ASSESSMENT OF AGRICULTURAL LOSS DUE TO 2018 FLOOD TO FARM HOUSEHOLDS IN THE FLOOD PLAINS OF CHALAKUDY RIVER

By

FEMI ELIZABETH GEORGE

(2018-11-021)

DEPARTMENT OF AGRICULTURAL ECONOMICS

COLLEGE OF HORTICULTURE
VELLANIKKARA, THRISSUR – 680656
KERALA, INDIA
2020

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DEPARTMENT OF AGRICULTURAL ECONOMICS

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KERALA, INDIA

2020

DECLARATION

I, hereby declare that the thesis entitled **"Assessment of agricultural loss due to 2018 Flood to farm households in the flood plains of Chalakudy river"** is a bonafide record of research done by me during the course of research and that it has not previously formed the basis for the award to me of any degree, diploma, fellowship or other similar title, of any other University or Society.

Vellanikkara,
20-08-2020

Femi Elizabeth George
(2018-11-021)

CERTIFICATE

Certified that this thesis entitled **"Assessment of agricultural loss due to 2018 Flood to farm households in the flood plains of Chalakudy river"** is a record of research work done independently by **Ms. Femi Elizabeth George (2018-11-021)** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to her.

Vellanikkara,
20-08-2020

Dr. Prema A.
(Major Advisor, Advisory Committee)
Professor and Head
Department of Agricultural Economics
College of Horticulture
Vellanikkara

CERTIFICATE

We, the undersigned members of the advisory committee of **Ms. Femi Elizabeth George (2018-11-021)**, a candidate for the degree of **Master of Science in Agriculture** with major field in **Agricultural Economics**, agree that this thesis entitled **“Assessment of agricultural loss due to 2018 Flood to farm households in the flood plains of Chalakudy river”** may be submitted by **Ms. Femi Elizabeth George**, in partial fulfillment of the requirement for the degree.

Dr. Prema A.
(Major Advisor, Advisory Committee)
Professor and Head
Dept. of Agrl. Economics
College of Horticulture
Vellanikkara

Dr. Chitra Parayil
(Member, Advisory Committee)
Assistant Professor
Dept. of Agrl. Economics
College of Horticulture
Vellanikkara

Dr. Hema M.
(Member, Advisory Committee)
Assistant Professor
Dept. of Agrl. Economics
College of Horticulture
Vellanikkara

Dr. P. Prameela
(Member, Advisory Committee)
Professor
Dept. of Agronomy
College of Horticulture
Vellanikkara

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CONTENTS

Chapter	Title	Page No.
1	INTRODUCTION	1
2	REVIEW OF LITERATURE	8
3	METHODOLOGY	21
4	RESULTS AND DISCUSSION	57
5	SUMMARY AND CONCLUSIONS	99
	REFERENCES	i
	APPENDICES	xiv
	ABSTRACT	xxix

LIST OF TABLES

Table No.	Title	Page No.
3.1	Land utilization pattern of Kerala (2017-18)	23
3.2	Cropping pattern of Kerala during 2017-18	24
3.3	Land utilization pattern of Thrissur and Ernakulam (2017-18)	35
3.4	Cropping pattern of selected districts during 2017-18	36
3.5	Crop loss due to 2018 Flood in the selected districts	37
3.6	Scoring adopted for Likert scale	50
3.7	Independent variables selected in the logistic model	53
4.1	Total damages to agricultural assets per farm household (₹)	59
4.2	Blockwise damages to major agricultural assets per farm household	60
4.3	Total damages to seasonal crops per farm household (₹)	61
4.4	Blockwise damages to major seasonal crops per farm household	62
4.5	Total damages to perennial crops per farm household (₹)	63
4.6	Blockwise damages to major perennial crops per farm household	64
4.7	Total damages to livestock and poultry per farm household (₹)	64
4.8	Blockwise damages to major livestock and poultry per farm household	65
4.9	Agricultural damage per farm household (₹)	66
4.10	Total losses from seasonal crops per farm household (₹ lakhs)	68
4.11	Blockwise loss from major seasonal crops per farm household	69
4.12	Total losses from totally destroyed perennial crops per farm household (₹ lakhs)	70

4.13	Blockwise loss from totally destroyed major perennial crops per farm household	71
4.14	Total losses from partially destroyed perennial crops per farm household (₹ lakhs)	72
4.15	Blockwise loss from partially destroyed major perennial crops per farm household	73
4.16	Agricultural loss per farm household (₹ lakhs)	74
4.17	Agricultural damage and loss in the flood plains of Chalakudy river (₹ crores)	77
4.18	Total damages to agricultural assets (₹ lakhs)	79
4.19	Total damages to seasonal crops (₹ lakhs)	80
4.20	Total damages to perennial crops (₹ lakhs)	81
4.21	Total damages to livestock and poultry (₹ lakhs)	82
4.22	Total losses from seasonal crops (₹ lakhs)	83
4.23	Total losses from totally destroyed perennial crops (₹ lakhs)	85
4.24	Total losses from partially destroyed perennial crops (₹ lakhs)	86
4.25	Socioeconomic profile of respondents in the study area (n =120)	87
4.26	Sample factor analysis table	91
4.27	Ranking of factors according to their importance	92
4.28	Resilience level of the farmers	93
4.29	Estimates of the logistic model for resilience	94
4.30	Hardships faced by the farm households	96

LIST OF FIGURES

Figure No.	Title	Page No.
1	Disaster effects to the agriculture sector in Kerala	25
2	Rainfall (total) recorded during 2010-2018	31
3	Per farm household damage to major agricultural assets (n=120)	60
4	Per farm household damage to major seasonal crops (n=120)	62
5	Per farm household damage to major perennial crops (n=120)	63
6	Per farm household damage to major livestock and poultry (n=120)	65
7	Box plot showing total damages to each of the respondent households – block-wise scenario	67
8	Loss incurred per farm household to major seasonal crops (n=120)	69
9	Loss incurred per farm household to totally destroyed major perennial crops (n=120)	71
10	Loss incurred per farm household to partially destroyed major perennial crops	72
11	Box plot showing total losses to each of the respondent households – block-wise scenario	75
12	Block wise disaster effect	78

13	Damage to major agricultural assets	79
14	Damage to major seasonal crops	80
15	Damage to major perennial crops	81
16	Damage to major livestock and poultry	82
17	Loss from major seasonal crops	84
18	Loss from totally destroyed major perennial crops	85
19	Loss from partially destroyed major perennial crops	86
20	Resilience level of the farmers	94

LIST OF PLATES

Plate No.	Title	Page No.
1	Map of Chalakudy river basin	27
2	Major sub watersheds in Chalakudy river basin	29
3	Sampling frame	39
4	Map of the study area	40
5	Field survey	106
6	Floods 2018 - A view of the devastated fields	106

LIST OF APPENDICES

Appendix No.	Title	Page No.
1	Survey questionnaire for farmers	xv
2	Loss estimated by respective Krishibhavans	xxvi
3	Proportionate selection of farmers in the selected panchayats	xxviii

Introduction

1. INTRODUCTION

Weather and climate parameters assume a significant role in deciding the accomplishment of agricultural pursuits in order to produce the food and fiber necessary to sustain human life. In monetary terms, agriculture represents 4.0 percent of GDP for the world as a whole, and is more important for low-income countries, amounting to almost one-fourth of GDP for least developed countries (World Bank, 2019). Agriculture being vulnerable to climate variability and change, the climatic extremes are often found to adversely affect farm production and productivity, thus adversely affecting the economy. The mounting evidences on global climate change and its effects leading to increased occurrence of natural disasters that directly impact the lives and livelihoods of people is a matter of serious concern. As per the annual report of Weather, Climate and Catastrophe Insight, natural disasters alone have caused economic losses in tune of USD 225 billion across the world in 2018 and its far reaching effects are now clearly visible on agricultural sector, on which relies the food production and economy of the world (Arora, 2019).

Natural disasters are low-probability, high-consequence events that can result in significant human losses and economic shocks. Disaster induced economic damage has been increasing in the past few decades and is likely to continue growing because of urban development, population growth and ecosystem alteration (IPCC, 2012). Climate related disasters represent the largest number of natural disasters and influence a greater number of individuals than any other type of natural hazards. Extreme weather and climate events often have extreme financial effects, for example, loss of lives and livelihoods, food, water and energy scarcity and adverse effects on human wellbeing and the environment (USAID, 2009). Many extreme climate and weather events being observed have been linked to human influences, and are being manifested either as low temperature extremes, high temperature extremes, rising sea level, or change in the nature and pattern of precipitation. The period between 1998 and 2017 witnessed natural disasters taking away 1.3 million lives leaving behind 4.4 billion people injured, homeless, displaced or in need of emergency assistance. While 91 percent of all disasters were caused by climate related events such as droughts, floods, heat waves, storms and other extreme weather events, geophysical events caused more fatalities (Wallemacq, 2018). In an era when due to climate change the frequency and severity of extreme weather events are increasing, disasters (may it be in the form of natural calamity or pandemics) will continue to be a regular phenomenon and we may have to learn to live with the disasters.

In the study report by CRED-EM-DAT (Centre for Research on the Epidemiology of Disasters-Emergency Events Database) and UNDRR (United Nations Office for Disaster Risk Reduction), during the period 1998-2017, India was listed among the top 10 countries in terms of absolute losses (in billion US$) due to disasters. Despite different regions of the country facing various forms of natural hazards every year, floods contribute majority of losses and are more frequent than any other disasters. India is the second largest flood affected nation after China (Wallemacq, 2018). Increasing flood disaster trend in Indian states can be attributed to numerous factors as like geo-climatic conditions and high degree of socio-economic vulnerability in different regions. According to GOI (2011) statistics, approximately 40 million hectares of land in the country is flood prone. During the period 1980-2011, the annual loss of GDP (Gross Domestic Product) was around 0.46 percent on account of flood, and the reduction to GDP contribution in terms of crop loss, damage to private and public properties were reported as 0.18, 0.25 and 0.21 percent respectively (Parida, 2017).

The state of Kerala, despite its impressive achievements in human development which gained global recognition and standing first in the country in terms of Human Development Index (HDI), is highly vulnerable to natural disasters. Its location along the sea coast with a steep gradient along the slopes of the Western Ghats renders the state highly vulnerable to natural disasters and the changing climatic dynamics. The high population density (860 persons per square kilometers) increases its vulnerability even more, to damages and losses on account of disasters.

Floods are the most common natural hazards in the state. Among the different states which are flood prone in the country, Kerala stands fourth in the state-wise vulnerability to flood, measured in terms of average annual flood damage as percentage of the state GSDP (Gross State Domestic Product). The state is also at fourth position in average annual area affected by floods as percentage of state geographical area (Parida, 2017). The Kerala State Disaster Management Plan identifies 14.4 percent of the state as landslide prone and nearly 14.5 percent of the state as prone to floods and the extent is as high as 50 percent for certain districts. Landslides during the monsoons are a significant danger along the Western Ghats in Wayanad, Kozhikode, Idukki and Kottayam districts (GOK, 2018).

Kerala encountered the most exceedingly awful floods in its history since 1924, between June 1st and August 19th of 2018. The whirling, unsettling monsoon rain is a piece of the express each year, however, the Southwest monsoon of 2018 had an alternate effect, with the state getting an unusually high precipitation from June 1st to August 19th of 2018, which brought about a grievous flood in 13 out of 14 districts in the state. The combined precipitation that the state received during this period was 42 percent in excess of the typical normal. The heaviest spell of downpour was during 1st to 19th of August, when the state got 771 mm of rainfall. The heavy rains set off several landslides across the state. The seven most noticeably awful hit districts were Pathanamthitha, Alappuzha, Kottayam, Idukki, Ernakulam, Thrissur and Wayanad, where the entire district was notified as flood affected. The overwhelming floods and landslides affected 5.4 million people, dislodged 1.4 million people and took 433 lives (GOK, 2018).

As per India Meteorological Department (IMD) data, the state received 2346.6 mm of rainfall in contrast to an expected 1649.5 mm of rainfall from 1st June 2018 to 19th August 2018. Detailed analysis indicated that the cumulative rainfall realized during 1st to 19th of August 2018 was quite significant, and was the cause for the unprecedented deluge. As per the rainfall records, it has been found that the rainfall depths recorded during the 15th to 17th of August 2018 were comparable to the torrential rain that occurred in the year 1924 (CWC, 2018). In addition, the rainfall information shows that the realized rainfall essentially surpassed the expected rainfall and this unexpected exceedance and high force of precipitation brought about the enormous overland stream causing destruction to life and property.

The extreme downpour and the subsequent deluge impacted all the aspects of human lives including transportation, socioeconomic conditions, infrastructure, agriculture and livelihood. Government of Kerala in conjunction with the European Union (EU), the World Bank and the United Nations (UN), conducted a PDNA (Post Disaster Need Assessment) and pegged the total disaster effects at around ₹26,720 crores, comprising of total damages (₹10,557 crores) and total losses (₹16,163 crores). Considering the agriculture sector comprising of crops, livestock and aquaculture/fisheries sub sectors, the total disaster effect was estimated as ₹7,154 crores. Crops were most vigorously affected, adding to 88 percent of the complete misfortune and harm to the segment (GOK, 2018).

The flood posed a severe blow to Kerala's economy whose 52 percent of the population lives in rural areas and 17.15 percent of the population depends on the agricultural sector (including crops, livestock and fisheries) for its livelihood (GOK, 2011). According to GOK (2019), agriculture sector contributed to 8 percent of the total Gross State Value Addition (GSVA) at current prices. The state's economy and a large number of agriculture dependent rural households, most of which are involved in subsistence agriculture, are found to have borne the brunt of the unprecedented deluge and its aftermath.

At the same time, the United Nation Sendai Frame Work for Disaster Risk Reduction 2015-30 which advocates for substantial reduction of disaster risk and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of persons, businesses, communities and countries has observed under- reporting of disaster induced damages in the case of low income countries; and in Asia that is to the tune of 42% (UN, 2015).

It is in this context that the present study entitled 'Assessment of agricultural loss due to 2018 Flood to farm households in the flood plains of Chalakudy river' was undertaken with the aim of estimating the damage and the loss suffered by the farm households along the flood plains of the Chalakudy river. The study also focused on the farmers' ability to cope with a complete devastation after a face-off with an unprecedented situation posed by the floods. The study also tried to observe the major difficulties that the farm households along the flood plains of the river faced during the event of the disaster.

The specific objectives of the study are

1. To assess the agricultural loss in the flood plain
2. To estimate the economic loss of the affected agricultural households
3. To analyze the resilience level of the affected farmers

Scope of the study

The post-disaster damage and loss assessment is primarily done to measure quantitative requirements for financial recuperation and recreation after disasters, to determine limit of government to lead post calamity programs on its own and to give quantitative basis for the *ex-ante* disaster risk management schemes. Loss of livelihood due to floods is an unavoidable phenomenon which is addressed not to the level desired. Also, in most cases, disaster loss assessment confines itself to just an assessment of damages. The loss of livelihood which has a greater long term impact is mostly neglected. This research tries to provide a more realistic estimate of the agricultural loss due to the flood as well as its impact on the farm households in the study area. The farmer perceptions about government involvement especially in building resilience are also considered.

1.2 Limitations of the study

The study is based on responses from the farmers in the flood plains of Chalakudy river spread across Thrissur and Ernakulam districts of Kerala and hence generalizations need not be quite accurate. The present study chiefly uses the primary data collected from farmers through pre-tested structured interview schedule. The farmers of the area were not maintaining any field book. So, the required information was collected from their memory and could suffer from recall bias. However, the data was cross-checked to minimize the errors and misconception to the extent possible. The inadequacy of information and common limitations of statistical analysis might also have affected the study slightly. Apart from these limitations, this study also suffered from scanty availability of published literature, as previous research studies in the area were less. Another important constraint was imposed by the Covid-19 pandemic and the associated lockdown which put up some restrictions on accessing some secondary data from the district offices. Despite all these constraints, every care has been taken to make the study as objective as possible.

1.3 Presentation of the thesis

The thesis entitled 'Assessment of agricultural loss due to 2018 Flood to farm households in the flood plains of Chalakudy river' is organized and presented in five chapters. The first chapter 'introduction' presents a brief note on the theoretical background of the study, its relevance, objectives, scope and the major limitations. The second chapter 'review of literature' intends to provide theoretical and empirical background of the study by reviewing previous studies related to the present research. Third chapter 'methodology' is comprised of an overview of the study area, nature and sources of data, details of design of the study and various methods adopted for carrying out the research work and its analysis. The results and discussion based on the observations are presented in the fourth chapter 'results and discussion'. A brief summary of the overall results and the main findings of the study is presented in the fifth chapter 'summary and conclusions'.

Review of literature

2. REVIEW OF LITERATURE

A comprehensive review of literature is an essential part of any scientific research. A review of past research studies helps in identifying the conceptual and methodological issues relevant to the study. This chapter presents a comprehensive review of past works which have a direct or indirect bearing on the objectives of the present study. Keeping in view the objectives of the study, the reviews are presented under the following headings.

2.1 Floods and agricultural losses

2.2 Resilience of households

2.3 Vulnerability assessment

2.4 Relationship between vulnerability and resilience

2.1 FLOODS AND AGRICULTURAL LOSSES

Lekuthai and Vongvisessomjai (2001) classified flood damages as tangible and intangible damage. Tangible damage consists of the direct and indirect damages to land, material and property whereas intangible damage includes environmental damage such as loss of biodiversity or aesthetic impacts; and health damage such as injuries, stress and anxiety. It is the tangible damage, i.e. the monetary value of all direct and indirect physical damages, which is mostly taken into account while the intangible damage is often not taken into consideration in the monetary evaluation of flood damage.

The literatures on flood damage assessment mostly point to flood damage assessment by way of flood damage modelling which requires three inputs as inundation maps, land use maps, depth-damage curves and damage functions. A comprehensive review of past studies showed the existence of several flood damage modelling methodologies and a comparison of these methodologies by different authors. Studies by Meyer and Messner (2005), Messner *et al* (2007) are some of the studies in this direction.

Jonkman *et al* (2008) classified flood damages as direct and indirect damage. While direct damage refers to the damage that occurs in the flooded area, indirect damage corresponds to what occurs outside the flooded area.

De Moel and Aerts (2010) made a comparison of damage assessment models as Rhine Atlas, Flemish model and the Netherlands Later in an attempt to estimate flood damages in low-lying areas in North-Western Europe. Both the studies made it a point that damage models are used to assess direct tangible damage and are mostly used for estimating damage to sectors other than agriculture.

Economic evaluation of flood damage to agriculture is necessary to get a real picture of the loss to the sector as a result of the hazard. This will help to analyze the impact of the disaster on the sector. The values would guide in formulating and evaluating the policy decisions made in response to the loss suffered. According to the Global Facility for Disaster Reduction and Recovery (GFDRR), the post-disaster damage and loss assessment is primarily done to measure quantitative requirements for financial recuperation and recreation after disasters, to determine limit of government to lead post calamity programs on its own and to give quantitative basis for the *ex-ante* disaster risk management schemes (GFDRR, 2010a).

Merz *et al* (2010) combined the classifications given by Lekuthai and Vongvisessomjai (2001) and Jonkman *et al* (2008) and made it a point that tangible damages itself can be considered to consist of four damage categories viz., direct instantaneous damage, direct induced damage, indirect instantaneous damage and indirect induced damage. This classification was done based on the spatial and temporal scales of tangible damage. According to the temporal scale, instantaneous damage alludes to the damage which happens during or following the flood occasion whereas induced damage is the damage which occurs later in time. Concerning the spatial scale, direct damage is related to direct exposure to flood, and indirect damage is the damage which occurs in an area that has not been exposed to flood.

In accordance with the Handbook for *Estimating the Socio-economic and Environmental Effects of Disasters* published by the United Nations Economic Commission for Latin America and the Caribbean (UN-ECLAC) and the subsequent work of the GFDRR; Food and Agriculture Organization (FAO) (2012) in its guidance note on 'Post disaster damage, loss and needs assessment in agriculture', clearly distinguished between flood damages and flood losses. Flood damages were defined as impacts on assets or stocks and along these lines ought to be esteemed as the expense of substitution of completely obliterated resources and cost of repair of partially destroyed assets. Losses on the other hand, were defined as the effects on economic flows and subsequently incorporate the estimation of lost yield or income. FAO additionally expressed that agricultural losses because of flooding include a) reduced income from planted crops, livestock, *etc*. after they were affected by disasters b) future income from harvests because of the devastation of land by floods, landslides, *etc.* c) foregone income from harvests due to the destruction of perennial crops and trees d) additional expenses to tidy up the trash of decimation, recovery of assets, *etc.* and e) investment losses or higher production costs.

Jongman *et al* (2012) qualitatively and quantitatively compared seven flood damage models developed for simulating direct flood damage: FLEMO (Germany), Damage Scanner (The Netherlands), Rhine Atlas (Rhine basin), the Flemish Model (Belgium), Multi-Coloured Manual (United Kingdom), HAZUSMH (United States) and the JRC Model (European Commission/HKV), while estimating flood damage in two separate countries. Their findings suggested that irrespective of the model used, the outcomes are very sensitive to uncertainty in both vulnerability (i.e. depth–damage functions) and exposure (i.e. asset values), whereby the first has a larger effect than the latter.

Agenais *et al* (2013) reviewed 26 studies focussing on direct damage to agriculture and remarked that to evaluate agricultural loss due to flood, three terms have to be considered viz., flood impact, flood damage and flood cost. Flood impacts are any effect flood may have on the system concerned; damage refers to a negative impact; and cost is the evaluation of damage in monetized terms. From the review, they concluded that damage functions for agriculture can be constructed with seasonality of the flood, water depth, duration, current velocity, deposits, contamination by pollution and salinity of water as flood parameters. While none of the studies reviewed had used all the parameters to construct damage function, a combination of one to five parameters was mostly seen used.

The classification of flood damages made by Merz *et al* (2010) was further explained based on farm examples by Agenais *et al* (2013). According to him, the various enterprises in a farm, some of which corresponds to economic flows and others to assets will be impacted differently by a flood event. While death of livestock and poultry, decline in crop output, crop loss, loss of livestock products, damage to assets, *etc*., forms the direct instantaneous damages in a farm, direct induced damages are reduction of herd size, loss of added value due to the loss of yield in the first year after replanting, loss of added value due to unavailability of production factors, *etc*. While increase in travel time due to damage to infrastructure, delay or cancellation of supply from the flooded area, *etc*., are the indirect instantaneous damages, indirect induced damages are loss of added value outside the flooded area due to damage to infrastructure, loss of added value outside the flooded area due to business interruption of assets in the flooded area, *etc*.

Moore and Phillips (2014) in an attempt to study whether the assessments carried out by the UN-ECLAC on the impact of disasters accurately captured the extent of the damage experienced by Caribbean states, applied the ECLAC's methodology to find out the damage and loss caused by the Hurricane Dean in Belize, Mexico. The study assessed the direct agricultural damage to be 21.2 million US dollars and, the indirect loss was estimated to be 32.6 million US dollars.

Studies focusing on impacts of flood disasters are increasingly gaining significance in the recent decades as frequency of occurrence of the flood events are on the rise. This is further complicated by the increasing population and socioeconomic activities in the river basins. Limited resources to cope with the ex-post disaster recovery efforts make the developing countries more vulnerable to these flood disasters. India, being one among the many developing countries of the world, the situation is in no way will be different from the others (Shrestha *et al*., 2014).

The Post Disaster Needs Assessment (PDNA) methodology developed in 2008 by the European Union (EU), the World Bank and the United Nations (UN) was used by Government of Kerala to assess the damage, loss and recovery needs across key affected sectors of the state economy. The PDNA pegged the total damages at ₹10,557 crores and total losses at ₹16,163 crores which amounts to a total disaster effects of ₹26,720 crores. The total recovery needs were estimated as ₹31,000 crores (GOK, 2018).

Win *et al* (2018) observed that there exist two different methods for damage and loss estimation. While the first method is to conduct a thorough questionnaire survey of the affected population and properties to estimate the incurred loss, which have long been accepted to be the most solid approach to predict flood damage, the other method is to use stage-damage functions, which define the relation between flood parameters and possible damage.

Though several flood damage models exist and literatures reveal developing flood damage models as the common method for estimating flood damage, in the present study, however, the method of damage and loss assessment developed by the UN-ECLAC in 1972 as cited by GFDRR (2010b) and FAO (2012), which estimates damage and loss using the data obtained from questionnaire survey, had been used. This was done purposefully as the method proved to be the simplest and less time consuming method available for estimating both damage and loss to agriculture.

2.2 RESILIENCE OF HOUSEHOLDS

The term resilience was conceptually introduced by Holling (1973), according to whom resilience is a measure of the ability of ecological systems to absorb changes of state variables, driving variables, parameters and still persist.

According to Freudenburg (1992), individuals or households having only one source of income have lower level of resilience than those who have more income sources.

The Community Resilience Manual (2000) defines a resilient community as, "one that takes intentional action to enhance the personal and collective capacity of its citizens and institutions to response to and influence the course of social and economic change". The manual makes it a point that resilience has got four dimensions which includes people in the community, organizations in the community, resources in the community and the community process.

De Vaus (2002) agreed to the use of multiple items approach to measure resilience, resilience being a multi-dimensional concept, and multiple items approach being the better method to measure a multi-dimensional concept. Multiple items approach using Likert scale was suggested to be the most widely used approach in measuring individual resilience to stresses in psychological disciplines (Wagnild and Young, 1993; Yu and Zhang, 2007; Baek et al., 2010; Wang et al., 2010), and individual resilience to institutional changes (Marshall and Marshall, 2007).

In the context of disaster, Few (2003) defined resilience as the ability of the human to minimize the impacts of a disaster through some form of adaptation. Further, on the basis of his study on flooding, vulnerability and coping strategies, he expressed the significance of research and interventions aimed at reinforcing local capacity to adapt to flooding, especially for the poor in developing countries.

Fiksel (2003) pointed out diversity, adaptability, efficiency and cohesion as the factors that contribute to system resilience. As diversity alludes to presence of various forms and behaviors, efficiency implies performance with modest resource utilization. Adaptability is flexibility to change in light of new pressures and cohesion means existence of unifying forces or linkages.

