowlands) is a region which floods almost every year. As the map indicates, there is a difference in vulnerability faced by both lowlands and lowlands. In the case of highlands, vulnerability was mainly due to the economic components, whereas in the case of lowlands vulnerability was mainly due to the physical vulnerability followed by social vulnerability. In the case of physical vulnerability, of Ambalappuzha panchayath, the major factors that has led to its vulnerability are high exposure and lower resilience. High exposure is mainly due to indicators such as increasing frequency of floods over a period of 10 years (1.00) and increasing height of flood water in homes (0.967). Figure 14 shows the vulnerability map of Ambalappuzha panchayath

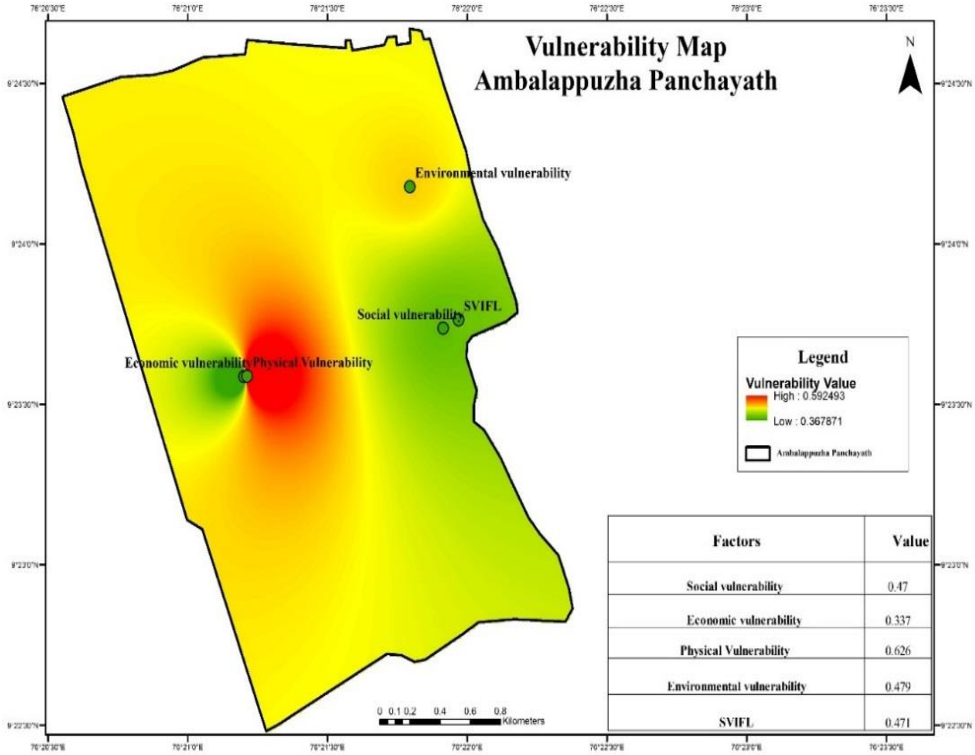


Fig.14. Vulnerability map of Ambalappuzha panchayath

4.2.6. Vulnerability map of Kainakari Panchayath

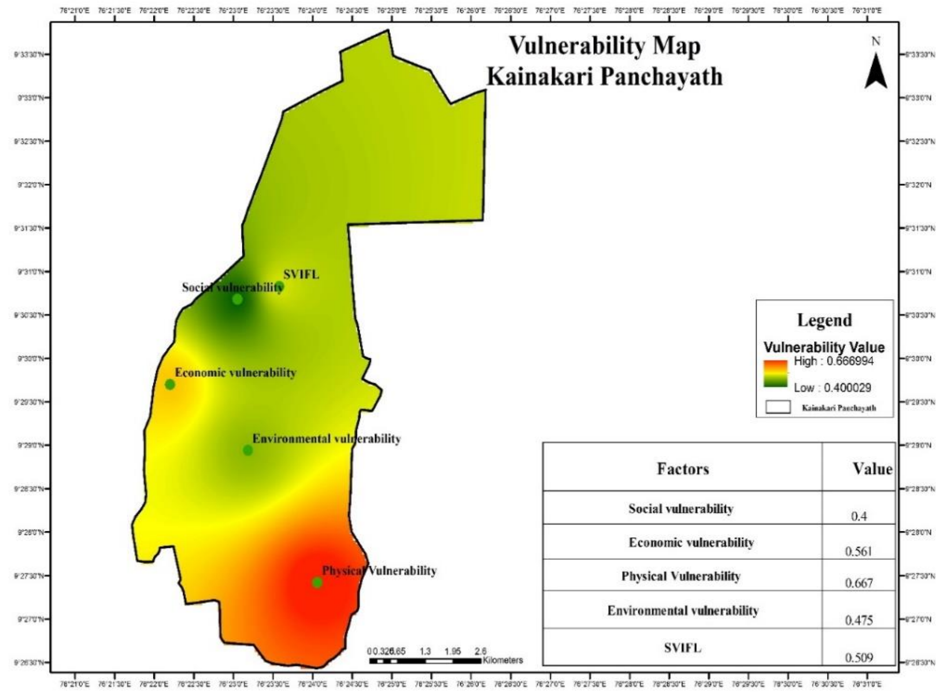


Fig.15.Vulnerability map of Kainakari panchayath

As the figure 15 indicates, Kainakari panchayath of Alappuzha district is also highly vulnerable to physical components followed by economic vulnerability. In this case of physical vulnerability, the major contributors were high exposure (0.803) and low resilience (0.886). High exposure can be attributed to indicators such as disaster frequency (1.00) and height of water level in the residence (0.967).

4.2.7. Vulnerability map of Kadapra

Kadapra panchayath of Pathanamthitta is also a lowlying region which has started experiencing recurrent floods in the last few years. In the case of Kadapra panchayath, it is the environmental vulnerability that has contributed to the overall vulnerability of the region, and it is the low resilience factor that has led to higher environmental vulnerability. Lower resilience might be due to indicators such as decreasing area under forest (1.00), lower water quality (1.00), lower adoption of homestead farming (1.00) and lower adoption of soil conservation measures (0.681). Figure 16. indicates the different components of vulnerability in Kadapra panchayath

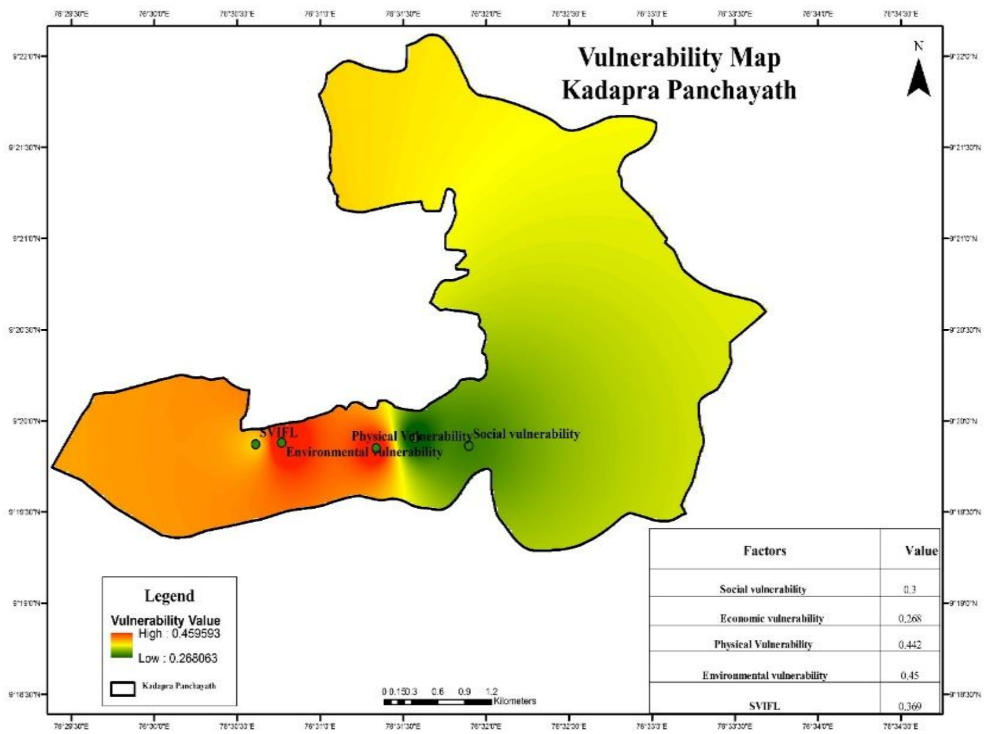


Fig.16. Vulnerability map of Kadapra panchayath

4.2.8. Vulnerability map of Niranam panchayath.

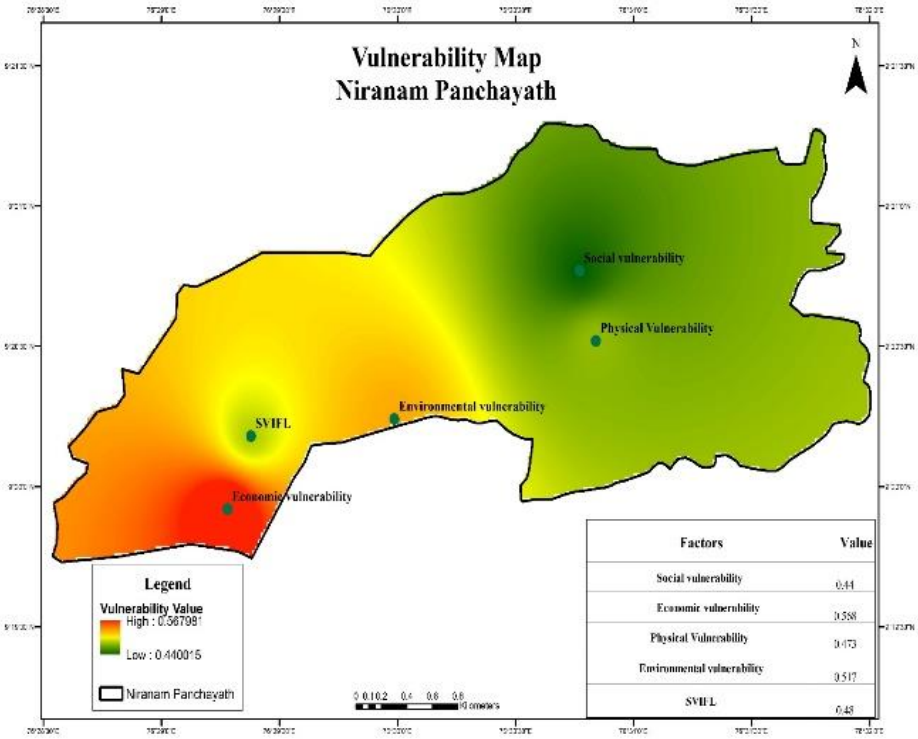


Fig.17. Vulnerability map of Niranam panchayath

In the case of Niranam panchayath, similar to that of highlands, it is the economic vulnerability that has led to higher vulnerability. Higher economic vulnerability is mainly due to higher proximity of residences to river (0.7), higher rates of unemployment (1.00), lower number of institutions dealing with disaster management, higher period of recovery and lower number of people enrolled in insurance schemes (0.86). Figure 17 indicates the vulnerability map of Niranam panchayath

4.3. DELINEATION OF COPING STRATEGIES AT INDIVIDUAL COMMUNITY AND ADMINISTRATIVE LEVELS

Coping mechanisms is a key concept of emergency management and is closely related to the idea of survival, and threat (WHO, 1999).Coping mechanisms adopted at three different levels of individual, community and administrative levels were analysed and the results are documented in the flowing sections

4.3.1. Coping mechanisms adopted by the farmer at individual level in highlands

In this, the different disaster coping mechanisms adopted by the farmer and his household in the different phases (pre, during and post) of the disaster are discussed. Here, the adoption of coping mechanisms depends upon the financial ability of the farmers, awareness about the disaster, and exposure to other related organizations etc. Coping Strategies Index for Floods and Landslides (CSI^{FL}) has been used to document the results. Table 10 indicates the CSI^{FL} scores and their rankings based on which the commonly adopted strategies has been identified (n=257)

Table 10. CSI^{FL} scores in highlands

Dimensions	**Flood coping strategies**	**CSI^{FL}**	**Ranking**
Food security	Storage of food items	391	20
	Collection and storing of drinking water	502	8
	Rely on less preferred items, and on food items received during relief	523	7
	Reduction in the frequency of meals	480	10
	Mean	**474**	
	Standard Error	**29.026**	
	Standard Deviation	**58.052**	
Housing and Shelter	Resorting to shelters and evacuation centers	572	5
	Daily observations	427	16
	Taking shelters at relatives houses	473	12
	Shifting from endangered homes	489	9
	Transferring of valuables to safer places	571	6
	Belting the slopes	279	26
	Mean	**468.6**	
	Standard Error	**44.53**	

	Standard Deviation	**109.08**	
Crop production, protection and livestock	Crop diversification is practiced by planting different types of crops on a single area	627	3
	Vegetables are grown in the homesteads and their seeds are preserved for the next season	661	2
	Cultivation of short duration crops	431	15
	Planting across the slope	417	17
	Transferring of livestock and poultry to warm & safer place	398	19
	Change in cropping pattern	326	24
	Increased dependence on chemical farming	581	4
	Construction of farm ponds and drilling bore well	373	23
	Field mulching	552	6
	Mean	**485.11**	
	Standard Error	**40.45**	
	Standard Deviation	**121.34**	
Health and sanitation	Traditional medicines are used	304	25
	A first aid kit is prepared in advance	257	27
	Arranging essential medicine	478	11
	Mean	**346.33**	
	Standard Error	**67.22**	
	Standard deviation	**116.42**	
	Livestock is sold for money	386	22

Means of livelihoods	Borrow from moneylenders, commercial banks, private banks and friends	669	1
	Engaging in meagre work to earn	468	13
	Spend money from savings	389	21
	Migrate to city or other area	467	14
	Diversifying income sources through new enterprises	415	18
	Mean	**465.6**	
	Standard Error	**43.26**	
	Standard Deviation	**105.96**	

In the case of highlands, the most commonly adopted coping strategy comes under the component means of livelihoods. In the post disaster phase, most of the farmers suffer from huge economic losses either due to loss of harvest, livestock or due to damage for homes, and other entities. As a result, there could be an increasing tendency among the farmers to borrow money from informal and formal sources. That would be the reason behind this strategy getting ranked one in CSI^{FL}. This finding is consistent with the results of He (2019) who reported that, during the post disaster phase in Nepal, poor farmers borrow money from wealthy people in other villages to cover their cash expenses for many years, even at interest rate ranges as high as 24%, generating an inexorable growth of indebtedness for poor households. Second most commonly followed strategy includes the increased adoption of homestead gardening among the respondents. In the case of highlands, the commonly grown crops in the pre- disaster phase included cultivation of banana, nutmeg, coffee, rubber, cardamom and tapioca. However in the post disaster phase, may be to ensure food and nutritional security, the number of households adopting homestead gardening has increased considerably. This is in line with the results of Alam *et al.* (2017) and Alam and Rahman (2013) who conducted studies in the flood prone regions of Bangladesh and reported that homestead vegetable gardening as a major coping strategy in the pre and post disaster phase.

Furthermore, mean, standard deviation and standard error has been calculated to find out which component has the highest number of strategies above the mean value. As per the results of the table, in housing component and crop component has the maximum number of strategies higher than the mean value. This is on par with the results of Mathew *et al*. (2018) who documented the adoption of maximum number of coping strategies under the areas of housing, crop production and food security.

4.3.2. Coping mechanisms adopted by the farmer at individual level in lowlands (n=263)

According to the results of Table 11, the most commonly adopted coping strategy among lowlands comes under the component crop and livestock production and protection. Under this component, increased dependence on chemical fertilizers for better yield and crop protection has scored the highest value (776) and the highest rank. Farmers of lowlands, mainly of Kainakari and Ambalappuzha are reported to have suffered huge losses in paddy farming due to floods and heavy rainfall. There are even *padashekharams* such as *Kanakasseri padashekharam* which could not harvest their paddy fields since 2018. Moreover, many farmers also reported heavy incidence of diseases such as sheath blight and attack of pests such as leaf minor and mealy bug.

Such a situation in the post flood phase might have made the farmers to depend more on chemical fertilizers and pesticides to overcome the losses and to obtain better yield in the next season. Osei *et al*. (2020) conducted an assessment in the flood prone farm lands of Tarkwa mining areas of Ghana and reported that 42.59% of the farm lands under study area were highly prone to flooding and farmers resorted to high usage of chemical fertilizers to increase yield , which further leached into nearby rivers, streams, lakes and groundwater during flood occurrence. Second most commonly adopted strategy is the increasing tendency to borrow money to cope with the desperate situations. This is similar to the case of highlands.

When mean, SD and SE was calculated for each component, it was found that higher mean value, low standard error and higher number of strategies with value greater than the mean value was found for the components namely Crop and livestock production and Housing and Shelter. These results are similar to the case of highland regions.

