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ELD & NELD

An Analysis of the Economic and Non-Economic Losses and Damages Incurred By Farmers due to Climate Change in Meenangadi, Wayanad

An Analysis of the Economic and Non-Economic Losses and Damages (ELD and NELD) Incurred By Farmers due to Climate Change in Meenangadi, Wayanad

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EXECUTIVE SUMMARY

The threats to global agriculture stand out as one of the most significant, of the many possible issues caused by climate change. Agriculture in India is especially vulnerable to the risks posed by climate change. Extreme weather events have been occurring often in India, resulting in a range of losses and damages. Addressing this problem is a climate justice issue since vulnerable people have been and will continue to be the ones most affected by loss and destruction. Climate change has a major impact on the social, economic, and environmental systems.

Economic losses and damages to agriculture might include crop damage, housing damage, and infrastructure destruction. Non-economic losses can be defined as the remaining non-economic items; that is, non-economic items that are not regularly sold in marketplaces. One of the main reasons why measuring non-economic losses is difficult is the lack of a market price. Their impact on human welfare, however, is not less significant. Non-economic losses could be loss of life, health, displacement and human movement, territory, cultural heritage, indigenous/local knowledge, biodiversity, and ecological services, among other things that can have an impact on individuals,society, and the environment.

Loss and damage cannot be adequately addressed until we close the current knowledge gaps and fully understand the range of impacts that climate shocks are creating, particularly the non-economic loss and damage. There are only limited studies in India that examine the entire cost of climate changes, including both non-economic and economic losses and damages. In order to expand our knowledge of non-economic losses and create standardized methods for estimating them, it is imperative that we do research on non-economic losses and damages at the regional or community level.

This study aims to assess and estimate the economic and non economic loss and damages (ELD & NELD) to Agriculture as a result of altered climatic patterns in Meenangadi, Wayanad. We have attempted to estimate the economic and non-economic losses and damages that have happened in Meenangadi in the past several years, as it is one of the Panchayats in Wayanad that has been severely affected by the climate change events. A multi stage sampling was carried out and 120 farmers were surveyed to get an estimate of the losses and damages. Using the FAO's Damage and Losses Approach, we calculated the losses and damages. The Garrett Ranking was used to determine the farmers' non-economic losses and damages. Recommendations to lessen the effects of climate change have been made in accordance with the values collected.

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1.1 Climate Change

According to the Natural Resources Defense Council (NRDC), *"Climate change is defined as the substantial alterations in average weather conditions, patterns, and their intensity such as weather becoming warmer, wetter or drier over several years or even decades. It is the longer-term tendency that distinguishes climate change from natural weather fluctuation"*.

Global climate change is not a worry for the future. It is happening now. Climate change caused by increased human emissions of heat-trapping greenhouse gases is already having a wide-ranging impact on the environment. Ice sheets and glaciers are decreasing, the geographic distribution of animals and plants is shifting, and trees and plants are flowering earlier.

Scientists have long projected that global climate change would result in effects such as sea ice loss, rapid sea level rise, and a longer period of more extreme heat waves. According to NASA, Certain changes which include wildfires, droughts, and too much rain appear to be happening at an earlier pace than formerly anticipated by experts

As per the ***Intergovernmental Panel on Climate Change (IPCC)***, a United Nations organization set up for the evaluation of climate change science, contemporary humans have never witnessed the observed shifts in the global climate earlier, and a few of those modifications are irreversible over the coming hundreds to many thousands of years. Scientists are convinced that the world's temperature is going to continue to rise for several decades, primarily by anthropogenic greenhouse gas emission.

According to the IPCC (2014), poorer populations, particularly in agrarian civilizations, are likely to suffer the most from climate change. Climate change has also been found to have direct and indirect consequences on labour productivity, crime, violent disputes, happiness, life expectancy, migration, and illness. (Carlton and Hsiang, 2016)

With extreme weather events making headlines and claiming lives and livelihoods worldwide thus far in 2023, the climate catastrophe is clearly still very much in play. A record-breaking hurricane in Southeast Africa, wildfires in Chile and Canada, oppressive heat waves throughout Asia, strong ice storms in the southern United States, and many other events have confirmed what we all already know: climate change is occurring right now (Khanyi Mlaba, Tess Lowery, and Fadeke Banjo, 2023).