According to Adger (2006), resilience refers to the extent to which a community is capable of withstanding external shocks and stresses without significant upheaval.

Gaillard (2007) observed on the basis of twelve case studies that resilience of a system depends on several factors such as demographic, social, cultural, economic, political, type of natural hazards, and geographical setting of the place.

Resilience needs to be assessed from the perspectives of economic, social, human, natural and physical capital. Of these, the most essential factor in most cases is the economic capital. Process of recovery is hastened when economic capital is sufficient (Mayunga, 2007). This was endorsed by Norris and Stevens (2007), when they stated that economic factors are necessary to support individual resilience.

Vugrin *et al* (2011) defined system resilience as “Given the occurrence of a particular disruptive event (or set of events), the resilience of a system to that event (or events) is the ability to reduce efficiently both the magnitude and duration of the deviation from targeted system performance levels”. The disruptive event, the efficiency of recovery of system, and the system performance were the factors used to define the system resilience. They concluded that the process of recovery of the system is more efficient when the time of recovery and amount of potentially used resources are less.

Nguyen and James (2013) in a bid to measure household resilience in the Vietnamese Mekong river delta, successfully demonstrated the use of multiple items approach using Likert scale and dichotomous response to measure resilience. They came up with the finding that three factors contribute to households’ resilience which included households' confidence in securing food, income, health, and evacuation during floods and recovery after floods; households' confidence in securing their homes from being affected by a large flood event; and households' interests in learning and practicing new flood-based farming practices that are fully adapted to floods for improving household income during the flood season.

Widiarto (2013) in an attempt to assess agricultural loss caused by 2007 flood and its household impact in Sidoharjo village, Indonesia, studied the resilience of farmers in the village towards flood as well. In the study wherein resilience was taken as ability of the farmer to continue next season cropping, factors influencing resilience were divided under two heads as human capital and economic capital. While farming experience, age and education were taken as human capital, economic capital included number of sources of income, farmer status, dependent number, intensity of flood loss to agriculture, losses apart from agricultural losses, and source of finance for next cropping. The study concluded that resilience in the village is closely related to the socioeconomic condition of the farmer and the intensity of flood loss which in turn depends on depth and duration of immersion. According to him, resilience has close relationship with vulnerability. While vulnerability gives an overview of the possible losses that can occur as a result of a disaster, resilience talks about the rate of response of the affected people to recover from the losses and damage. When vulnerability speaks about the pre-disaster preparedness based on the anticipated impact of disaster, resilience is all about post-disaster measures to support the victims of the disaster in their efforts to recover.

Tortajada *et al* (2017) studied coping responses and resilience building in the backgrounds of California drought and concluded that coping and resilience building rely on numerous policy, regulatory, institutional, and management decisions taken at the local, state and federal levels and also the resource availability. The case showed the importance of extraordinary preparedness and response measures to cope with the extreme events.

Sina *et al* (2019a) studied the factors affecting livelihood resilience in a post-disaster scenario in Indonesia following the 2004 Indian Ocean Tsunami. A questionnaire survey and interviews in five selected relocation sites in Banda Aceh and Aceh Besar, Indonesia, were undertaken. Their findings suggested the importance of building livelihood resilience to natural disasters in generating sustained income flow and thereby ensuring economic development of the post-disaster relocated communities. They came up with the finding that income support for early recuperation, physical and emotional wellbeing, ability to move to different occupations/skills, availability and promptness of livelihood support together with its cultural sensitivity and governance structure were the significant elements which influenced livelihood resilience.

Sina *et al* (2019b) developed a conceptual framework for measuring livelihood resilience, through a survey of five post-2004 Indian Ocean tsunami relocated villages in Banda Aceh and Aceh Besar, Indonesia, came up with four indicators viz., individual livelihood coping ability, individual wellbeing, access to livelihood resources, and socio-physical robustness of the local community for measuring livelihood resilience. The study suggested the importance of self-sufficiency over external factors in building the livelihood resilience.

Wang *et al* (2019) analysed the different definitions of resilience and classified the definitions under the heads of qualitative definitions and quantitative definitions. Ecological resilience, system resilience and organizational resilience are the qualitative definitions. On the other hand, resilience based on reliability, dynamic resilience, integrated resilience, engineering resilience, stochastic resilience and resilience based on probabilistic event trees are the quantitative definitions. Among these, system resilience becomes important in the context of disaster resilience.

2.3 VULNERABILITY ASSESSMENT

Vulnerability is an important concept in hazards research and vulnerability assessments has got an important place in hazards studies as these are imperative to decide the likely harm and death toll from outrageous characteristic occasions. Furthermore, these are significant in proposing hazard reduction alternatives as well.

Chambers (1989) one of the pioneers in the field of developing social-science-related concepts of vulnerability in geographic development and poverty research postulated that vulnerability has two sides: an external side and an internal side. While the external side comprises of risks, shocks and stress to which an individual or household is subjected, the internal side is defencelessness which implies an absence of means to adapt without damaging loss.

Adger (1996) on studying the social vulnerability to climate change reported that though both low-income and high-income groups suffer from a disaster, the relative impact is more for low-income groups even though the highest magnitude of economic damage is often borne by the wealthier populations. This has been attributed to their poor access to resources and the disruption of their sole means of livelihood. Thus, the prime focus on reducing the vulnerability should be based on formulating policies enhancing investment in maintaining the resources which support them.

Cutter (1996) classified vulnerability as biophysical, social and spatially expressed vulnerabilities. While biophysical vulnerability includes the spatial distribution of hazardous conditions, social vulnerability looks into the ability of an individual or the society to cope with the disasters. On the other hand, social groups and all the characteristics of a place are located in spatially expressed vulnerability.

Adger (1999) defined vulnerability as the capacity to anticipate, cope with, resist and recover from the impact of a natural disaster. According to Cutter *et al* (2003), vulnerability is the potential for loss of property or life from hazards of the nature and it varies over time and space.

According to Blaikie *et al* (2003) vulnerability assessment should not be confined to determining the potential damage to life and property alone, but should also include measurement in terms of the damage to future livelihoods. Vulnerability is closely correlated with socio-economic position. Vulnerable groups are those that find it difficult to reconstruct their livelihoods following disaster, and thus making them progressively helpless against the impacts of subsequent hazard events.

United Nations/International Strategy for Disaster Reduction (2004) defined vulnerability as the ‘‘conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of a community to the impact of hazards’’.

Several scientists studied the relation between socio-economic status of the affected population and their vulnerability towards natural hazards, the impacts of disaster and post-disaster recovery. The studies of Watts and Bohle (1993), Blaikie *et al* (1994), Adger and Kelly (2000), Cutter *et al* (2000), Fothergill and Peek (2004), Masozera *et al* (2007) are some of the many such studies. They all came up concluding that socio-economic status is a crucial predictor of social vulnerability and physical as well as psychological impacts in the pre and post-disaster stages.

The potential to overcome disasters in different regions with distinctive economies can be measured by the concept of vulnerability. Traditionally, vulnerability analysis (regional vulnerability) was done based on disaster frequency, disaster loss, the economic impact and the population of each region (Yi-Ming *et al*., 2004).

According to Balica *et al* (2013) two approaches can be used to estimate the vulnerability to floods or any other natural disaster at the micro level. He suggested both deterministic and parametric approaches for estimation of flood vulnerability. In the deterministic approach, risk to life or damage based on physical vulnerability or by assuming a homogeneous vulnerability of the entire population is assessed to find out the vulnerability of a particular place (Lee *et al*., 2014).

Balica *et al* (2013) and Lee *et al* (2014) came up with the parametric approach as the one consisting of vulnerability metrics such as the Environmental Vulnerability Index

(EVI), Global Risk and Vulnerability Index (GRVI), and the Climate Vulnerability Index (CVI), involving indicator selection and weight determination.

According to Varghese (2015), vulnerability index could be constructed with indicators such as social (literacy, crop insurance and land ownership status), economic (sources of income, total household income and proportion of livestock income to total income) and agronomic factors (cropping intensity, diversity index and variety tolerance). While social and economic factors impose a direct influence on the vulnerability, agronomic factors were found to have an indirect influence.

Fatemi *et al* (2017) in an attempt to develop social vulnerability indices in the Iranian context, based on a systematic review of 43 peer-reviewed English and Persian language journals came up with top four categories of social vulnerability indices. These were gender, public health condition, public infrastructures and migration.

2.4 RELATIONSHIP BETWEEN VULNERABILITY AND RESILIENCE

There are two views regarding relationship between resilience and vulnerability. While one sees disaster resilience and vulnerability as factors of each other, the other sees them as separate entities. The views are based on the difference in approach towards defining vulnerability. While some definitions portray vulnerability and resilience as closely related, there are other definitions which show little or no relationship between vulnerability and resilience.

Scientific background paper for the World Summit on Sustainable Development produced by the Resilience Alliance on behalf of the Environmental Advisory Council to the Swedish Government as cited by Klein et al (2003) referred to resilience as the flip side of vulnerability and also called it to be one of the determinants of vulnerability, along with exposure and sensitivity. The paper interpreted vulnerability of a system as the one resulting from reduced resilience. However, he observed that the interpretation lends itself to a circular reasoning: a system is vulnerable because it is not resilient; it is not resilient because it is vulnerable.

Vulnerability is closely associated with the level of resilience where vulnerability is related to the degree of capacity, in which case, vulnerability and resilience can be viewed as positive and negative poles on a continuum. If one is situated more towards the positive pole of the continuum, one becomes more resilient than vulnerable, and vice versa (Manyena, 2006).

Literature reviews on the topic clearly indicate a gap in studies related to flood loss assessment carried out in India and Kerala. The dearth of vast knowledge base in the study topic coupled with the limited access to resources due to the Covid-19 lockdown has constrained the literature review to some extent. However, the FAO disaster loss assessment framework could be considered as a near appropriate methodology for assessing the flood loss and damages inflicted by 2018 Floods to agriculture.

Methodology

3. METHODOLOGY

Research is the systematic approach towards purposeful investigation and for successful conduct of a research study an appropriate research design is a pre-requisite. Methodology is an important component of research that outlines the way in which research is to be undertaken and identifies the method to be used in it, for effectively channelizing the ideas in the right direction. The present study to assess the agricultural loss due to 2018 floods in Kerala is one of a pioneering attempt in this direction aiming at developing a systematic procedure for disaster loss assessment in agriculture. This chapter discusses in detail about the study area, concepts, sampling procedure and analytical tools adopted in the study under the following sub divisions.

3.1 Study area

3.2 Sampling procedure

3.3 Nature and sources of data

3.4 Analytical tools

3.1 STUDY AREA

The study was undertaken in the flood plains of Chalakudy river in Thrissur and Ernakulam districts. In this section an attempt is made to detail the physiography, geography, climatic factors, land utilization pattern and cropping pattern of Kerala state, with special mention on the Chalakudy river basin.

3.1.1 Kerala

Situated in the southwestern Malabar Coast of India, Kerala is known as God's own country. According to 2011 census, Kerala has a population of 3,33,87,677, which accounts to about 2 percent of India's population, with a population density of 860 persons per square kilometer. The state has a sex ratio of 1,084 females for every 1,000 males. Despite being a small state lying at the southern coastal region of the country, it has significant achievements in global socio-economic and health arena.

With a life expectancy at birth of 75.2 years and literacy rate of 94 percent, the state is at par with those of developed countries with regard to human development.

3.1.1.1 Location

The state lies between 08°17'30" and 12°47'40" North latitude and 74°27'47" and 77°37'12" East longitudes. Spanning over an area of about 38,863 square kilometers, Kerala is flanked by Karnataka to the north and northeast, Tamil Nadu to the east and south, and the Lakshadweep Sea to the west.

3.1.1.2 Land utilization pattern

The land utilization pattern of Kerala presented in Table 3.1 indicated that about five percent of the total land area falls under the category of fallow and cultivable waste. The efforts of the state government at present towards attaining food self-reliance are mainly focused on this category of land. While total cropped area was 66 percent of the total geographical area of the state, net sown area was just 52 percent of the total geographical area. Of the total geographical area, 11 percent was put to non-agricultural uses.

Table 3.1 Land utilization pattern of Kerala (2017-18)

Category	Area (ha)	Percentage to total geographical area
Total cropped area	2579699.44	66.38
Net cropped area	2040415	52.5
Cropping intensity	126.43	-
Land put to non-agricultural uses	443041	11.4
Current Fallow	57522	1.48
Fallow other than current fallow	49461	1.27
Cultivable waste land	96491	2.48
Area sown more than once	539284.44	13.88
Marshy land	14	0.00
Still water	98889	2.54
Water logged area	3235	0.08
Social forestry	2571	0.07
Barren and uncultivable land	10894	0.28
Land under miscellaneous tree crops	2245	0.06

Forest	1081509	27.83
Permanent pastures and other grazing land	0	0
Total geographical area	**3886300**	**100**

Source: Agricultural Statistics 2017-18, Department of Economics and Statistics, Government of Kerala**.**

3.1.1.3 Cropping pattern

The cropping pattern of Kerala presented in Table 3.2 indicated that about 29 percent of the total cropped area is under the cultivation of oil seeds which include coconut, groundnut, sesamum and few other minor crops, of which the highest area falls under the cultivation of coconut.

Table 3.2 Cropping pattern of Kerala during 2017-18

Crop	Area (ha)	Percentage to total cropped area
Cereals and millets	194591	7.54
Pulse	1992	0.08
Sugar crop	3082	0.12
Spices and Condiments	260787	10.11
Fresh fruits	328219	12.72
Dry fruits	39720	1.54
Tapioca	70193	2.72
Tubers	18451	0.72
Vegetables	46363	1.80
Oil seeds	762718.1	29.57
Fibers, Drugs and Narcotics	563	0.02
Plantation crop	680818	26.39
Other non-food crops	172203	6.68
Total cropped area	**2579699.44**	**100.00**

Source: Agricultural Statistics 2017-18, Department of Economics and Statistics, Government of Kerala

3.1.1.4 Flood status in the state

When the torrential rains bashed the state, Kerala encountered the most exceedingly awful floods in its history since 1924, between June 1st and August 19th of 2018. The unprecedented deluge created havoc and wreaked the economy of the state including all the sectors and thus agricultural sector was no exception. The disaster effects presented in Fig 1 showed that agriculture sector of the state had suffered disaster effects worth ₹7,154 crores with 88 percent of the complete misfortune and harm to the crop segment.

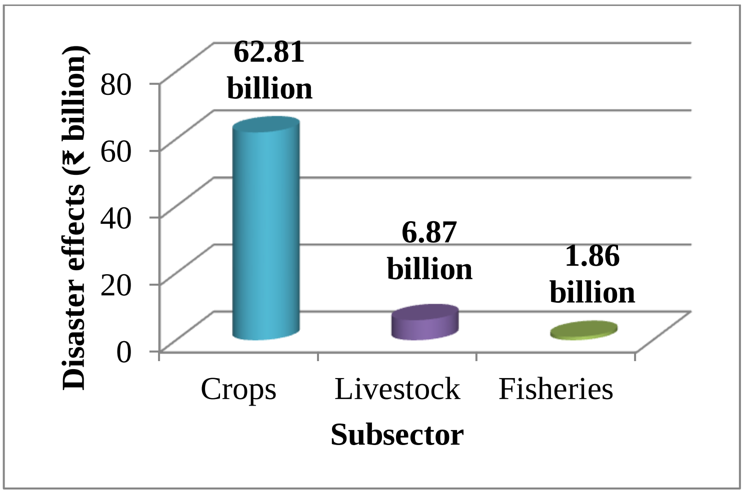

Fig 1 Disaster effects to the agriculture sector in Kerala

(Source: GOK, 2018)

3.1.2 Chalakudy river basin

Rivers are likely the most unique and dynamic of all waterscapes. The state Kerala is bestowed with 44 rivers of which 41 are west flowing and the rest three are east flowing. The rivers which are monsoon fed flow fast due to the specific terrain of the state. Blessed with 44 rivers, almost all village and town is a part of the catchment area and thus also of the sprawling river basin.

Chalakudy river is the seventh longest river in Kerala. The west flowing river has Sholayar, Parambikulam, Kuriarkutty and Karappara rivers as its tributaries. Originating from the Anamalai and Nelliampathy ranges of the Western Ghats, the 130 km long river flows through the districts of Palakkad, Thrissur and Ernakulam in the state. However, a major portion of the river lies in the Thrissur district. The river joins the right arm of the Periyar at Elanthikkara in the Puthenvelikkara Grama Panchayath of Ernakulam district, before it discharges into the Arabian Sea at Munambam through the Kodungallur–Azhikode estuary (Latha *et al.*, 2012).

As about one third length of the river takes its course through natural forestlands, the basin contains a significant stretch of evergreen and semi-evergreen forests, the bamboo and reed brakes, deciduous forests, the riparian forests and the plantations. Hence, this area underpins a significant segment of the wild life as well as acts as a corridor for many wild animals. Forest divisions of the basin include 1) Parambikulam Wildlife Division 2) Vazhachal Division 3) Chalakudy Division and 4) Nemmara Division (LAK, 2001).

The exceptionally high variation in rainfall pattern and distribution across different locations within the river basin ranging from Parambikulam, a low precipitation region (around 1400 mm) to Valparai, an extremely overwhelming precipitation region (around 5000 mm), has permitted diverse ecological niches to evolve in the valleys over time (Latha and Vasudevan, 2016). During its excursion from the slope reaches to the fields, the waterway makes various rapids and falls and the most excellent and notable are the Athirappilly and Charpa cascades and Vazhachal rapids.

3.1.2.1 Location

The river basin lies between 10^0 05' to 10^0 35' North latitude and 76^0 15' to 76^0 55' East longitude (Amitha bachan, 2003). The basin is spread across 19 Panchayats in six blocks (Kodakara, Chalakudy, Mala, Angamaly, Parakkadavu and Nemmara), one Municipality (Chalakudy) and three Districts (Ernakulum, Thrissur and Palakkad). The basin is limited by Chittur and Alathur Taluks of Palakkad district and Mukundapuram Taluk of Thrissur district in the North, Alwaye, Kunnathunad and Paravur Taluks of Ernakulum district in the South, Kodungallur Taluk of Thrissur district in the West and Tamil Nadu in the East (LAK, 2001). The total drainage area is 1704 square kilometers out of which 1404 square kilometers lies in Kerala and the rest 300 square kilometers lies in Coimbatore district of Tamil Nadu (Amitha bachan, 2003). The river basin is triangular with its base along the east, having a length-width ratio of 3:1(LAK, 2001).

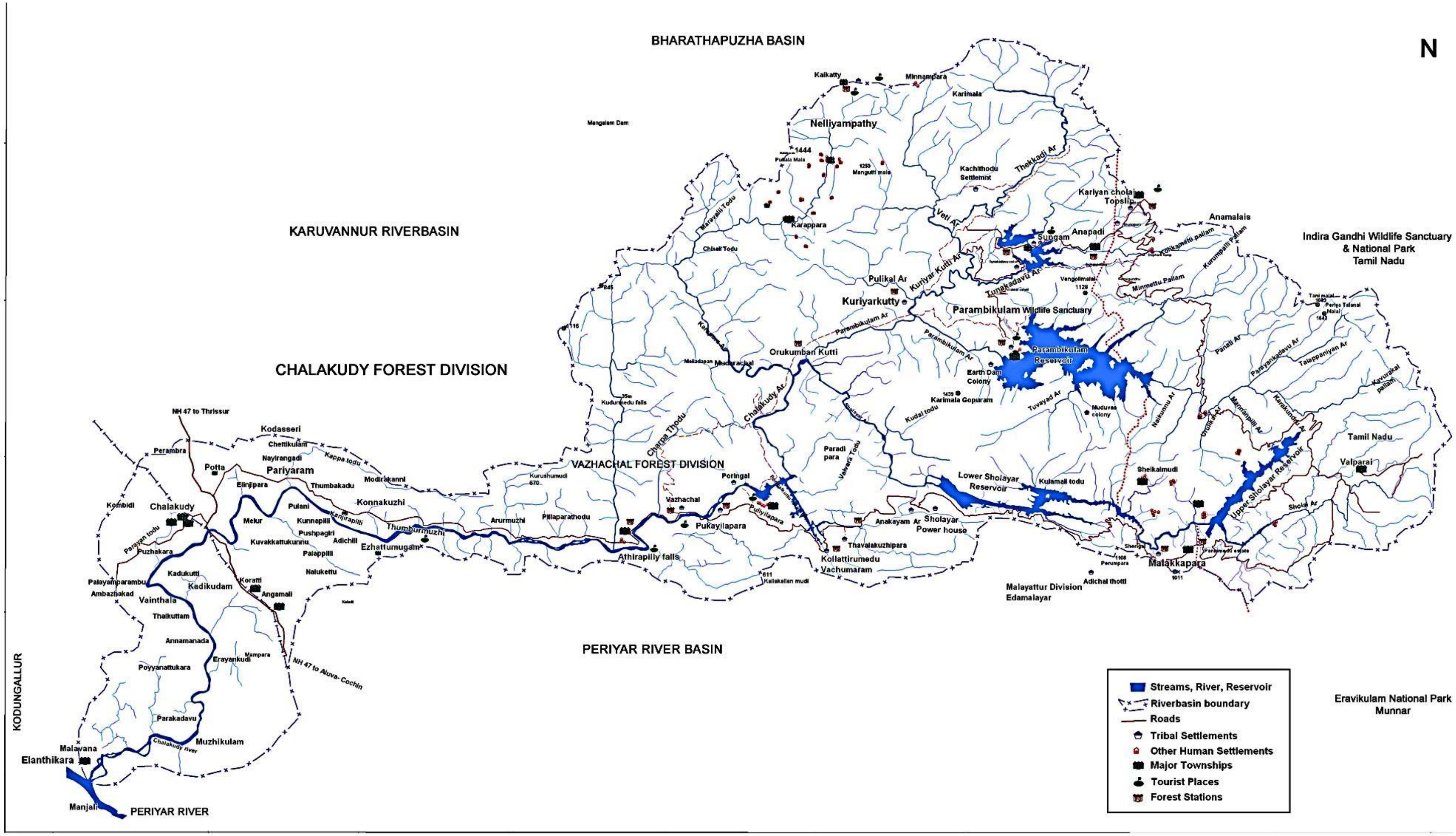

Plate 1 Map of Chalakudy river basin

3.1.2.2 Physiography

Chalakkudy river is formed by the conversion of four major tributaries, to be specific Sholayar, Parambikulam, Kuriarkutty and Karapara.

Sholayar river

Originating from the Anamalai ranges in the Coimbatore district of Tamil Nadu, this 44 km long tributary gets together with the Parambikulam river just upstream at Orukombankutty (455m above MSL) in Kerala on the Southern fringe of the Nelliampathy plateau.

Parambikulam river

The river originates in Ramakrishna Malai with the name of Periyar at an elevation of 4,000 to 5,000 ft. in Coimbatore District. It flows parallel to and North of Sholayar river and joins Kuriarkutty river at Kuriarkutty (536 m above MSL).

Kuriarkutty river

Originating from the Anamalai ranges of the Kerala region, the river joins with Parambikulam river at Kuriarkutty (536 m above MSL).

Karapara river

The river starts from Nelliyampathy Hills of Palakkad district in Kerala. It joins the main river at Orukumbankutty (455m above MSL) and further on the river is called the Chalakudy river.

There are also certain autonomous and enormous streams straightforwardly joining the main river namely Anakayam Thodu, Charpa Thodu, Kannamkuzhi Thodu, Pillapara Thodu and Arurmuzhi Thodu (LAK, 2001).

3.1.2.3 Watershed delineation

The Chalakudy river basin contains about 57 sub watersheds and 140 micro watersheds. These sub watersheds are mainly in the catchments and henceforth the basin becomes narrower towards the west (Amitha bachan, 2003). With the drainage channels resembling the branching pattern of tree roots, the river, in general, exhibits a dendritic drainage pattern.

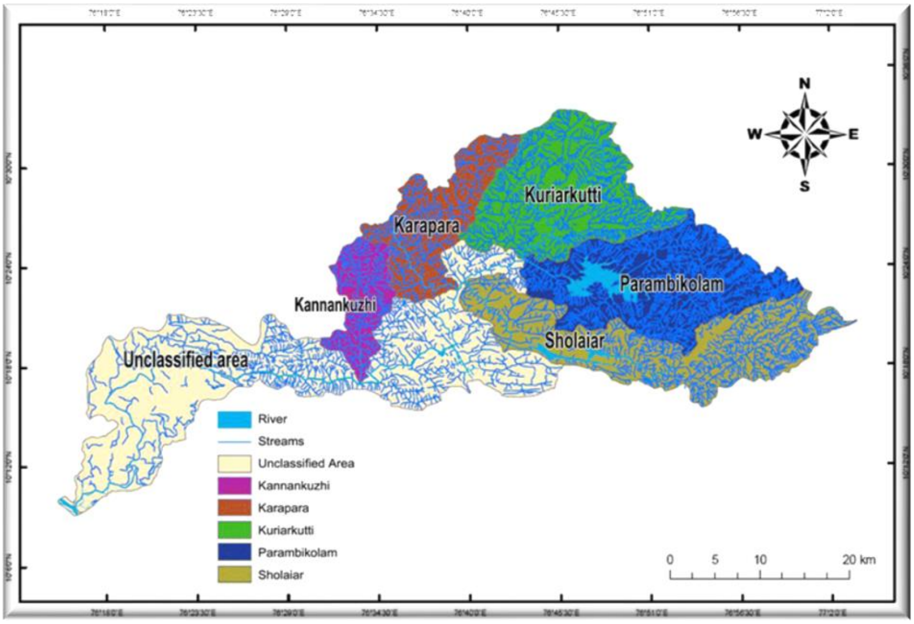

Plate 2 Major sub watersheds in Chalakudy river basin (Babu *et al*., 2014)

3.1.2.4 Dams in the basin

Six dams are built in the basin till this date. The only dam in the main river is the first dam built in the basin and it was for Poringalkuthu Hydro-electric project, commissioned in 1957. During 1960s, as part of the inter-state Parambikulam-Aliyar Project (PAP) five additional dams were constructed in various tributaries of the river. They are Tamil Nadu Sholayar dam, Parambikulam, Peruvarippallam, Thunacadavu, and Kerala Sholayar dam. First four were constructed by Tamil Nadu and the latter was constructed by Kerala (Latha and Vasudevan, 2016). The Parambikulam, Peruvarippallam and Thunacadavu dams are together known as Parambikulam group dams (Ravi *et al*., 2004).