Table 11. CSI^{FL} Scores in lowlands

Dimension	Statements	CSI^{FL}	Ranking
Food Security	Storage of food items	536	9
	Collection and storing of drinking water	702	3
	Storage of grains in structures (Pathayam)	374	20
	Rely on less preferred items, and on food items received during relief	651	5
	Reduction in the frequency of meals	437	13
	Mean	**540**	
	Standard Error	**61.9**	
	Standard deviation	**138.52**	
Housing and Shelter	Increased plinth height of the house	463	11
	Placing of sandbags around the house at the onset of monsoons	357	21
	Resorting to shelters and evacuation centres	652	4
	Taking shelters at relatives houses	560	7
	Construction of house on pillars	305	27
	Construction of houses with materials like hollow bricks	323	25
	Increase the storey of the house or add a roof to the terrace	425	16

	Transferring of valuables to safer places	550	8
	Mean	**451.89**	
	Standard Error	**39.05**	
	Standard deviation	**117.149**	
Crop production, protection and Livestock	Crop diversification is practiced by planting different types of crops on a single area	464	10
	Vegetables are grown in the homesteads and their seeds are preserved for the next season	464	10
	Cultivation of short duration crops before floods	326	24
	Cultivation of flood tolerant varieties	265	31
	Livestock and poultry sheds at a height	319	26
	Managing dry feed for cattle and poultry	339	22
	Transferring of livestock and poultry to warm & safer place	402	18
	Change in cropping pattern	429	15
	Increased dependence on chemical fertilizers for higher yield and pesticides against pests	776	1
	Mean	**420.44**	
	Standard error	**39.05**	
	Standard deviation	**117.15**	
Health and sanitation	Traditional medicines are used	294	29
	A first aid kit is prepared in advance	302	28
	Storing ‘oral saline’ to control outbreak of diarrheal disease	263	32

	Arranging essential medicine and water purifying tablets	587	6
	Keeping carbolic acid in room to prevent snake	263	33
	Mean	**341.8**	
	Standard error	**56.43**	
	Standard deviation	**138.21**	
Means of livelihoods	Livestock is sold for money	395	19
	Borrow from moneylenders, commercial banks, private banks and friends	712	2
	Engaging in meagre work to earn	410	17
	Spend money from savings	448	12
	Migrate to city or other area	282	30
	Diversifying income sources through new enterprises	335	23
	Mean	**430.33**	
	Standard error	**61.21**	
	Standard deviation	**149.93**	

Moreover, an ANOVA test (Table 12) has been performed to find out the significant difference between the different coping strategies adopted by the farmers among the four panchayaths of highlands and lowlands respectively.

Table 12. ANOVA of coping strategies among the four panchayaths of highlands and lowlands

Comparison of coping strategies among the four panchayaths of highlands and lowlands	
Region	**p- value**
Highland	2.04E-10
Lowland	2.17392E-14

The results of ANOVA shows that there is significant difference among the strategies adopted by the farmer households among the regions under study. This might be due to the differences in age, gender, family size, farm income, and farm size across different households.

This is in line with the results of Bate *et al*. (2019) and Marie *et al*. (2020), who claimed that farmer's decision to coping strategies is influenced by age, gender, family size, farm income, market access and access to market information.

4.3.3. Coping strategies adopted at the community level

In the previous section, coping mechanisms at the individual level was dealt with .Here, the coping strategies adopted at the society or community level has been analysed. For this, farmer respondents were asked to identify those coping strategies which were implemented in the community they reside in.

4.3.3.1. Coping strategies at community level in highlands (n=257)

Coping strategies specific to the regions of highlands has been identified and they have been scored and ranked to calculate the Coping Strategies Index at community level. Table 13 shows the different strategies identified and their scores obtained.

Table 13. Coping strategies at community level in highlands

Dimension	Statements	CSI^{FL}	Ranking
Food security	Providing relief materials including food, medicines, blankets and clothes.	744	1
	Provisions for availability of drinking water	702	2
	Sharing of food and food materials between neighbours	433	8
	Mean	**626.33**	
	Standard deviation	**168.74**	
	Standard error	**97.4240**	

Housing and shelter	Arrangement of temporary shelters	720	3
	Evacuating the people, especially the children, pregnant women and elderly to safer places	582	5
	Restoration of communication facilities	403	10
	Cleaning of houses and roads	418	9
	Mean	**530.75**	
	Standard deviation	**149.97**	
	Standard error	**74.98**	
Crop production, protection and livestock	Arranging feed for cattle and poultry	335	16
	Transferring livestock and poultry to safer places	391	13
	Bunding and terracing	434	7
	Redirecting active streams from the landslide site	362	15
	Afforestation	384	14
	Mean	**381.2**	
	Standard deviation	**36.72**	
	Standard error	**16.42**	
Health and Sanitation	Providing medicines at the relief camps	514	6

	Evacuating people with serious health conditions to hospitals	656	4
	Distribution of safety gears for those who are involved in rescue operations	267	20
	Distribution of medicines after the disaster	299	19
	Moral support to the victims	319	18
	Mean	**411**	
	Standard deviation	**167.61**	
	Standard error	**74.95**	
Means of livelihoods	Sharing of labour	398	12
	Repairing and construction of temporary roads for emergency services	402	11
	Distribution of seeds	334	17
	Mean	**378**	
	Standard deviation	**38.15**	
	Standard error	**22.030**	

In the case of community level coping mechanisms, most of the coping mechanisms were implemented during the disaster phase, and the component given the most attention was food and security. In the highlands, as the table depicts, distribution of relief materials and ensuring the availability of drinking water has been the priority. During the time of disaster, for the inmates at the evacuation centres, poor households and people trapped within their homes, local people and volunteers ensured that they received food and water on a timely basis. At the community level, relief and rehabilitation was mostly implemented through local people, volunteers, and members of Self Help Groups and NGO's. This is similar to the results of Paul (1998), who conducted a study in the drought prone areas of Bangladesh and reported that when the government response was delayed, members of the community organized themselves as volunteers and led the relief works. Distribution of free food, clothes, medicine and other relief has been the most appropriate public response to those affected by drought.

Mean, Standard error and Standard deviation was calculated. Highest mean value was obtained for the component food security, and the component with higher number of strategies greater than the mean value also belongs to food security followed by housing and shelter. The component with the lowest number of strategies above the mean value belongs to the component of means of livelihoods.

4.3.3.2. Coping strategies at community level in lowlands

Lowlands are more prone to frequent flooding which makes the community more aware and informed about the relief and rescue measures to be undertaken at the time of disaster. Table 14 shows the different coping strategies at community level in lowlands.

Table 14. Coping strategies at community level in lowlands.

Dimension	**Statements**	**CSI^{FL}**	**Rank**
Food Security	Construction of community grain banks	263	18
	Providing relief materials including food, medicines, blankets and clothes.	827	1
	Provisions for availability of drinking water	788	2
	Sharing of food and food materials between neighbours	692	6
	Mean	**642.5**	

	Standard Deviation	**259.28**	
	Standard Error	**129.64**	
Housing and shelter	Arrangement of temporary shelters	718	4
	Evacuating the people, especially the children, pregnant women and elderly to safer places	688	7
	Restoration of communication facilities	367	15
	Cleaning of houses and roads	501	12
	Mean	**568.5**	
	Standard Deviation	**165.12**	
	Standard error	**82.56**	
Crop production protection and Livestock	Digging of drainage channels	479	13
	Construction of embankments and bunds around fields	647	9
	Preservation of seeds in raised structures	263	18
	Arranging feed for cattle and poultry	339	16
	Transferring livestock and poultry to safer places	525	10
	Mean	**401.5**	
	Standard deviation	**152.12**	
	Standard error	**68.03**	
	Providing medicines at the relief camps	654	8
	Evacuating people with serious health conditions to hospitals	737	3

Health and Sanitation	Distribution of safety gears for those who are involved in rescue operations	373	14
	Distribution of medicines post flood	693	5
	Moral support to the victims	298	17
	Mean	**551**	
	Standard deviation	**200.66**	
	Standard error	**89.74**	
Means of livelihoods	Sharing of labour	520	11
	Repairing and construction of temporary roads for emergency services	525	10
	Distribution of seeds	520	11
	Mean	**521.66**	
	Standard Deviation	**2.88**	
	Standard error	**1.66**	

In the case of lowlands too, even though there is difference in nature of disaster and impacts caused by the disaster, the coping mechanisms at the community level remain more or less the same. At community level in lowlands most of the coping mechanisms were adopted during and in the post disaster phase. As the table shows, the most commonly and primarily adopted strategy was distribution of relief materials and ensuring the availability of drinking water with scores 827 and 788 respectively. The results are on par with the findings of Joseph *et al.* (2020), who reported that during the 2018 floods in Kerala, community's apt response overcame the widespread notion of passive victim hood at the time of disasters, wherein even the poor and marginalized fishermen community became volunteers and pooled money from their own pockets to hire trucks that would transport their boats to flood-hit areas for rescue and distribution of food packets.

ANOVA was performed to understand the significant difference between the coping strategies adopted among the different panchayaths of highlands and lowlands. Table 15 shows that there is significant difference between the coping mechanisms adopted within highlands and lowlands. In the case of highlands, even though Wayanad and Idukki has experienced flood associated landslides, the intensity of impact is considerably different for both the regions. When in Wayanad, at Meppadi, the landslide event at Puthumala caused tremendous losses both in terms of lives and assets, it was not much severe in Adimali and Vellathooval when compared to that of Meppadi. This would have resulted in differences in coping mechanisms adopted by the community.

In the case of lowlands too, Kainakari of Alappuzha faces floods almost every year and access to this place is also limited due to physiographic peculiarities. In this case also, coping mechanisms adopted in Pathanamthitta would have been different from that of Alappuzha due to the changes in physiography, nature of impact and frequency of disaster (Table 15)

Table 15. ANOVA of coping strategies among the four panchayaths of highlands and lowlands

Comparison of coping strategies among the four panchayaths of highlands and lowlands	
Region	**p- value**
Highland	9.5669E-124
Lowland	0.007967067

4.3.4. Coping strategies adopted the administrative/ government level

Coping strategies are also adopted at the policy level in the pre, during and post disaster phase to manage the disaster situation. Often such strategies contribute significantly to manage distress shocks.

This section deals with the various coping strategies adopted at the policy level in highlands and lowlands. Table 16. shows the coping strategies adopted at policy/ administrative level in highlands.

4.3.4.a. Coping strategies adopted at policy level in highlands

Table 16. Coping strategies adopted at policy level in highlands.

Dimension	**Indicators**	**CSI^{FL}**	**Rank**
Food Security	Community kitchens at the relief camp sites	837	1
	Incentives for home gardens	380	12
	Supply of foods with greater durability	398	9
	Free food grains through PDS	344	13
	Mean	**489.75**	
	Standard deviation	**232.58**	
	Standard error	**116.29**	
Housing and shelter	Setting up of relief Camps	766	2
	Financial support in clearance of debris	417	8
	Financial support for damaged houses	445	7
	Belting the slopes	257	16
	Mean	**471.25**	
	Standard deviation	**213.24**	
	Standard error	**106.61**	
Crop production protection, livestock and poultry rearing	Early warning system	629	3
	Crop loss compensation	335	14
	Providing support in the implementation of alternative cropping programme	302	15
	Setting up of livestock shelters	277	16
	Vaccination of livestock	490	6

	Mean	**406.6**	
	Standard deviation	**149.39**	
	Standard error	**66.81**	
Health and sanitation	Supply of first aid kits	257	17
	Support for victims suffering from PTSD, anxiety and depression	390	10
	Ensuring stock of, essential medicines and medical supplies	556	5
	Directing trained emergency medical personnel to the affected areas to prevent and respond to outbreak of disease or any other identified health risks	594	4
	Mean	**449.25**	
	Standard deviation	**155.79**	
	Standard error	**77.89**	
Means of livelihoods	Awareness generation programme and activities	257	17
	Vulnerable area adoption	257	17
	Organization of rehabilitation programs	381	11
	Grants to enable people to re-launch business activities	257	17
	Mean	**288**	
	Standard deviation	**62**	
	Standard error	**31**	

In the case of highlands, (Table 16) at the policy or administrative level, the government have focussed mostly on the coping mechanisms during the disaster phase and post disaster phase. In the scenario, as represented in the table, it can be found that the major strategies adopted by the government includes setting up of relief camps (766) and establishing community kitchens (837) at the disaster site. It was followed by another pre disaster strategy of providing early landslide warnings to the landslide prone regions of highlands. However, people failed to realise the gravity of the situation and therefore ignored the warning. As a result, the intensity of the disaster was high in both Meppadi of Wayanad and Kanjiraveli of Adimali.

This result goes in line with the report of National Institute of Disaster Management (2019), wherein they claimed that the major strategies taken up by the government at the policy level falls under the category of evacuation. In this, response consisted of evacuation of humans, livestock and other animals. Immediately after the floods, the basic amenities of providing food, clothing, shelter and medicines to disaster survivors were given utmost importance. The results of mean, SD and SE shows that the highest mean value was obtained for the food security component (489.75) followed by the housing and shelter component (449.25), as component with the most number of strategies, with values higher than the mean value.

4.3.4.b. Coping strategies adopted at policy level in lowlands

The results of the coping mechanisms in lowlands (Table 17) shows that in the case of lowlands too, setting up of relief camps and community kitchens has been given the prime importance. In this case, the results of the highlands and lowlands has been similar. However, the component which has scored the highest mean value is different from that of highlands, wherein housing and shelter has scored the highest value, different from that of lowlands. Table 17 shows the coping strategies adopted at policy level in lowlands.

Table 17. Coping strategies adopted at policy level in lowlands.

Dimension	Indicators	CSI^{FL}	Rank
Food Security	Community kitchens at the relief camp sites	921	2
	Incentives for home gardens	304	15

	Supply of foods with greater durability	341	12
	Free food grains through PDS	381	10
	Mean	**486.75**	
	Standard deviation	**291.20**	
	Standard error	**145.60**	
Housing and shelter	Setting up of relief Camps	945	1
	Financial support in clearance of debris	645	5
	Financial support for damaged houses	456	8
	Mean	**682**	
	Standard deviation	**246.59**	
	Standard error	**142.37**	
Crop production protection, livestock and poultry rearing	Early warning system	820	3
	Repair and maintenance of the embankments	336	13
	Crop loss compensation	333	14
	Providing support in the implementation of alternative cropping programme	368	11
	Setting up of livestock shelters	269	16
	Vaccination of livestock	433	9

	Mean	**426.5**	
	Standard deviation	**200.02**	
	Standard error	**81.66**	
Health and sanitation	Supply of first aid kits	263	17
	Support for victims suffering from PTSD, anxiety and depression	529	7
	Ensuring stock of, essential medicines and medical supplies	658	4
	Directing trained emergency medical personnel to the affected areas to prevent and respond to outbreak of disease or any other identified health risks	548	6
	Mean	**499.5**	
	Standard deviation	**167.60**	
	Standard error	**83.80**	
Means of livelihoods	Awareness generation programme and activities	263	17
	Vulnerable area adoption	263	17
	Organization of rehabilitation programs	263	17
	Grants to enable people to re-launch business activities	263	17
	Mean	**263**	
	Standard deviation	**0**	
	Standard error	**0**	

The results of ANOVA shows that there is significant difference in the different coping strategies implemented by the government in the different regions of highlands. This is probably due to the difference in intensity of landslide events in Wayanad and Idukki. However in the case of lowlands, there is no significant difference in the coping strategies implemented among the four regions of lowlands. Table 18 shows the comparison of coping strategies among the four panchayaths of highlands and lowlands

Table 18. ANOVA of coping strategies among the four panchayaths of highlands and lowlands

Comparison of coping strategies among the four panchayaths of highlands and lowlands	
Region	**p- value**
Highland	2.67064E-41
Lowland	0.08

4.4. DOCUMENTATION OF POST FLOOD LIVELIHOOD INCLUSIVE ACTIVITIES

Livelihood recovery is considered as still being in the experimental stage in disaster management. The knowledge transfer at the time of livelihood recovery suffers considerable shortcomings compared to housing recovery. There is indeed significant gap in knowledge, policies and practices for addressing the complexities of livelihood recovery in urban and agricultural contexts. In this we discuss the various post flood livelihood inclusive activities adopted at the farmer household level in both highlands and lowlands. Table 19 indicates the results of the analysis of livelihood activities adopted by the farmers in the post flood situation.

As the table indicates, the adoption percentage of post flood livelihood inclusive activities were low in both highlands and lowlands. However, when we look in detail into the livelihood activities adopted in the case of highlands, it can be found that, farm diversification (60.8%) is the most commonly adopted livelihood sustaining strategy among the identified livelihood mechanisms. In the case of highlands, in the pre – disaster phase, farming was mostly limited to the cultivation of crops such as pepper, banana, cardamom, tapioca and nutmeg in Idukki and paddy, arecanut, coffee, cardamom and pepper in Wayanad. However in the post flood phase, in Adimali and Vellathooval panchayaths of Idukki, farmers began to incorporate crops such as vegetables, yam, ginger and they have also taken up livestock rearing of exotic varieties of cattle such as HF and Jersey, and goat varieties such as Malabari and Jamnapyari.