1.2 Impact of Climate Change on Agriculture

The threats to global agriculture stand out as one of the most significant issues among the several possible issues caused by climate change. As is well known, developing nations often have more to lose than industrialised nations when it comes to the consequences of climate change on agriculture. Compared to their wealthier neighbours, the majority of emerging nations are less adaptive and they also tend to have a larger proportion of the population employed in agriculture. (Cline, W.R., 2008).

In the agricultural sector, climate variations that threaten the world's crops and cereal productivity, such as variations in global rainfall, the constant rise in carbon dioxide, and average temperature, have increased the frequency of extreme events that result in flood and drought disasters (Farzana Bibi and Azizur Rahman, 2023).

Table 1.1: Forecasted impacts of climate change on agriculture by 2050

Climatic element	Expected changes by 2050	Effects on Agriculture
CO_2	Increase to 600 ppm	Beneficial to crops; boosts photosynthesis and uses less water
Sea Level Rise	Rise by 10-15 cm	Land loss, coastal erosion, flooding, and groundwater salinization
Temperature	Rise by 1-2 C, Warmer winters, increased frequency of heat waves	Faster, shorter, earlier growing seasons, range moving north and to higher altitudes, heat stress risk, increased evapotranspiration
Precipitation	Seasonal Changes by ±10 per cent	Water logging or drought: based on the increase or decrease in rainfall.
Storminess	Increased wind speeds. More intense rainfall.	Lodging, Soil Erosion and Reduced Infiltration

Source: Anupama Mahato, 2014

1.3 Impact of Climate Change on Indian Agriculture

In India, rain-fed agriculture makes up two-thirds of the agricultural land and even the irrigated system depends on monsoon rain. Hence, Indian agriculture is extremely vulnerable to the hazards associated with climate change, particularly drought. More than 80 per cent of Indian farmers are small farmers with cultivable land areas between one and two hectares and limited capacity to cope, or marginal farmers with less than one hectare of arable land. Besides, the farmers in India are diverse and disorganised. Because of the strain that climate change and its variability will likely place on agriculture and impact its sustainability, the issue of future food security is expected to get worse.

The staple food of India is Rice and its production decreases by 3 to 15 per cent for every 1.5°C increase in temperature and 2 mm drop in precipitation (Ahluwalia and Malhotra, 2006). There are frequent dry spells in Western Rajasthan, certain areas of Haryana, Uttar Pradesh, Maharashtra, Southern Bihar, Madhya Pradesh, Southern Gujarat, Northern Andhra Pradesh, and Karnataka, and these areas are extremely susceptible to drought (Bhandari et al., 2007).

Increases in heatwave frequency and intensity in India are negatively impacting all related agricultural industries, such as dairy, poultry, fisheries, etc. Heatwaves and low water availability have a serious impact on the nation's food security. In addition to the long-standing horticultural orchards drying up, there is a drinking water crisis for people and cattle. Mid-May to mid-June of 2019 saw the worst and the longest heatwave to be ever recorded in India and its bordering nations (Srinivasa Rao, Ch., Prasad, R.S. and Mohapatra, T., 2019).

One of the worst natural catastrophes to ever strike Uttarakhand was the flooding that occurred from 14–18 June 2013, resulting in numerous landslides and avalanches that damaged Apple plantations. In Andhra Pradesh, hail storms in February 2013 caused damage to 1,47,986 hectares of agricultural crops and 1,45,000 hectares of horticultural crops. Floods in Jammu & Kashmir during the second week of September 2014 severely damaged crops. In addition to severely damaging Tamil Nadu's crops, 322 people lost their lives in floods and strong rains during the 2015 North East (NE) Monsoon (especially Chennai). In Punjab and Haryana in 2015, Wheat and other Rabi crops suffered damage from severe rains and a hailstorm. (Ray, Kamaljit, Kopal Arora, and A. K. Srivastav, 2019)