3.1.2.5 Flood plains

Flood plains are low-lying ground areas adjacent to rivers and streams, subject to recurring inundation and are formed mainly of sediments. Further, water will be practically stagnant in the flood plains. The flood plains are highly fertile owing to the progressive deposition of alluvial silt. They are also ideal feeding, breeding and the nursery grounds of several fishes and other riverine organisms.

There were broad flood plains along Chalakkudy river at Meloor, Kadukutty, Vayanthala, Mambra, Moozhikulam, Kuzhur, Kundur, Puthenvelikkara, *etc*. All these flood plains were changed into paddy fields as the hydrologic system of flood plains is generally perfect for rice development. These paddy fields perform practically all fundamental functions of normal flood plain wetland. As of late, broad regions of these paddy fields have been recovered for the development of industrial, residential and commercial complexes, digging of soil for block and tile making, or for development of dry land crops.

A portion of these flood plain areas, especially in the extreme down ranges, stay immersed for over a half of the year. In such regions paddy development might be conceivable just for one season. Such paddy lands are locally called as Kolefields. Certain extensive Kolelands are found at the down reaches of the river (LAK, 2001).

3.1.2.6 Soils

Soils of the basin fall within six broad categories: 1) lateritic soil 2) hydromorphic saline soil 3) brown hydromorphic soil 4) riverine alluvium 5) coastal alluvium and 6) forest loam. A major portion of the midland is covered by lateritic soils. The brown hydromorphic soil is mostly restricted to valley base of the midland. Forest loams are the predominant soil type of the upland region. The riverine alluvium happens generally along the stream channels and their tributaries, while marine and estuarine processes are believed to have led to the formation of coastal alluvium (Maya, 2005).

3.1.2.7 Climate

Chalakudy river basin lies in the Tropical Monsoon Climate (Am) as per the Köppen Climate Classification System, which is the most widely used system for classifying the world's climates. The study area, thus experiences a tropical humid climate with summer season from March to May and rainy season from June to September. With half of the land covered by the forests, wet type of climate prevails in the higher hill ranges. The basin is characterised by an average annual rainfall of 3250 mm from heavy Southwest monsoon during June-September contributing more than 70 percent of annual rainfall, shorter Northeast monsoon during October-November, hot summers during March-May with pre-monsoon showers and a mild winter during December-February with rainfall activity. Spatial distribution of rainfall is highly heterogeneous in the basin which is evident in varying average annual rainfall which varies from 1400 to 5000 mm from west to east in the basin.

The total rainfall received in the river basin during the period from 2010-2018 as presented in Fig. 2 revealed that the rainfall in the basin had been on a steady increase from 2016 onwards after a period of steady decline from 2014 to 2016. The river basin received about 3256 mm of rainfall in the year of the deluge.

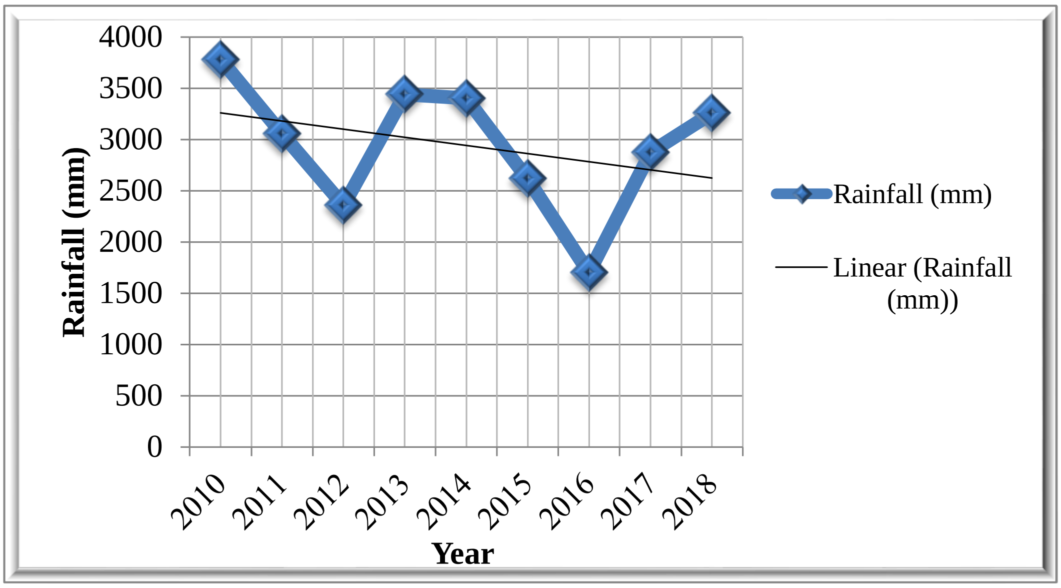

Fig 2 Rainfall (total) recorded during 2010-2018

(Source: Agricultural Research Station, Chalakudy)

3.1.2.8 Land use

The land use/land cover of the study area can be broadly grouped into agricultural land, forest land, wastelands and water bodies. Land use varies from the low ranges to the high ranges in the basin. The river basin can broadly be divided into 3 major zones as lowland (< 8m above MSL), midland (8 - 75m above MSL) and highland (>75m above MSL) based on which the landuse of the area differs.

The highland consists of forest land, agricultural land, wastelands and water bodies. The forest land consists of forest plantations, ever green/semi-ever green forests, deciduous forests and degraded forests, while agricultural land is mainly under mixed agricultural/horticultural plantations. Wasteland is equally occupied by barren rock and land with or without scrub.

The midland consists of agricultural land, forest land and wasteland. Agricultural land is mainly under mixed agricultural/horticultural plantations and wasteland is land with or without scrub. Forest land is occupied by evergreen/semi-evergreen forests and degraded forests.

The lowland consists of agricultural land and water bodies. Agricultural land is under mixed agricultural/horticultural plantations and double cropped paddy lands (Maya, 2005).

3.1.2.9 Cropping pattern in the basin

Coconut, paddy, nutmeg, banana and plantain are the major crops cultivated in the basin. According to the 2017-18 Agricultural Statistics, coconut occupies the largest area under cultivation in the basin followed by paddy, nutmeg, banana and plantain. Maximum area under coconut is in Kodakara block, whilst maximum area under paddy is in Nemmara block. While Chalakudy block has the highest area under nutmeg, Angamaly block has the highest area under banana and plantain.

3.1.2.10 Biodiversity in the river basin

The river basin is known for its rich biodiversity, which is favoured by the protected areas or forests that occupy one third of the river’s length. Chalakudy river has the highest fish diversity index among all the rivers of Kerala. There are 108 species of fishes of which 5 species were new species discovered in the year 2000. The National Bureau of Fish Genetic Resources has suggested declaring the upper spans of the river as a Fish Sanctuary way back in 2000. In addition, 170 species of butterflies and 231 species of birds are also reported from the basin. The river basin holds three IBAs (Important Bird Areas) and encompasses the Anamudi Elephant Reserve No.9. Vazhachal Forest Division has the maximum elephant density among all the Forest Divisions under the Elephant Reserves in the state, and one of the frequent elephant movement paths (Parambikulam Valley - Pooyamkutty-Idamala Valley) traverses through this division. A study conducted by Latha and Vasudevan (2016) in collaboration with the French Institute of Pondicherry has acknowledged the rich biodiversity of Vazhachal Forest Division and has identified the division as the one with high conservation value (75 percent).

3.1.2.11 Environment protection activities in the Chalakudy river basin

In a bid to save the river and the basin and to conserve the rich biodiversity, many activities are being undertaken by ecologically sensitive and socially conscious people through forming non-governmental and no-profit organizations. Chalakudy River Protection Forum, initially formed as Chalakudy Puzha Samrakshana Samithi (CPSS) is the most important among all. CPSS was formed in 1986 when the already deteriorated river faced the threat of further degradation due to new river basin development projects. CPSS was renamed as Chalakudy River Protection Forum in 2005. The forum even proposed an integrated river revival and management plan that addresses several aspects like pollution control, catchment area re-forestation, synchronisation of operations of various projects, maintaining environmental flows in the river, better management of available water resources, conservation of aquatic fauna and budgeting integration of community interests with river conservation. River Research Centre, founded by late environmentalist Dr. Latha Anantha, who spearheaded the public resistance to construction of dams and dislocation of people settled along the peripheries of the Chalakudy river, is another organization which is highly vocal about conserving the integrity of the river and the basin.

3.1.3 Selected districts in the study area

This section presents the general features of Thrissur and Ernakulam districts which constitute the area under study.

3.1.3.1 Thrissur District

Situated in the central part of Kerala, Thrissur, the cultural capital of the state is famous as the land of Poorams. Spanning over an area of about 3,032 square kilometres, Thrissur district is home to over 10 percent of Kerala's population. As per the 2011 census, Thrissur district has a population of 31,10,327 persons. The district has a population density of 1,026 occupants per square kilometer. The sex ratio of the district is 1,109 females for every 1,000 males and the literacy rate is 95.32 percent.

3.1.3.1.1 Location

The district lies between $10^0 10'$ and $10^0 46'$ North latitude and $75^0 57'$ and $76^0 54'$ East longitudes. Thrissur district is flanked by the districts of Palakkad and Malappuram to the north, and the districts of Ernakulam and Idukki to the south. The Arabian Sea lies to the west and Western Ghats stretches towards the east.

3.1.3.1.2 Land utilization pattern

The land utilization pattern of Thrissur presented in Table 3.3 indicated that about eight percent of the total land area falls under the category of fallow and cultivable waste. While total cropped area was 56 percent of the total geographical area of the district, net sown area was just 43 percent of the total geographical area. Of the total geographical area, 13 percent was put to non-agricultural uses.

3.1.3.1.3 Cropping pattern

The cropping pattern of Thrissur presented in Table 3.4 indicated that about 47 percent of the total cropped area is under the cultivation of oil seeds including coconut, and few other minor crops like sesamum, of which the highest area falls under the cultivation of coconut.

3.1.3.2 Ernakulam District

Ernakulam district, situated in the central part of Kerala, is called the commercial capital of Kerala. Spanning over an area of about 3,068 square kilometers, the district is home to over 12 percent of Kerala's population. As per the 2011 census, Ernakulam district has a population of 32,82,388. The district has a population density of 1,072 occupants per square kilometer. Ernakulam has a sex ratio of 1,024 females for every 1,000 males and a literacy rate of 97.05 percent.

3.1.3.2.1 Location

The district lies between 9^{0}47' and 10^{0}18' North latitudes and 76^{0}9' and 77^{0}6' East longitudes. The district is limited by Thrissur district in the north, Idukki district in the East, Alappuzha and Kottayam districts in the south. The Arabian Sea lies to the west of the district.

3.1.3.2.2 Land utilization pattern

The land utilization pattern of Ernakulam presented in Table 3.3 indicated that about nine percent of the total land area falls under the category of fallow and cultivable waste. While total cropped area was 53 percent of the total geographical area of the district, net sown area was just 48 percent of the total geographical area. Of the total geographical area, 14 percent was put to non-agricultural uses.

3.1.3.2.3 Cropping pattern

The cropping pattern of Ernakulam presented in Table 3.4 indicated that about 37 percent of the total cropped area is under the cultivation of plantation crops which include rubber and cocoa, of which the highest area falls under the cultivation of rubber.

Table 3.3 Land utilization pattern of Thrissur and Ernakulam (2017-18)

Particulars	Thrissur		Ernakulam	
	Area (ha)	Percentage to total geographical area	Area (ha)	Percentage to total geographical area
Forest	103619	34.21	70617	23.09
Land put to non-agricultural uses	39650	13.09	45256	14.80
Barren and uncultivable land	72	0.02	349	0.11
Permanent pastures and other grazing land	0	0.00	0	0.00
Land under miscellaneous tree crops	202	0.07	113	0.04
Cultivable waste	9179	3.03	15040	4.92
Fallow other than current fallow	6045	1.99	6591	2.16
Current fallow	8341	2.75	7999	2.62
Marshy land	0	0.00	0	0.00
Still water	5035	1.66	11171	3.65
Water logged area	318	0.10	290	0.09
Social forestry	147	0.05	105	0.03
Net area sown	130311	43.02	148295	48.49
Area sown more than once	41086.75	13.56	16300.65	5.33
Total cropped area	171398	56.58	164596	53.82
Total geographical area	**302919**	**100.00**	**305826**	**100.00**

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

Table 3.4 Cropping pattern of selected districts during 2017-18

Crop	Thrissur		Ernakulam	
	Area (ha)	Percentage to total cropped area	Area (ha)	Percentage to total cropped area
Cereals and millets	21564	12.58	5440	3.31
Pulse	0	0.00	36	0.02
Sugar crop	109	0.06	117.2	0.07
Spices and condiments	16236	9.47	13075	7.94
Fresh fruits	22882	13.35	25350	15.40
Dry fruits	1381	0.81	469	0.28
Tapioca	1248	0.73	5760	3.50
Tubers	473	0.28	520	0.32
Vegetables	2856	1.67	3113	1.89
Oil seeds	80832.75	47.16	40742.49	24.75

Fibers, Drugs and Narcotics	4	0.00	4	0.00
Plantation crop	16242	9.48	61217	37.19
Other non-food crops	7570	4.42	8752	5.32
Total Cropped Area	**171398**	**100.00**	**164596**	**100.00**

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

3.1.3.3 Flood status in the selected districts

Heavy rain, cyclone and flood that occurred during the Southwest monsoon of 2018 severely affected major parts of both the districts and caused misery to large number of farmers. Crops got submerged under several feet of water as the fields remained inundated for several days. The report presented in Table 3.5 revealed that Thrissur district had an estimated crop loss of ₹90 crores while Ernakulam district had an estimated crop loss of ₹20 crores.

Table 3.5 Crop loss due to 2018 Flood in the selected districts

Crop	Thrissur		Ernakulam	
	Area (ha)	Estimated loss (₹ lakhs)	Area (ha) / Nos. damaged	Estimated loss (₹ lakhs)
Paddy	2290.20	937.69	396.23 ha	53.49
Banana	904.21	6714.96	1389296	1304.05
Coconut	147.28	441.61	16300	40.52
Arecanut	30.99	237.32	8944	454.76
Nutmeg	200.40	460.20	79661	245.45
Vegetables	580.46	346.95	126.73 ha	17.11
Tapioca	389.88	68.44	286.04 ha	19.45
Tuber	59.00	10.62	153.56 ha	10.44
Pepper	41.24	83.93	40219	30.16
Rubber	18.87	155.20	8361	20.93
Cocoa	0.20	1.50	8544	8.54
Cashew	2.85	5.70	209	0.31
Ginger/ Turmeric	75.24	8.53	36.12 ha	2.46
Pineapple	-	-	120.90 ha	21.80
Betelvine	5.00	7.50	-	-
Total	**4745.82**	**9480.14**	**-**	**2229.46**

Source: State Department of Agriculture Development and Farmers Welfare, Kerala

3.2 SAMPLING PROCEDURE

For primary data collection, multistage purposive sampling procedure was adopted. At the first stage, out of three districts that make up the Chalakudy river basin, two districts were purposively selected based on the extent of flood havoc. In the second stage, all the panchayats in the Chalakudy river basin were identified and listed using the physical map of the river basin obtained from the Regional office of the Kerala State Land Use board at Thrissur. Accordingly, 19 panchayats falling in three districts, viz., one panchayat (Nelliampathy) in Palakkad district, six panchayats (Ayyampuzha, Karukutty, Manjapra, Mookkannur, Parakkadavu and Puthenvelikkara) in Ernakulam district and 12 Panchayats (Mattathur, Athirappilly, Kadukutty, Kodassery, Koratty, Meloor, Pariyaram, Annamanada, Aloor, Mala, Kuzhur and Poyya) lying in Thrissur district were identified. From the 19 panchayats that make up the Chalakudy river basin, those panchayats that were mostly affected by the flood were selected in consultation with the Assistant Directors of Agriculture of the concerned blocks.

Thus, 10 Panchayats falling under three blocks of the two districts were selected for the study. Though the river flows through three districts in Kerala, Thrissur and Ernakulam districts were purposefully selected as these were among the districts badly hit by the unprecedented deluge in 2018. The quantum of loss and livelihood destruction caused by an overflowing Chalakudy river was much high in these two districts as compared to Palakkad.

The list of farmers who had applied for the natural calamity claims in each of the selected panchayats was obtained from the respective Krishibhavans. The number of respondents from each panchayat was decided proportionate to the total number of farmers applied for the claims, so as to make the total sample size as 120. From each panchayat, the farmers were then randomly selected from the list for the survey.

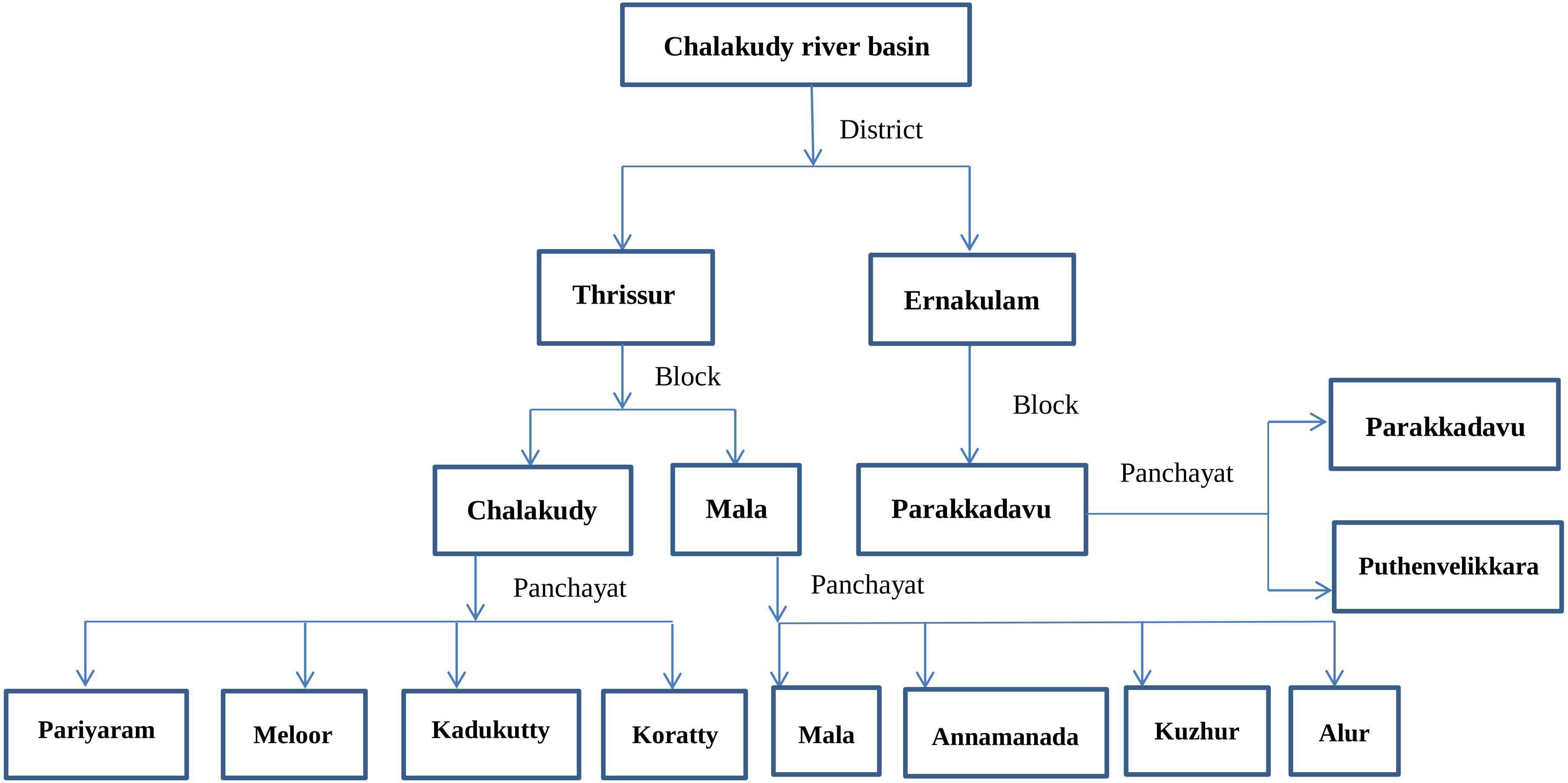

Plate 3 Sampling frame

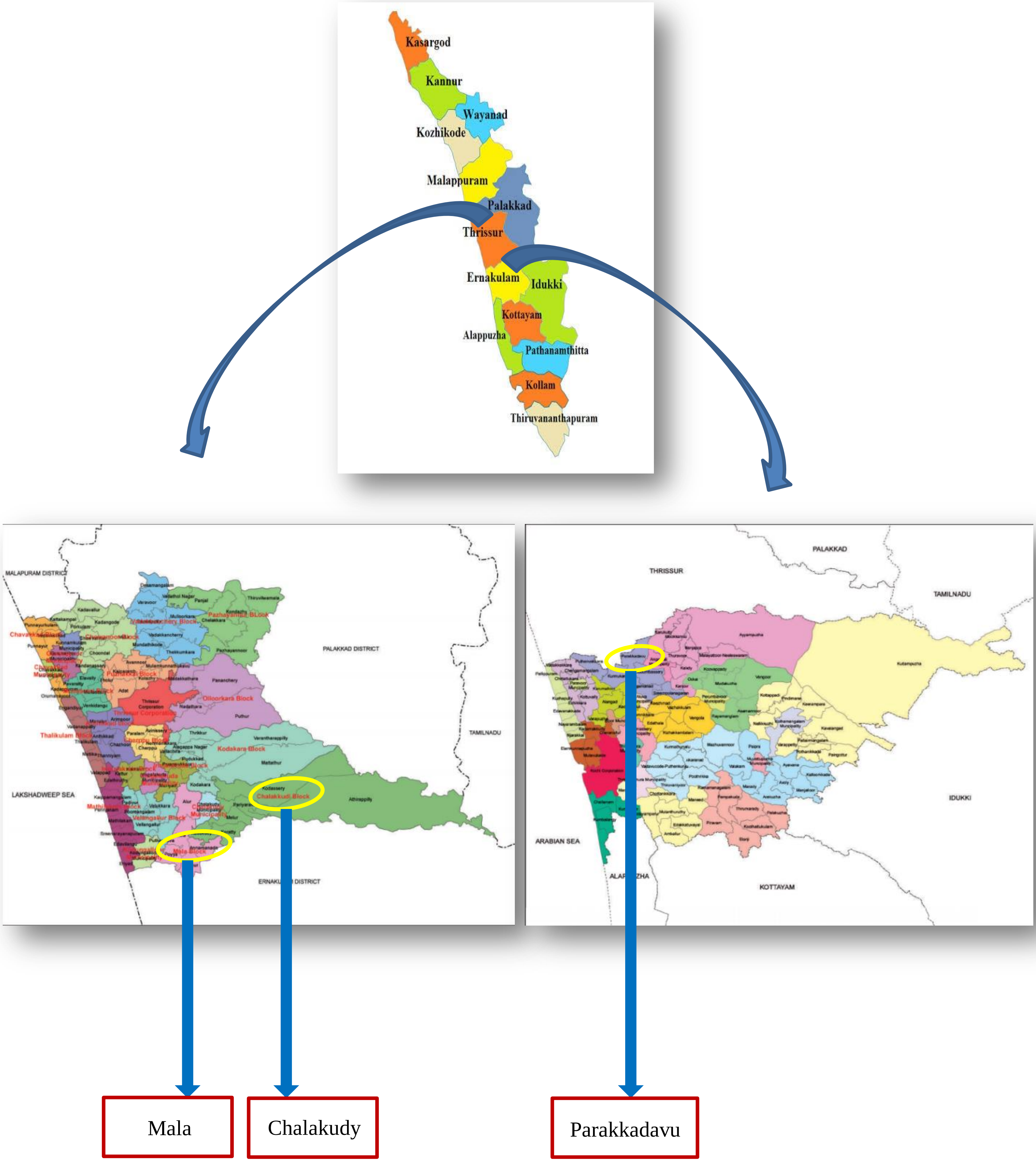

Plate 4 Map of the study area

3.3 NATURE AND SOURCES OF DATA

The study made use of both primary as well as secondary data for analysis and reaching at meaningful conclusions. The secondary data regarding agricultural loss in the selected panchayats was obtained from the respective Krishibhavans. The weekly wholesale price data of the major crops for the year 2018 corresponding to the month of August in the major markets near the selected panchayats in the districts of Thrissur and Ernakulam were collected from the website of AGMARKNET. Relevant information from the memorandum on the monsoon calamity losses prepared and submitted by the State Relief Commissioner, Disaster Management to the Government of Kerala was also used.

The primary data required to make observations for the present study was gathered through a survey of 120 farmers spread across the selected panchayats. By employing personal interview method using pre-tested structured interview schedule, the data pertaining to cost incurred for raising crops that were lost to flood, damage to assets including crops and loss experienced by the households in their income flow were obtained. The hardships faced by the households during the event of deluge were also elicited using the survey to draw inferences regarding factors imparting resilience to those affected by the disaster. Personal interview method was used to collect primary data as this will generate relevant, comprehensive and reasonably correct and precise data which commensurate with real situation.

3.4 ANALYTICAL TOOLS

To achieve the specific objectives of the study, the primary as well as the secondary data collected were analysed using the accredited methods and tools discussed below. The data has been run in the SPSS software package.

3.4.1 Post disaster damage and loss assessment in agriculture

The post disaster damage and loss assessment in agriculture was done using the Damage and Loss Assessment (DaLA) methodology given by the Food and Agriculture Organization (FAO) in its guidance note on 'Post disaster damage, loss and needs assessment in agriculture' in the year 2012, with appropriate modifications.