In the case of Wayanad, post flood farming witnessed the cultivation of fruit trees and pig farming in the landslide affected areas. The least popular or the least adopted livelihood options adopted in the highlands includes cage farming of fishes (0), eco-tourism (0) and migration of male youth in the post disaster phase (6%).

This finding is on par with the results of Armah *et al*. (2020), who conducted a study in the flood prone regions of Northern Ghana, and reported that farm diversification reduces the risk of livelihood failure by spreading it across more than one income source. It also helps to overcome the uneven use of assets (principally labour) caused by seasonality, to reduce vulnerability, to generate financial resources in the absence of credit markets, and it confers a host of other advantages in the presence of widespread market failures and uncertainties.

In the case of lowlands, there is a change in the type of livelihood activities adopted by the farmers in the post flood situation. As indicated by the table, shifting to non-farm sources of livelihood (36.78%) has been the most commonly adopted strategy among the different strategies identified.

Lowlands under study especially the regions of Ambalappuzha and Kainakari has been experiencing frequent floods in the last three years and furthermore the frequency of floods has increased over the last 10 years. However, in the case of Kadapra and Niranam regions of Pathanamthitta, the frequency and intensity of floods has started increasing within a span of 2-3 years.

Table 19. Livelihood activities adopted by the farmers in the post flood situation

Dimension	**Livelihood activities**	**Highlands (n=257)**	**Lowlands (n=263)**
		Adoption percentage	**Adoption percentage**
Changes in cropping pattern	Cultivation of short duration crops and vegetables	18.4	19.16
	Farm diversification	60.8	28.74
	Cultivation of new crop varieties	12.8	4.98
Poultry and Fisheries	Cage farming	0	0
	Poultry farming	22	25.67
Non-farm sources of livelihood	Non-farm based livelihoods	27.6	36.78
	Performance of wage labour	18	9.2
	Migration of male youth	6	7.66
New enterprises	Ecotourism	0	0
	Development of value added products	9.6	4.6

As a result, paddy farmers of lowlands have been experiencing heavy losses and agriculture has slowly turned into a less profitable sector. As a result, there is an increasing tendency among the farmers to switch to other non-farm sources of livelihood, which includes different forms of wage labour. Livelihood diversification, is considered as a complementary adaptation strategy for addressing food insecurity, livelihood collapse and poverty.

It represents, the processes by which households construct a diverse portfolio of activities and social support capabilities for survival and in order to improve their standard of living. It involves farm and off-farm activities including factors that induce people to engage in multiple livelihoods (Ellis and Allison, 2004; Bang and Gordon, 2018).

Furthermore, a t- test was also conducted to analyse the existence of any significant difference between the different coping strategies adopted between highlands and lowlands. As the table 20 indicates, p value is greater than 0.05 and therefore, there is no significant difference between the different coping strategies adopted in highlands and lowlands. The rate of adoption of certain livelihood activities in the post flood phase is relatively lower in both lowlands and highlands. Hence, to increase sustainable food production and enhance livelihood stability, viable and alternative livelihood options are needed, with strong, transformative institutional support.

Table 20. Analysis of differences between highlands and lowlands in the case of Punarjani scheme

T- test	
P- value	**0.871464**

4.5. IMPACT ANALYSIS OF PUNARJANI SCHEME

Punarjani Scheme was implemented for the revival of agricultural sector through social participation by adopting scientific and eco-friendly cultivation methods. It was a special programme for handholding and creating awareness among flood affected farmers, by the name 'Punarjani' and was conducted in all the 14 districts.

It was implemented with the help of Department officials, people's representatives, Scientists from Kerala Agricultural University, NGOs and members of Agro service centres and Karshika Karma Sena.

As part of this Punarjani scheme, soil testing campaigns , removal of silt deposited by flood in farmers' fields, application of soil ameliorants, plant protection measures including rodent control, repair of farm machinery had to be organized and demonstrated. It had to boost the morale and regain the confidence of the farmers. This section therefore analyses the impact of Punarjani scheme in the economic, production, human capital and socio- psychological aspects of farmers. Table 21 and Figure 18 represents the impact of Punarjani scheme in both the regions.

Table 21. Impact of Punarjani scheme in both the regions.

Component	Questions	Highlands (n=257)	Lowlands (n=263)
Economic impact	Did you receive financial support soon after the floods?	10.8	19.16
Socio psychological impact	Did the scheme restore motivation to pursue farming after the receding of flood waters?	5.2	11.11
Impact on human capital	Did the scheme increase your knowledge on post flood land management practices through trainings?	2.8	13.41
Impact on crop production	Did the scheme provide inputs for crop production	7.6	26.05

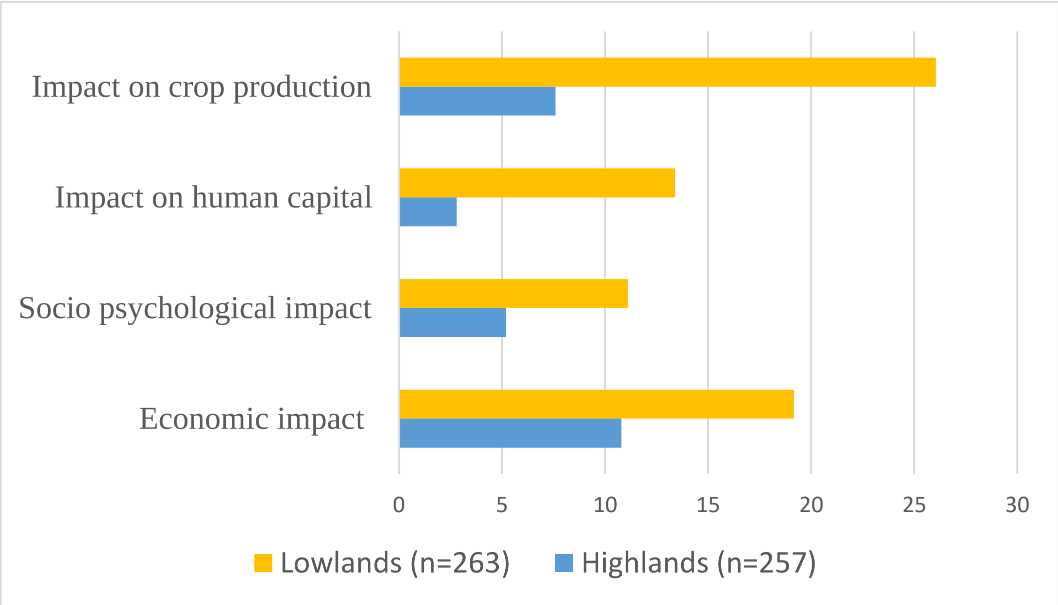


Fig. 18. Impact of Punarjani scheme

As is evident from the table, the impact of Punarjani scheme on farmers is almost negligible. The number of farmers benefitted through this scheme is very less. However, regional analysis of impact gives you a better picture of the scenario. In case of highlands which includes Idukki and Pathanamthitta regions, economic impact seems to be the major impact, followed by impact on crop production. Moving into details it can be found that, about 10.8 per cent of the 257 respondents reported that they have received monetary benefits either in the form of direct cash transfer or as compensation for crop loss. Secondly, for the continuation of farming after the disaster, about 7.6 per cent respondents received support in the form of inputs for crop production.

However, in the case of lowlands, the situation is slightly different from that of highlands. In the case of lowlands, the number of respondents who benefitted from this scheme is comparatively higher than that of lowlands. About 26.05% of the respondents benefited from this scheme as a support for crop production. The flood affected farmers received free seeds, and lime for the next season. Crop production was followed by economic impact wherein about 19.16% of the respondents reported that they have received money in the form of crop loss compensation under the banner of Punarjani scheme.

Regarding punarjani scheme also known as karshika Punarjani, activists say that the project failed because it deviated from the recommendations. Another reason they cite is lack of coordination between the different departments, which executed the project. Moreover, negligible efforts has been taken by the concerned officials to increase the reach of the programme among the disaster affected farmers.

4.6. PROFILE CHARACTERISTICS OF THE FARMERS

4.6.1. Neighbourhood cohesion

To compute neighbourhood cohesion, a scale derived from Buckner (1988), and followed by Smith (2012) has been used. The statements were scored in a continuum of strongly agree (5), agree (4), neutral (3), disagree (2), and strongly disagree (1) and the following results were obtained. Table 22 and Figure 19 represents the results of neighborhood cohesion in both highlands and lowlands.

Table 22. Neighborhood cohesion of highlands and lowlands.

Categories	Highlands (n=257)		Lowlands (n=263)	
	F	%	F	%
Low neighbourhood cohesion	57	22.179	51	19.39
Medium neighbourhood cohesion	136	52.918	161	61.22
High neighbourhood cohesion	64	24.903	51	19.39

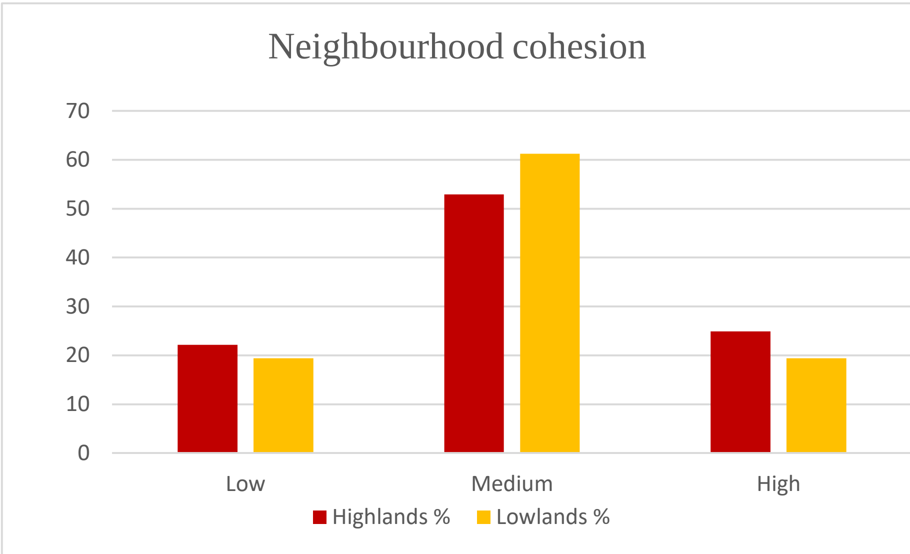


Fig. 19. Neighborhood cohesion in both highlands and lowlands

Neighbourhood cohesion is a concept describing the residents' sense of community, engagement in acts of neighbouring, and attractiveness of living in the neighbourhood (Damurski, 2021).The table demonstrates that in both highlands and lowlands, majority of the respondents (52.9 per cent and 61.22 per cent respectively) belonged to the medium category of neighbourhood cohesion.

However, when analyse the results in detail, it can be found that there is higher percentage of people in the category of high neighbourhood cohesion in highlands (24.9 per cent) when compared to that of lowlands (19.39). This indicates the medium to high neighbourhood cohesion of members of highlands.

This result is in consistent with the results reported by Aphiwe *et al.*, 2021, who conducted a study among the local farmers of South Africa. As per the study, more than 55.8% of the respondents had medium neighbourhood cohesion and majority of them agreed that food-sharing is one major factor that contributes to neighbourhood cohesion during and after the disaster.

4.6.2. Self-Efficacy

Self-efficacy refers to an individual's belief in his or her capacity to execute behaviours necessary to produce specific performance attainments (Bandura, 1977, 1986, 1997). In this study, self- efficacy was studied using a scale developed by Schwarzer's (1992) and followed by Tokunaga (1993), Mewse *et al*., (2010), Wang *et al*., (2011), Nunes, Schwarzer and Jerusalem (1999) and Medeiros (2006).

The statements were scored in a continuum of 1 = Not at all true 2 = Hardly true 3 = moderately true 4 = exactly true and the results are discussed in detail below. Table 23 and Figure 20 represents the results of self – efficacy. As the table indicates, about 57.5 per cent of the respondents in highlands and 60.84 per cent of the respondents in lowlands belong to the category of medium of self- efficacy. However, percentage of respondents belonging to the higher category of self – efficacy is larger in lowlands when compared to that of highlands. This indicates the medium to high self-efficacy of farmer respondents of lowlands.

Table 23. Region wise results of self – efficacy

Categories	**Highlands**		**Lowlands**	
	F	**%**	**F**	**%**
Low self-efficacy	59	22.95	48	18.25
Medium self-efficacy	148	57.58	160	60.84
High self-efficacy	50	19.45	55	20.91

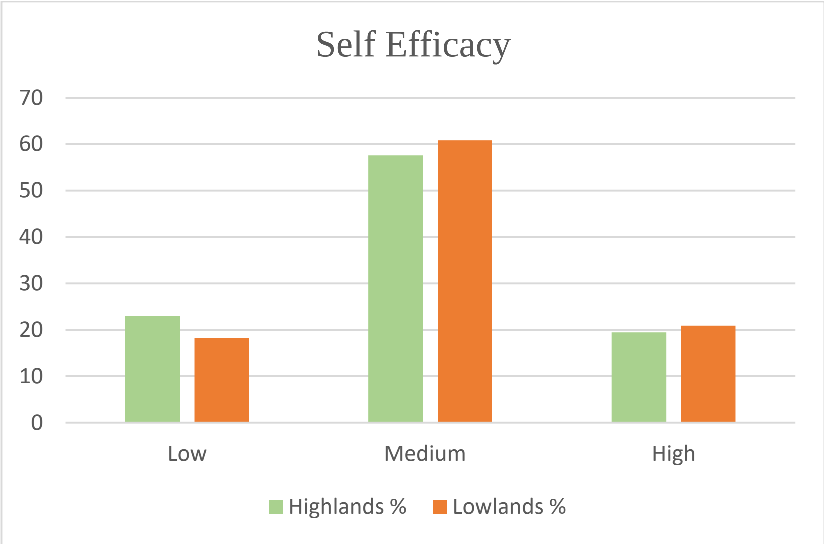


Fig.20. Region wise results of self – efficacy

Peng *et al*. (2020) conducted a study in the disaster prone regions of China to analyse the role of self -efficacy of farmers in disaster management. The results showed that about 48.87% of the framers under study had high self -efficacy and as the self – efficacy increased their contribution in Community Based Disaster Management Measures also increased.

4.6.3. Optimism

It is defined as a form of positive thinking that includes the belief that you are responsible for your own happiness and that more good things will continue to happen to you in the future. It was measured using Life Orientation Test (LOT**)** developed by Scheier *et al.*(1994) and followed by Vautier *et al*. (2003) and Wimberly *et al.* (2008). Table 24 and Figure 21 represents the results of optimism of both highlands and lowlands.

The results indicate that majority of the respondents in highlands (57.98%) and 65.02 per cent of the respondents in lowlands belong to the category of medium optimistic attitude towards life. However, respondents of highlands exhibited comparatively higher optimistic attitude (22.18 per cent) when compared to that of lowlands (11.79 per cent).

Table 24. Region wise results of Optimism

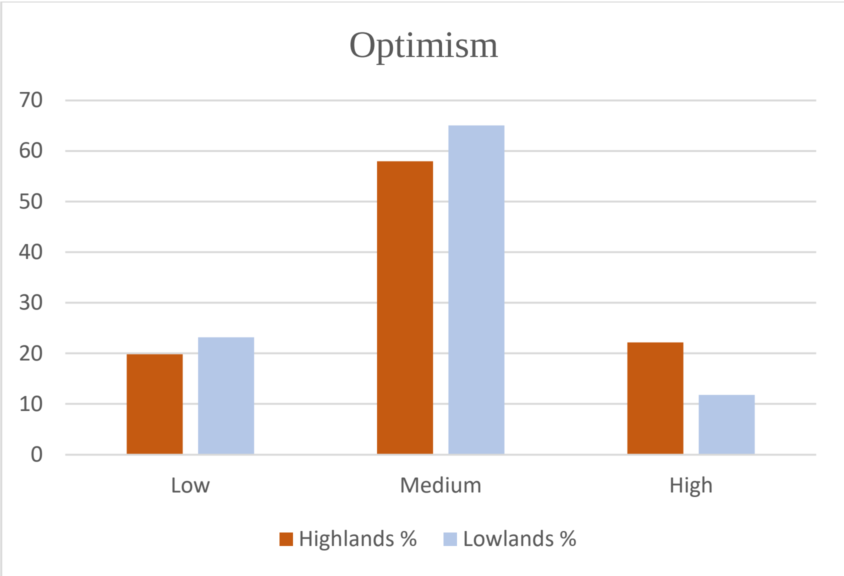


Fig.21. Region wise results of Optimism

Coughenour and Swanson (1992), in their study on optimism, and farm satisfaction in disaster prone areas of Kentucky reported that life satisfaction and happiness is notably correlated with the optimism and net farm income. Moreover, majority (34.56%) of the respondents in the flood prone areas had low optimistic attitude towards life.