Furthermore, beginning on 15 August 2018, Kerala experienced the worst natural disaster, a deluge that lasted for a full week. The exceptionally heavy rainfall which was more than 164 per cent, caused dams to fill, forcing open all barriers and causing catastrophic flooding that severely harmed Kerala's farmers by destroying not only their farms but also their homes, assets, livestock, implements etc. Paddy and Banana were the most affected. (Veerakumaran, G., and S. L. Santhi, 2019)

These catastrophic climate events have resulted in significant financial and non-financial losses and devastation in India.

1.4 Losses and Damages

Loss and damage have harmed and will continue to harm vulnerable groups the most, making tackling the issue a matter of climate justice. Collective measures to reduce greenhouse gas emissions and adapt to climate change are now insufficient to address the speed and scale of climatic impacts, implying that some losses and damages are unavoidable as a result of climate change (World Resources Institute, 2022).

Currently, the United Nations has no formal definition of loss and damage. However, losses and damages pertain to the adverse consequences of climate change threats including elevated sea levels, increased heat waves, increasing desertification, marine acidification, and catastrophic circumstances including forest fires, extinction of animals, and failure of crops. As the climate issue becomes more severe, these types of events are bound to get increasingly common, and the implications are likely to become increasingly severe. All of these cause economic and non-economic loss and damage. (The London School of Economics, 2022).

1.5 Economic and non-economic loss and damage (ELD and NELD)

Climate change has a wide-ranging impact on social, economic, and environmental systems. These impacts are divided into economic and non-economic losses and damages. Economic losses and damages are defined as the depletion of resources, goods, and services that are routinely traded in markets. As a result, they need to be recorded and manifested in the national accounting system. Economic losses and damages can be valued using market prices. Economic losses and damages to agriculture might include crop damage, housing damage, and infrastructure destruction.