The methodology was at first evolved by the United Nations Economic Commission for Latin America and the Caribbean (UN-ECLAC) in 1972 and hence is also termed as the UN-ECLAC methodology (GFDRR, 2010). It has since been improved through close cooperation of World Health Organization (WHO), Pan American Health Organization (PAHO), World Bank, Inter-American Development Bank (IADB), United Nations Educational, Scientific and Cultural Organization (UNESCO) and International Labour Organization (ILO) to catch the nearest estimate of damage and losses due to disaster events. The DaLA approach bases its assessments on the general economy of the affected country. It utilizes the national records and statistics as gauge information to assess damage and loss. The methodology additionally factors in the effect of disasters on employments and livelihoods to completely characterize the requirements for recuperation and reconstruction.

3.4.1.1 Conceptual framework

The types of disaster effects on a society and economy considered for valuation are the destruction (total or partial) of physical assets and the subsequent changes or modifications to economic flows in the affected area (GFDRR, 2010). The former is addressed as damage. Damage occurs during and immediately after the disaster. Its monetary value is expressed in terms of replacement or repair costs respectively. On the other hand, the latter is reckoned by the term loss. Decline in crop output is a typical example for loss due to flood. The estimation of damage is utilized as the basis for assessing reconstruction needs, while the worth and type of losses gives the way to evaluating the overall financial effect of the catastrophe and the requirements for monetary recuperation.

In short it can be concluded that,

i) Damages are the costs of repair of partially damaged assets to restore them to their pre-disaster condition and/or replacement of totally destroyed assets

ii) Losses are the values of foregone income, investment losses or higher production costs and other unexpected expenditures.

iii) The value of damages and losses should be at pre-disaster prices. They should not be affected by the post-disaster inflation.

The aggregate of these damages and losses together constitutes the disaster effects.

3.4.1.2 Steps in undertaking post-disaster damage and loss assessment in agriculture sector

The procedure for analyzing post-disaster damage and loss assessment in the agriculture sector developed by FAO (2012) is detailed below as four specific steps.

Step 1. - Create pre-disaster baseline information

A proper post-disaster damage and loss assessment should be based on previous conditions and thus creation of a baseline is utmost important in post-disaster damage and loss assessment. Important information that is to be gathered to create the baseline from which damage and loss will be assessed includes:

1. Population and income

   a. Social and economic profile
   b. Farmers profile

2. Seasonal and perennial crops

   a. Planting to harvest season chart
   b. Production and prices
   c. Investment costs in crops by stages of growth

3. Livestock and poultry

   Number and value of livestock and poultry

4. Fisheries

   Fisheries production, prices and number of fishers

5. Irrigation Assets

6. Other agricultural assets

Number and purchase price of equipments and machineries used in agriculture

7. Other agriculture-related cottage industries/livelihood

Step 2. - Assess damages

Damages are the effects on assets or stocks and are valued as the cost of:

a. Replacement of totally destroyed assets

b. Repair of partially destroyed assets

While replacement cost is the value of the asset just before it was totally destroyed, repair cost is the amount required to put the asset back into its condition just before its partial destruction. However, in the present study, the replacement cost is taken as the cost of replacing the damaged asset.

As far as agriculture is considered, damages include total or partial destruction of assets such as animal sheds, farm equipment and machineries, irrigation systems, fertilizers, seed stock, *etc*. Apart from these, crops in harvesting stage that got destroyed by disasters and totally destroyed perennial crops are also considered part of damages. While crops in harvesting stage that got destroyed by disasters are valued at the farm gate prices for these crops at the time of disaster, the totally destroyed perennial crops are valued at the cost of replanting such types of trees. The average replanting cost per crop is the amount required to replant each of the totally destroyed perennial crops. However, if a destroyed tree has a salvage value (like a fallen coconut tree can be sold for a certain amount), the said salvage value is deducted from the cost of replanting. However, in the present study, the crops that got destroyed at the harvest stage are valued at the market wholesale price.

Damages are to be assessed under the following heads:

a. Damages to agricultural assets

Damage = [Number/Quantity of partially damaged assets x Average repair cost] +

[Number/Quantity of totally destroyed assets x Average replacement cost]

b. Damages to irrigation systems

Damage = [Number/Quantity of partially damaged systems x Average repair cost] +

[Number/Quantity of totally destroyed systems x Average replacement cost]

c. Damages to livestock

Damage = Number of dead animals x respective values

d. Damages to perennial crops and forestry

Damage = Total damages - Salvage value

Where, Total damages = Number of tress totally destroyed x Average replanting cost per tree

However, in the present study, the section damages deals only with damages to agricultural assets, crops and livestock. As mentioned earlier, in the section damages to crops, crops in the harvesting stage that were destroyed by disasters are also considered along with totally destroyed perennial crops. Thus, in the study, damages include:

1. Damages to farm assets (D_A)

D_A = [Number/Quantity of partially damaged assets x Average repair cost] +

[Number/Quantity of totally destroyed assets x Average replacement cost]

2. Damages to crops (D_C)

a) Damages to seasonal crops (D_{SC})

D_{SC} = Production loss x Market wholesale price

Where, Production loss = Expected pre-disaster yield – Realized post-disaster yield

b) Damages to perennial trees and crops (D_{PC})

$$D_{PC} = \text{Total damages - Salvage value}$$

Where, Total damages = Number of tress totally destroyed x Average replanting cost per tree

3. Damages to livestock (D_L)

$$D_L = \text{Number of dead animals x respective values}$$

$$\text{Total damages} = D_A + D_C + D_L$$

Step 3. - Estimate losses for the year that the disaster occurred

Losses are effects on economic flows and are the value of lost output or income. Losses can be experienced several years after the disaster occurred (up to the time that the pre-disaster level of production is regained) causing macroeconomic impacts.

Losses in the agriculture sector comprises of,

a. Investment loss or higher production cost
b. Foregone income or production loss
c. Additional expense in cleaning debris

In agriculture, an important type of loss is the investment loss. When the standing crops are totally destroyed by a disaster and the farmers are not able to replant, the value of investment put into the destroyed crops will be considered as loss and not the value of the expected production.

Another important type of loss in agriculture is the production losses. The value of the reduction in harvest due to the disaster is estimated as production loss. This will be the expected pre-disaster yield less the post-disaster estimated yield (if any) within the year that the disaster occurred.

The third type of loss in agriculture is the additional expenses incurred in tidying up the trash of decimation, recovery of assets, *etc.*

Loss from seasonal crops and perennial crops requires differential treatment in assessment.

1. Losses from Seasonal Crops

Total loss = Production loss + Higher production cost + Other losses

Where, Production loss = Expected pre-disaster yield - Post-disaster estimated yield

Higher production cost will be the initial investment put into the crops before they were destroyed by the disaster plus the added cost due to re-planting expenses of the farmer, if they re-plant in time for harvest within the year. However, the higher production cost will depend on the timing of occurrence of the disaster.

2. Losses from perennial crops and forestry

Total loss = Production loss + Other losses

Where, Production loss = Expected pre-disaster yield - Post-disaster estimated yield

Since destroyed perennial crops cannot regain its pre-disaster level of production within the year that the disaster occurred, there will be no higher production costs. Also, losses from perennial crops will extend beyond the disaster year since perennial crops will usually take a longer time to regain its productive capacity.

3. Losses from fisheries

Total loss = Production loss + Higher production cost + Other losses

Where, Production loss = Expected pre-disaster yield - Post-disaster estimated yield

Higher production costs will be the initial investment put into the fingerlings before they were destroyed by the disaster plus the added cost to the re-stocking expenses of the fish farmers, if they re-stock in time for harvest within the year.

4. Losses from livestock production

Total loss = Production loss + Higher production cost + Other losses

Where, Production loss = Expected pre-disaster yield - Post-disaster estimated yield

The higher production cost for livestock can be due to additional veterinary and medical expenses for the affected livestock, building temporary shelters for animals, *etc*.

5. Losses from irrigation fees within the disaster year

Loss = Expected pre-disaster income from fees – Realized post-disaster income from fees

There can be foregone income from destroyed irrigation facilities only if they were charging fees from users.

However, in the present study, the section losses deal only with losses from crops. Under losses from perennial crops, losses from totally destroyed as well as losses from partially destroyed perennial crops are considered. Thus, in the study, losses include:

1. Losses from seasonal crops (L_{SC})

$$L_{SC} = \text{Production loss} + \text{Higher production cost} + \text{Other losses}$$

Where, Production loss = Expected pre-disaster yield - Post-disaster estimated yield

But, for those seasonal crops that got fully destroyed at the stage of harvest, the loss is considered equivalent to investment loss (cost incurred in bringing the destroyed seasonal crops to that stage when they got destroyed). The investment cost/cost of cultivation was obtained from the farmers during the survey.

2. Losses from perennial crops (L_{PC})

a) Losses from totally destroyed perennial crops (L_{PC1})

$$L_{PC1} = \text{Production loss} + \text{Investment loss}$$

Here, investment loss is the cost incurred in bringing the totally destroyed crop to the stage of destruction (including establishment cost and maintenance cost). Production loss is computed by the method of discounting costs and returns over the next seven years keeping in view that the replanted crop will start to yield in the next seven years.

b) Losses from partially destroyed perennial crops (L_{PC2})

$$L_{PC2} = \text{Production loss x Market wholesale price}$$

Where, Production loss = Expected pre-disaster yield – Realized post-disaster yield

$$\text{Total losses} = L_{SC} + L_{PC}$$

Step 4. - Summarize the damages and losses for the year that the disaster occurred

The damages and the losses estimated for the year that the disaster occurred in the steps two and three are summarized, and the total disaster effect is worked out through direct summation.

$$\text{Total disaster effect} = D_A + D_C + D_L + L_{SC} + L_{PC}$$

In the present study, the total disaster effect worked out for an individual farmer was then extrapolated and the total disaster effect in the flood plain was computed.

Due to the time constraint inflicted upon by the Covid 19 pandemic and the associated lockdown, assessment of damages and losses to assets other than crops was excluded.

3.4.1.3 Box plot

This was employed to understand the spread of the data regarding total damages and total losses to individual households. The boxplot is a graphical technique that depicts five numeric summaries about a data set in order to visualise its dispersion and skewness. Those summaries are based on the median and correspond to the smallest observation, the median of the first half of the data, the median, the median of the second half of the data and the largest observation (McGill *et al.*, 1978). Spread of the data is represented on a boxplot by the distance between the smallest value and the largest value, including any outliers.

3.4.2 Resilience level of the affected farmers

In the study, resilience is taken as the ability of the farmer to continue cropping in the next season.

3.4.2.1 Developing statements for identifying factors contributing to resilience

A questionnaire was prepared keeping in view the objective of identifying factors contributing to resilience using factor analysis. Appropriate statements were carefully prepared to elicit answers in a dichotomous response of agreement/disagreement.

For framing statements, opinion of faculties specialized in Agricultural Extension and Agricultural Economics from Kerala Agricultural University and the state Department of Agriculture Development and Farmers Welfare were sought. Available literature and internet sources were also reviewed for framing the relevant statements.

Framed statements were measured on a Likert scale which was arbitrarily developed based on the one developed by Nguyen and James (2013) to measure household resilience to floods in Vietnamese Mekong River Delta. Likert scale was originally devised by Rensis Likert in 1932. The scale was developed to measure attitude in a scientifically accepted and validated manner.

The statements were measured in a five point continuum on the Likert scale. The respondents agreement to the statements was rated on the continuum as strongly agree, agree, neither agree nor disagree, disagree and strongly disagree. The scoring adopted is given below:

Table 3.6 Scoring adopted for Likert scale

Sl. No.	Agreement	Score
1	Strongly agree	5
2	Agree	4
3	Neither agree nor disagree	3
4	Disagree	2
5	Strongly disagree	1

3.4.2.2 Factor analysis

Factor analysis was employed to identify the underlying components of resilience. Factor analysis is essentially a method of meaningful reduction of data (Dillon and Goldstein, 1984). It is a generic term for a family of statistical techniques concerned with the reduction of a set of observable variables in terms of small number of latent factors (Ather and Balasundaram, 2009). The purpose of this technique is to reduce the large amount of variables to a smaller set of underlying variables by creating factors (Kim and Mueller, 1978).

There are several ways to conduct factor analysis (principal components, unweighted least squares, generalized least squares, maximum likelihood, principal axis factoring, alpha factoring, image factoring) and alternative choice of methods (correlation matrix or a covariance matrix) (Ather and Balasundaram, 2009). However, the principal component analysis method is used in this study.

Kasier – Meyer –Olkin (KMO) measure of Sampling Adequacy in factor analysis is a measure of whether or not the distribution of value is adequate for conducting factor analysis. As per KMO measure, a measure of >0.9 is marvelous, >0.8 is meritorious, >0.7 is middling, >0.6 is mediocre, >0.5 is miserable and <0.5 is unacceptable.

Bartlett's test of Sphericity is a measure of the multivariate normality of the set of distributions in factor analysis. It also tests whether the correlation matrix conducted within the factor analysis is an identity matrix. Factor analysis would be meaningless with an identity matrix. A significance value of <0.05 indicates that the data do not produce an identity matrix and are thus appropriately multivariate normal and acceptable for factor analysis (George and Mallery, 2003).

3.4.2.3 Cronbach's alpha coefficient

Cronbach's alpha was employed to test if multiple-question Likert scale survey is reliable. Lee Cronbach developed Cronbach's alpha or Coefficient alpha (α) in 1951. It measures reliability or internal consistency. How well a test measures what it should measure is indicated by the reliability. Cronbach's alpha coefficient will tell if the test designed is accurately measuring the variable of interest.

Cronbach’s alpha coefficient is calculated as,

$$\alpha = \frac{k}{k-1}\left(1 - \frac{\sum_{i-1}^{k} \sigma_i^2}{\sigma_t^2}\right)$$

where, k = the number of items in a scale

σ_i^2 = the variance of i^{th} item

σ_t^2 = the variance of the scale (total) scores

Cronbach’s alpha reliability coefficient normally ranges between 0 and 1. The closer Cronbach’s alpha coefficient is to one, the greater the internal consistency of the items in the scale. The size of alpha is determined by both the number of items in the scale and the mean inter-item correlations (Gliem and Gliem, 2003). George and Mallery (2003) provided the following rules of thumb: “>0.9 – Excellent, >0.8 – Good, >0.7 – Acceptable, >0.6 – Questionable, >0.5 – Poor and <0.5 – Unacceptable”.

3.4.2.4 Socio-economic profiling and characterisation

The primary data collected through direct personal interview of the sample respondents during survey using pre-tested structured interview schedule was tabulated to facilitate easy comprehension and analysis. Secondary data was also presented in tabular form to draw conclusions regarding the total number of farmers affected, total agricultural area affected and total loss suffered in monetary terms in the study area.

Tabular presentation of the primary data was adopted to analyse the general characteristics of the respondents, the distribution of land holdings and to create a pre-disaster baseline upon which post-disaster situation was built and the damage and losses for the agriculture sector was worked out. Simple statistical tools like averages and percentages were used to compare, contrast and interpret results properly.

Moreover, the influence of socio-economic characteristics on resilience was studied fitting a logistic regression.

3.4.2.5 Model specification of logistic resilience function for farmers

Logistic resilience function was fitted for the surveyed farmers. Resilience index worked out for the individual farmers was fitted as a function of age of the farmer, education, experience in farming, family size, land area, crop diversification index, education of the respondent, education of the family members and subsidiary occupation. Of the independent variables used in the function, dummy variables were used for the education of the respondent, education of the family members and subsidiary occupation.

The specified resilience function is as follows:

$$\text{Ln}\left(\frac{P_i}{1 - P_i}\right) = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4 + b_5x_5 + b_6x_6 + b_7x_7 + b_8x_8$$

Where,

P_i = Probability of having high or low resilience

1 = Respondent is having high resilience

0 = Respondent is having low resilience

x_1 = Age (years)

x_2 = Education of the respondent (= 0, if below SSLC, = 1, if SSLC or above)

x_3 = Subsidiary occupation (= 0, if no, = 1, if yes)

x_4 = Experience in farming (years)

x_4 = Education of family members (= 0, if below SSLC, = 1, if SSLC or above)

x_5 = Family size (nos.)

x_6 = Land area (acres)

x_7 = Crop diversification index

b_0 = Intercept

$b_1, b_2, b_3, \ldots b_8$ = Regression coefficients

Table 3.7 Independent variables selected in the logistic model

Sl. No.	Particulars	Expected sign
1	Age	+
2	Subsidiary occupation	+
3	Education of the respondent	+
4	Experience in farming	+
5	Education of family members	+
6	Family size	-
7	Land area	+
8	Crop diversification index	_

3.4.2.6 Herfindahl index

The extent of crop diversification for individual farms in the study area was examined using the Herfindahl index. The index for an individual farm was calculated using the formula,

$$\text{Herfindahl index} = \Sigma^{N}_{i=1} P_i^2$$

Where, N = Total number of crops

P_i = Acreage share of i^{th} crop in total cropped area

Herfindahl index is the index of concentration and thus a lower value is always preferred. Perfect diversification is indicated by an index equal to zero whereas a farm with index equal to one is a clear manifestation of monocropping/specialization.

3.4.3 Hardships faced by the households during floods

The hardships faced by the farm households during the 2018 flood were identified and analysed.

3.4.3.1 Garrett's ranking technique

Garrett's ranking technique was employed to find out the most important hardship faced by the farm households during and immediately after the disaster. As the first step towards analysing the hardships, the major difficulties faced during the flood were identified. The respondents were then asked to rank these difficulties and the ranks were then converted into percent position by using the following formula,

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

Where, R_{ij} = Ranking given to the i^{th} attribute by the j^{th} individual

N_j = Number of attributes ranked by the j^{th} individual.

These percentages were then converted into scores on a scale of 100 points referring to the table given by Garrett and Woodworth (1969). For each factor, the scores of the various respondents were added, from which total value of scores and mean value of scores were calculated. The mean score values were then arranged in the descending order. The factor having the highest mean value is considered to be the most important factor and thus was given the rank one and the others followed in order.

3.4.3.2 Coefficient of Concordance

Kendall's W statistic, called the Coefficient of Concordance was employed to assess agreement between different respondents in ranking the hardships faced during the disaster.

Kendall's coefficient of concordance (W) is calculated as,

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

Where, n = the number of objects

p = the number of judges

T = the correction factor for tied ranks

$$S' = \sum_{i=1}^{n} R_i^2 = SSR$$

$$T = \sum_{k=1}^{m} (t_k^3 - t_k)$$

Where, 'S' = the sum of squares from row sums of ranks R_i.

m = the number of groups

t_k = the number of tied ranks in each (k) of m groups

Kendall's W statistic ranges from 0 to 1. Zero shows there is absolutely no agreement between raters, while 1 shows perfect agreement. The higher the value of Kendall's W statistic, the stronger is the association. Usually Kendall's coefficients of 0.9 or higher are considered to be very good.

Results and Discussion

4. RESULTS AND DISCUSSION

The present study entitled 'Assessment of agricultural loss due to 2018 Flood to farm households in the flood plains of Chalakudy river' was conducted in the flood plains of Chalakudy river in Thrissur and Ernakulam districts of Kerala with the objectives of assessing the agricultural damage and loss in the flood plain and the same to the individual farm households, analysing resilience of the affected farmers and identifying the difficulties faced in the event of the flood. The results of the study are discussed in five sections as given below.

4.1 Agricultural damage and loss to the affected farm households

4.2 Agricultural damage and loss in the flood plain

4.3 Resilience level of the affected farmers

4.4 Hardships faced by the farm households during the event of flood

4.5 Socio-economic profile of the sample farmers

4.1 Agricultural damage and loss to the affected farm households

An attempt has been made in this section to assess the disaster effects on the farm households along the flood plains of the river with regard to damage and loss suffered to crops, agricultural assets and livestock and the results are explained under two headings viz., damages and losses. Throughout the section, mean values indicate the average value of the disaster effect per household.

4.1.1 Damages to farm household

Damages to farm households are discussed under three headings viz., damages to agricultural assets, damages to crops and damages to livestock and poultry. The procedure explained under section 3.4.1.2 which is a modified version of FAO (2012) is used for assessing the damage.

4.1.1.1 Damages to agricultural assets

The damages to agricultural assets as presented in Table 4.1 show that on an average a farm household in the flood plain has suffered a damage of ₹12,837 to its agricultural assets. Some of the assets were fully damaged and required to be replaced while others were partially damaged and thus were in need of repair. The study has shown that it is the Chalakudy block, which has suffered the highest damage wherein a farm household on an average lost about ₹20,465 through repair and replacement of the different assets that were either partially or fully damaged. It was Parakkadavu block, which suffered the least damage with a farm household losing an amount of ₹7,535 to repair and replacement of damaged assets.

Table 4.1 Total damages to agricultural assets per farm household (₹)

Sl. No.	Block	Mean	Aggregate
1	Chalakudy (n=44)	20464.77	900449.88
2	Mala (n=40)	9255	370200
3	Parakkadavu (n=36)	7534.72	271249.92
4	**Average (n=120)**	**12837.37**	**1540484.4**

Poultry shed, cattle shed, sprayer, motor pump and seeds are the major assets that were damaged with poultry sheds suffering the highest damage as shown in Fig 3.

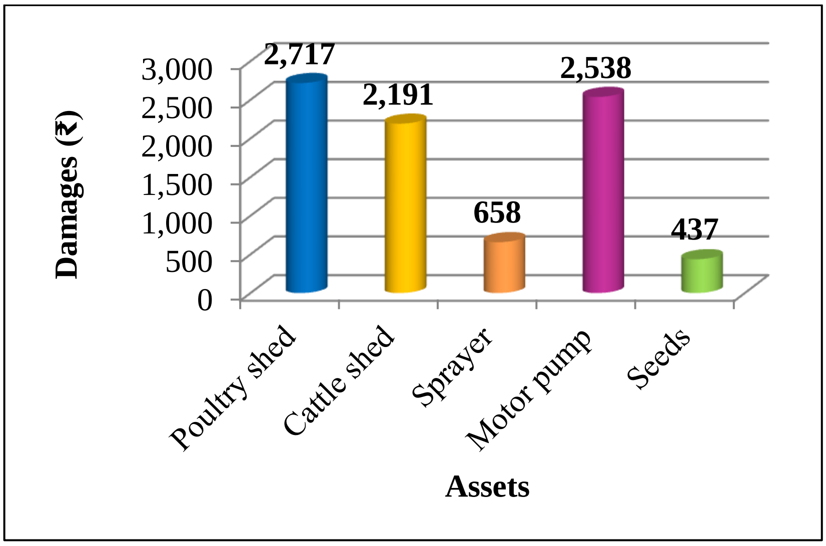

Fig 3 Per farm household damage to major agricultural assets (n=120)

Analysing block-wise damage to major agricultural assets (Table 4.2) revealed that damage to poutry sheds, cattle sheds and seed stock was the highest in Chalakudy block with a household on an average spending about ₹4,216, ₹3,455 and ₹818 respectively for repair and replacement of these assets, whilst damage to sprayers was the highest in Parakkadavu block with a household on an average spending about ₹868 and that to motor pump was the highest in Mala block wherein a household on an average lost about ₹2,923 to the repair and replacement of the respective assets.

Table 4.2 Blockwise damages to major agricultural assets per farm household

Sl. No.	Particulars	Damages (₹) Chalakudy (n=44)	Mala (n=40)	Parakkadavu (n=36)
1	Poultry shed	4215.91	2287.5	1361.1
2	Cattle shed	3454.6	2672.5	111.11
3	Sprayer	803.4	307.5	868.1
4	Motor pump	2029.6	2922.5	2733.3
5	Seeds	818.2	360	55.56

4.1.1.2 Damages to crops

The damages to crops were studied under two heads as damages to seasonal crops and damages to perennial crops. The damages to seasonal crops as presented in Table 4.3 show that on an average a farm household in the flood plain has suffered a damage of ₹75,538 due to the destruction of crops that were in the harvesting stage. The study has shown that it is Chalakudy block, which has suffered the highest damage to seasonal crops in the harvesting stage, where a farm household on an average lost about ₹94,770 through total destruction of these crops. It was Parakkadavu block, which suffered the least damage with a farm household losing an amount of ₹47,020 as the seasonal crops in the harvesting stage were totally destroyed. The aggregate value of damage to seasonal crops to selected farm households in the study area amounted to ₹90 lakhs with the highest share for Chalakudy block (₹41 lakhs).

Table 4.3 Total damages to seasonal crops per farm household (₹)

Sl. No.	Block	Mean	Aggregate
1	Chalakudy (n=44)	94769.48	4169857.12
2	Mala (n=40)	79969.86	3198794.4
3	Parakkadavu (n=36)	47020	1692720
4	**Average (n=120)**	**75537.80**	**9064536**

Banana, gourds, cowpea, bhindi, ginger/turmeric, tapioca, tuber and paddy are the major ready to harvest crops that were destroyed with banana suffering the highest damage as shown in Fig 4. And, the crop wise damage was highest for banana (₹42,340).