Categories	**Highlands**		**Lowlands**	
	F	**%**	**F**	**%**
Low optimism	51	19.84	61	23.19
Medium optimism	149	57.98	171	65.02
High optimism	57	22.18	31	11.79

4.6.4. Altruism

Altruism is when we act to promote someone else's welfare, even at a risk or cost to ourselves. The altruistic scale developed by Rushton *et al*. (1987) and followed by Eisenberg (2002) has been used for the calculation of Altruistic attitude of farmers. Table 25 and Figure 22 indicates the results of altruism.

Table 25. Results of altruism of highlands and lowlands.

Categories	Highlands		Lowlands	
	F	%	F	%
Low altruism	59	22.96	64	24.33
Medium altruism	135	52.53	153	58.17
High altruism	63	24.51	46	17.49

As per the table, majority of the respondents in both highlands (52.53%) and lowlands (58.17), showed medium altruistic attitude. In the case of altruistic attitude, respondents of highlands exhibited a higher altruistic attitude when compared to that of lowlands. However, the difference between lowlands (17.49) and highlands (24.51%) is comparatively less. Nurhayati and Irham (2018) conducted a study among the organic farmers of Yogyakarta and reported that the altruistic behaviour of farmers is mostly dominated by economic motives and only 35% of the respondents had shown medium to high altruistic attitude.

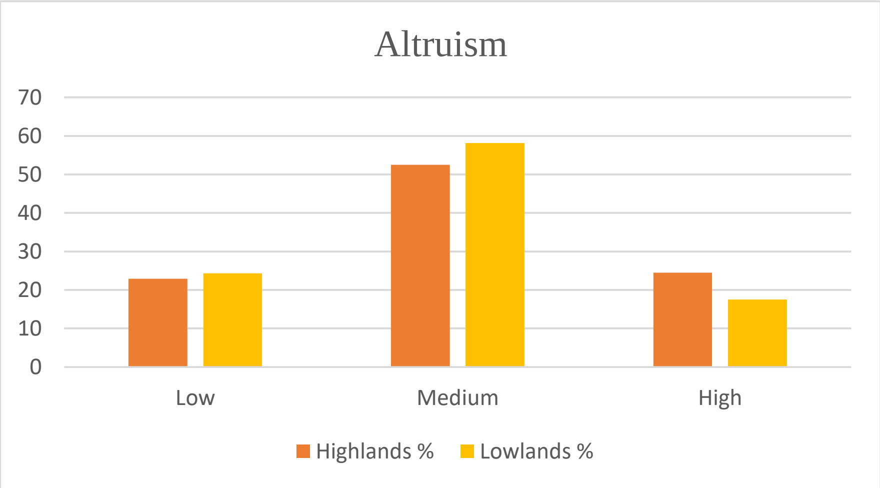


Fig. 22 Graph showing the results of altruism

4.6.5. Risk Propensity

Risk propensity may be operationally defined as an individual's willingness to take or avoid risks. It was measured using **General Risk Propensity Scale**

(GRiPS) developed by Zhang *et al.* (2018) in a five point continuum. Table 26 and figure 23 shows the results of risk propensity of farmers of lowlands and highlands.

In the case of risk propensity, same as in the case of all other psycho social variables studied, majority of the respondents in both high and lowlands had medium level of risk propensity.

Table 26. Risk propensity of farmers of highlands and lowlands

Categories	**Highlands**		**Lowlands**	
	F	**%**	**F**	**%**
Low risk propensity	31	12.06	50	19.01
Medium risk propensity	176	68.48	164	62.36
High risk propensity	50	19.46	49	18.63

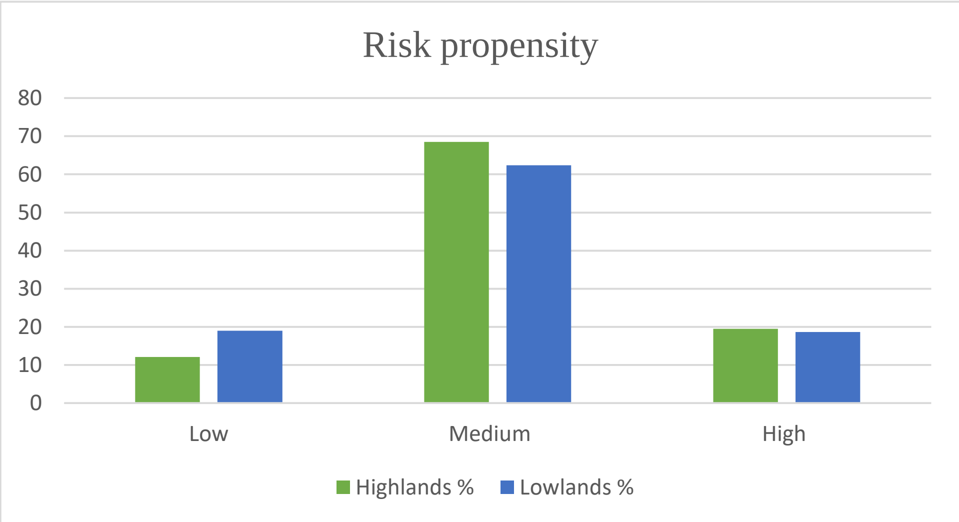


Fig. 23. Graph showing the results of Risk propensity

Wahdat *et al.* (2021) conducted a study to understand the individual risk behaviour of farmers towards natural disasters and it was found that most of the farmers (65.88%) of the farmers exhibited risk averse attitude, which shows that they are not willing to take up risks in the face of natural disaster.

4.7. CLIMATE ADAPTIVE AGRICULTURAL EXTENSION APPROACHES (CAAEA)

Climate adaptive agricultural approach is an approach for developing agricultural strategies to secure sustainable food security under climate change. For the development of CAAEA, initially major problems faced by the farmers in relation to climate risk were identified and they were scored on a four point continuum ranging from most important (4) to least important (1). The ranking of the individual problems identified in highlands and lowlands are given in Table 27.

Table 27. Problems identified in highlands and lowlands

Major Climate Risks	**Score (n=257)**
Highlands	
Landslide	996
Excessive rain	980
Wild animal attack / Crop scouting	1028
Increased incidence of pests and diseases	516
Drought	514
Heavy winds	829
Poultry and livestock diseases	514

Major Climate Risks	**Score (n=263)**
Lowlands	
Flooding	999
Pest and disease infestation	1022
Poultry and livestock diseases	1021
Salt water intrusion	745
Scarcity of drinking water	1043
Drought	490

As is evident from the Table 27, the major problems faced by the farmers of highlands related to climate change are wild animal attack / crop scouting (1028), increasing frequency of landslides (996) and excessive rains (980) over the last three years. Whereas in the case of lowlands, the major problems faced by the farmers were acute shortage of drinking water (1043), heavy pest and disease infestation (1022) and flooding (999). These ranked problems were further correlated with the total climate risk score to understand the degree of relation of each individual problem with total climate risk at 5 per cent level of significance. The results of the correlation analysis for both highlands and lowlands are given in Table 28 at 1 and 5 per cent significance level.

Table 28. Results of correlation analysis of individual problems with climate risks of highlands and lowlands.

Problems	**Highlands (r value)**
Landslide	0.34848546*
Excessive rain	0.422402731*
Wild animal attack / Crop scouting	0.552389*
Increased incidence of pests and diseases	0.824864413**
Drought	0.193691
Heavy winds	0.368095
Poultry and livestock diseases	0.016962

Problems	**Lowlands (r value)**
Flooding	0.508276*
Pest and disease infestation	0.46308061*
Poultry and livestock diseases	0.357669
Salt water intrusion	0.093035
Scarcity of drinking water	0.463616**
Drought	0.208653

*1 % level of significance ** 5 % level of significance

In the case of highlands, landslide, excessive rain and wild animal attack shows positive and significant correlation with climate risks at one per cent level of significance and incidence of pests and diseases at five per cent level of significance.

Whereas in the case of lowlands, positive and significant relation at one per cent level of significance with climate risks were shown by the problems such as flooding, and pest and disease infestation and scarcity of drinking water has shown to be positively and significantly related with climate risk at five per cent level of significance.

The results of the correlation analysis were further used to formulate CAAEA as given in the Figure 24. In this framework, straight arrows indicate the problems which have strong correlation with the climate risks and the broken arrows indicates weak relation with climate risks. On the basis of the major problems identified, climate adaptation measure for each specific problem and specific location has been identified.

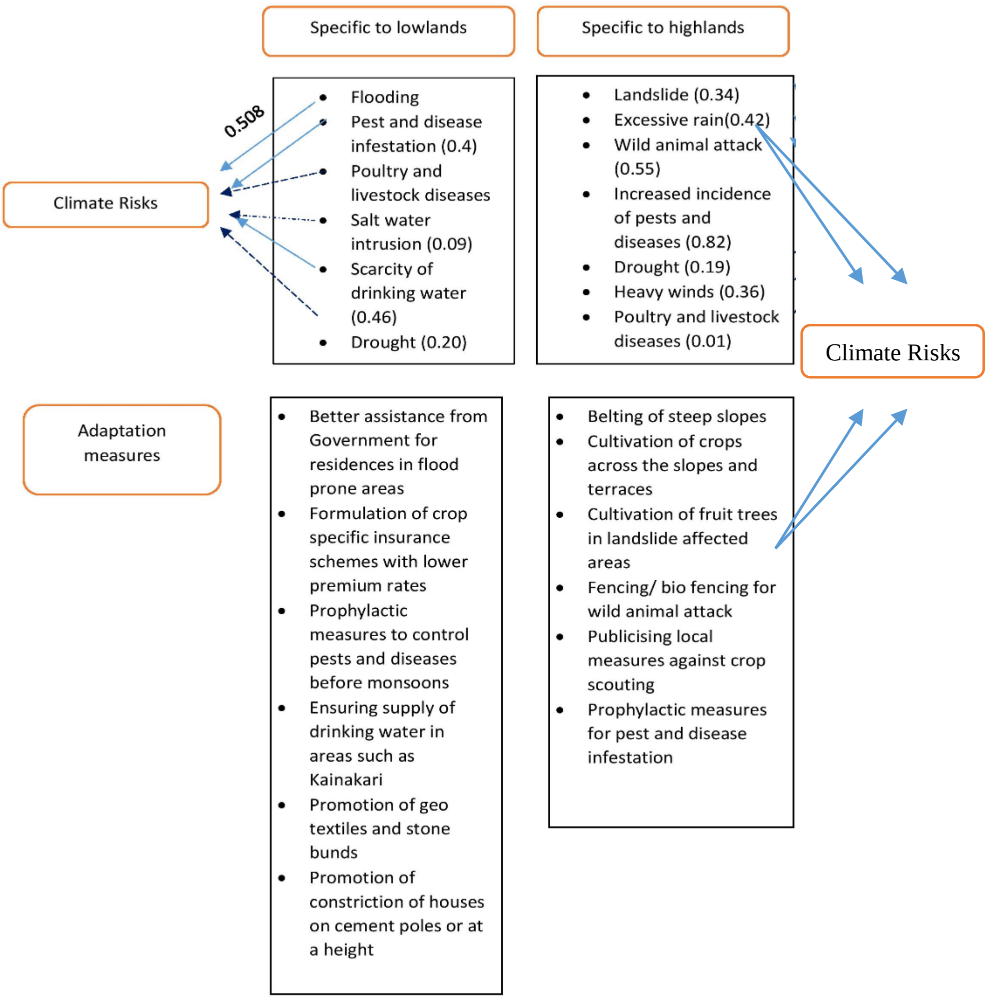


Fig. 24. Climate Adaptive Agricultural Extension Approach (CAAEA)

4.8. CONCLUSION

This study demonstrates a quantitative societal vulnerability assessment for farmers in the state of Kerala. On a regional scale, indicators specific for the composition of social vulnerability towards floods and associated landslides have been identified, transformed into quantifiable indicators along with a secondary data set. Societal vulnerability as a concept applied in other regions and populations has been successfully applied and advanced on the validation part. This assessment of societal vulnerability captures not only exposure and susceptibility but also indicates capacities of humans to mitigate and adapt to disasters.

There can be no analysis of risk management, resilience and adaptation options without understanding vulnerability first. Vulnerability is a detector of exposure, susceptibility and capacities of any system. Social systems in context to a hazard are determined by their attributes of demography, physical location, temporal development, their internal and external influences and exchanges.

This place-based notion of complex problems can be measured by the exposure of this system to external threats. Place-based exposure however, only manifests as a problem, when certain negative and positive, passive and active abilities and conditions coincide. Encompassing the exposure, susceptibility and capacities of a system at risk provides a broad research lens that helps to capture aspects that might have been neglected by traditional hazard or risk analyses so far.

The Societal Vulnerability Index for Floods and Landslides (SVI^{FL}) could be an excellent tool for starting a monitoring process that captures both social dynamics and links to environmental processes by taking into consideration components such as physical, economic and environmental along with social dimension. The comprehensibility and versatility of these indices and maps provide decision-makers information about complex phenomena that can be used for the development of strategies and policies.

The study contributes to the overall objective of disaster risk reduction of farming community. Vulnerability, resilience, climate change and sustainability are high on the agenda of national policy and research. These are fields where advancement in information depth and awareness are prerequisites for developing strategies for the future in the light of population growth and environmental strain.

Knowledge on complex relationships translated into measurable indicators will be a key field for the identification and valuation of future action priorities.

Achievements and benefits from this study are:

- The successful demonstration that a societal vulnerability assessment for farmers can be carried out
- The enhancement of common hazard and vulnerability approaches by developing information about the vulnerable population
- Maps that are easy to interpret
- Documentation of coping strategies

Challenges identified in this study are:

- Data availability and spatial resolution of data can be improved
- Awareness about the availability and versatility of social vulnerability assessments must be raised
- Integrative multi-disciplinary scientific projects require openness and engagement from all disciplines

4.9.RECOMMENDATIONS FOR FUTURE RESEARCH

The assessment of societal vulnerability is not an end in itself and should not stop at the description of potential weaknesses and strengths in four components. Therefore, in order to accomplish a truly multi-disciplinary, holistic and balanced approach on flood vulnerability, the research could be further extended to include the following areas.

- Gender dimensions of vulnerability to flood and landslide hazards
- Community insurance and property security in disaster prone areas
- Extension of assessment to other regions of the state
- Inclusion of infrastructural and attitudinal component
- Community based risk communication and advocacy strategies

Summary

5. SUMMARY

Kerala, has a tropical monsoon climate with seasonally excessive rainfall of around 3000 mm and hot summers. In the recent past due to significant alterations in the characteristics of the SW monsoon, Kerala has suffered flooding and landslides. The 2018 flood was the worst of its kind in a century since the 1924 floods. The state has a population density of 819 persons per sq. km. being the highest in India. Amidst much potential in agriculture sector, the state witnesses countless challenges and risks impairing its growth. Preventing the occurrence of natural hazards or keeping the state secure from disasters is impossible. However, life and property loss due to such extreme events can substantially be reduced by adopting proper measures. There are several social, environmental and cultural factors that make this state vulnerable to floods. Societal vulnerability refers to the inability of people, organizations, and societies to withstand adverse impacts from multiple stressors to which they are exposed. These impacts are due in part to characteristics inherent in social interactions, institutions, and systems of cultural values. Reducing societal vulnerability can decrease both human suffering and economic loss. The study aims to understand the vulnerability of farmers of Kerala and their response, in the different phase of disaster.

The major objectives of the study were to establish a Societal Vulnerability Index for Floods and Landslides (SVI^{FL}) and map the vulnerability hotspots for the affected areas. Delineated the coping strategies adopted during various phases of the floods and study the impact of various post flood schemes and measures by the Government. The study also developed a Climate Adaptive Agricultural Extension Approach (CAAEA) to formulate mitigation strategies and suggest adaptation strategies for the farmers.

The present study was conducted in the highlands and lowlands of Kerala. From the highlands, Idukki and Wayanad districts has been purposively selected for the study and from lowlands, Alappuzha and Pathanamthitta districts were selected for the study From Idukki district, Vellathooval and Adimali panchayaths and from Wayanad district, Meppadi and Panamaram panchayaths were selected for the assessment. In the case of lowlands, from Alappuzha district, Ambalappuzha and Kainakari panchayaths and from Pathanamthitta district, Kadapra and Niranam panchayaths were selected for the study purpose. Using proportionate random sampling method, 520 farmer respondents were interviewed for data collection.

Detailed review of literature, judges rating, and discussion with experts and scientists were used in the selection of variables. The major observations for the study were establishment of a Societal Vulnerability Index for Floods and Landslides (SVI^{FL}), coping strategies index, post flood analysis of livelihood activities and impact assessment. A climate Adaptive Agricultural Extension Approach (CAAEA) was also developed. Profile characteristics were selected as the independent variables. The statistical tools used were frequency, simple percentage analysis, correlation analysis, t-test and ANOVA.

The salient findings of the study are summarised below:

1. In the case of Societal Vulnerability Index for Floods and Landslides, panchayat MD (Meppadi) in Wayanad appears to be the most vulnerable region among the study areas and second highest vulnerability was recorded for panchayat KK (Kainakari), the low-lying flood-prone region of Alappuzha.