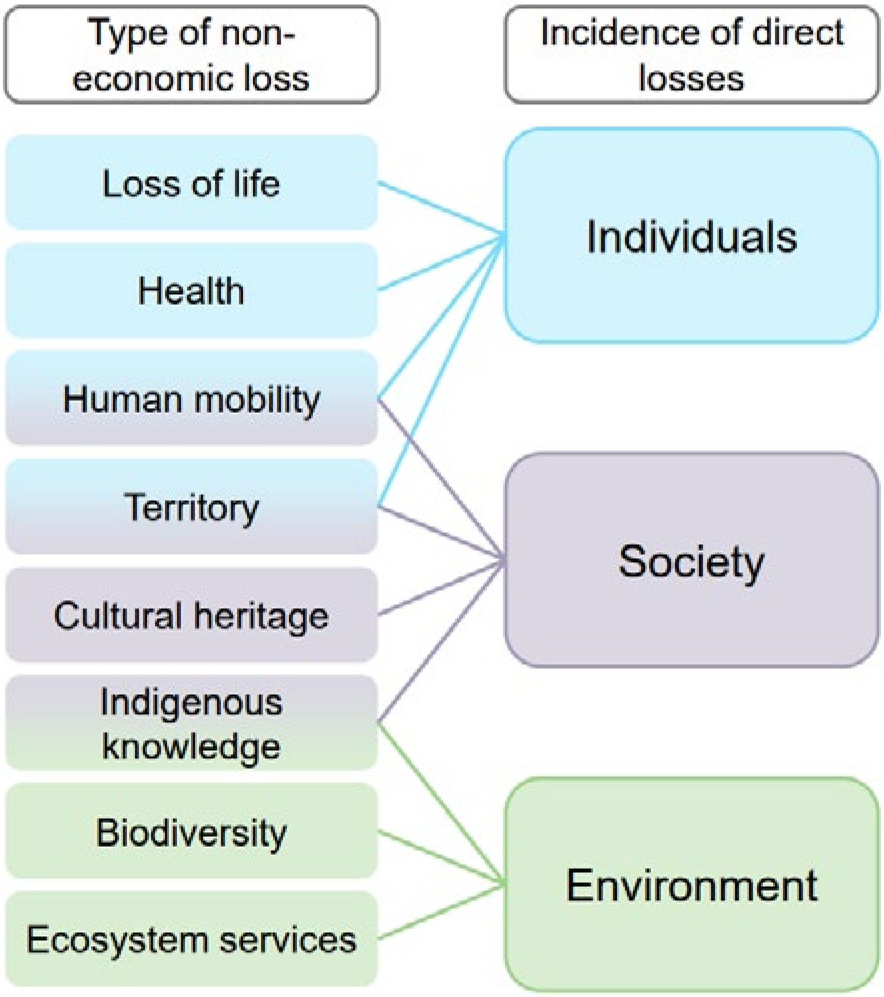

Figure 1.1: Inter-linkages Between the Suggested Types of Non-economic Losses

(Source: Technical paper, UNFCCC, 2013)

Non-economic losses can be defined as the remaining non-economic items; that is, non-economic items that are not regularly sold in marketplaces. One of the main reasons why measuring non-economic losses is difficult is the lack of a market price. Their impact on human welfare, however, is no less significant. Non-economic losses can have an impact on individuals, society, and the environment. Non-economic losses could be loss of life, health, displacement and human movement, territory, cultural heritage, indigenous/local knowledge, biodiversity, and ecological services, among other things.

Non-economic losses may be greater than economic losses in numerous developing countries. Identifying and mitigating the danger of non-economic loss should thus be a key aspect of climate change policy.

The line between non-economic and economic loss will occasionally blur. Natural ecosystem damage, for example, is essentially a non-economic loss because ecosystem services are rarely purchased on the market. However, market impacts may occur if one of the ecosystem's services is food or fibre, the provision of which is part of the market economy. (Technical paper, UNFCCC, 2013).

1.6 COP 27

UN climate summits, which are commonly referred to as Conference of Parties (COP) have been held yearly since the inaugural United Nations Climate Agreement in 1992, with the exception of 2020 because of the COVID-19 pandemic. Governments utilise these conferences to make agreements on measures to restrict increases in global temperature and prepare for the effects of climate change.

Sharm-El-Sheik, Egypt hosted the Conference of Parties of the United Nations Climate Change Conference 2022, often known as COP 27 (Esme Stallard, 2022)

A strong framework to fund the costs of losses and damages linked to climate change was demanded by several countries and organisations. Furthermore, the subjects of climate justice and the reform of international financial organisations like the World Bank and the International Monetary Fund dominated COP 27. (Naylor, Angus William, and James Ford, 2023).

The historic agreement to establish a new fund, wherein nations with high carbon emissions will compensate disadvantaged nations experiencing climate damages, marked the conclusion of the 27th UN Climate Change Conference (COP27).

This momentous agreement was reached during a year of unrelentingly harsh weather, including drought in the Horn of Africa and flooding in Pakistan. (Arthur Wyns, 2023)

However, unless we fill in the knowledge gaps that now exist and comprehend the whole spectrum

Figure 1.2: United Nations Framework Convention on Climate Change- COP 27

(Source: UNFCCC News and Media Website)

of effects that climate shocks are causing, especially the non-economic loss and damage, loss and damage cannot be sufficiently handled. Decision-making and funding can then be influenced by this knowledge. The current state of knowledge gaps includes, among other things, a lack of research on losses and damages from global south countries (Brazil, Pakistan, Indonesia, India and China), a lack of focus on non-economic losses and damages, a dearth of collaboration on collective research, a lack of cutting-edge interdisciplinary research, and a shortage of standard methodologies to quantify losses and damages, particularly the non-economic losses and damages (Ritu Bharadwaj Tom Mitchell and Saleemul Huq, 2023)

Grantham Research Institute on Climate Change and Environment (established by the London School of Economics and Political Science in 2008), suggests that, given the variety of local implications, evaluation must be extremely customised to local contexts. Practical study into defining and assessing NELD will be necessary in order to include a holistic understanding of NELD in international negotiations, catastrophe response, and advance planning.