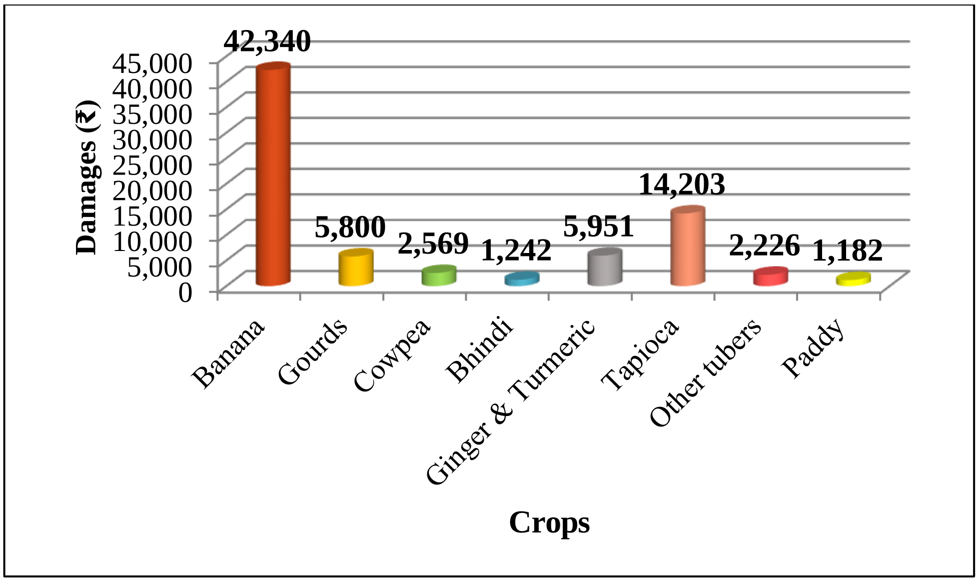

Fig 4 Per farm household damage to major seasonal crops (n=120)

Analysing block-wise damage to major ready to harvest crops (Table 4.4) revealed that Chalakudy block topped the list regarding damage to banana, ginger/turmeric and tapioca with a household on an average losing about ₹50,538, ₹6,774 and ₹26,894 respectively. While, the damage to gourds, cowpea, bhindi, tuber and paddy was the highest in Mala block wherein on an average a household lost about ₹12,189, ₹3,599, ₹2,660, ₹2,595 and ₹1,733 respectively.

Table 4.4 Blockwise damages to major seasonal crops per farm household

Sl. No.	Particulars	Damages (₹)		
		Chalakudy (n=44)	**Mala** (n=40)	**Parakkadavu** (n=36)
1	Banana	50537.57	44208.39	30244.95
2	Gourds	3851.84	12189.02	1080.4
3	Cowpea	2232.04	3599.09	1834.68
4	Bhindi	542.3	2660.29	520.72
5	Ginger/Turmeric	6774.38	5927.89	4969.86
6	Tapioca	26894.44	7057.53	6630
7	Tuber	2344.73	2595.14	1669.4
8	Paddy	1592.18	1732.5	700

The damages to totally destroyed perennial crops as presented in Table 4.5 show that on an average a farm household in the flood plain has suffered a damage of ₹9,391 due to the destruction of perennial crops. The study has shown that it is the Parakkadavu block, which has suffered the highest damage to perennial crops, wherein a farm household on an average lost about ₹12,342 through total destruction of these crops. It was Chalakudy block, which suffered the least damage with a farm household losing an amount of ₹8,054. The aggregate value of damage to perennial trees and crops to selected farm households in the study area amounted to ₹11 lakhs with the highest share for Parakkadavu block (₹4 lakhs).

Table 4.5 Total damages to perennial crops per farm household (₹)

Sl. No.	Block	Mean	Aggregate
1	Chalakudy (n=44)	8053.64	354360.16
2	Mala (n=40)	8222.75	328910
3	Parakkadavu (n=36)	12341.81	444305.16
4	**Average (n=120)**	**9391.04**	**1126924.8**

Nutmeg, coconut, arecanut and black pepper are the major perennial crops that were totally destroyed with nutmeg suffering the highest destruction as shown in Fig 5. And, the crop wise damage was highest for nutmeg (₹7,161).

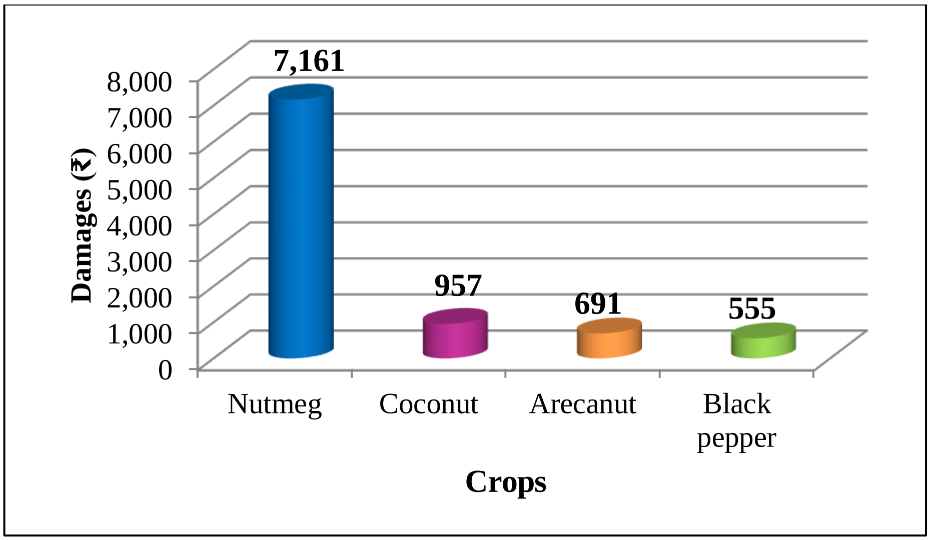

Fig 5 Per farm household damage to major perennial crops (n=120)

Analysing block-wise damage to major perennial crops (Table 4.6) revealed that damage to nutmeg and coconut was the highest in Parakkadavu block wherein on an average a household lost about ₹9,606 and ₹1,667 respectively. On the other hand, damage to arecanut and black pepper was the highest in Mala block with a household on an average losing about ₹1,138 and ₹1,181 respectively.

Table 4.6 Blockwise damages to major perennial crops per farm household

Sl. No.	Particulars	Damages (₹)		
		Chalakudy (n=44)	**Mala** (n=40)	**Parakkadavu** (n=36)
1	Nutmeg	6954.55	5187.75	9605.69
2	Coconut	594.32	716.25	1666.67
3	Arecanut	293.18	1137.5	680.56
4	Black pepper	120.68	1181.25	388.89

4.1.1.3 Damages to livestock and poultry

On an average a farm household in the flood plain has suffered a damage of ₹12,216 due to the death of livestock and poultry (Table 4.7). The study has shown that it is Mala block, which has suffered the highest damage to livestock and poultry, wherein a farm household on an average lost about ₹24,041 due to the death of livestock and poultry. It was Chalakudy block, which suffered the least damage with a farm household losing an amount of ₹4,336 to the dead livestock and poultry.

Table 4.7 Total damages to livestock and poultry per farm household (₹)

Sl. No.	Block	Mean	Aggregate
1	Chalakudy (n=44)	4336.36	190799.84
2	Mala (n=40)	24041.25	961650
3	Parakkadavu (n=36)	8552.78	307900.08
4	**Average (n=120)**	**12215.62**	**1460349.6**

Cattle, goat and chicken are the major livestock and poultry that were dead with chicken suffering the highest death calamity as shown in Fig 6.

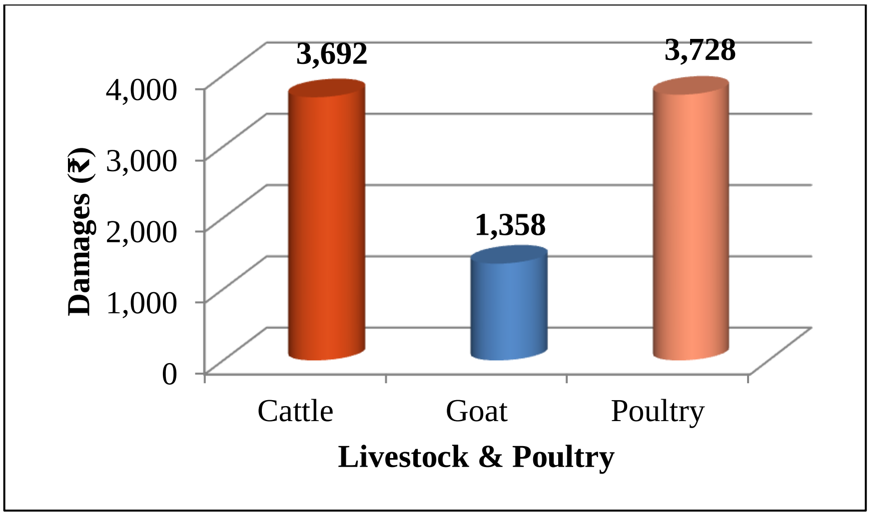

Fig 6 Per farm household damage to major livestock and poultry (n=120)

Analysing block-wise damage to major livestock and poultry (Table 4.8) revealed that it is in Mala block that a farm household suffered the highest damage to cattle and chicken with a household losing on an average about ₹4,475 and ₹2,841 respectively, whilst the damage to goat was the highest in Parakkadavu block with a household losing on an average about ₹2,444.

Table 4.8 Blockwise damages to major livestock and poultry per farm household

Sl. No.	Particulars	Damages (₹)		
		Chalakudy (n=44)	**Mala** (n=40)	**Parakkadavu** (n=36)
1	Cattle	3181.82	4475	3444.44
2	Goat	500	1325	2444.44
3	Chicken	654.55	2841.25	2663.89

A consolidated table indicating the damages incurred to the farm households on account of damages to seasonal and perennial crops, livestock and other agricultural assets are presented in Table 4.9.

Table 4.9 Agricultural damage per farm household (₹)

Block	Seasonal crops		Perennial crops		Livestock and poultry		Assets		Damages	
	Mean	Aggregate	Mean	Aggregate	Mean	Aggregate	Mean	Aggregate	Mean	Aggregate
Chalakudy (n=44)	94769.48	4169857.12	8053.64	354360.16	4336.36	190799.84	20464.77	900449.88	127624.25	5615467
Mala (n=40)	79969.86	3198794.4	8222.75	328910	24041.25	961650	9255	370200	121488.86	4859554.4
Parakkadavu (n=36)	47020	1692720	12341.81	444305.16	8552.78	307900.08	7534.72	271249.92	75449.31	2716175.2
Average (n=120)	**75537.80**	**9064536**	**9391.04**	**1126924.8**	**12215.62**	**1460349.6**	**12837.37**	**1540484.4**	**109981.83**	**13197820**

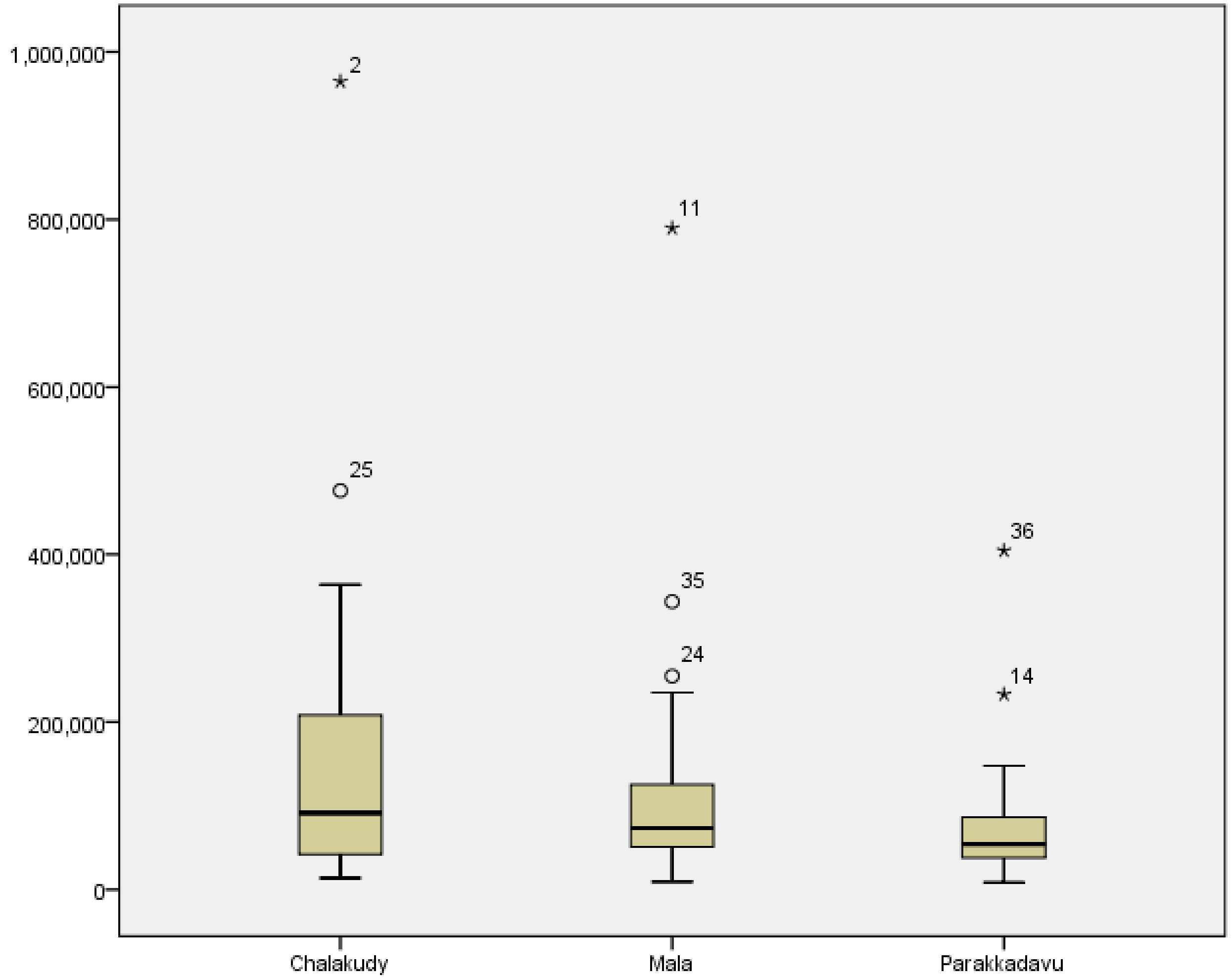

Fig 7 Box plot showing total damages to each of the respondent households – block-wise scenario

Box plot as given in Fig. 7 was drawn to get an idea on the spread of the data regarding total damages to individual households. The spread was found to be more in the case of Chalakudy block. The positioning of box plot in between the whiskers indicates that the given data set has a skewed distribution. Since the mean is greater than median it can be concluded that the distribution is positively skewed. There are extreme outliers present beyond the upper whisker for all three blocks pulling the mean towards the right, thus making the distribution positively skewed.

4.1.2 Agricultural losses to the farm household

Unlike the FAO methodology, in the study, crop loss alone was considered under the title losses in the agriculture sector. Agricultural losses to the farm households are discussed under two headings viz., losses from seasonal crops and losses from perennial crops. The procedure explained under section 3.4.1.2 which is a modified version of FAO (2012) is used for assessing the loss.

4.1.2.1 Losses from seasonal crops

The losses from seasonal crops as presented in Table 4.10 show that on an average a farm household in the flood plain has suffered a loss of ₹1,59,469 due to the destruction of these crops. The study has shown that it is the Mala block, which has suffered the highest loss from the destruction of seasonal crops, wherein a farm household on an average lost about ₹1,97,318. It was Parakkadavu block, which suffered the least monetary loss with a farm household losing an amount of ₹1,06,718 from seasonal crops.

Table 4.10 Total losses from seasonal crops per farm household (₹ lakhs)

Sl. No.	Block	Mean	Aggregate
1	Chalakudy (n=44)	1.68	73.92
2	Mala (n=40)	1.97	78.8
3	Parakkadavu (n=36)	1.06	38.52
4	**Average (n=120)**	**1.59**	**190.8**

Banana, gourds, cowpea, bhindi, ginger/turmeric, tapioca, tuber and paddy are the major seasonal crops that suffered a loss with banana incurring the highest loss as shown in Fig 8.

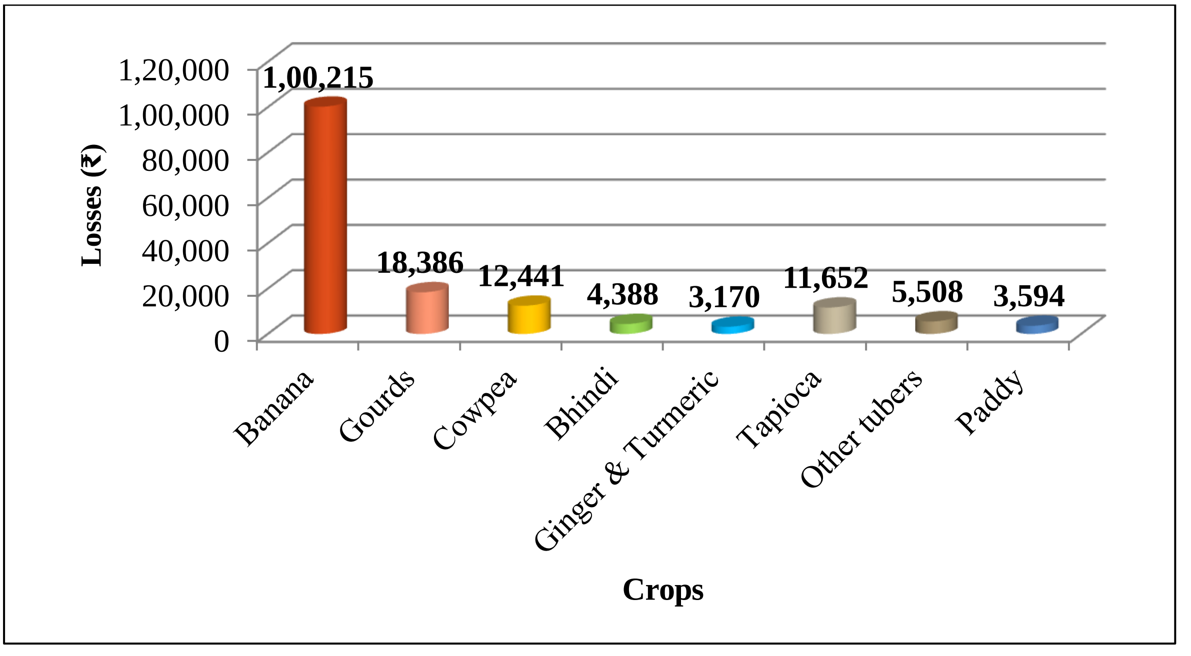

Fig 8 Loss incurred per farm household to major seasonal crops (n=120)

Analysing block-wise loss from seasonal crops (Table 4.11) revealed that farm households in the Mala block suffered the highest loss to banana, gourds, cowpea, bhindi, tuber and paddy wherein on an average a household lost about ₹1,10,918, ₹39,745, ₹18,705, ₹10,218, ₹6,770 and ₹5,145 respectively. The loss incurred by a farm household to ginger/turmeric and tapioca was the highest in Chalakudy block with the average loss suffered by a farm household amounting to ₹4,503 and ₹22,917 respectively.

Table 4.11 Blockwise loss from major seasonal crops per farm household

Sl. No.	Particulars	Losses (₹)		
		Chalakudy (n=44)	**Mala** (n=40)	**Parakkadavu** (n=36)
1	Banana	106021.9	110918.4	84305.65
2	Gourds	10806.71	39745.14	3917.81
3	Cowpea	11455.65	18704.74	6684.03

4	Bhindi	1729.4	10217.5	1142.6
5	Ginger/Turmeric	4503.03	2682.57	2081.96
6	Tapioca	22917.03	6075.88	4080.38
7	Tuber	5449.89	6770.43	4211.47
8	Paddy	4883.87	5145.32	293.75

4.1.2.2 Losses from perennial crops

The losses from perennial crops were studied under two heads as losses from perennial crops that were totally destroyed and those that were not totally destroyed. The losses from totally destroyed perennial crops include both investment as well as production losses. Production loss was accounted for the next seven years till the replanted crop starts yielding. The losses from totally destroyed and partially destroyed perennial crops for a household is worked out separately and then aggregated. Table 4.12 shows that on an average a farm household in the flood plain has incurred a loss of ₹1,52,358 including both investment and production loss. The study has shown that it is Mala block, which has suffered the highest loss from totally destroyed perennial crops, wherein a farm household on an average lost about ₹1,88,471. It was Parakkadavu block, which suffered the least loss with a farm household losing an amount of ₹1,20,394.

Table 4.12 Total losses from totally destroyed perennial crops per farm household (₹ lakhs)

Sl. No.	Block	Mean	Aggregate
1	Chalakudy (n=44)	1.45	63.8
2	Mala (n=40)	1.88	75.2
3	Parakkadavu (n=36)	1.20	43.2
4	**Average (n=120)**	**1.52**	**182.4**

Nutmeg, coconut, arecanut and black pepper are the major perennial crops that were totally destroyed with nutmeg suffering the highest destruction as shown in Fig 9.

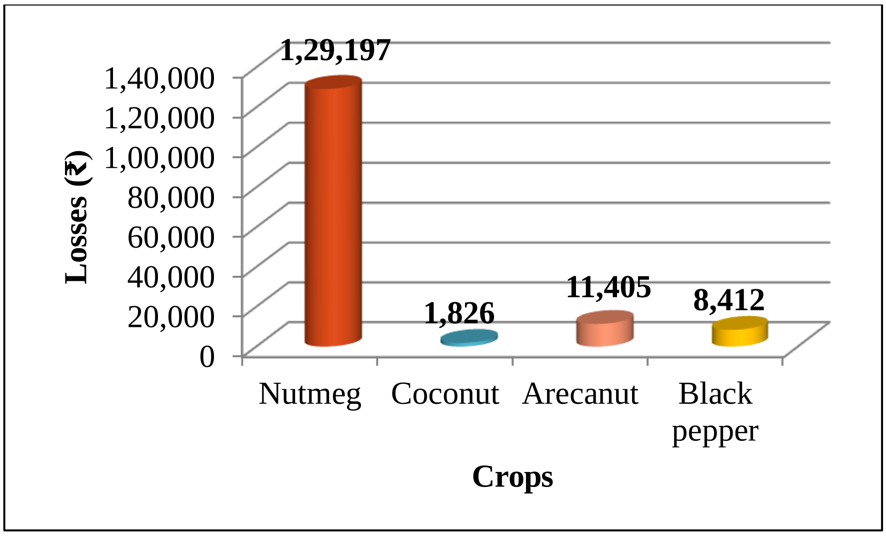

Fig 9 Loss incurred per farm household to totally destroyed major perennial crops (n=120)

Analysing block-wise loss from totally destroyed perennial crops (Table 4.13) revealed that the average loss suffered by a farm household from nutmeg, coconut, arecanut and black pepper were all the highest in Mala block wherein on an average a household lost about ₹1,42,476, ₹3,281, ₹25,072 and ₹17,643 respectively as these crops got totally destroyed.

Table 4.13 Blockwise loss from totally destroyed major perennial crops per farm household

Sl. No.	Particulars	Losses (₹)		
		Chalakudy (n=44)	**Mala** (n=40)	**Parakkadavu** (n=36)
1	Nutmeg	131490	142475.8	111639.28
2	Coconut	1576.59	3281.25	513.89
3	Arecanut	4034.09	25071.88	5227.78
4	Black pepper	4437.66	17642.5	3012.78

The losses from partially destroyed perennial crops include just the production losses. Production loss was accounted for the year that the disaster occurred. The losses from partially destroyed perennial crops as presented in Table 4.14 show that on an average a farm household in the flood plain has suffered a loss of ₹32,854. The study has shown that Mala block has suffered the highest loss from perennial crops, wherein a farm household on an average lost about ₹37,134. It was Parakkadavu block, which suffered the least loss with a farm household losing an amount of ₹22,854.

Table 4.14 Total losses from partially destroyed perennial crops per farm household (₹ lakhs)

Sl. No.	Block	Mean	Aggregate
1	Chalakudy (n=44)	0.37	16.28
2	Mala (n=40)	0.37	14.8
3	Parakkadavu (n=36)	0.23	8.28
4	**Total (n=120)**	**0.33**	**39.6**

Nutmeg, coconut and arecanut were the major partially destroyed perennial crops with nutmeg suffering the highest loss as indicated in Fig 10.

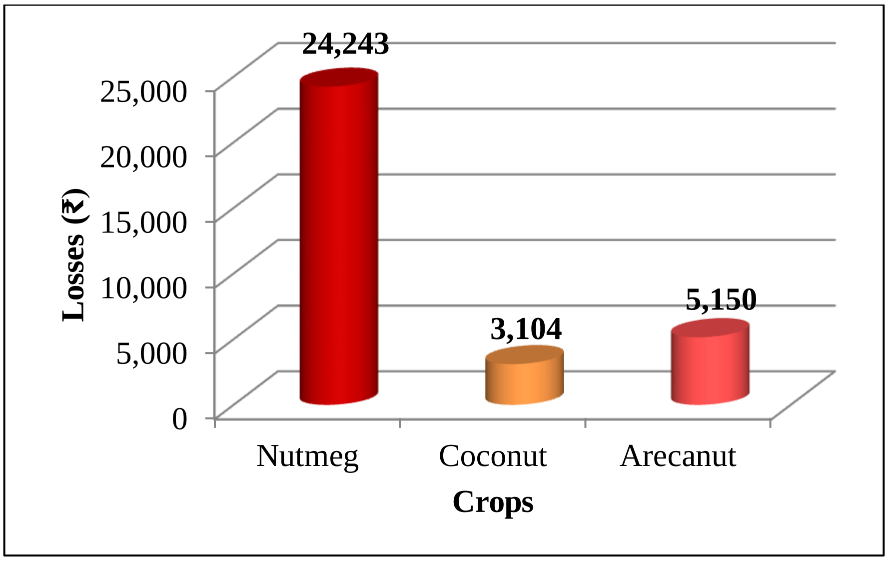

Fig 10 Loss incurred per farm household to partially destroyed major perennial crops

Analysing block-wise loss from partially destroyed perennial crops (Table 4.15) revealed that the production loss from nutmeg and arecanut suffered by a farm household was the highest in Mala block with a household losing on an average about

₹27,867 and ₹7,646 respectively, whilst the loss from coconut was the highest in Parakkadavu block wherein a household on an average lost about ₹4,926.

Table 4.15 Blockwise loss from partially destroyed major perennial crops per farm household (₹)

Sl. No.	Particulars	Losses (₹)		
		Chalakudy	Mala	Parakkadavu
1	Nutmeg	26358.19	27866.72	17631.29
2	Coconut	2960.17	1620.94	4925.91
3	Arecanut	6883.44	7646.01	257.44

A consolidated table indicating the losses to the farm households on account of losses from seasonal and perennial crops are presented in Table 4.16.