2. In the case of Social component, social vulnerability is highest in the highlands. Among them, Meppadi has the highest vulnerability to disasters, especially landslides. The most important characteristic that makes the population in MD (Meppadi) exposed to landslides is the higher number of causalities and post-traumatic stress disorders.

3. The economic vulnerability to floods and associated landslides is highest in the highlands. The major characteristics that make the highlands particularly vulnerable to landslides are greater proximity of residences and agricultural areas to steep slopes, higher unemployment rates, and higher number of people below the poverty line, lower enrolment in insurance schemes, higher recovery time, and low savings to adapt to the changes.

4. In the context of environmental component, the highlands are more vulnerable compared to the lowlands. Among the highlands, VT (Vellathooval) of Idukki has the highest vulnerability, followed by MD (Meppadi) of Wayanad. The main environmental characteristics that make the highlands vulnerable to floods and associated landslides are higher rainfall in a short period of time, lower wetland acreage, nature of soil, quality of soil, lower adoption of soil conservation measures and wild animal attack
5. The physical component is the only area where the lowlands are more vulnerable than the highlands. This is primarily due to attributes such as a greater frequency of disasters per year, increasing water levels in the residence during floods, type of dwelling, and fewer number of water harvesting structures.
6. The different disaster coping mechanisms adopted by the farmer and his household in the different phases (pre, during and post) of the disaster were discussed. In the case of highlands, the most commonly adopted coping strategy comes under the component means of livelihoods.
7. In the case of highlands, the most commonly adopted coping strategy comes under the component means of livelihoods. Farmers borrowing money from formal and informal sources to meet the losses in the post flood phase was the most commonly adopted strategy. Second most commonly followed strategy includes the increased adoption of homestead gardening among the respondents
8. The most commonly adopted coping strategy among lowlands comes under the component crop and livestock production and protection. Under this component, increased dependence on chemical fertilizers for better yield and crop protection has scored the highest value (776) and the highest rank.
9. In the case of community level coping mechanisms, most of the coping mechanisms were implemented during the disaster phase, and the component given the most attention was food and security. In the highlands,

10. distribution of relief materials and ensuring the availability of drinking water has been the priority.
11. At community level in lowlands, most of the coping mechanisms were adopted during and in the post disaster phase. The most commonly and primarily adopted strategy was distribution of relief materials and ensuring the availability of drinking water with scores 827 and 788 respectively.
12. At the policy or administrative level, the government have focussed mostly on the coping mechanisms during the disaster phase and post disaster phase. In the scenario,in highlands, it can be found that the major strategies adopted by the government includes setting up of relief camps (766) and permitting community kitchens (837) at the disaster site.
13. In the case of lowlands too, setting up of relief camps and community kitchens has been given the prime importance at the administrative level.
14. Under the analysis of Post flood livelihood inclusive activities, in the case of highlands, it can be found that, farm diversification (60.8%) is the most commonly adopted livelihood sustaining strategy among the identified livelihood mechanisms.
15. In the case of lowlands, shifting to non-farm sources of livelihood (36.78%) has been the most commonly adopted strategy among the different strategies identified.
16. An impact analysis was conducted to analyse the impact of Punarjani scheme and it was found that in highlands, about 10.8 per cent have received monetary benefits either in the form of direct cash transfer or as compensation for crop loss. Secondly, for the continuation of farming after the disaster, about 7.6 per cent respondents received support in the form of inputs for crop production.

17. In the case of lowlands, the number of respondents who benefitted from this scheme is comparatively higher than that of lowlands. About 26.05% of the respondents benefited from this scheme as a support for crop production.
18. In the case of neighbourhood cohesion, in both highlands and lowlands, majority of the respondents (52.9 per cent and 61.22 per cent respectively) belonged to the medium category.
19. In the case of self-efficacy about 57.5 per cent of the respondents in highlands and 60.84 per cent of the respondents in lowlands belong to the category of medium of self- efficacy.
20. The results of optimism indicate that majority of the respondents in highlands (57.98%) and 65.02 per cent of the respondents in lowlands belong to the category of medium category of optimism.
21. In the case of altruism, majority of the respondents in both highlands (52.53%) and lowlands (58.17), showed medium altruistic attitude.
22. In the case of risk propensity, same as in the case of all other psycho social variables studied, majority of the respondents in both high and lowlands had medium level of risk propensity.

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Abstract

Vulnerability Assessment for Livelihood Inclusion and Social Empowerment (VALISE) of farmers: a post flood analysis of Kerala state

by

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ABSTRACT

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Abstract

The study entitled 'Vulnerability Assessment for Livelihood Inclusion and Social Empowerment (VALISE) of farmers: a post flood analysis of Kerala state was conducted during 2018 to 2021 with the major objectives to establish a Societal Vulnerability Index for Floods and Landslides(SVI^{FL}) and map the vulnerability hotspots for the affected areas. The study also delineated the coping strategies adopted during various phases of the floods and the impact of various post flood schemes and measures by the Government. The study also developed a Climate Adaptive Agricultural Extension Approach (CAAEA) to formulate mitigation strategies and suggest adaptation strategies for the farmers.

For this study, four of the 14 districts of Kerala, namely, Alappuzha and Pathanamthitta from lowlands, Idukki and Wayanad districts from highlands were purposively selected for flood and landslide vulnerability assessment. Two severely flood affected panchayats of Alappuzha, namely Kainakari (KK) and Ambalappuzha (AP), were selected for the study. From Pathanamthitta, Kadapra (KD) and Niranam (NM), two low lying panchayats where floods occur almost every year were selected. Adimali (AD) and Vellathooval (VT) panchayats were particularly selected for landslide vulnerability assessment in the Idukki district. Panamaram (PM) and Meppadi (MD) panchayats from Wayanad district were considered for the landslide vulnerability assessment. A multistage sampling method was adopted for data collection in this study. A total of 520 farmers were selected for the study using proportionate sampling method.

In this study, a Societal Vulnerability Index for Floods and Landslides (SVI^{FL}) was established for highlands and lowlands to assess the flood vulnerability according to the local situation. The SVI^{FL} developed for this study consists of four major components such as social, physical, environmental and economical, which were estimated in terms of the three factors of exposure, sensitivity and resilience. Component wise results revealed that social vulnerability is highest in the highlands. Among them, MD (0.514) has the highest vulnerability to disasters, especially landslides, followed by VT (0.485) and AD (0.456). In case of lowlands, social vulnerability to flooding is highest in AP (0.442) of Alappuzha. In the case

of economic component, economic vulnerability to floods and associated landslides is highest in the MD (0.715) of Wayanad district followed by PM (0.626) of Wayanad and VT (0.571) of Idukki district. In the context of environmental component too, the highlands are more vulnerable compared to the lowlands. Among the highlands, VT (0.549) of Idukki has the highest vulnerability, followed by MD (0.526) of Wayanad. In the case of Physical component, KK (0.667) has the highest physical vulnerability followed by AP (0.626) of Alappuzha. According to the SVI^{FL}values, panchayat MD in Wayanad appeared to be the most vulnerable region among the study areas with a SVI^{FL} index value of 0.555. The second highest vulnerability was recorded for panchayat KK (0.509), the low-lying flood-prone region of Alappuzha. The lowest vulnerability when compared to other regions was found for KD (0.369) of Pathanamthitta.

Coping mechanisms played an important role in reducing the disaster risk factors, and smoothening the consequences of the disaster to improve the livelihood and living conditions of disaster affected communities. In this study, coping mechanisms adopted at farmer level, community level and government level have been documented with the help of a Coping Strategies Index for Floods and Landslides (CSI^{FL}). Results revealed that at farmer level in highlands, borrowing of money, in the post disaster situation (669), homestead vegetable gardening (661), and crop diversification (627) scored the highest scores and in the case of lowlands, increased dependence on chemical fertilizers (776) have scored the highest value. At the community level, in both highlands and lowlands, coping strategies were frequently adopted in the food security component with CSI^{FL} values 626.33 and 642.5 respectively. At the government level, in highlands and lowlands, setting up of community kitchens (837) and relief camps (766) were ranked first and second according to CSI^{FL} values.

Documentation of post flood livelihood inclusive activities, helped us to understand the extent to which the farmers were affected by the disaster and the different livelihood options adopted by the farmers after the disaster. The results of post flood livelihood analysis revealed that in highlands, farm diversification was the most adopted (60.8%) post flood livelihood mechanism followed by switching to non-farm based livelihoods (27.6%). In the case of lowlands, switching to non-farm based livelihoods (36.78) was the most adopted post flood livelihood mechanism followed by farm diversification.

An impact assessment was conducted to analyse, the impact of Punarjani scheme among the farmers in the flood and landslide affected panchayaths. The results of the study revealed that, in highlands, 10.8% farmers have benefitted from the scheme economically, 7.6% benefitted from the scheme in the aspect of crop production, 5.2% in the socio psychological aspect and 2.8% in terms of human capital. In the case of lowlands, Punarjani scheme had an impact on farmers mostly in the area of crop production (26.05%), followed by monetary benefits (19.16%).

Five personal and psychological characteristics of the farmers were selected as independent variables of the study. In the case of neighbourhood cohesion, about 53% of the farmers in highlands and 61.22% farmers in lowlands were found to have medium neighbourhood cohesion. In terms of self-efficacy, 58% of the farmers in highlands and 60.84% of the farmers in lowlands were reported to have medium level of self-efficacy. Similarly, majority of the farmers in highlands (57.98%, 52.53%) and lowlands (65.02%, 58.17%), were observed to have medium level of optimism and altruism respectively. In the case of risk propensity, 68.48% of the farmers in highlands and 62.36% of the farmers in lowlands belonged to the medium category of optimism.

A Climate Adaptive Agricultural Extension Approach (CAAEA) was developed to suggest adaptation strategies to the farmers as well as policy makers to various climate risks. For the construction of framework, major problems faced by the farmers in relation to climate change, were scored on a four point continuum. The results further revealed, wild animal attack, landslide and excessive rain in a short period of time, to be the major climate risks in highlands and scarcity of drinking water, increased pest and disease infestation and poultry and livestock diseases in lowlands. These individual problems were further correlated with the climate risks, to understand the relation and construct the framework.

To conclude, SVI^{FL} can be used as an effective tool for assessing farmers' vulnerability to floods and landslides. The results of this study may enable stakeholders to determine the vulnerability of their residential areas. For policy makers, the documentation of coping mechanisms adopted at various levels may be useful in formulating disaster risk reduction strategies at the panchayat or community level. Results of post flood livelihood mechanisms shows the areas in which livelihood alternatives may be formulated in the post disaster phase. Impact study of Punarjani scheme shows that, the program could not achieve the major objectives, it was primarily implemented for and only few farmer respondents benefitted from this post flood scheme.

Appendices

APPENDIX I

I. Components and list of indicators

A.1. Social Component

Social composition of the region has the greatest impact on socioeconomic conditions of the people, which in turn influence the inherent capability to cope with the effects of disaster.

A.1.1.Exposure

Sr. No	Name of the Indicator	Rationale / Role of the indicator	Source	Relation with vulnerability
1	Population Density	Higher concentration of people at an area implies that higher social vulnerability to floods for the area	Hashim *et al.*, 2018	Increase
2	Elderly Population (60 years and above)	Aged population can be left out from rescue and relief due to mobility constraints and ailments	Nasiri *et al.*, 2019	Increase
3	Rural population	Rural areas are highly vulnerable to floods due to limited social, economic, and physical resources	Karmaoui and Balica, 2019	Increase
4	Per cent of households that did not receive warning about natural disasters	Absence of a an early warning system, increases the vulnerability to floods	Madhuri *et al.*, 2014.	Increase
5	Per cent of households that reported that their household members suffered from injury or death from the past	Previous history of injury or death indicates their vulnerability	Madhuri *et al.*, 2014	Increase

	disasters (E.g. Tsunami, 2004)			
6	Post-Traumatic Stress Disorder	PTSD, anxiety and depression decreases the capacity to recover from floods and return to normalcy	Mason *et al.*, 2010	Increase
7	Percent of households where the head has not attended the school	Education makes people more aware and able to adjust to change in environmental condition. Higher % reflects less capacity to adapt	Hahn *et al.*, 2009 Madhuri *et al.*, 2014	Increase
8	Temporary structure houses	Absence of permanent house adds to the resilience time inhabitants need as they are left in unsafe open surrounding	Anees *et al*, 2019	Increase
9	Population near polluted water bodies	Population near polluted water bodies are highly prone to water borne diseases (Solihah, 2019)	New	Increase

A.1.2. Sensitivity

Sr. No	**Name of the Indicator**	**Rationale / Role of the indicator**	**Source**	**Relation with vulnerability**
1.	Percent of disabled population	Higher the number, Higher the vulnerability	Karmaoui and Balica, 2019	Increase

2.	Population in the age group 0–6 years	Children below the age of 6 demand extreme care and considerable time and resources are required to cater the needs	Panthi *et al.* 2016	Increase
3.	Female headed households	Social structures can often face difficulties as they are forced to look out for families and make extra efforts to gather aid post-disaster	Jha *et al.*, 2020	Increase
4.	Agriculture dependent households	Absolute dependence on agriculture for their means of livelihood increases vulnerability.	Sam *et al.*, 2017	Increase
5.	Percent of farmer households that do not save seeds	Lack of seeds for subsequent planting could generate a reinforcing effect of lower food production and another resulting lack of seeds	Hahn *et al.*, 2008	Increase
6.	Household size	High household size increases vulnerability	Hashim *et al.*, 2018	Increase
7.	Untreated water source	Water-borne diseases are one of the major problems post-disaster and untreated source increases the risk of spreading such diseases	Anees *et al.*, 2019.	Increase

8.	Percent of households that utilise natural water source	Households who reports water from common well, river, lake as their primary water source	Anees *et al.*, 2019	Increase
9.	Average time to water source	The shorter the time, the less sensitivity	Panthi *et al*, 2014	Increase
10.	Population growth	Sensitivity increases with increase in population	Karmaoui and Balica, 2019	Increase
11.	Fish farmers	The flood waters completely washes away cultured fishes leading to huge losses	New	Increase
12.	Dependence on natural sources for inputs and feed of livestock	Natural calamities like floods directly affect the availability of feeds, especially from natural sources	New	Increase
13.	Percent of households with family member suffering from chronic illness	Family with illness are more sensitive	Madhuri *et al.*, 2014 Panthi *et al*, 2014	Increase
14.	Average number of households receiving treatment in hospitals	Higher the number, greater the sensitivity	Madhuri *et al.*, 2014	Increase
15.	Percent of households depending solely on family farm for food	High sensitivity because limited source for food	Panthi *et al*, 2014	Increase
16.	Average loan amount	High amount of borrowing indicates financial stress, less capacity to adapt	Panthi *et al*, 2014	Increase

17.	Households that do not have toilet facilities	Unhygienic conditions around the residence is bound to increase the chances of transmitting diseases	Donohue and Biggs, 2015	Increase
18.	No lighting households	Unavailability of electricity post-disaster can increase the difficulty in accessing appliances and communication devices	Donohue and Biggs, 2015	Increase

A.1.3.Resilience

Sr. No	**Name of the Indicator**	**Rationale / Role of the indicator**	**Source**	**Relation with vulnerability**
1.	Awareness and preparedness	Higher awareness and preparedness of past floods, lower the vulnerability	Balica *et al.*, 2012	Decrease
2.	Flood warning	The availability of flood warning systems to indicate the early warning of floods decreases vulnerability.	Hashim *et al.*, 2018 Karmaoui and Bakica, 2019	Decrease
3.	Percent of households having access to communication media (TV/radio, telephone and internet)	Communication media make people aware of hazard occurrence and preparation	Panthi *et al*, 2014	Decrease
4.	Percent of households having access to institution to	Seed sources strengthen adaptive capacity	Panthi *et al*, 2014	Decrease

	purchase fodder seed/seedlings			
5.	Percent of farmers who cultivate/ store flood tolerant rice varieties	Flood tolerant rice varieties are resilient to flood submergence for up to two to three weeks, thereby reducing risk and providing a higher yield potential for farmers.	New	Decrease
6.	Percent of farmers who plant early-maturing crops to avoid the flooding season	Early-maturing varieties of crops are useful because they take less time to mature. It is therefore easier to avoid the flooding season.	New	Decrease
7.	Percent of households associated with any organization (SHG/ Milk cooperative/group)	Group insurance and information sharing increases adaptive capacity	Panthi *et al*, 2014	Increase
8.	Average time to health facility	The shorter this time, the less vulnerability	Panthi *et al*, 2014	Decrease
9.	Percent of households with family member working outside their community for job	Income diversification increases adaptive capacity	Panthi *et al*, 2014	Decrease
10	Education level-Graduate and above	Education have a profound effect on how families deal with post-disaster conditions and fairly educated members are expected to	Anees *et al*., 2019	Decrease

		communicate and acquire resources better		
11	Average livestock diversification index	Diverse species of livestock reduces the risk of major losses	Panthi *et al*, 2014	Decrease
12	Average Crop Diversity Index	Average number of households who grow 1 additional crop to reduce risk	Madhuri *et al*., 2014	Decrease
13	Past experience of disasters (Tsunami, 2004)	The experience of past floods helps the affected households to deal with the recent floods	Balica and wright, 2004 Hashim *et al*., 2018	Decrease
14	Emergency services	Availability of emergency services in the vicinity reduces vulnerability	Gonzalez *et al*., 2020	Decrease
15	Long term residents	They have better knowledge regarding the topography of the area and hence reduced vulnerability	Hahn *et al*., 2008	Decrease
16	Trainings on flood coping mechanisms	Trainings on flood coping mechanisms enables the farmers to better adapt to the flood disaster	New	Decrease

Appendix A.2. Economic Component

The economic components are related to income or issues which are inherent to economics that are predisposed to be affected. The breakdown of these activities can influence the economic prosperity of a community, region or a country.

A.2.1.Exposure

Sr. No	Name of the Indicator	Rationale / Role of the indicator	Source	Relation with vulnerability
1	Proximity to river	The proximity of business and agriculture areas to the water structure, increases the vulnerability	Messner and Meyer, 2006	Increase
2	Number of industries (MSME)	Industries can be negatively impacted by flooding, thereby increasing the vulnerability of an area	Karmaoui and Balica, 2019	Increase
3	Life Expectancy Index	-	Karmaoui and Balica, 2019	Decrease

A.2.2. Sensitivity

Sr. No	Name of the Indicator	Rationale / Role of the indicator	Source	Relation with vulnerability
1	Unemployment	Unemployment is related to the possible inability of a household to invest economical resources in flood insurance or in flood mitigation measures, all of which contribute to a slower recovery	Fekete, 2010 Jimenez *et al.*, 2017	Increase
2	Urban growth rate	Fast urban growth may result in poor quality housing and thus make people more vulnerable	Karmaoui and Balica, 2019	Increase
3	Households below poverty line	Economic vulnerability of households increases due to the prevalence of income disparities	Hashim *et al.*, 2019	Increase

A.2.3.Resilience

Sr. No	Name of the Indicator	Rationale / Role of the indicator	Source	Relation with vulnerability
1	Insurance	Crop insurance purchased by farmers protect them against either the loss of their crops due to natural disasters, such as floods and Droughts	New	Decrease
2	Institutional Organizations	Existence of IO increases the adaptive capacity of the society	Balica *et al.*, 2011	Decrease
3	Veterinary institutions	Presence of veterinary institutions helps in outbreak management of various diseases affecting Livestock during and after floods	New	Decrease
4	Recovery time	Amount of time needed by the society to recover to a functional operation after flood events The lesser amount of time, the higher resilience	Balica *et al.,* 2012 Hashim *et al.*, 2018	Increase
5	Savings	Poverty and vulnerability rates are lower among households with savings	New	Decrease
6	Disruption of services	Long term disruption of basic services impedes the recovery process and vice versa	New	Increase

A.3. Environmental Component

Ecological indicators have a long-term effect on the regions capability to cope with disaster-related problems. A region poor in water and forest cover are more prone to hazards like drought and flood as their ecological stability is reduced.

A.3.1.Exposure

Sr. No	**Name of the Indicator**	**Rationale / Role of the indicator**	**Source**	**Relation with vulnerability**
1.	Rainfall amount	The average volume of rainfall in a year.	Hashim *et al*., 2018	Increase
2.	Percent of conversion of paddy fields over the last 5 years	Rice root development reduces the impacts of flooding	New	Increase
3.	Concentration of pollutants	-	New	Increase
4.	Average number of drought events in the past 10 years	More reflects higher exposure	Panthi *et al*., 2015	Increase
5.	Decrease in area under wetlands	Wetlands prevent flooding and also reduce water flow. Decrease in area under wetlands increases exposure to more damage during floods	New	Increase

A.3.2.Sensitivity

Sr. No	**Name of the Indicator**	**Rationale / Role of the indicator**	**Source**	**Relation with vulnerability**
1.	Number of rivers	Higher the number, higher the vulnerability	New	Increase
2.	Nature of soil	Nature of soil influences the probability of flood occurrence and vulnerability of people to floods. More permeable soil has more infiltration capacity and therefore reduces surface run-off, whereas less permeable soil has	Munyayi *et al.*, 2019	Increase

		less infiltration capacity and is more prone to water logging		
3.	Mean standard deviation of the monthly average maximum temperature by month	Indicates change in temperature over the years (2010 - 2020)	Hahn *et al.*, 2008	Increase
4.	Temperature during flooding period	Crops are damaged faster during flooding at higher temperatures. The crop survival period may decrease by 50 per cent or more if temperatures are unusually high during the flooding period.	New	Increase
5.	Wild animal attack	Increases the vulnerability and reduces resilience	New	Increase

A.3.3. Resilience

Sr. No	Name of the Indicator	Rationale / Role of the indicator	Source	Relation with vulnerability
1.	Land use : Forest	Higher the proportion, lesser the vulnerability	Karmaoui *et al.* 2019	Decrease
2.	Soil quality	Soil quality is an indisputable factor determining agricultural potential which further influences the adaptive capacity of the region	New	Decrease
3.	Water quality	Good quality irrigation and drinking water enables the population to cope better	New	Decrease

4.	Crop land density	Area of land under cultivation is used as a proxy for arable land density, providing an indication of the general potential for agriculture in each region	Donohue and Biggs, 2015	Decrease
5.	Homestead farming	Homestead farming, helps to ensure nutritional security as well as economic support after floods (Hasan and Sultanan, 2011)	New	Decrease
6.	Soil conservation measures	Soil conservation measures helps to reduce erosion and increase soil water uptake. It also helps to reduce sediment and nutrient loads transported in a runoff	New	Decrease

A.4.Physical Component

The physical component comprises of geo-morphological and climatic characteristics of the system, and different infrastructures, like channels, reservoirs, dams, weirs, levees which have shaped its physical conditions. The physical component relates to the predisposition of infrastructure to be damaged by a flooding event

A.4.1 Exposure

Sr. No	**Name of the Indicator**	**Rationale / Role of the indicator**	**Source**	**Relation with vulnerability**
1.	Disaster Frequency	Higher the frequency, higher the vulnerability	Hashim *et al*, 2018	Increase
2.	Flood Duration	The expected time of flood impact to prolong	Hashim *et al*, 2018	Increase

3.	Heavy rainfall	Excessive rain that potentially cause a severe flooding of an area	Hashim *et al*, 2018	Increase
4.	Height of water level in the residence	Higher the flood depth, Greater will be the damage to the physical structures	New	Increase

A.4.2.Sensitivity

Sr. No	**Name of the Indicator**	**Rationale / Role of the indicator**	**Source**	**Relation with vulnerability**
1	Housing type	The percent of traditional and single-storey houses, which are very susceptible to floods, currently inhabited by the respondents.	Hashim *et al*., 2018	Increase
2	Dilapidated houses	Weak structures increase the chances of physical damage to inhabitants	Hashim *et al*., 2018	Increase
3	Age of the buildings	Buildings that are older than 20 years old are likely to experience high flood damages compared to buildings that are less than 10 years old	Fatemi et al., 2020	Increase

A.4.3. Resilience

Sr. No	**Name of the Indicator**	**Rationale / Role of the indicator**	**Source**	**Relation with Vulnerability**
1.	Villages connected with pucca roads		Kumar and Bhattacharya, 2020	Decrease

2.	Dams storage capacity	Higher the storage capacity, greater the resilience	Balica and Wright, 2011	Decrease
3.	No. of hospital/lakh population	Presence of well-functioning hospitals increases the adaptive capacity	Kumar and Bhattacharya, 2020	Decrease
4.	Water harvesting structures	It reduces soil erosion and flood hazards by collecting rainwater and reducing the flow of storm water to prevent urban flooding (GOI, 2019)	New	Decrease

APPENDIX II.

Individual values of indicators

B.1.Social Component

B.1.1. Exposure factor of social component

Region	Population density	Elderly population	Rural population	Households(HH) without warning	HH who suffered injury /Death	PTSD *	HH head without school education	Temporary houses	Polluted water bodies
AD	0	0.943	0.918	0.634	0.775	0.188	0	0	0
AP	1	1	0	0	0	1	0	0.961	0.258
KD	0.560	0	0.999	0.181	0	0.584	0	0.316	0.092
KK	0.165	0.629	0.998	0.073	0	0.659	0	0.076	1
MD	0.066	0.580	0.888	0.154	1	0.991	0	0.808	0.164
NM	0.386	0.279	1	0.220	0	0.838	0	0.916	0.344
PM	0.184	0.313	0.747	1	0.200	0.489	0	0.720	0.065
VT	0.082	0.796	0.994	0.955	0.382	0	0	1	0.062

(Post-Traumatic Stress Disorder)

B.1.2. Sensitivity factor of social component

Region	DP	0-6 years	FH	AD	SS	SF	UW	NWS	ATW	PG	FF	NFS
AD	0.277	0.716	1	0.346	0.011	0.129	0.597	0.609	0	0.850	0.308	0.257
AP	0	0.777	0.642	0.911	0.738	0.262	0.158	0.069	0	0.794	0.894	0.006
KD	0.806	0.582	0.457	0	0	0.244	0.021	0	0	1	1	0.305
KK	0.136	0	0.153	1	0.822	0.313	0	0	0	0.404	0.404	0
MD	1	1	0	0.474	0.144	0.595	0.321	0.210	0	1	0	0.009

NM	0.136	0.627	0.361	0.199	0.239	1	0.370	0.267	0	0	0.302	0.125
PM	0.143	0.791	0.544	0.234	1	0.202	0.389	0	0	0.993	0.268	0.533
VT	0.136	0.765	0.776	0.142	0.122	0	1	1	0	0.824	0.251	1

(DP=Disabled population, FH=Female headed households,AD=Agriculture dependent households,SS=Households which do not save seeds, SF=Size of the family,UW=Untreated Water source, NWS= Natural Water Source, ATW= Average Time to Water source,PG=Population Growth,FF=Fish Farmers,NFS=Natural Feed and Input Sources,CI= Chronic Illnesses,HT= Currently receiving Hospital Treatment,SA= Solely Agriculture Dependent Households,ALA= Average Loan Amount,ST= Sanitation, ET=Electricity)

B.1.3. Social Resilience

Region	AD	AC	AI	FT	EM	AO	ATH	FM	HEQ	LD	CD	P
AD	0.839	0	0	1	1	0.355	1	1	0.999	0	0	0.
AP	0.339	0	0.323	1	0.588	0.329	0.417	0.285	0.908	0.233	0.233	0
KD	0.292	0	0.677	1	0.409	0.171	0	0.379	0	0.601	0.601	0
KK	0.080	0	1	1	0	0.333	0.411	0.252	0.691	0.591	0.591	0
MD	1	0	0.312	1	1	0.850	0.21	0	0.813	0.646	0.646	0.
NM	0	0	0.672	1	0	1	0.036	0.324	0.691	1	1	0
PM	0.790	0	0.656	1	0.162	0.751	0.43	0.755	0.905	0.217	0.217	1
VT	0.882	1	0.672	1	1	0	0.091	0.937	1	0.264	0.264	1

(AD=Awareness to Disaster,AC=Access to Communication sources, AI=Access to Input sources,FT=Flood tolerant varietiesEM= Early maturing varieties,AO= Association in Organizations,ATH = Average Time to Health facility,FM=Family members working outside the community, HEQ= Higher Educational Qualification,LD=Livestock Diversification,CD= Crop Diversification,PE= Past

Experience, ESP= Emergency Service Police, ESH= Emergency Services Health Staff, LTR= Long Term Residents)

B.2. Economic Component

B.2.1. Exposure factor

Region	Proximity to river	Number of industries	Life Expectancy index
AD	0.102	0.215	0.513
AP	0	0.607	0.513
KD	0.038	0.130	0.333
KK	1	1	1
MD	0.885	0.476	0.631
NM	0.71	0.132	0
PM	0.577	0.537	0.667
VT	0.997	0	0.289

B.2.2. Sensitivity factor

Region	Unemployment	Urban growth rate	HH below poverty line
AD	0.765	1	0.873
AP	0	0.240	0.153
KD	0.104	0.080	0
KK	0.556	0.040	0.039
MD	0.804	1	0.731
NM	0.620	0	0.220
PM	0.339	0.320	0.951
VT	1	0.320	1

B.2.3.Resilience factor

Region	Insurance	No.of IO	No.of VI	Recovery time	Savings	Disruption of services
AD	1	0.200	0.500	0.909	0.616	0.381
AP	0.152	0	0.25	0.696	0.971	0.461
KD	0.522	1	0.250	0.520	0	0.241
KK	0	1	0	1	0.529	0.567
MD	0.951	1	0.250	0.718	1	0.134
NM	0.860	1	0.750	1	0.529	1
PM	0.543	1	1	0.718	0.865	0
VT	0.921	0.800	0.500	0	0.529	0.499

(IO= Institutional Organizations, VI= Veterinary Institutions)

B.3.Environmental Component

B.3.1.Exposure factor

Region	Average rainfall over the years	Rate of paddy field conversion	Pollutant concentration	Drought events	Decrease in area under wetlands
AD	0.982	0	1	0	0.245
AP	0.154	0.922	0.020	1	0.160
KD	0	1	0.548	0.250	1
KK	0.246	0.494	0	1	0.027
MD	0.855	1	0.923	0.500	0.553
NM	0.044	0.608	0.760	0.250	0.708
PM	0.879	1	0.010	0.500	0.272
VT	1	0	0.990	0.250	0

B.3.2.Sensitivity factor

Region	Number of rivers	Nature of soil	Change in monthly average maximum temperature	Temperature during flooding period	Wild animal
AD	0.500	0	0	0.857	0.485
AP	0.500	1	0.236	0.857	0
KD	0.750	0	0.317	1	0
KK	0.500	1	0.274	0.714	0
MD	0	1	0.880	0.143	1
NM	1	0	0.317	0.857	0
PM	0	1	1	0	0.739
VT	0	0	0	0.857	0.851

B.3.3. Resilience factor

Region	Land use - Forest	Soil quality	Water quality	Crop land density	Homestead farming	Soil conservation
AD	0	0.400	0.199	0.554	0.515	1
AP	1	0	0	0.288	0.262	0.271

KD	1	0.615	1	0.045	1	0.681
KK	1	0.538	0.421	0.624	0.761	0
MD	0.349	0.974	0.135	0	0	0.100
NM	1	1	0.297	0.323	0.761	0.341
PM	0.794	0.538	0.322	0.332	0	0.918
VT	0.635	0.308	0.179	1	0.761	0.948

B.4. Physical Component

B.4.1. Exposure component

Region	Disaster frequency(last 10 years)	Heavy rainfall days	Height of water level in the residence
AD	0.196	1	0.734
AP	1	0.297	0.967
KD	0.059	0.403	1
KK	0.659	0.848	0.901
MD	0.011	0.508	0.287
NM	0.621	0.955	0.979
PM	0.382	0.270	0.584
VT	0	0	0

B.4.2.Sensitivity Component

Region	Housing type	Dilapidated houses	Age of the buildings
AD	0.794	0.060	0
AP	1	0.149	0.143
KD	0.781	0.155	0.475
KK	0.314	0.204	0.199
MD	0	1	1
NM	0.875	0.165	0.368
PM	0.294	0	0.469
VT	0.735	0.700	0.368

B.4.3.Resilience component

Region	Village connected with roads	Average dams storage capacity	Hospitals per lakh population	Water harvesting structures
AD	0.477	0.014	0.918	1
AP	0.031	1	1	0.695
KD	0.595	0	0.564	0.360
KK	0.832	1	0.826	0
MD	0.250	0.285	0.845	0.962
NM	0.395	0	0.179	0.752
PM	0	0.285	0	0.962
VT	1	0.014	0.429	0.501

APPENDIX III

Vulnerability Assessment for Livelihood Inclusion and Social Empowerment of farmers: a post flood analysis of Kerala state

INTERVIEW SCHEDULE FOR FARMERS (Primary Data)

1. **General Information**

a. Name of the respondent: ………………………………………………….

b. Address ………………………………………………………………

c. Nearest Town: …………………………………………...

d. Distance to the nearest major town: …………………………………….

e. Land use type:

Sr. No	Type	Score
1	Residential	1
2	Institutional	2
3	Commercial	3
4	Industrial	4
5	Infrastructure	5
6	Agricultural	6

f. Approximate. Distance from river: ………. m

g. Distance from a height/ Cutting of land: ………. M

Personal and Family characteristics:

1. Name of the head of the household …………………………………..
2. Age :

Sr. No	Age Group	Score
1	30 -40	1
2	40 - 50	2
3	50 - 60	3
4	60 -70	4
5	70 and above	5

3. **Marital status**

Sr. No	Marital status	Score
1	Unmarried	1
2	Married	2
3	Divorced	3
4	Widow	4
5	Widower	5

4. **Education of the head of household**

Sr. No	**Level of education**	**Score**
1	Illiterate	1
2	Read and write	2
3	Secondary education	3
4	Senior secondary	4
5	Graduation	5
6	Post-graduation and higher	6

5. Characteristics of the members of family

S. No	**Name**	**Relation to the head of the household**	**Age**	**Education**	**Profession**
1					

6. Is there any member working outside the community : Yes/ No (1/0)

If Yes, where and the kind of job

7. Do you have any disabled family members with you? ☐Yes ☐No (1/ 0)

If yes, how many? ……………………………….