Table 4.16 Agricultural loss per farm household (₹ lakhs)

Block	Seasonal crops		Totally destroyed perennial crops		Partially destroyed perennial crops		Losses	
	Mean	**Aggregate**	**Mean**	**Aggregate**	**Mean**	**Aggregate**	**Mean**	**Aggregate**
Chalakudy (n=44)	1.68	73.92	1.45	63.8	0.37	16.28	3.50	154
Mala (n=40)	1.97	78.8	1.88	75.2	0.37	14.8	4.23	169.2
Parakkadavu (n=36)	1.06	38.52	1.20	43.2	0.23	8.28	2.50	90
Average (n=120)	**1.59**	**190.8**	**1.52**	**182.4**	**0.33**	**39.6**	**3.44**	**412.8**

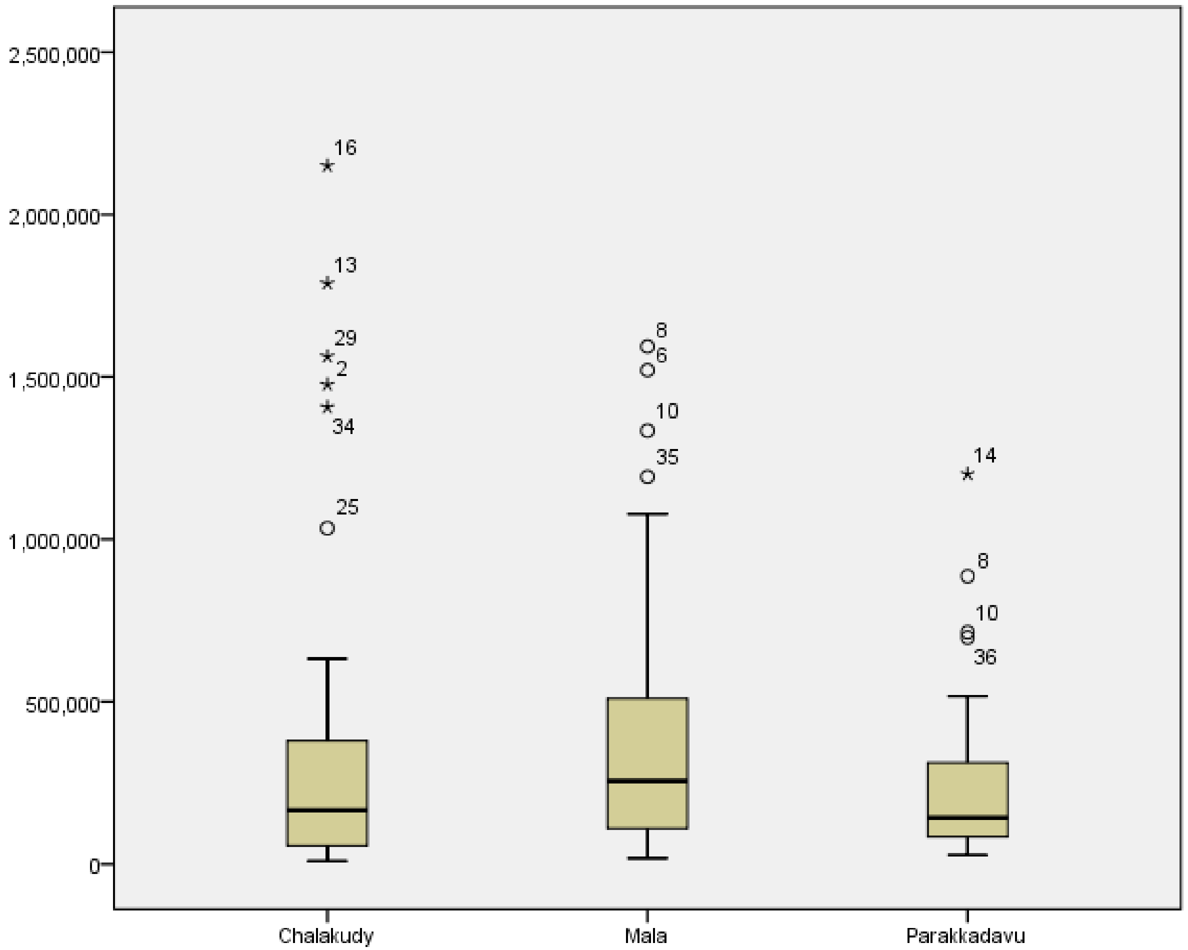

Fig 11 Box plot showing total losses to each of the respondent households – block-wise scenario

Box plot as given in Fig. 4.9 was drawn to get an idea on the spread of the data regarding total losses to individual households. The spread was found to be more in the case of Mala block. Box plot for all the blocks are placed in between the whiskers. This suggests that the given data set has a skewed distribution. Since the mean is greater than median it can be concluded that the distribution is positively skewed. Though the concentration of values is more on the left, the extreme outliers present beyond the upper whisker pull the mean towards the right making it positively skewed.

In a similar study undertaken by Naveen (2014) in the Don river basin of the Bijapur district, the average loss from cattle shed due to a flood event in the basin was estimated as ₹49,725 for large farmers and ₹48,725 for small farmers, while the loss from motor shed was estimated as ₹26,325 for large farmers and ₹20,075 for small farmers. The average loss from livestock viz., cattle, sheep and goat was estimated as ₹9,50,000, ₹2,35000 and ₹97,500 respectively for large farmers, while it was estimated as ₹7,89,000, ₹8,20,000 and ₹4,32,500 respectively for small farmers. The average loss in value from crops viz., groundnut, maize, Bengal gram, jowar and wheat was estimated as ₹11,700, ₹95,040, ₹35,280, ₹26,800 and ₹25,200 respectively for large farmers, while the same was estimated as ₹13,650, ₹82,720, ₹42,000, ₹24,960 and ₹23,100 respectively for small farmers.

4.2 Agricultural damage and loss in the flood plain

An attempt has been made in this section to assess the total disaster effects in the flood plains of the river with regard to damage and loss suffered to crops, assets and livestock.

Summarizing the damages and losses caused by the 2018 Flood in the flood plains of Chalakudy river as presented in Table 4.17 shows that the flood plain has suffered an agricultural loss of ₹258.87 crores due to the unprecedented disaster. The study has shown that it is Mala block, which has suffered the highest, wherein the total loss to the agricultural sector was estimated at ₹104.18 crores. It was Parakkadavu block, which suffered the least with the flood plains in the block losing an amount of ₹55.11 crores as the floods ravaged the agricultural sector.

In a similar flood situation in Uttarakhand in the year 2013, a Joint Rapid Damage Needs Assessment (JRDNA) was conducted by the Government of Uttarakhand along with the World Bank, the Asian Development Bank and the Global Facility for Disaster Reduction and Recovery (GFDRR). And, the JRDNA pegged the total economic loss at 3.8 billion USD (GFDRR and World Bank, 2014).

Though the estimated disaster effect in the selected three blocks of the flood plain is much higher than the consolidated loss reported (₹6 crores) by the respective blocks of the state Department of Agriculture Development and Farmers Welfare (Appendix II), the result is justified by the fact that in the study disaster effects include both damage and loss to crops, whereas disaster effect as per the secondary data obtained from the offices of the Assistant Directors of Agriculture of the concerned blocks includes only the assessed value of damage. Also, the study has considered damage to agricultural assets and livestock, which was not included while enumerating the agricultural loss and damages by the agricultural department in the secondary data. Moreover, it was a quick estimation considering just the damaged crops and assigning each damaged crop a value based on a pre-fixed rate corresponding to the government norms.

Table 4.17 Agricultural damage and loss in the flood plains of Chalakudy river (₹ crores)

Sl. No.	Particulars	Chalakudy	Mala	Parakkadavu	Flood plain
1	**Damages**				
a	Assets	4.27	1.77	1.28	7.32
b	Crops	21.44	16.91	10.11	48.46
c	Livestock	0.90	4.61	1.46	6.97
2	**Losses**				
a	Crops	72.97	80.89	42.26	196.12
3	**Total**	**99.58 (38.47)**	**104.18 (40.24)**	**55.11 (21.29)**	**258.87 (100.00)**

Note: Figures in parentheses indicate percent to row total

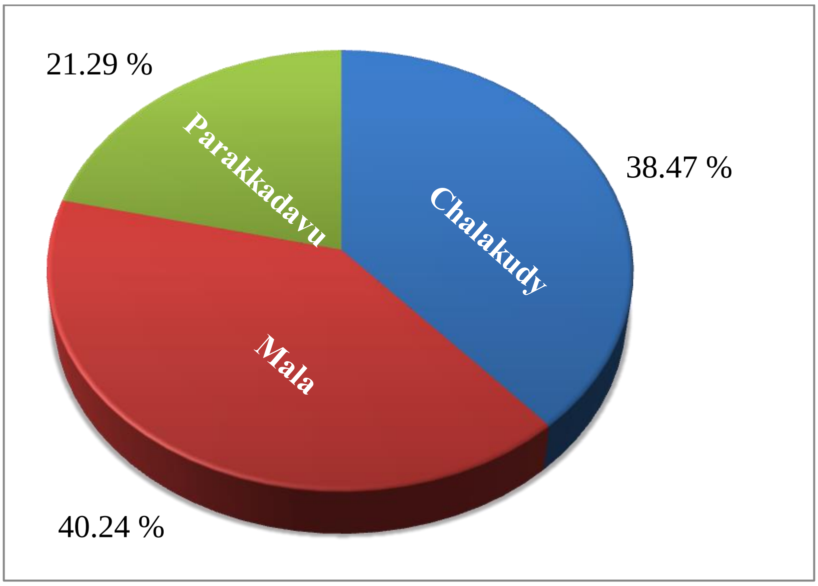

Fig 12 Block wise disaster effect

4.2.1 Damages to farm households

Damages are discussed under three headings viz., damages to agricultural assets, damages to crops and damages to livestock and poultry. The damage figures were worked out extrapolating the values obtained for individual farm households.

4.2.1.1 Damages to agricultural assets

The damages to agricultural assets as presented in Table 4.18 show that the flood plain has suffered a damage of ₹7.32 crores to agricultural assets. The study has shown that it is Chalakudy block, which has suffered the highest damage wherein the total damage to agricultural assets was estimated at ₹4.27 crores through repair and replacement of the different assets that were either partially or fully damaged. It was Parakkadavu block, which suffered the least damage with the flood plains in the block losing an amount of ₹1.28 crores to repair and replacement of damaged assets.

Table 4.18 Total damages to agricultural assets (₹ lakhs)

Sl. No.	Block	Damage
1	Chalakudy	426.69 (58.25)
2	Mala	177.42 (24.22)
3	Parakkadavu	128.39 (17.53)
4	**Total**	**732.50 (100.00)**

Note: Figures in parentheses indicate percent to column total

Poultry shed, cattle shed, sprayer, motor pump and seeds are the major assets that were damaged with poultry sheds suffering the highest damage as shown in Fig. 4.13. Apart from these there were other assets too that were damaged either partially or fully and thus were repaired or replaced which include motor shed, tiller, weeder, drum, iron rod, spade and fertilizers amounting to ₹77 lakhs.

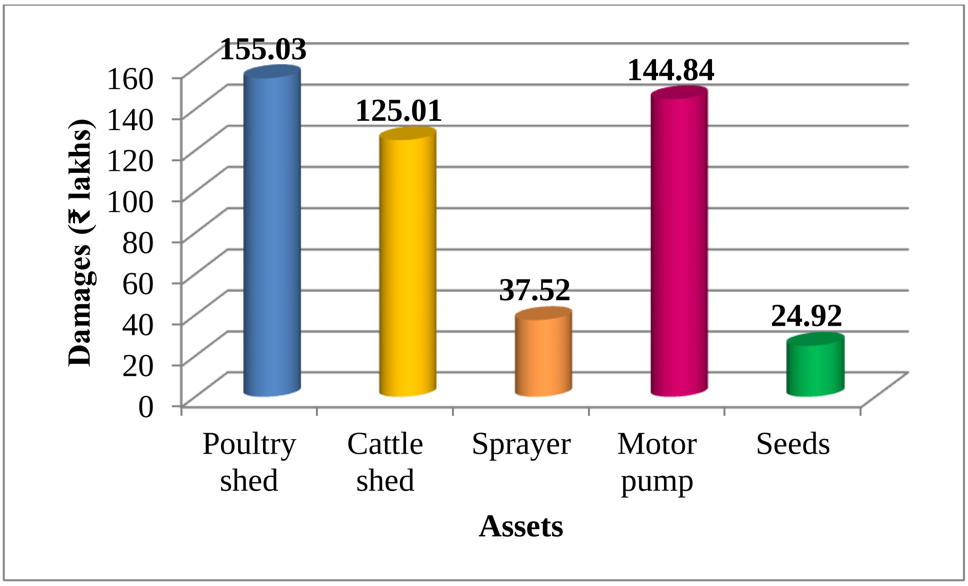

Fig 13 Damage to major agricultural assets

4.2.1.2 Damages to crops

The damages to crops were studied under two heads as damages to seasonal crops and damages to perennial crops. The damages to seasonal crops as presented in Table 4.19 show that the flood plain has suffered a damage of ₹43.10 crores due to the destruction of crops that were in the harvesting stage. The study has shown that it is the Chalakudy block, which has suffered the highest damage to seasonal crops, wherein the total damage to seasonal crops was estimated at ₹19.76 crores through total destruction of these crops. It was Parakkadavu block, which suffered the least damage with the flood plains in the block losing an amount of ₹8.01 crores as the seasonal crops were totally destroyed.

Table 4.19 Total damages to seasonal crops (₹ lakhs)

Sl. No.	Block	Damage
1	Chalakudy	1975.94 (45.84)
2	Mala	1533.02 (35.57)
3	Parakkadavu	8.01 (18.59)
4	**Total**	**4310.19 (100.00)**

Note: Figures in parentheses indicate percent to column total

Banana, gourds, cowpea, bhindi, ginger/turmeric, tapioca, tuber and paddy are the major seasonal crops that were destroyed with banana suffering the highest destruction as shown in Fig 14. This is in line with the cropping pattern observed in the basin with banana occupying the highest area under cultivation among the seasonal crops cultivated. Though paddy was found to be cultivated on a larger area than banana, the extent of damage to paddy was less as the crop was yet to be sown in most parts of the basin when the disaster occurred.

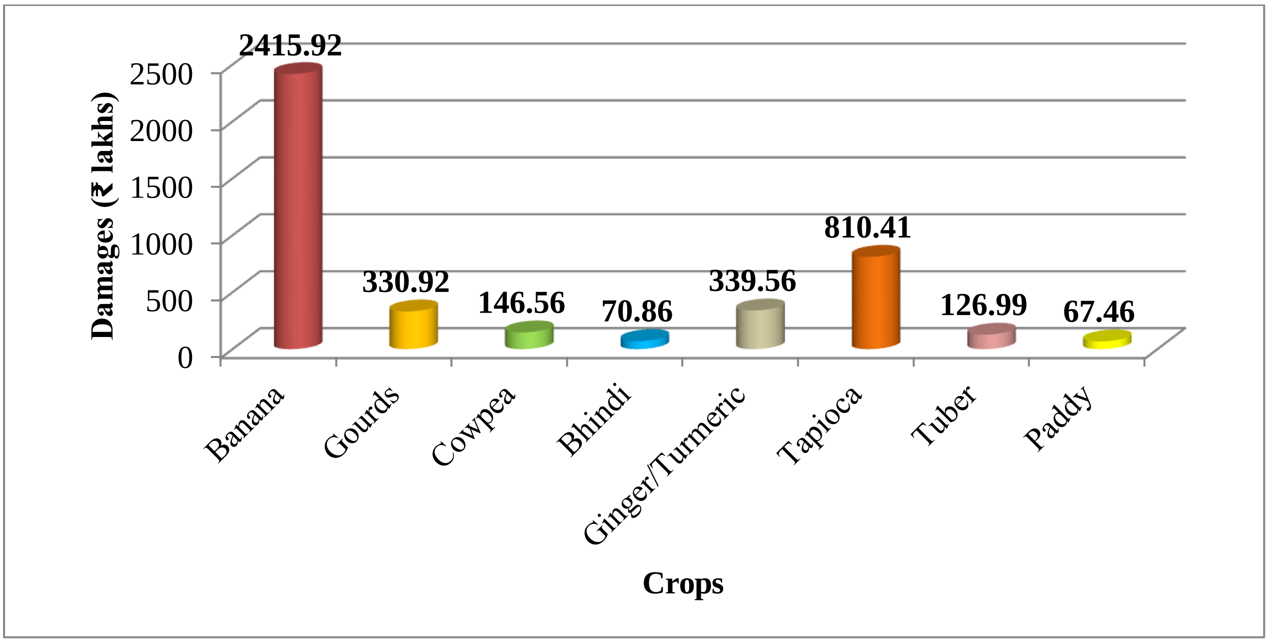

Fig 14 Damage to major seasonal crops

The damages to perennial crops as presented in Table 4.20 show that the flood plain has suffered a damage of ₹5.36 crores due to the destruction of perennial crops. The study has shown that it is the Parakkadavu block, which has suffered the highest damage to perennial crops, wherein the total damage to the perennial crops was estimated at ₹2.10 crores. It was Mala block, which suffered the least damage with the flood plains in the block losing an amount of ₹1.58 crores.

Table 4.20 Total damages to perennial crops (₹ lakhs)

Sl. No.	Block	Damage
1	Chalakudy	167.92 (31.33)
2	Mala	157.63 (29.42)
3	Parakkadavu	210.30 (39.25)
4	**Total**	**535.85 (100.00)**

Note: Figures in parentheses indicate percent to column total

Nutmeg, coconut, arecanut and black pepper are the major perennial crops that were totally destroyed with nutmeg suffering the highest destruction as shown in Fig 15. Apart from these there were other perennial trees and crops too that were totally destroyed which include rubber amounting to ₹2,00,000.

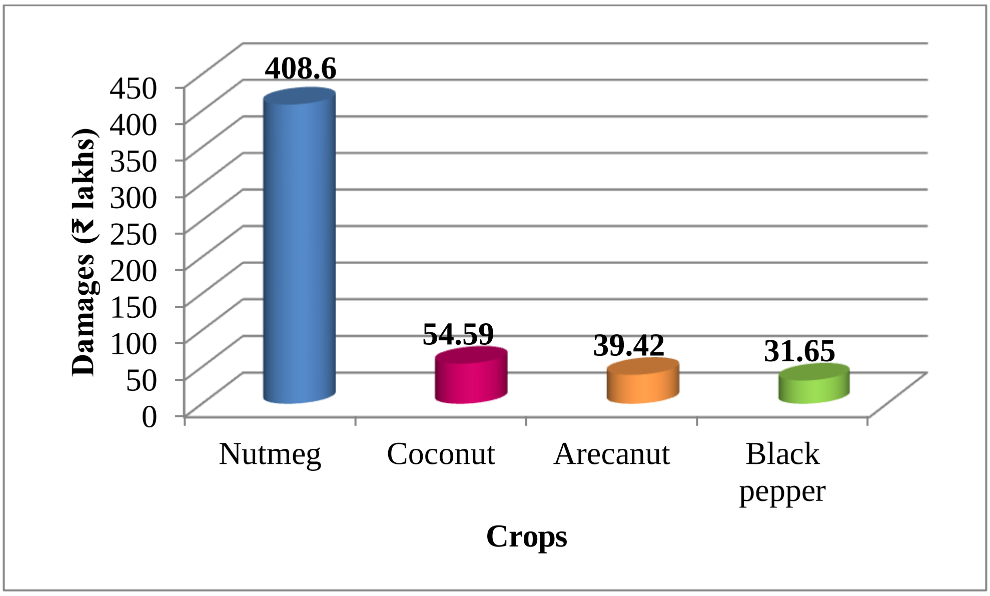

Fig 15 Damage to major perennial crops

4.2.1.3 Damages to livestock and poultry

The damages to livestock and poultry as presented in Table 4.21 show that the flood plain has suffered a damage of ₹6.97 crores to the death of livestock and poultry. The study has shown that it is the Mala block, which has suffered the highest damage to livestock and poultry, wherein the total damage was estimated at ₹4.61 crores due to the death and loss of livestock and poultry. It was Chalakudy block, which suffered the least damage with the flood plains in the block losing an amount of ₹90 lakhs to the dead livestock and poultry.

Table 4.21 Total damages to livestock and poultry (₹ lakhs)

Sl. No.	Block	Damage
1	Chalakudy	90.41 (12.97)
2	Mala	460.87 (66.12)
3	Parakkadavu	145.74 (20.91)
4	**Total**	**697.02 (100.00)**

Note: Figures in parentheses indicate percent to column total

Cattle, goat and chicken are the major livestock and poultry that were dead with chicken suffering the highest death calamity as shown in Fig 16. Apart from these there were other livestock and poultry too that were dead which include duck amounting to ₹3,00,000.

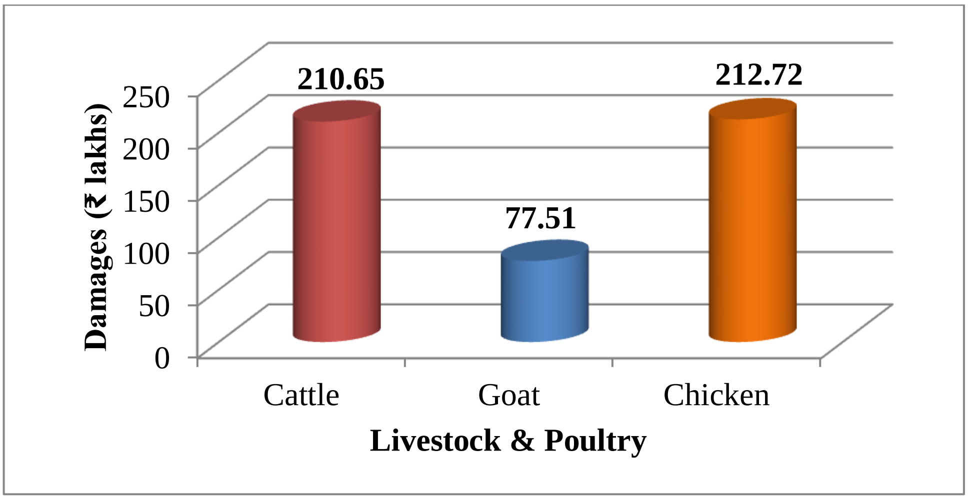

Fig 16 Damage to major livestock and poultry

4.2.2 Agricultural losses

Unlike the FAO methodology, in the study, crop loss alone was considered under the title losses in the agriculture sector. Agricultural losses are discussed under two headings viz., losses from seasonal crops and losses from perennial crops. The loss figures were worked out extrapolating the figures obtained for individual farm households.

The cropping pattern of the basin needs to be brought forth before a discussion on the results. As discussed under section 3.1.2.9, coconut, paddy, nutmeg, banana and plantain are the major crops cultivated in the basin. However, considering the study area comprising of 10 panchayats from three blocks of two districts, the major crops were coconut, nutmeg, banana, mango and paddy. According to the 2017-18 Agricultural Statistics, coconut occupies the largest area under cultivation in the study area followed by nutmeg, banana, mango and paddy. Maximum area under coconut and paddy is in Mala block, whilst maximum area under nutmeg and mango is in Chalakudy block. Parakkadavu block has the highest area under banana.

4.2.2.1 Losses from seasonal crops

The losses from seasonal crops as presented in Table 4.22 show that the flood plain has suffered a loss of ₹90.85 crores due to the destruction of these crops. The study has shown that it is the Mala block, which has suffered the highest loss from the destruction of seasonal crops, wherein the total loss was estimated at ₹37.76 crores. It was Parakkadavu block, which suffered the least monetary loss with the flood plains in the block losing an amount of ₹18.06 crores from seasonal crops.

Table 4.22 Total losses from seasonal crops (₹ lakhs)

Sl. No.	Block	Loss
1	Chalakudy	3502.8 (38.55)
2	Mala	3776.49 (41.57)
3	Parakkadavu	1806.24 (19.88)
4	**Total**	**9085.53 (100.00)**

Note: Figures in parentheses indicate percent to column total

Banana, gourds, cowpea, bhindi, ginger/turmeric, tapioca, tuber and paddy are the major seasonal crops that suffered a loss with banana incurring the highest loss as shown in Fig 17.

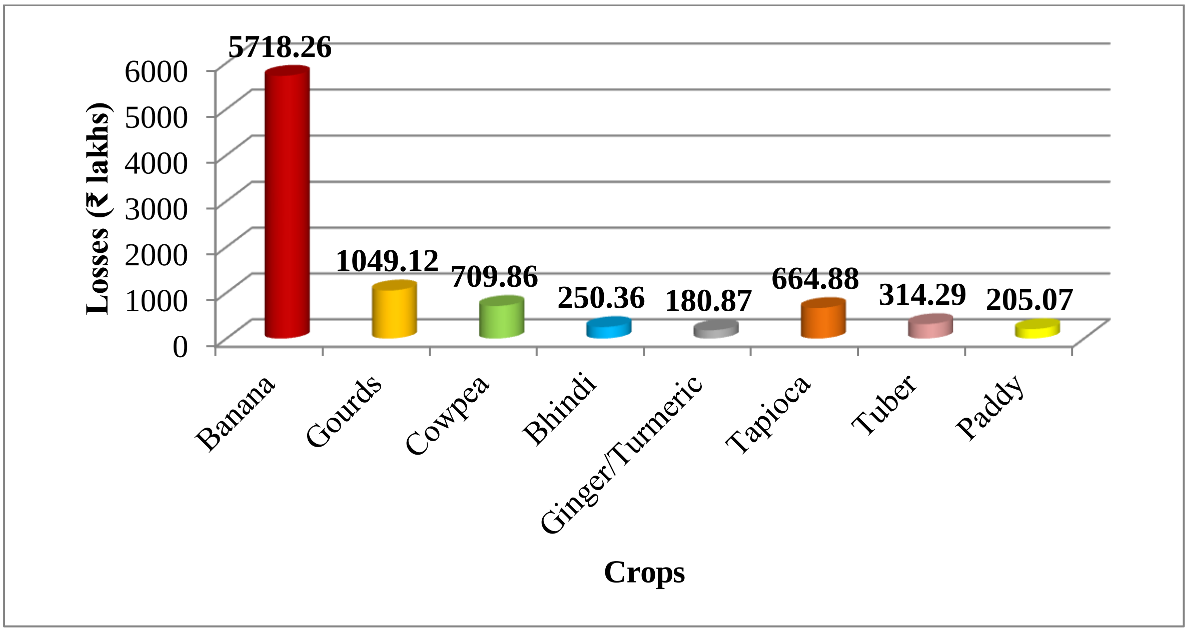

Fig 17 Loss from major seasonal crops

4.2.2.2 Losses from perennial crops

The losses from perennial crops were studied under two heads as losses from totally destroyed perennial crops and those that were partially destroyed. The losses from totally destroyed perennial crops include both investment as well as production losses. Production loss was accounted for the next seven years till the replanted crop starts yielding. The losses from totally destroyed perennial crops as presented in Table 4.23 show that the flood plain has incurred a loss of ₹86.72 crores. The study has shown that it is the Mala block, which has suffered the highest loss from totally destroyed perennial crops, wherein the total loss was estimated at ₹36.04 crores. It was Parakkadavu block, which suffered the least loss with the flood plains in the block losing an amount of ₹20.45 crores.