8. Do you have any savings in case of an emergency? ☐Yes ☐No (1/0)

9. Do you have any other job other than farming : Yes / No (1/0)

If yes:

	Wage labour	1	Service	2
	Business	3	Others	4

10. Which are the major health problems in your family and does any of the member have serious health issues

Sr. No	**Major health issue**	**Score**
1	Asthma	1
2	Diabetes	2
3	Cancer	3
4	HIV and AIDS	4
5	Hypertension/high blood pressure	5
6	Arthritis	6
7	Stroke	7
8	Heart attack/myocardial infarction	8
9	Tuberculosis	9
10	Metal illness	10
11	High cholesterol	11
12	Osteoporosis	12

13	Old age problems	13
14	Other	14

11. How would you describe your health status in general

Sr. No	Category	Score
1	Excellent	5
2	Very good	4
3	Good	3
4	Fair	2
5	Poor	1

12. Distance to the major hospital

Sr. No	Distance	Score
1	Within 10 km	1
2	10 – 20	2
3	More than 20 km	3

13. Frequency of check up

Sr. No	Frequency	Score
1	Always	1
2	Sometimes	2
3	Never	3

II. Characteristics of place of residence

1. How many times did you experience flood while living at this address in the last five years?

   ☐Never been flooded ☐One ☐Two ☐ Three ☐Every year (0/1/2/3/4)
2. Do you own this house : Yes / No [1/0]

   If No, mention the type of ownership: Leased / Rented
3. For how long have you been living here ……………………………… years

Sr. No	Number of years	Score
1	0-20	1
2	20 -40	2
3	40-60	3
4	More than 60	4

4. Age of the building (year of construction)………………………………..

Sr. No	Age of the building	Score
1	Less than 20 years	1
2	20- 40 years	2
3	40 -60 years	3
4	60 – 80 years	4
5	More than 80 years	5

5. Kindly indicate the type of materials used for construction of the house

Sl. no	**type of the house**	**Score**	**Condition of the house**		
			Good (3)	**Average (2)**	**Poor (1)**
1	Thatched shed(wall and roof)	1			
2	Mud walled thatched	2			
3	Brick or laterite walled sheet	3			
4	Brick or laterite walled tiled	4			
5	Concrete house(small)	5			
6	Concrete house (big)	6			

6. How many rooms and floors does the house have?

Sr. No	**Number of floors**	**Score**
1	Single floor	1
2	Two floor	2

7. What was the maximum water level and duration of flood entered your building?

Sr. No	**Depth (m)**	**Score**	**Duration (hrs.)**
1	Up to the plinth level and steps	1	
2	Inside the house	2	
3	Knee height	3	
4	One man height	4	

8. What was the amount of structural damage to your building?

Sr. No	**Category of Damage**	**Score**
1	Built-in shelves and appliances	1
2	Exterior walls, windows, doors (painting included) and roofing	2
3	Interior doors and walls (painting included)	3
4	Footing and foundation and ceiling	4
15	One part of house	5

6	Whole of house	6

9. What was the content damage to the building (Content damage refers to damage to personal property kept inside the building that is not permanently affixed to the building)

Sr. No	**Category of Damage**	**Score**
1	Equipment (including all electronics)	1
2	Furniture	2
3	Clothes	3
4	Kitchen items	4
5	Important documents	5
6	All the above	6

10. Location of the sanitation facilities

Sr. No	**Sanitation facilities**	**Score**
1	Inside dwelling	1
2	In yard	2
3	Outside yard	3

11. Presence of grain storage structures (Yes/ No) (1/0)
12. Which of the following methods are commonly used to protect your house from flood waters

Sl. No	**Flood coping strategies**	**Score**
1	No particular mechanism	0
2	Barriers are installed before doorways to stop the entry of flood water	1
3	Increased the plinth height of the house	2
4	Elevated shelves are built inside the homes to keep utensils	3
5	Construction of makeshift high platforms at home	4
6	Placing of sandbags around the house at the onset of monsoons	5
7	Transferring children and goods to relative's house	6

III. Cropping pattern and floods

1. Total cropped area
2. Ownership
   a. Owned (1)
   b. Leased (2)
3. Area under fallow land :
4. Area under permanent fallow:
5. Have you lost land in floods/ landslides (Yes/ No)

If yes mention the area lost under floods/ landslides

6. Cropping pattern :
   a. Major crops grown
7. Have you suffered crop losses during floods : Yes / No

If yes, mention the area under cultivation lost due to floods

8. Do you have any kind of insurance : Yes / No

If yes, mention the kind of insurance

Sr. No	Type	Score
1	No insurance	0
2	Building insurance	1
3	Crop/ Livestock insurance	2
4	Life Insurance	3

9. Do you have farming in the areas immediate to your home: Yes/ No (1/2)

If yes, mention the type of crops grown.

10. Experience in farming (in years):

Sr. No	**Number of years**	**Score**
1	Less than 10	1
2	10 - 20	2
3	20- 30	3
4	More than 30	4

11. What were the major crops grown before floods:
12. What were the major crops grown before 5-10 years :
13. Change in cropping pattern:
14. Do you store rain water: yes / No

If yes: Tick the appropriate boxes

Water harvesting structures	**Choose from the following**
Roof water harvesting	1
Ponds	2
Tanks	3
Trenches	4
Bunds	5
Rain pits	6
Contour bunds	7

15. Do you practice any soil moisture retention methods? Yes No

If yes, which among the following:

A) Bio fencing (1) b) Bench terracing (2) c) mulching (3) d) others (4) Nil (0)

16. From where do you get water for irrigation:
Choose from the following sources of irrigation

Sources of Irrigation	**Choose from the following**
Government canal	1
Private canal	2
Well	3
Tube well	4
Bore well	5
Natural sources	6

17. How do you preserve soil fertility?
    - Nil (0)
    - Fertilisation (Chemicals, animal manure, green manure etc) (1)
    - Crop rotation (Cultivation of a series of dissimilar types of crops in the same area in sequential seasons) (2)
    - Intercropping (Cultivation of two or more dissimilar types of crops in the same area in the same season) (3)
    - Tillage(4)
    - Other (specify): ....
18. In case fertilisers are applied, which kinds do you use?
    - Chemical fertilisers (1)
    - Organic fertilisers (non-chemicals like animal manure, green manure, compost, etc.) (2)
    - ___________________________
19. How do you control pests and diseases?
    - Biological & organic control methods (non-chemical control methods) (1)
    - Integrated pest management (IPM) methods (2)
    - Chemical pesticides (treatment), specify what do you use? (3)…………………………………………………………… ………………
    - Other methods (specify)………..……………………………..................................
20. How do you control weeds?
    - By burning plant residues after harvesting (1)
    - By grazing through animals (2)
    - By mechanical weeding (tillage, mowing and/or manual) (3)
    - By crop rotation and/or intercropping (4)
    - By chemical herbicides, specify what do you use? (5)..
21. Have you received help from the fellow farmers or farmer groups for the construction of bunds and embankments : Yes / No (1/0)

22. How did you receive the seeds for the next season
    a. Obtained from Panchayath (1)
    b. Obtained from the Krishi Bhavan (2)
    c. Distributed by the Local groups (3)
    d. Purchased from university (4)
    e. Purchased from private shops (5)
    f. Seeds stored from the previous seasons (6)

23. Did you receive any support from government institutions for doing farming after floods : Yes/ No (1/0)

If yes, what kind of support did you receive?

24. Have you adopted any soil and water conservation measures in your fields after the floods of 2018 and 2019 YES / NO (1/0)

If YES, give details on Soil and water conservation measures in your own farm

Sl. No.	**Practices**	**Score**
1	Mulching	1
2	Bunding	2
3	Grass planting	3
4	Vegetative fencing	4
5	Afforestation	5
6	Geotextiles	6

IV. Poultry and Livestock

1. Do you have livestock/ poultry/farming: Yes / No (1/0)

If yes, fill in the following details

Type of farming	**Number / Area under farming**
Cattle	
Goat	
Poultry	

2. Varieties of cattle

Sr. No	**Category of breed**	**Score**
1	Indigenous	1
2	Exotic	2
3	Cross bred	3

3. Varieties of goat

Sr. No	**Category of breed**	**Score**
1	Indigenous	1
2	Exotic	2
3	Cross bred	3

4. Varieties of poultry

Sr. No	Variety of poultry	Score
1	Indigenous egg type	1
2	Native egg type	2

5. Cattle and poultry loss during floods :

Type of farming	Number of animals lost due to floods	Variety
Cattle		
Goat		
Poultry		

6. What is the source of your feed?

Sr. No	Source of feed	Score
1	Natural sources	1
2	Retail or wholesale shops	2
3	Farmer cultivators	3
4	Own cultivation	4
5	Authorized government offices	5

7. When was the last time you sold your livestock?

Sr. No	Time of selling livestock	Score
1	2018	1
2	2019	2
3	2020	3

8. Did the animals suffer from any diseases after floods : Yes/No (1/0)

If yes

Sr. No	Incidence of diseases	Score
1	Incidence of new diseases	1
2	Increased intensity of old diseases	2

9. Did you get poultry and livestock vaccinated? Yes / No (1/0)
10. Distance to the veterinary hospital

Sr. No	Distance	Score
1	Within 10 km	1
2	10 – 20	2
3	More than 20 km	3

V. Fish farming

1. Do you practice fish farming : Yes / No (1/0)

If yes, kindly answer the questions below

a. Type of fish farming : traditional/ cage / bio floc
b. Variety of fish being cultivated

Sr. No	**Type of variety**	**Score**
1	Indigenous	1
2	Exotic	2

c. Have you suffered losses in fish cultivation during floods : Yes/ No (1/0)

If yes, mention

i.the kind of losses (destruction of cages and nets/ breach of ponds and waterbeds)

VI. Communication and emergency response

1. Do you have access to or knows to use any of the following

Sr. No	**Items**	**Yes / No**
1	Radio	1
2	Television	2
3	Mobile phone	3
4	Internet	4
5	Mobile apps	5
6	Email	6

2. Just before the flood, how did you first become aware that flood waters might reach your home?

S. No	**Communication media**	**Scoring**
1	**Nil**	0
2	TV	1
3	Siren	2
4	Radio	3
5	Newspaper	4
6	SMS	5
7	Loudspeaker announcement by panchayath	6

3. How many hours were there between the time you became aware that flooding might reach your home until the water actually reached to your property?…………..... hrs

S. No	Time period	Scoring
1	Less than 1 hour	1
2	2-4 hours	2
3	4-6 hours	3
4	More than 6 hrs	4

4. What was the percent of potential damage prevented due to warning? ……… %

S.No	Percent of damage prevented	Scoring
1	Nil	0
2	Less than 50%	1
3	More than 50%	2
4	100 %	3

5. When did the rescue operations reach
   a. Soon after the water level rose (1)
   b. Remained strangulated for quite a long time (2)
   c. Never came (3)

6. What is the minimum warning time you would need to move all your transportable contents to a safe location? ……………. Hrs

S. No	Time period	Scoring
1	Less than 1 hour	1
2	2-4 hours	2
3	4-6 hours	3

7. a.Did you move to the relief centres: Yes / No (1/0)

If yes

a. Distance to the relief centre

S. No	Distance	Scoring
1	Within 5 km	1
2	5 – 15 km	2
3	More than 15 km	3

b. If No

Did you move to relatives houses : Yes / No (1/0)

c.Available mode of transportation to the relief centre

S. No	Mode of transportation	Scoring
1	Own Vehicle	1
2	Vehicle of relief operations	2
3	Neighbour vehicle	3

d. Who helped you in reaching the relief centres

S. No	Mode of help	Score
1	Self	1
2	Local people	2
3	Relief operations (police, army, volunteers)	3

8. In the relief camps , what were the different kinds of compensation you received
   a. Food (1)
   b. Clothes (2)
   c. Mosquito nets (3)
   d. Medicines (4)
   e. First aid kits (5)
   f. All the above
9. For how many days you had to stay in the relief camps?

S. No	No.of days	Score
1	Less than 1 week	1
2	1 week	2
3	More than a week	3

10. Have you received support from other organizations/ groups other than government (Yes/ No)

If Yes, Mention the kind of organizations

Sr. No	**Type of organization**	**Score**
1	NGO	1
2	Farmer groups	2
3	Youth groups	3
4	Local people	4
5	Political organizations	5

11. After receding of flood waters, how did you clean the debris from home and fields

Sr. No	**Mode of operation**	**Score**
1	Family members	1
2	Wage labourers	2
3	Local people	3
4	NGO members	4
5	Volunteers	5

12. Did you face any kind of stress after floods and how did you cope with it (Yes/ No)(1/2)

…………………………………………………………………………………………
......

13. Were you provided service of qualified medical practitioners (Yes / No)
14. Presently, do you have a safe place to move in case of flooding? (Yes/ No)

VII. Characteristics of floods

1. How many days does floods prolong : (in weeks/ days)

S.No	No.of days	Scoring
1	0 – 7	1
2	7 – 14	2
3	More than 14	3

2. After 2018 floods, have you received any trainings on flood coping mechanisms

Yes / No (1/0)

If yes

i.. who conducted the training …………………………………………………..

ii. Duration of the training …………………………………………………..

iii. What did you learn from the training? ……………………………………..

3. What are the measure you adopt to prevent the entry of flood waters into the field and to redirect the flow of water from the fields.

Sr. No	**Measures to prevent flooding**	**Score**
1	Deepening and cleaning of canals and waterways	1
2	Strengthening of bunds	2
3	Construction of stone walls	3
4	Placing of sand bags	4
5	Increasing the height of bunds	5

4. Supply Damage

Categories of damage	**No.of days**	**Score**
For how many hours water supply was interrupted? (hr/days)	Less than 5 days	1
	5 to 10 days	2
	10 to 15	3
	More than 15	4
How long did it take for you and your household to get back to your normal daily routines? (hrs/days/months)	1 month	1
	1- 2 months	2
	2- 4 months	3
	4-6 months	4
	6- 18 months	5
	Not yet normal	6
For how many hours electric supply was interrupted? (hr)	Less than 5 days	1
	5 to 10 days	2
	10 to 15	3
	More than 15	4
For how many hours telephone supply was interrupted? (hr)	Less than 5 days	1
	5 to 10 days	2
	10 to 15	3

	More than 15	4

5. Which are the various organizations that supported you to regain livelihood after floods (1/0)

Mention the organization and type of support received

Sr. No	Type of support	Score
1	Financial support	1
2	Technical support	2
3	Moral support	3

6. Whether the sewerage lines and septic tanks submerged under flood waters?

☐Yes ☐No (1/0)

VIII.Contact with officials and access to institutions

1. Do you have an account in Banks? Yes/ No (1/0)

If yes, name of the bank and distance to the bank?