Table 4.23 Total losses from totally destroyed perennial crops (₹ lakhs)

Sl. No.	Block	Loss
1	Chalakudy	3023.25 (34.86)
2	Mala	3603.96 (41.56)
3	Parakkadavu	2044.8 (23.58)
4	**Total**	**8672.01 (100.00)**

Note: Figures in parentheses indicate percent to column total

Nutmeg, coconut, arecanut and black pepper are the major perennial crops that were totally destroyed with nutmeg suffering the highest destruction as shown in Fig 18. Apart from these there were other perennial crops too that were totally destroyed which include rubber amounting to ₹78 lakhs.

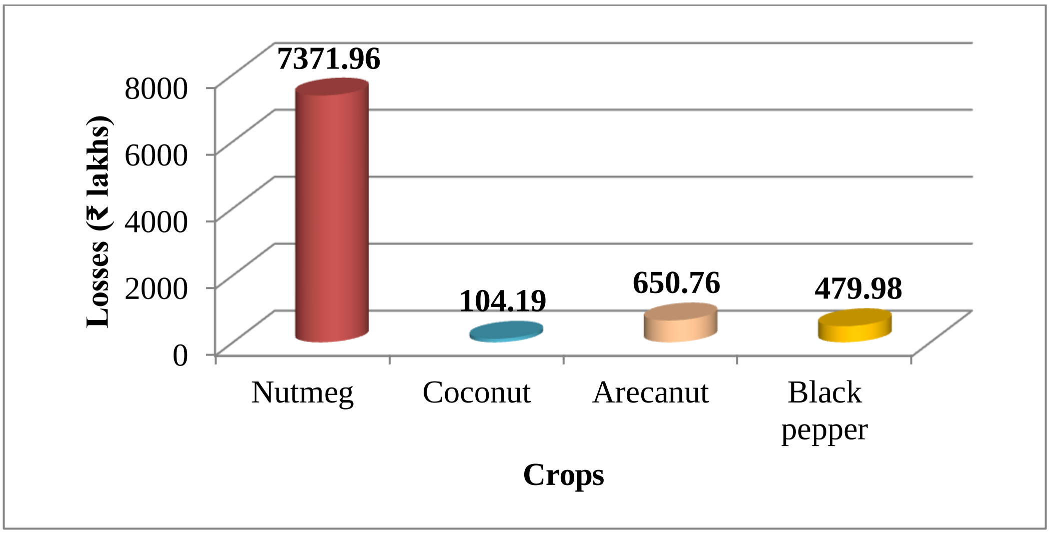

Fig 18 Loss from totally destroyed major perennial crops

The losses from partially destroyed perennial crops include just the production losses. Production loss was accounted for the year that the disaster occurred. The losses from partially destroyed perennial crops as presented in Table 4.24 show that the flood plain has suffered a loss of ₹18.56 crores. The study has shown that it is the Chalakudy block, which has suffered the highest loss from perennial crops, wherein the total loss was estimated at ₹7.71 crores. It was Parakkadavu block, which suffered the least loss with the flood plains in the block losing an amount of ₹3.75 crores.

Table 4.24 Total losses from partially destroyed perennial crops (₹ lakhs)

Sl. No.	Block	Loss
1	Chalakudy	771.45 (41.57)
2	Mala	709.29 (38.22)
3	Parakkadavu	374.88 (20.21)
4	**Total**	**1855.62 (100.00)**

Note: Figures in parentheses indicate percent to column total

Nutmeg, coconut and arecanut are the major perennial crops that were not totally destroyed but suffered a production loss with nutmeg suffering the highest loss as shown in Fig 19. Apart from these there were other perennial crops too which were not totally destroyed but suffered a loss which include rubber and black pepper amounting to ₹19 lakhs.

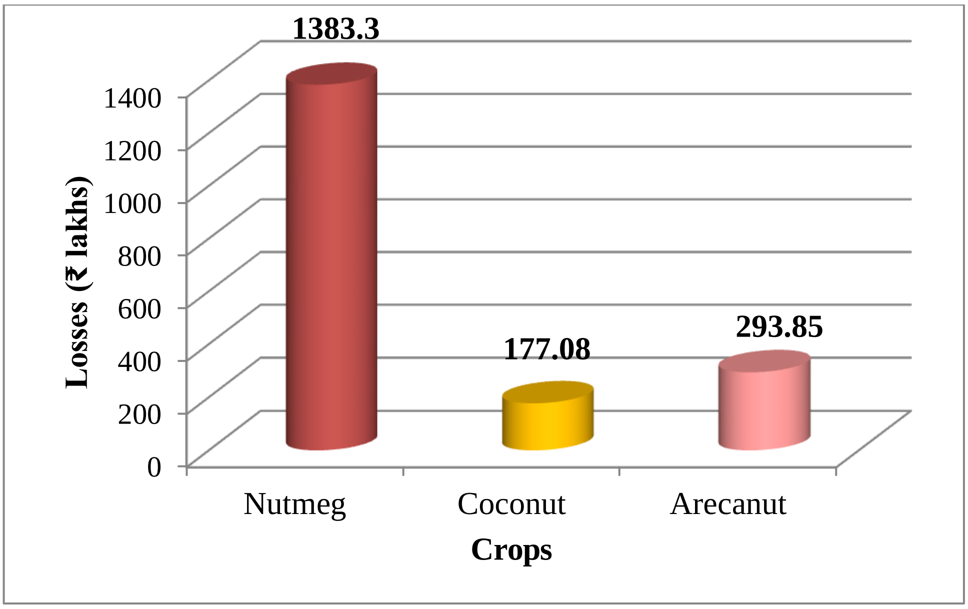

Fig 19 Loss from partially destroyed major perennial crops

4.3 Resilience level of the affected farmers

In the study, resilience is taken as the ability of the farmer to continue cropping in the next season. Socio-economic conditions of farmers are found to have a profound influence on resilience (Weldegebriel and Amphune, 2017) and Widiato ,2013)

4.3.1 Socio-economic profile of the sample farmers

It is important to understand the socio-economic status of the sample respondents as this gives an idea about the background information of these respondents and provides a better understanding of the farms as well as the rural farming scenario. The distribution of sample respondents with respect to age, gender, family size, education, occupation, land holding, annual income and experience in farming is presented below.

Socioeconomic profile of the sample respondents in the study area in general can be summarized as follows (Table 4.25).

Table 4.25 Socio-economic profile of respondents in the study area (n =120)

Sl. No.	Characteristic	Classification				Mean
1	Gender	Male	Female			NA
		114 (95.00)	6 (5.00)			
2	Age (years)	20-40	40-60	>60		56
		7 (5.83)	63 (52.50)	50 (41.67)		
3	Family size (nos.)	Upto 2	3-5	>5		3
		47 (39.17)	72 (60.00)	1 (0.83)		
4	Land holding (acres)	<1	1-2	>2		1.24
		60 (50.00)	32 (26.67)	28 (23.33)		
5	Occupation	Agriculture	Self-employed	Others		NA
		107 (89.17)	7 (5.83)	6 (5.00)		
6	Education	Below SSLC	SSLC	Plus two	Graduation	SSLC
		47 (39.17)	44 (36.67)	15 (12.50)	14 (11.67)	
7	Annual income (₹)	<75000	75000-1 lakh	1 lakh-2 lakhs	>2 lakhs	135542
		16 (13.33)	24 (20.00)	61 (50.83)	19 (15.83)	
8	Experience in farming	<10	10-30	30-50	>50	38
		1 (0.83)	23 (19.17)	68 (56.67)	28 (23.33)	

4.3.1.1 Age

Age-wise distribution of the sample respondents as furnished in the Table 4.35 shows that majority of the sample respondents belonged to the age group 40-60 (53.50 percent) and about 41.67 percent of the sample farmers were above the age of 60. Only seven respondents (5.83 percent) belonged to the age group of 20-40. This clearly is an indication for the young generation moving away from the agriculture sector showing high inclination towards salaried jobs.

4.3.1.2 Gender

Gender-wise distribution of the sample respondents as presented in the Table 4.35 shows that majority of the sample respondents were males (95.00 percent) and only six were females (5.00 percent).

4.3.1.3 Family size

The distribution of sample respondents according to the family size as furnished in the Table 4.35 shows that majority of the sample respondents had 3-5 members in the family (60.00 percent) while about 39.17 percent of the sample farmers had only 0-2 members in the family. Only one respondent (0.83 percent) had more than five members in the family.

4.3.1.4 Education

The distribution of sample respondents according to their educational status as presented in the Table 4.35 shows that majority of the sample respondents had education only below SSLC (39.17 percent) and about 36.67 percent of the sample farmers had education upto SSLC. 12.50 percent had pre-degree education while 11.67 percent were graduates.

4.3.1.5 Occupation of respondents

The distribution of sample respondents based on their occupation as furnished in the Table 4.35 shows that majority of the sample respondents were dependent on agriculture and allied sectors as their main source of income (89.17 percent). 10.83

percent of the respondents were either self-employed or having some other means of living other than agriculture, of which 5.83 percent were self-employed.

4.3.1.6 Land holding pattern

The distribution of sample respondents according to their land holding pattern is presented in the Table 4.35. It is evident that majority of the sample respondents owned only less than 1 acre of land (50.00 percent). 26.67 percent of the respondents owned 1-2 acres of land and only 23.33 percent owned more than 2 acres of land. Thus, it was observed that an overwhelming majority of the sample farmers were marginal farmers owning less than a hectare of land (<2.5 acres).

4.3.1.7 Annual income

The distribution of sample respondents based on their annual income is furnished in the Table 4.35. It is evident that majority of the sample respondents had an annual income of one to two lakhs (50.83 percent). 20.00 percent of the respondents had an annual income of ₹75,000 to ₹1,00,000, just 15.83 percent had an annual income of more than ₹2,00,000 while 13.33 percent of the respondents had an annual income less than ₹75,000.

4.3.1.8 Experience in farming

The distribution of sample respondents based on their experience in farming is presented in the Table 4.35. It is evident that majority of the sample respondents had an experience of 30-50 years in farming (56.67 percent). 23.33 percent of the respondents had an experience of more than 50 years in farming, 19.17 percent had an experience of 10-30 years and only one (0.83 percent) had less than 10 years of farming experience.

According to Widiarto (2013) socioeconomic condition of the farmer has a profound influence on his resilience. Weldegebriel and Amphune (2017) studied resilience in the face of recurring floods and stated that human capital and natural capital endowments mainly education and size of land holding has a positive influence and thus are major determinants of household resilience.

4.3.2 Measuring household resilience to floods

The resilience level of the individual affected households were estimated administering a well framed questionnaire. The factors playing crucial role in building resilience were selected by subjecting 32 statements to factor analysis after testing for adequacy of distribution of values and reliability of the scales used.

The results from factor analysis as presented in Table 4.26 reveal that 28 of 32 statements reliably contributed to the scale and formed the basis for measuring household resilience to floods. It is evident that the responses to the statements were best described by seven factors that represent seven components of resilience. These seven factors represented 68.408 percent of the variance. The first factor including four statements (1, 2, 3, 4) relating to savings that boost the ability to continue cropping in spite of the damage and loss suffered represented 14.658 percent of the variance. The second factor, representing 11.109 percent of the variance, consisted of four statements (29, 30, 31, 32) relating to the level of confidence of households that their houses and any other material possession that they have will not be affected (submerged/collapsed/washed away) by future floods as large as the floods of 2018. The third factor consisting of four statements (25, 26, 27, 28) relating to the level of indebtedness that is potential enough to pull back the farmer from taking up next season cropping represented 9.650 percent of the variance. The fourth factor, representing 8.990 percent of the variance, consisted of four statements (21, 22, 23, 24) relating to assistance from the Government in the form of relief fund and its significance in helping the farmers to recoup. The fifth factor including five statements (10, 11, 12, 14, 15) relating to the orientation of farmers towards the risks and uncertainties in agriculture represented 8.522 percent of the variance. The sixth factor, representing 7.803 percent of the variance, consisted of four statements (6, 7, 8, 9) relating to the level of confidence of farmers that their crops will not be affected by future floods as large as the floods of 2018. The seventh factor consisting of five statements (16, 17, 19) relating to insurance as a pillar to lean upon during the event of crop loss providing necessary liquidity to continue cropping in the next season despite the huge loss incurred represented 7.676 percent of the variance.

Table 4.26 Sample factor analysis table

	Factors						
	Savings	**Other losses**	**Level of indebtedness**	**Relief fund**	**Risk Orientation**	**Damage level**	**Insurance**
	S2=0.943	O30=0.940	L26=0.885	Rf23=0.904	Ro14=0.739	D7=0.814	I17=0.932
	S1=0.936	O29=0.938	L25=0.882	Rf24=0.888	Ro15=0.693	D8=0.811	I19=0.913
	S4=0.917	O31=0.898	L27=0.748	Rf21=0.763	Ro12=0.669	D9=0.703	I16=0.674
	S3=0.875	O32=0.844	L28=0.706	Rf22=0.571	Ro10=0.665	D6=0.629	
					Ro11=0.595		
Eigen value	4.691	3.555	3.088	2.877	2.727	2.497	2.456
Percentage variance	14.658	11.109	9.650	8.990	8.522	7.803	7.676
Cumulative percentage	14.658	25.767	35.417	44.407	52.929	60.732	68.408

Note: Statements are given in the appendix

Reliability analysis showed that Cronbach's alpha coefficient of factor one is 0.922; factor two is 0.939; factor three is 0.897; factor four is 0.819; factor five is 0.764; factor six is 0.809 and factor seven is 0.608 clearly indicating high internal consistency of the items in the scale. Factors one and two showed excellent internal consistency; factors three, four and six had good internal consistency; factor five showed an internal consistency which is well acceptable while factor seven showed a questionable internal consistency. However, all the factors had an internal consistency higher than 0.6 thus revealing scales used were sufficiently reliable for data analysis.

Validity analysis of the data returned KMO measure of sampling adequacy of 0.732 indicating middling. The high sampling adequacy value indicated the distribution of value was adequate for conducting factor analysis. Bartlett's test of Sphericity returned a significance value <0.05 indicating that the data do not produce an identity matrix and is thus acceptable for factor analysis.

The statements were measured in a five point continuum on the Likert scale wherein the respondents' agreement to the statements was rated on the continuum from 5 to 1 corresponding to strongly agree, agree, neither agree nor disagree, disagree and strongly disagree respectively. Ranking of the above factors in order of their importance, along with index of the respective factor, is shown in Table 4.27. The importance of these factors has been ranked on the basis of index of the respective factor

.

Table 4.27 Ranking of factors according to their importance

Factor	Index of the factor	Rank
Risk orientation	0.6195	1
Level of indebtedness	0.5538	2
Insurance	0.5370	3
Relief fund	0.5196	4
Savings	0.5127	5
Other losses	0.3446	6
Damage level	0.2896	7

However, studying the livelihood resilience to recurring floods in Ethiopia, Weldegebriel and Amphune (2017) recorded the time for recuperation after been affected by floods, size of land holding, critical asset holdings such as livestock, exposure to flooding in terms of the location of the farm and availability of social capital in terms of the ability to draw help from relatives residing in locations outside the flood affected zone as the significant factors contributing to building resilience. Apart from these major factors, accessibility to credit services was also found to significantly influence the livelihood resilience.

The resilience level was determined based on the resilience index of each respondent. The resilience indices of the farmers along the flood plains varied between 0.32 and 0.67. 0.48 turned out to be the composite resilience index for the respondents. Meanwhile, the composite resilience index for the respondents of Chalakudy, Mala and Parakkadavu blocks were 0.51, 0.45 and 0.48 respectively. The results as presented in the Table 4.35 show that majority of the respondents (67.50 percent) showed moderate level of resilience while 20.00 percent showed high level of resilience. Only 15 respondents (12.50 percent) showed low level of resilience. The resilience categories were decided based on mean and standard deviation of the resilience indices for the respondents.

Table 4.28 Resilience level of the farmers

Resilience index	Resilience level	Chalakudy	Mala	Parakkadavu	Flood plain
<0.41	Low	4 (9.09)	7 (17.50)	5 (13.89)	15 (12.50)
0.41-0.55	Moderate	33 (75.00)	27 (67.50)	23 (63.89)	81 (67.50)
>0.55	High	7 (15.91)	6 (15.00)	8 (22.22)	24 (20.00)
	Total	**44 (100.00)**	**40 (100.00)**	**36 (100.00)**	**120 (100.00)**

Note: Figures in parentheses indicate percent to column total

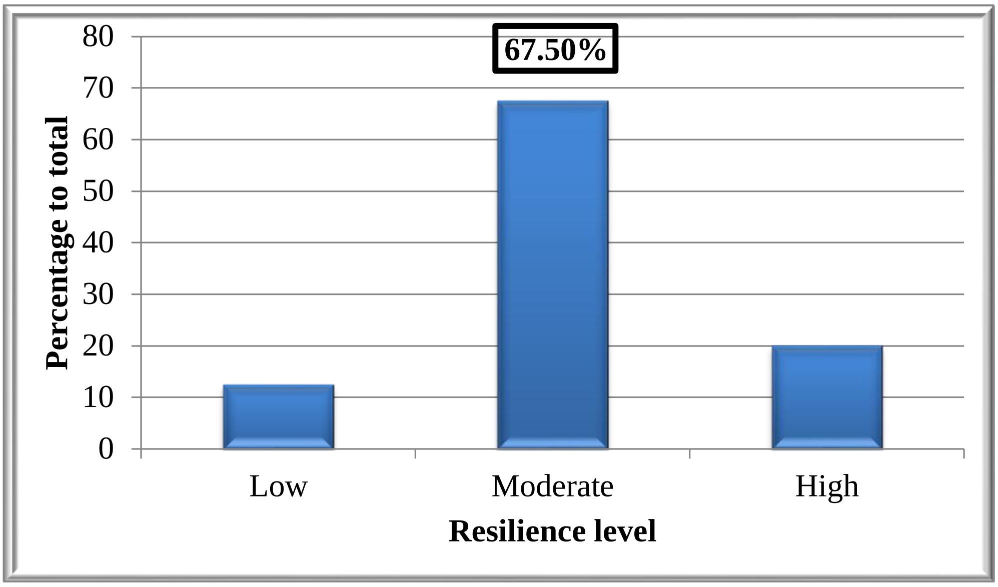

Fig 20 Resilience level of the farmers

4.3.3 Factors influencing resilience level of farmers

Binary logistic regression model was fitted to find out the factors influencing resilience of an individual farmer and the estimates are presented in Table 4.29. The model was found to be satisfactory with a significant chi-square value and the likelihood ratio test at 111.117. The signs of all the independent variables were in conformity with the hypothesis. Four out of eight factors viz. education, subsidiary occupation, family size and crop diversification index were found to have significant influence on the probability of a farmer becoming resilient.

It was observed that for the fitted binary logistic resilience function, the Cox and Snell R^2 value was 0.36 and Nagelkerke R^2 value was 0.49.

Table 4.29 Estimates of the logistic model for resilience

Sl. No.	Variable	B	Standard Error	Wald Statistic	Sig.	Exp (B)	Probability
1	Constant	3.293	2.158	2.329	0.127	26.932	0.9642
2	Age	0.007	0.040	0.032	0.858	1.007	0.5017
3	Education of the respondent	1.369*	0.548	6.251	0.012	3.932	0.7972

4	Subsidiary occupation	3.222**	1.202	7.187	0.007	25.088	0.9617
5	Experience in farming	0.020	0.035	0.315	0.575	1.020	0.5049
6	Education of family members	0.528	0.530	0.992	0.319	1.696	0.6291
7	Family size	-0.764**	0.223	11.774	0.001	0.466	0.3179
8	Land area	0.035	0.054	0.410	0.522	1.035	0.5086
9	Crop diversification index	-6.801**	1.683	16.321	0.000	0.001	0.0009

Note: ** denotes significant at 1 % level of probability and * denotes significant at 5 % level of probability

Education of the respondent was found to influence resilience positively at one percent level of significance. It was found that respondents with higher level of education are around 4 times more likely to occupy the above average resilience group than the respondents with lower level of education keeping all the other variables fixed. This may be attributed to the fact that education will help the farmers to think positively and find novel ways to come over the aftermath of a disaster and thus education contributes to building resilience. Among the 120 farmers surveyed, majority had education only below SSLC (39.17 percent) while the average education of the farmers was SSLC. Having a subsidiary occupation was also found to influence the resilience positively at five percent level of significance, as this will act as a source of finance for all the post disaster activities including cleaning up the debris, repair and replacement of destroyed assets, taking up next season crop *etc*. The analysis found that respondents with a subsidiary occupation are around 25 times more likely to occupy the above average resilience group than the respondents without any subsidiary occupation keeping all the other variables fixed.

Family size was found to have a negative influence on the resilience at five percent level of significance. The study revealed that respondents with less number of dependents are around 0.4 times more likely to occupy the above average resilience group than the respondents with more number of dependents in the family keeping all the other variables fixed. This may be attributed to the fact that as the family size increases, the ability of the farmer to continue cropping with the limited means decreases, as the priority should be given for food and shelter for the family. Among the 120 farmers surveyed, majority had 3-5 members in the family (60.00 percent) and the average family size was 3. Crop diversification index was also found to have a negative influence on the resilience at five percent level of significance. It was found that respondents with high crop diversification index are around 0.001 times more likely to occupy the above average resilience group than the respondents with low crop diversification index keeping all the other variables fixed. This could be attributed to the fact that as crop diversification index increases, diversity in farming decreases and thus potential risk of losing the crop to disaster increases making the farmers less resilient.

The analysis highlights the importance of encouraging farmers to diversify their farms and take up subsidiary occupations so that they will be able to tide over any unexpected and unprecedented situations like that of 2018 floods.

4.4 Hardships faced by the farm households during the event of flood

An attempt has been made in this section to identify the hardships faced by the farm households during and immediately after the disaster by incorporating specific questions in the interview schedule. The responses have been analysed using Garrett's ranking technique and the results are presented in Table 4.30.

Table 4.30 Hardships faced by the farm households

Hardships	Score value	Rank	Kendall's 'W' statistic
Flooded house	73.43	1	0.577*
Crop loss	64.66	2	
Disruption in power supply	64.61	3	
Inadequate transportation facilities	63.14	4	
Field inundation	60.11	5	
Disrupted communication services	58.76	6	
Loss of labor days	56.24	7	
Non availability of drinking water	54.28	8	

Increase in incidence of pest and disease	44.86	9
Non availability of food	40.86	10
Lack of medical facilities	38.05	11
Non availability of farm inputs	37.03	12
Loss of farm soils	35.49	13
Non availability of labor	30.78	14
Closure of schools	27.82	15

***** significant at 1% level of significance

It is evident that the major hardship faced by the respondent farmers was a flooded house. As water level in Chalakudy river rose to several feet above its normal due to the heavy downpour in the catchments, there was a huge inflow leading to heavily flooded situation in the banks of the river rendering many homeless. Majority of the respondents were made to flee from their homes in search of a safe place to reside, as water receded only after three days to one week. Crop loss was also a major problem that they faced as most of the seasonal crops that were about to be harvested were either submerged and rotten or toppled down and the fruits dusted with mud and dirt making the produce unacceptable to the consumers. This is in commensurate with the damage and loss figures estimated in the sections 4.1 and 4.2. Disruption in power supply was another difficulty faced by the respondents as the power supply was hit by the storms. Many areas remained secluded from the outer world as they got surrounded with water and transportation facilities were down with roads submerged under the busy flowing river. Apart from these, they also confronted with other difficulties including field inundation, disrupted communication services, loss of labor days, non-availability of drinking water, increase in incidence of pest and disease, non-availability of food, lack of medical facilities, non-availability of inputs, loss of farm soils, non-availability of labor and closure of schools as the heavy rain lashed the river basin in an unprecedented disaster.

Running Kendall’s W test returned a value of 0.577 as Kendall’s coefficient of concordance (W). Kendall’s ‘W’ of 0.577 suggests that there was a high degree of agreement among the respondents to rank the constraints in the order as obtained through Garret ranking.

According to Naveen (2014) the major difficulties faced by the households during the time of flood are crop loss followed by non-availability of drinking water, non-availability of food, loss of farm soils, shortage of dry fodder for the livestock, problem with electricity, non-availability of labour, closure of schools and shortage of green fodder. The findings were based on an opinion survey. When 92.22 percent of the households reported non-availability of drinking water as the major problem, for 89.36 percent of the households non-availability of food was the major difficulty. Loss of farm soils was a constraint for 85.89 percent of the households.

Summary and Conclusions

5. SUMMARY AND CONCLUSIONS

Kerala encountered the most exceedingly awful floods in its history since 1924, between June 1st and August 19th of 2018. As the torrential rainfall and associated storm thrashed the state, the entire state got buried under water with only few areas remaining above water resembling isolated islets in the midst of an ocean. The combined precipitation that the state received during this period was 42 percent in excess of the typical normal. This was especially true from 1st to 19th of August when the state received 164 percent higher rainfall and the state was put in a standstill as we confronted with an unprecedented disaster.

The exceptional spell of rainfall inflicted heavy damage on the life and properties of thousands of people in the state. The extreme downpour and the subsequent deluge impacted all the aspects of human lives including transportation, socioeconomic conditions, infrastructure, agriculture and livelihood. A large number of agriculture dependent rural households, most of which are involved in subsistence agriculture, are found to have borne the brunt of the unprecedented deluge as the billowing monsoon rains vandalized the agricultural fields. It is in this context that the present study entitled ‘Assessment of agricultural loss due to 2018 Flood to farm households in the flood plains of Chalakudy river’ was undertaken. The objectives of the study were to assess the agricultural loss in the flood plain, to estimate the economic loss of the affected agricultural households and to analyze the resilience level of the affected farmers.

Both primary as well as the secondary data were used for the study, however, the study was based mostly on primary data. Primary data was collected from the respondents using pretested structured interview schedule through personal interview method for analysis of resilience level of the affected farmers, to identify the hardships faced by the households during the time of flood and to estimate the economic loss of the affected agricultural households in the flood plain. The flood plains of Chalakudy river comprises of 19 grama panchayats, out of which 10 worst affected panchayats were selected. The secondary data regarding the agricultural loss in the selected panchayats were obtained from the respective Krishibhavans. The weekly price of major crops cultivated in the flood plains for the year 2018 corresponding to the month of August was collected from the website of AGMARKNET. Memorandum submitted to the state government on the monsoon calamity losses prepared and submitted by the State Relief Commissioner, Disaster Management to the Government of Kerala was also used. Field survey for primary data collection was done during the period November 2019 to February 2020.

The standard procedure for flood loss and damage assessment devised by FAO (2012) was used with slight modification, for this study. The assessment of disaster effects on the farm households along the flood plains of the river with respect to damage and loss suffered to crops, assets and livestock showed that on an average a farm household in the flood plain has suffered a damage of ₹12,837 to agricultural assets, while the damage suffered was ₹75,538 for seasonal crops and ₹9,391 for perennial crops. With respect to livestock and poultry, on an average a farm household has suffered a damage of ₹12,216. The result is an indication that the destruction of seasonal crops at its stage of harvest has imposed greater monetary loss to the farm households than any other damage. While the damage to agricultural assets and seasonal crops in the harvesting stage suffered by an individual household was the highest in Chalakudy block, Parakkadavu block topped the list of damage to perennial crops with an individual household bearing damage worth ₹12,342. The damage borne by an individual household to livestock and poultry was the highest in Mala block.

Crop loss to the individual farm households as the crops were either damaged/lost or the production declined in response to the external shock to which the crops were exposed was also estimated. The results revealed that on an average a farm household in the flood plain has suffered a loss of ₹1.59 lakhs from seasonal crops and ₹1.52 lakhs from totally destroyed perennial crops and ₹0.32 lakhs from partially destroyed perennial crops. The result suggested that it is the loss from seasonal crops which was accounted as investment loss contributed the most to the total loss suffered by a farm household. Mala block suffered the highest loss in all three cases considered for loss assessment as loss from seasonal crops, loss from totally destroyed perennial crops and loss from partially destroyed perennial crops.

The assessment of disaster effects in the flood plains of the river with respect to damage and loss suffered to crops, assets and livestock showed that the flood plain has suffered a damage of ₹7.32 crores to agricultural assets, while the damage suffered was ₹43.10

crores for seasonal crops and ₹5.36 crores for perennial crops. The flood plain has lost about ₹6.97 crores due to the death of livestock and poultry. The result made it clear that damage to the seasonal crops constituted the lion share of the total damage figure. While the damage to agricultural assets and ready to harvest crops was the highest in Chalakudy block, Parakkadavu block topped the damage to perennial crops. The damage to livestock and poultry was the highest in Mala block.

An estimation of the agricultural loss was also carried out to draw conclusion regarding crop loss in the flood plain as almost all the households reported losses from seasonal crops and perennial crops. The study showed that the flood plain has suffered a loss of ₹90.85 crores from seasonal crops and ₹86.72 crores from totally destroyed perennial crops and ₹18.55 crores from partially destroyed perennial crops. The result revealed that the investment loss of seasonal crops, which were in its stage of harvest or fruiting/bunching when the incessant heavy rain lashed the fields burying these crops under water, formed the major part of the total loss figure. It is evident that Mala block suffered the highest loss in all three cases considered for loss assessment as loss from seasonal crops, loss from totally destroyed perennial crops and loss from partially destroyed perennial crops.

The total disaster effect inflicted by the 2018 Floods in the flood plains was obtained through summation of the damages and losses in monetary terms. The study concluded that the flood plain has lost about ₹258.87 crores to the 2018 Kerala floods. The study pegged the total damages at ₹62.75 crores. This included an estimated damage of ₹7.32 crores, ₹48.46 crores and ₹6.97 crores to the agricultural assets (including repair and replacement of partially and fully damaged assets respectively), crops (including damages to seasonal and perennial crops), and livestock and poultry respectively. The total losses were estimated as ₹196.12 crores. This included losses from seasonal and perennial crops.

An attempt was made to analyse the resilience level of the affected farmers. In the study wherein resilience was taken as the ability of the farmer to continue next season cropping, it was found that the sample respondents on an average showed a resilience of 0.48 in a scale of zero to one. The sample farmers of Chalakudy block showed a higher resilience than the farmers of other block with an average resilience of 0.51 which was well above the total average. Risk orientation, level of indebtedness, insurance, relief fund, savings, other losses and damage level were found to be the important perceived factors that help in building resilience with importance of these factors in the order mentioned above. Despite crop insurance being identified as an important perceived factor for building farmer resilience in the post-disaster scenario, only few farmers reported that they had insured their crops (26.67 percent). This is a clear indication for the fact that though crop insurance is proclaimed as a pillar to lean upon during the events of crop loss, it is still not very popular among the farmers. Inadequacy of claim amount and a delay in settlement and receipt of the claims were the two major issues cited by the farmers for their reluctance to insure the crops. The issues cited were similar to the ones observed by Anirudh (2019) during his study on crop insurance scheme for paddy in Palakkad district. The complex procedural formalities in availing the crop loan added to their general resentment. Among the farmers who had insured the crops, the insurance for banana was common. The premium was dependent on whether the insurance was from Krishibhavan or VFPCK. In case of insurance arranged by Krishibhavan, the premium was ₹7 per plant, whilst the premium was ₹6 per plant for insurance arranged by VFPCK of which the farmer needs to pay only ₹3 per plant.

Logistic regression analysis was carried out to study the influence of socio-economic variables on resilience. Education, subsidiary occupation, family size and crop diversification index were found to have significant influence on the probability of a farmer becoming highly resilient. The results suggested that while education and subsidiary occupation positively influenced the resilience, family size and crop diversification index was found to have a negative influence.

Major hardships faced by the respondents were identified as flooded house, crop loss, disruption in power supply, inadequate transportation facilities, field inundation, disrupted communication services, loss of labour days and non-availability of drinking water. Crop loss and field inundation were both connected as in all cases of field inundation, either the crops got submerged and the produce was lost or the production reported a decline as the crops stood in standing water for quite a few days.

To help farmers recoup after the disaster and to hasten the process of recuperation, the Government through the state Department of Agriculture Development and Farmers

Welfare introduced several recovery strategies along with augmenting the existing agricultural development schemes. Most important of all, farmers were given the freedom to claim both natural calamity claims and insurance for the crops that were lost to the disaster. Along with that, through the Krishibhavans, farmers were given planting materials and other agricultural inputs for replanting of seasonal and annual crops either free of cost or at a subsidized rate. Soil reclamation works were incentivized through the supply of subsidized liming materials. Assistance was also given for reconstruction of breached bunds, replacement and repairs of pumps and repair of infrastructure. These were supplemented with desilting assurance and providing additional motors for dewatering.

To conclude, the assessment of agricultural loss inflicted upon by the 2018 floods to the farm households in the flood plains of Chalakudy river pegged the overall damage and loss to crops, assets and livestock to the tune of ₹258.87 crores. The consolidated report of damage to crops in the selected blocks compiled from the concerned offices of the state Department of Agriculture Development and Farmers Welfare was ₹6 crores and the corresponding figure obtained in the study is ₹48.46 crores. The marked difference in the two estimates points out to the need for adopting a common procedure for crop damage and loss assessment, so that the affected farmers can be adequately compensated. The study restates the United Nation Sendai Frame Work for Disaster Risk Reduction (2015) observation that under- reporting of disaster induced damages have been observed in the case of low income countries, and in Asia it is to the tune of 42%.

Based on the results of the study and the observations made during the field survey, the following policy suggestions are made:

- A standardized methodological approach based on internationally approved frame work for assessing the impact of disasters on agriculture may be adopted. This is important to capture the total disaster effect in the aftermath of any disaster accurately.
- The need to distinguish damages (total or partial destruction of physical assets existing in the affected area) from losses (changes in economic flows) arising

from the disaster. This aspect is mostly neglected in rapid estimations usually done immediately after the occurrence of any disaster leading to underestimating the disaster effect.

- Strengthening the capacity of the authorities involved in disaster impact assessment in agriculture. This would help to avoid chances of under estimation of the disaster effect to any sector.
- The need for short term and long term plans for the recuperation of the lost and damaged assets which aim at increasing the economic activity and resilience of the sector to disaster events.
- Under taking similar studies in other disaster affected areas as this would help in getting a realistic picture of the total disaster effect on the farm households, which could be used as the guide line for extending Government aid and compensation to the affected farmers.
- Design and use of mobile data collection tools to improve the efficacy, to minimize the time lag and to reduce the cost of post-disaster impact assessment.
- Simplifying the procedural formalities in availing insurance claim and increasing the claim amount based on the value of the lost produce. This will encourage more farmers to insure their crops and thereby lessen the impact of crop loss.
- Encourage farmers to take up different crop related and other enterprises instead of relying solely on crop cultivation. This will help farmers thrive any unexpected and adverse situations and increase their resilience.

Plate 5 Field survey

Plate 6 Floods 2018 - A view of the devastated fields

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Appendices

APPENDIX I

Survey questionnaire for farmers

KERALA AGRICULTURAL UNIVERSITY

COLLEGE OF HORTICULTURE, VELLANIKARA, THRISSUR

Department of Agricultural economics

Assessment of agricultural loss due to 2018 Flood to farm households in the flood plains of Chalakudy river

Interview schedule

Survey questionnaire for farmers

District……………………… Block………………………
Panchayat………………….

1. Basic information

Name: ……………………………………………………

Age: ………………

Address: …………………………………………………….

…………………………………………………….

…………………………………………………….

…………………………………………………….

Contact no: ………………………………………………….

No. of years staying in the place:

No. of years of farming:

2. Family Details:

Sl. No.	Name	Gender	Age	Relation with head of family	Education*	Occupation		Annual income	Household expense
						Main	Subsidiary		
1									
2									
3									
4									
5									
6									

***(Below SSLC-1 SSLC-2 Plus two-3 Graduation-4 Post Graduation-5 Illiterate-6)**

3. Land holdings (Acres)

Sl. No.	Particulars	Wetland	Garden land
1	Owned		
2	Leased in		
3	Leased out		
4	Total		

4. Investment Costs in Crops

Crop	Cropping time	Area	Item	Cost of cultivation							
				Seed	Fertilizer	PP Chemicals	Transport	Machine	Intercultural operations	Others	Total
			Cost of input								
			Labor								

			Cost of input								
			Labor								

5. Irrigation pattern

Particulars	Area Irrigated (Hectares)

6. Agricultural Assets

Assets	No./Quantity (kg)	Year of purchase/ construction	Cost of purchase/ construction (₹)	Maintenance cost(Rs./year)
General Physical Assets				
1. Agricultural Buildings (farm house, store house)				
2. Others				
Farming Assets				
1. Tractor				
2. Tiller				
3. Power sprayer				
4. Thresher				
5. Weeder				
6. Winnower				
7. Harvester				
8. Plough				
9. Seeds				
10. Fertilizers				
11. Others (tools &				

implements)				

7. Number and value of livestock and poultry

Particulars	Number	Value (₹)
Livestock		
i) Cattle		
ii) Buffalo		
iii) Goat		
iv) Pig		
v) Others		
Poultry		
i) Chicken		
ii) Duck		
iii) Others		

8. Damages to Agricultural Assets

Assets	Partially Destroyed (No./Qty)	Average Repair Cost (₹)	Totally Destroyed (No./Qty)	Average Replacement Cost (₹)
General Physical Assets				
1. Agricultural Buildings (farm house, store house)				
2. Others				
Farming Assets				
1. Tractor				
2. Tiller				
3. Power sprayer				
4. Thresher				
5. Weeder				
6. Winnower				

7. Harvester				
8. Plough				
9. Seeds				
10. Fertilizers				
11. Others (tools & implements)				

9. Damages to Livestock

Particulars	Number(dead)	Value (₹)
Livestock		
i) Cattle		
ii) Buffalo		
iii) Goat		
iv) Pig		
v) Others		
Poultry		
i) Chicken		
ii) Duck		
iii) Others		

10. Damages to Permanent Crops

Permanent Crops	Number of Trees Totally Destroyed	Average Replanting Cost per Tree (Rs./unit)
Plantation Crops		
1.Rubber		
2.Coconut		
3.Arecanut		
4.Coffee		
5.Cocoa		
6.Cashew		
7.Others		

Fruit Crops		
1.Banana		
2.Pineapple		
3.Papaya		
4.Jackfruit		
5.Mango		
6.Others		
Spice Crops		
1.Black Pepper		
2.Ginger		
3.Mango Ginger		
4.Nut Meg		
5.Turmeric		
6.Others		

11. Losses from Seasonal Crops

Crops	Area affected	Average crop yield in a normal year	Average yield in the year of disaster	Higher Production Cost (₹) (If any)	Other Losses (₹)	Total Losses (₹)
Field crops						
1.						
2.						
3.						
Vegetable crops						
1.						
2.						
3.						
Pulse crops						

1.						
2.						
3.						
Tuber crops						
1.						
2.						
3.						
Garden plants						
1.						
2.						
3.						
Fodder plants						
1.						
2.						
Others						

12. Losses From Permanent Crops

Permanent Crops	Area affected	Average crop yield in a normal year	Average yield in the year of disaster	Other Losses (₹)	Total Losses (₹)
Plantation Crops					
1.Rubber					
2.Coconut					
3.Arecanut					
4.Coffee					
5.Cocoa					

6.Cashew					
7.Others					
Fruit Crops					
1.Banana					
2.Pineapple					
3.Papaya					
4.Jackfruit					
5.Mango					
6.Others					
Timber Crops					
Spice Crops					
1.Black Pepper					
2.Ginger					
3.Mango Ginger					
4.Nut Meg					
5.Turmeric					
6.Others					

13. Hardships faced during floods

Particulars	Difficulty faced		Rank
	Yes	No	
Human problems			
1. Non availability of food			
2. Non availability of drinking water			
3. Problem with electricity			
4. Problem with communication			
5. Closure of schools			
6. Loss of labour days			

7. Problem with dwelling			
8. Lack of medical facilities			
9. Inadequate transportation facilities			
10. Others			
Farm problems			
1. Crop loss			
2. Loss of farm soils			
3. Non availability of labor			
4. Non availability of inputs			
5. Field inundation			
6. Increase in incidence of pest and disease			
7. Others			

14. Statements regarding resilience

Items	Statements	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
1	I am confident that I will not borrow money to continue farming after floods					
2	I am afraid that I cannot take up next crop without external source of money					
3	I am confident that crop loss will not limit my ability to take up next season crop					
4	I will be forced to borrow money to continue farming if my crops are completely destroyed					
5	I have the potential to continue cropping even if the harvest is poor					
6	I am sure that my crops will not be completely destroyed by the highest floods as in 2018					

7	I am afraid I will lose all that I invest if floods as high as 2018 occurs					
8	I am confident that my field will not be inundated by the highest floods as in 2018					
9	If floods as high as 2018 occurs, my crops will be completely destroyed					
10	I am aware that agriculture will not give regular and steady income					
11	I am confident that I can earn enough money even if one or two seasons are lost					
12	I have diversified crop production activities to reduce risk					
13	I can well absorb economic loss due to any unexpected occurrences					
14	I am prepared to accept the weather uncertainties in agriculture					
15	I can least absorb economic loss due to unpredicted weather and climate					
16	Crop insurance is all about procedural formalities and zero assistance for the needy					
17	Crop insurance provided me financial security during the time of crisis					
18	Delayed payment affected my ability to take up next season crop					
19	Insurance claim amount proved to be a great relief after the flood loss					
20	Inadequate compensation added to our woes					

21	I was able to recoup after the flood event because of the assistance from the Government					
22	No/poor assistance from government added to my worries					
23	Prompt payment of relief fund helped me manage my debts and take up next crop					
24	Untimely and inadequate disbursal of relief fund proved to be of no use					
25	I was not able to take up next crop for my debts and repayments were very high					
26	My debts were not large enough to stop me from taking up next crop					
27	Debts were my major concern which pulled me back from continuing cropping					
28	My debts never influenced my decision regarding next season cropping					
29	I am confident that my house will not get submerged by the highest floods as in 2018					
30	I am confident that none of my material possession will be damaged by the highest floods as in 2018					
31	My house will be submerged by floods as high as 2018 flood					
32	I am worried that my material possessions will be damaged or even be swept away by the highest floods as in 2018					

APPENDIX II

Loss estimated by respective Krishibhavans (No./Cents) :

Particulars \ Panchayats	Pariyaram	Meloor	Kadukutty	Koratty	Annamanada	Kuzhur	Aloor	Mala	Parakkadavu	Puthenvelikkara
Banana bunched	66716 Nos.	90157 Nos.	29624 Nos.	10289 Nos.	11205 Nos.	117999 Nos.	15867 Nos.	18010 Nos.	66350 Nos.	55095 Nos.
Banana non bunched	Nil	30723 Nos.	27416 Nos.	4841 Nos.	5464 Nos.	18093 Nos.	7769 Nos.	6888 Nos.	19455 Nos.	12951 Nos.
Nutmeg bearing	2045 Nos.	1154 Nos.	2138 Nos.	752 Nos.	2115 Nos.	6280 Nos.	885 Nos.	1009 Nos.	2786 Nos.	2832 Nos.
Nutmeg non bearing	Nil	803 Nos.	758 Nos.	360 Nos.	739 Nos.	2480 Nos.	421 Nos.	415 Nos.	870 Nos.	1393 Nos.
Coconut bearing	90 Nos.	60 Nos.	97 Nos.	32 Nos.	61 Nos.	181 Nos.	32 Nos.	57 Nos.	140 Nos.	57 Nos.
Coconut non bearing	Nil	109 Nos.	162 Nos.	116 Nos.	119 Nos.	758 Nos.	86 Nos.	138 Nos.	172 Nos.	211 Nos.
Coconut seedling	Nil	142 Nos.	Nil	Nil	176 Nos.	Nil	Nil	Nil	65 Nos.	375 Nos.
Rubber tapping	Nil	34 Nos.	Nil	5 Nos.	Nil	Nil	Nil	Nil	22 Nos.	Nil
Rubber non tapping	Nil	1 No.	Nil	Nil	Nil	Nil	55 Nos.	Nil	Nil	Nil
Arecanut bearing	Nil	351 Nos.	530 Nos.	65 Nos.	128 Nos.	239 Nos.	56 Nos.	233 Nos.	22 Nos.	340 Nos.
Arecanut non bearing	Nil	11 Nos.	Nil	180 Nos.	35 Nos.	93 Nos.	40 Nos.	Nil	Nil	10 Nos.
Cocoa bearing	Nil	1 No.	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

Cashew bearing	Nil	Nil	Nil	10 Nos.	Nil	Nil	Nil	Nil	Nil	Nil
Pepper	Nil	1172 Nos.	1333 Nos.	807 Nos.	1000 Nos.	3682 Nos.	1157 Nos.	1438 Nos.	876 Nos.	2165 Nos.
Vegetable	100 cents	1697 Cents	100 Cents	412 Cents	287.5 Cents	908 Cents	977.5 Cents	1200 Cents	920 Cents	1010 Cents
Ginger/Turmeric	Nil	943 Cents	Nil	460 Cents	22.5 Cents	387 Cents	Nil	205 Cents	452.5 Cents	275 Cents
Tapioca	750 cents	10035 Cents	Nil	2487 Cents	297.975 Cents	868.5 Cents	420 Cents	918 Cents	4080 Cents	935 Cents
Tuber	Nil	385 Cents	2217.5 Cents	205 Cents	140 Cents	1012.5 Cents	415 Cents	375 Cents	147.5 Cents	Nil
Fodder grass	Nil	300 Cents	Nil	Nil	Nil	Nil	Nil	300 Cents	Nil	Nil
Betel vine	Nil	43 Cents	Nil	Nil	Nil	40 Cents	249 Cents	40 Nos.	Nil	Nil
Paddy	Nil	500 Cents	2425 Cents	600 Cents	120 Cents	Nil	Nil	2337.5 Cents	362 Cents	772.5 Cents
Pineapple	Nil	Nil	Nil	Nil	Nil	Nil	Nil	100 Cents	Nil	Nil
Passion fruit	Nil	Nil	Nil	Nil	Nil	Nil	Nil	100 Cents	Nil	Nil
AMOUNT (₹)	8743187	119372 69	5698022	2272262	2904683	9609784	2899407	3368120	10856017	9084568

APPENDIX III

Proportionate selection of farmers in the selected panchayats

Particulars / Panchayats	No. of farmers affected	No. of farmers selected
Paiyaram	486	10
Meloor	658	14
Kadukutty	645	14
Koratty	296	6
Annamanada	447	9
Kuzhur	896	19
Aloor	282	6
Mala	292	6
Parakkadavu	1009	21
Puthenvelikkara	695	15
Total	**5706**	**120**

ASSESSMENT OF AGRICULTURAL LOSS DUE TO 2018 FLOOD TO FARM HOUSEHOLDS IN THE FLOOD PLAINS OF CHALAKUDY RIVER

By

FEMI ELIZABETH GEORGE

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ABSTRACT OF THESIS

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COLLEGE OF HORTICULTURE

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Abstract

Disaster-induced economic damage has been increasing in the past few decades and is likely to continue growing because of urban development, population growth and ecosystem alteration. The state Kerala, with its location along the sea coast with a steep gradient along the slopes of the Western Ghats is highly vulnerable to natural disasters. Floods are the most common natural hazard in the State.

Kerala encountered the most exceedingly awful floods in its history since 1924, between June 1st and August 19th of 2018. The state's economy and a large number of agriculture dependent rural households, most of which are involved in subsistence agriculture, are found to have borne the brunt of the unprecedented deluge and its aftermath. It is in this context that the present study entitled 'Assessment of agricultural loss due to 2018 Flood to farm households in the flood plains of Chalakudy river' was undertaken. Damage and Loss Assessment (DaLA) methodology given by the Food and Agriculture Organization (FAO) in 2012 was used for the damage and loss assessment with appropriate modifications. The term damage in the study means destruction (total or partial) of physical assets, while the term loss indicates the change in economic flows arising from the disaster. The study was conducted selecting 10 panchayats across three blocks, viz. Chalakudy and Mala blocks in Thrissur district and Parakkadavu block in Ernakulam district. Both primary as well as the secondary data were used for the study, however, the study was based mostly on primary data.

The assessment of disaster effects on the farm households along the flood plains of the river with respect to damage and loss suffered to crops, assets and livestock showed that on an average a farm household in the flood plain has suffered a damage of ₹12,837 to agricultural assets, while the damage suffered was ₹75,538 for seasonal crops and ₹9,391 for perennial crops. With respect to livestock and poultry, on an average a farm household has suffered a damage of ₹12,216. Crop loss to the individual farm households as the crops were either damaged/lost or the production declined was also estimated. The results revealed that on an average a farm household

in the flood plain has suffered a loss of ₹1,59,469 from seasonal crops and ₹1,52,358 from totally destroyed perennial crops and ₹32,854 from partially destroyed perennial crops. The result suggested that it is the loss from seasonal crops which was accounted as investment loss contributed the most to the total loss suffered by a farm household.

The assessment of disaster effects in the flood plains of the river with respect to damage and loss suffered to crops, assets and livestock showed that the flood plain has suffered a damage of ₹7.32 crores to agricultural assets, while the damage suffered was ₹43.10 crores for seasonal crops and ₹5.36 crores for perennial crops. The flood plain has lost about ₹6.97 crores due to the death of livestock and poultry. An estimation of the agricultural loss was also carried out in the flood plains as almost all the households reported losses from seasonal crops and perennial crops. The study showed that the flood plain has suffered a loss of ₹90.85 crores from seasonal crops and ₹86.72 crores from totally destroyed perennial crops and ₹18.55 crores from partially destroyed perennial crops. The study concluded that the flood plain has lost about ₹258.87 crores to the 2018 Kerala floods.

An attempt was made to analyse the resilience level of the affected farmers. In the study wherein resilience was taken as the ability of the farmer to continue next season cropping, it was found that the sample respondents on an average showed a resilience of 0.48 in a scale of zero to one. Risk orientation, level of indebtedness, insurance, relief fund, savings, other losses and damage level were found to be the important perceived factors that help in building resilience with importance of these factors in the order mentioned above. The results of logistic regression to understand the influence of socio-economic variables on resilience suggested that while education and subsidiary occupation positively influenced the resilience, family size and crop diversification index was found to have a negative influence.

Major hardships faced by the respondents were identified as flooded house, crop loss, disruption in power supply, inadequate transportation facilities, field inundation, disrupted communication services, loss of labour days and non-availability of drinking water. Keeping in view the inconsistencies with regard to the xxxi estimated flood impact to agriculture and the corresponding reported values by the Government offices, adopting standardized methodological approach based on internationally approved frame work for assessing the impact of disasters on agriculture was suggested as the major policy intervention. Understanding the importance of having a subsidiary income in building the farmer resilience, encouraging farmers to take up different crop related and other enterprises was the other major policy intervention suggested.