Sr. No	**Distance to the bank**	**Score**
1	Less than 5 km	1
2	5 – 10 km	2
3	10-15 km	3
4	15 – 20 km	4
5	More than 20 km	5

2. Have you taken loan from any of the institutions: Yes/ No

If yes, mention the type of institution

Sr. No	**Name of the institution**	**Score**	**Remaining amount to be paid**
1	Commercial banks	5	
2	Private banks	4	
3	Money lenders	3	
4	Kudumbasree	2	
5	Friends and family	1	

3. From where do you buy fertilizers and other farm inputs?

Sr. No	**Name of the centre**	**Score**
1	University sale centres	1
2	Private shops	2
3	Krishi Vigyan Kendra	3
4	Others	4

4. Are you a member of any of the following organizations?

Sr. No	Name of the Organization	Score
1	Farmer groups	1

2	Padasekhara Samithis	2
3	SHG	3
4	Farmer Cooperatives	4
5	Kudumbashree	5
6	Others	6

5. How often do you have interaction with the officials of agriculture and other related departments (Often (1)/Sometimes(2)/ Never(3))
6. Soon after the floods, did you face financial problems? Yes / No (1/0)

If yes, mention the kind of problem

Sr. No	**Type of problem**	**Score**
1	Inability to pay off debts	1
2	Difficulty in meeting day to day expenses	2
3	Difficulty in meeting medical expenses	3

IX. Water and Sanitation

1. From where do you get water for your daily needs

Sr. No	**Name of the water source**	**Score**
1	Own well	1
2	Bore well	2
3	Public well	3
4	Pipe connection	4
5	Natural water source	5

2. If, Pipe connection, what is the frequency of water availability : Daily(1)/ Once in 2days (2) / once in a week (3)
3. Scarcity of drinking water during floods – Yes/ No (1/0)
4. If natural source, distance to the source from the house.
5. Have you faced any illnesses during the floods? (Yes / No) (1/0)

If yes, mention the kind of diseases

6. What are the different water purifications methods used by you?

Sr. No	Purification method	Score
1	Nil	0
2	Chlorine	1
3	Water purifier	2

7. No. of months with acute shortage of water

Sr. No	No. of months of water shortage	Score
1	0-3 M	1
2	3-6 M	2
3	6-9 M	3
4	9-12 M	4

8. Has the depth of water table changed over last 10 years? (ft)

Sr. No	Depth of water table	Score
1	Gone down	1
2	Gone up	2
3	No change	3
4	Fluctuating	4

8. Have you dug new open well/new borewell during the last 10 years? YES/NO (1/0)
9. Have you ever been faced well failure in the case of digging new open well/drilling new bore well/deepening of existing well? YES/NO (0/1)
10. List the initiatives you have taken to manage water scarcity at farm level

Sl. No.	**Measures**	**Score**
1	Drilling new borewells	1
2	Deepening of existing wells	2
3	Joint wells	3
4	Farm surface storage tank	4
5	Farm pond	5
6	Adoption of drip/sprinkler irrigation method	6
7	Planting of trees	7
8	Field mulching	8
9	Water saving irrigation methods (conventional)	9
10	Growing rainfed crops	10

X. Transportation

1. Do you own any vehicles? Yes/ No (1/0)

If yes, which one

a. Two wheeler (1) b. Four wheeler (2)

2. Is the roads connecting, hospitals, town, boat jetty and bus stops metalled: Yes / No

4. Do the metal roads get damaged during floods/ rainy season? (1/0)

5. Soon after the floods, were the roads and bridges repaired? Yes/ No.

6. Time of repairing of bridges and roads

Sr. No	**Time of repair**	**Score**
1	Less than 3 months	1
2	3 – 6 months	2
3	6 – 12 months	3
4	More than a year	4
5	Not yet repaired	5

XI. Food

1. Do you experience shortage of food : Yes / No

If yes, in which months do you experience shortage of food

2. How do you cope with food shortage during the time of floods? Pick up the commonly adopted measures

Sl. No	Flood coping strategies	Score
1	Storage of food items in pots	1
2	Collection and storage of drinking water	2
3	Storage of grains in structures (*Pathayam*)	3
4	Rely on less preferred items, and on food items received during relief	4
5	Reduction in the frequency of meals	5

3. During and after floods, do you share food with your neighbours or those who are in need of it (Yes/ No)
4. How did the local people help you in arranging food, shelter and water (Yes/ No)
5. Is the ration shop in your area active , what is the colour of your card (Yes/ No)

Sr. No	Colour of ration card	Score
1	Pink	1
2	Blue	2
3	White	3

6. What are the various food items you received from PDS for free after the flood other than the regular quota

Plate 1. Houses near steep unstable slope in Vellathooval panchayath of Idukki district

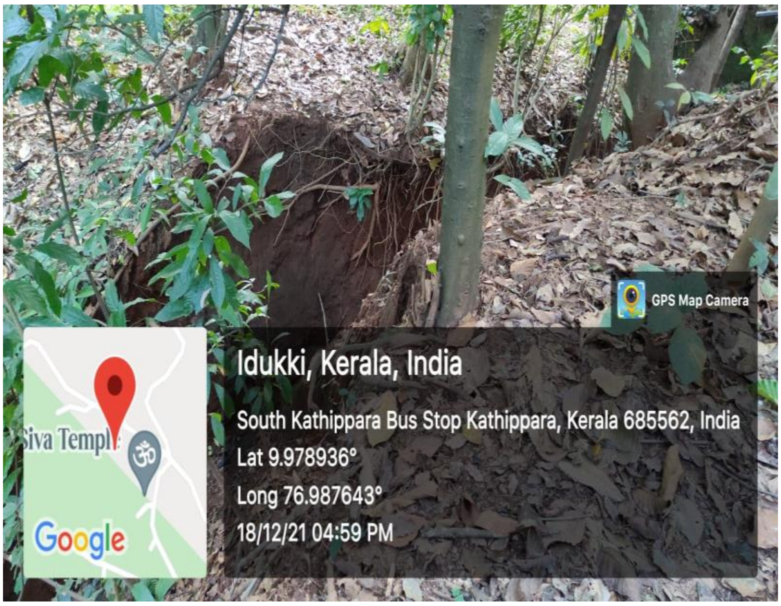

Plate 2. Huge crack formed in Rubber plantation due to landslides in Vellathooval

Plate 3. Conducting survey among the landslide farmers of Kanjiraveli region of Adimali panchayath

Plate 4. A devastated family in Adimali who lost their house completely in landslide

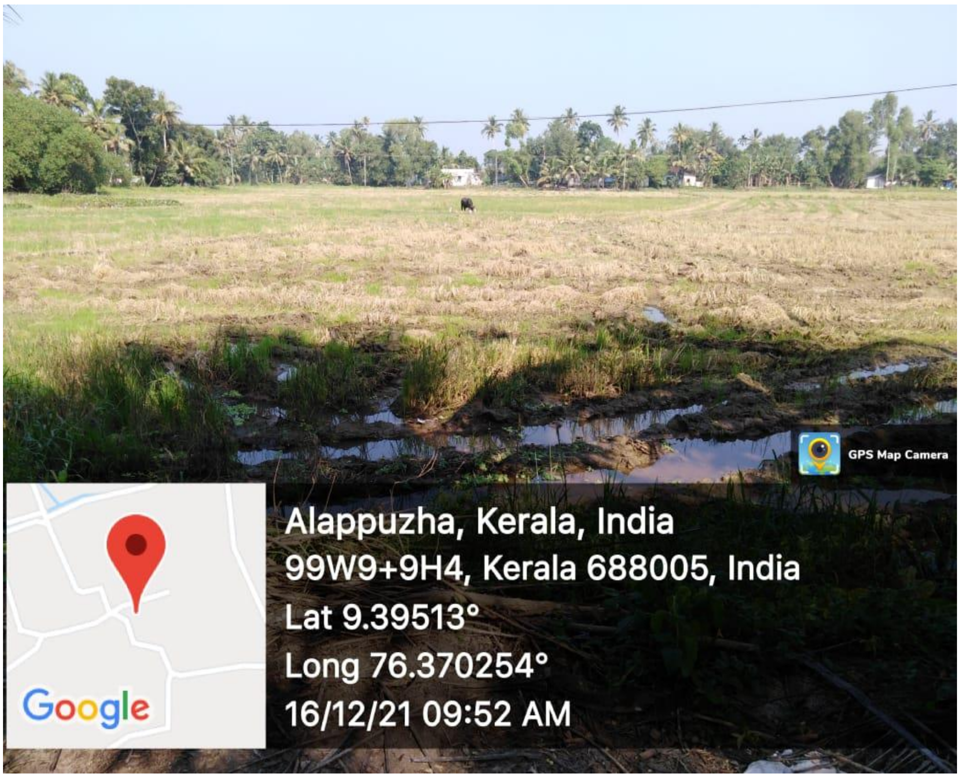

Plate 5. A paddy field in Ambalappuzha which could not be harvested due to floods

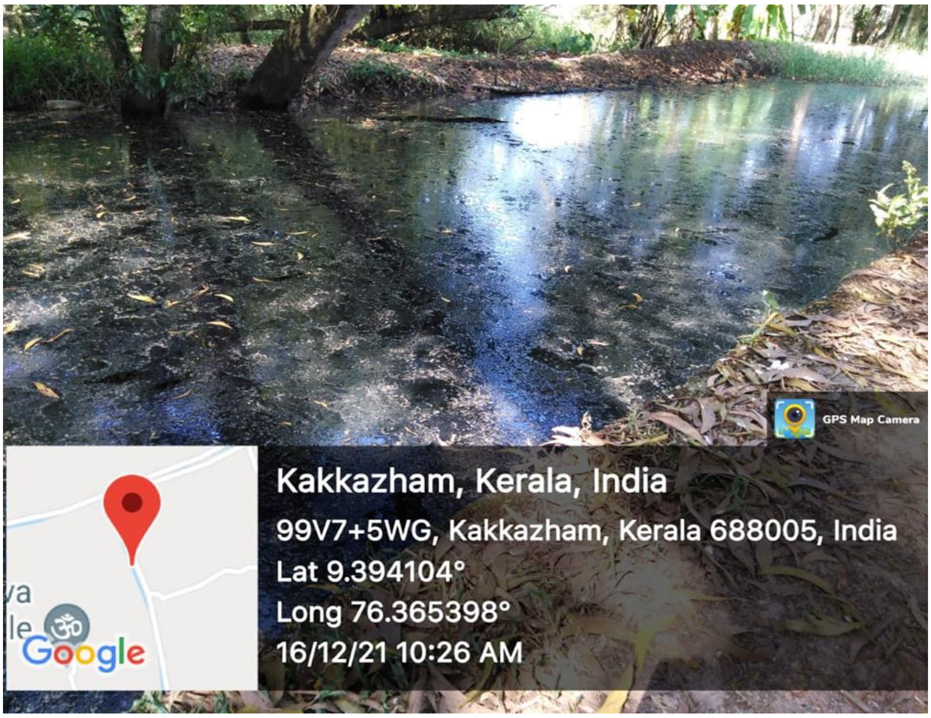

Plate 6. Polluted *Kappithodu* water network in Ambalappuzha

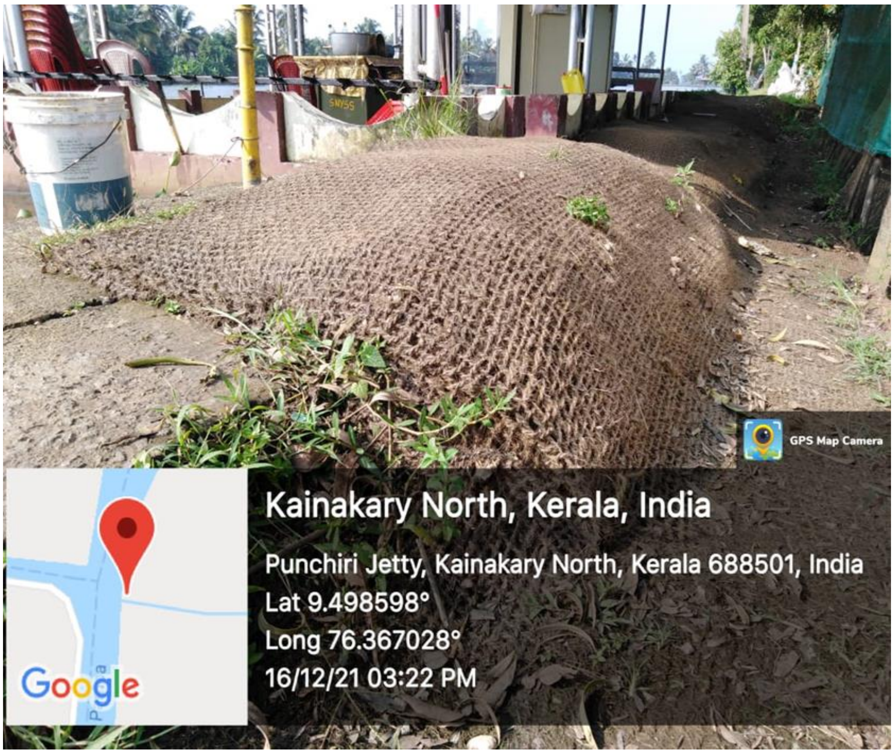

Plate 7. Application of Geotextiles as a flood protection measure in Kainakari panchayath of Alappuzha

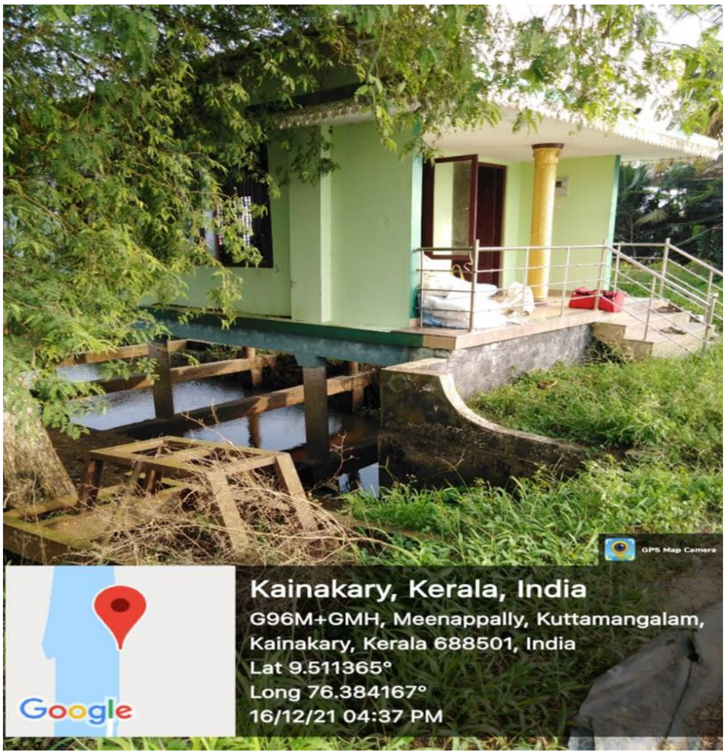

Plate 8. Houses built on cement poles in Kainakari

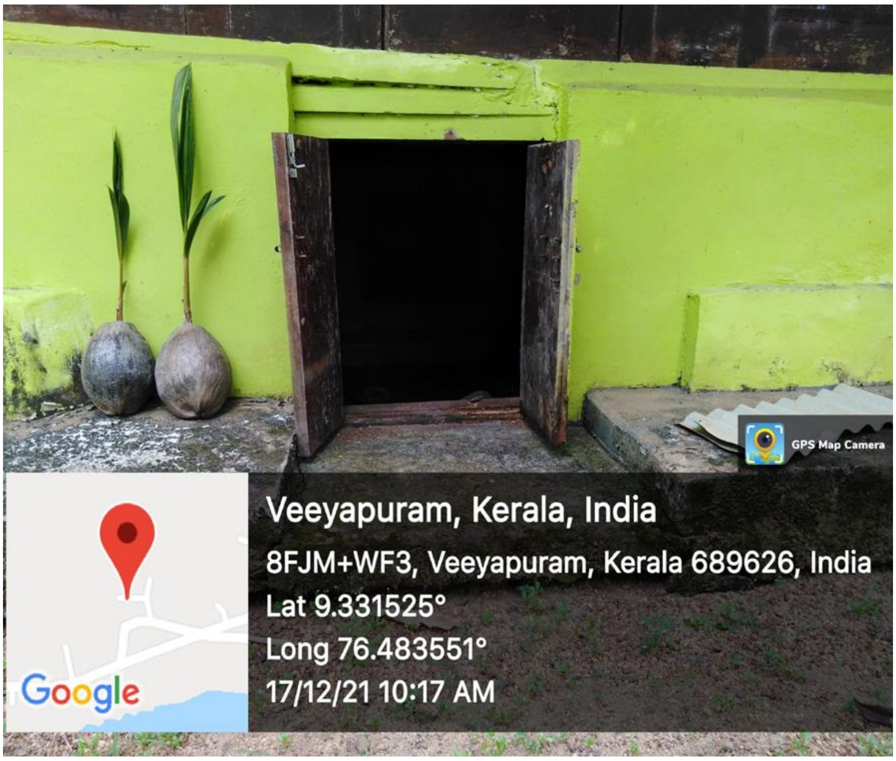

Plate 9. The '*Ara and Para'* system in Pathanamthitta. This in built system found in traditional homes of Niranam and Kadapra protected the homes from flood waters

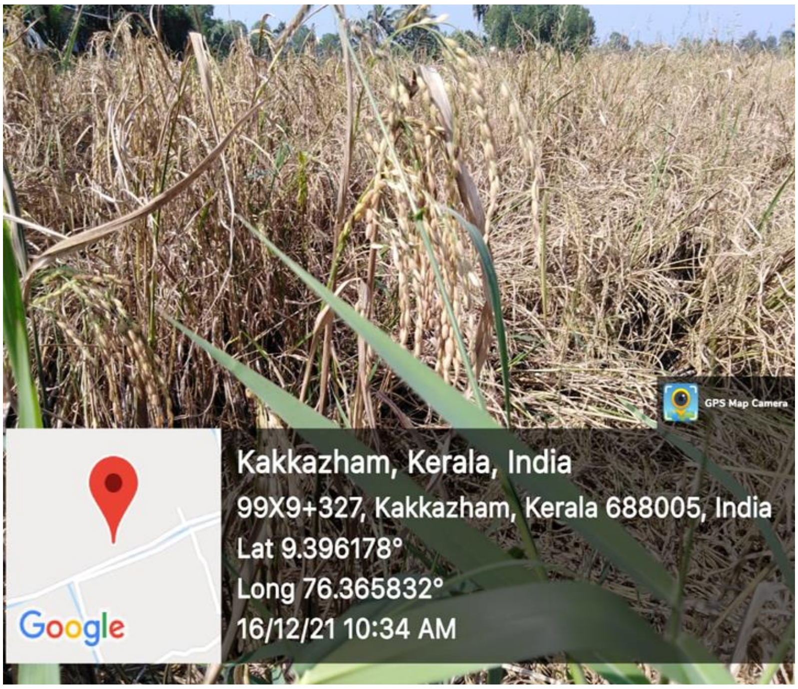

Plate 10. Fully ripe paddy spikelet's withered in flood waters- A view from a rice field in Niranam