1.7 Wayanad

Wayanad is positioned in the Western Ghats and is home to thermo-sensitive and climate-vulnerable food crops such as coffee, rice, and pepper. It also happens to be one of the world's eight "hottest hotspots" of biological diversity, with roughly 5,000 species of plants and animals present. (Krishi Jagran, 2019).

1.7.1 Land Use Pattern of Wayanad District

The Wayanad district is primarily agrarian in nature with plantation and other agricultural land use accounting for fifty per cent of its geographical area. The forests and mountains, monsoons and valleys have all contributed to the formation of an environment that has provided Wayanad with fertile soil that has produced copious crops of coffee, pepper, paddy, and other spices, which are the mainstay of the people of this land. Over ninety per cent of the district's population works in agriculture, either as farmers, farm workers, or in adjacent industries. It also holds one of the highest numbers of tribes, with seventeen per cent of the district's population being tribal (Krishi Jagran, 2019).

The entire geographic area of Wayanad district is estimated to be 212966 hectares based on information gathered from the Agricultural Statistical Report that the state of Kerala issued in 2022. In 2021–2022, this district's total cultivated area was 164425.9 hectares, while 12439 hectares of land were used for non-agricultural purposes. Additionally, there were roughly 78787 hectares of forest cover. The area covered by still water, according to this assessment, was around 4047 hectares. Water-logged areas accounted for nineteen hectares of land.

Figure 1.3: Wayanad District Map

1.7.2 Area Under Major Crops In Wayanad District

Wayanad is an agrarian district, as previously mentioned. According to the Kerala government's 2021–2022 Statistical Report, coffee was the district's most important crop, grown on over 67705 hectares of land. With an area of 11090, 10134, 10750, 9718, and 8143.91, the other principal crops grown in 2021–2022 were arecanut, banana, rubber, pepper, and paddy. Along with these commer-

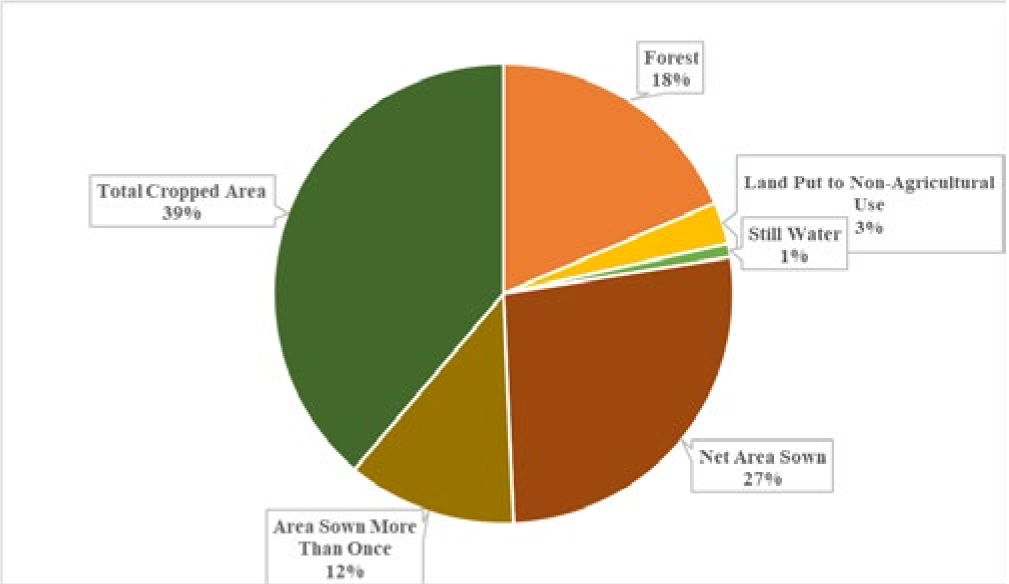

Figure 1.4 Land Use Pattern In Wayanad District

(Source: Compiled from Agricultural Statistics Report, Government of Kerala (2021-2022))

cially significant crops, Wayanad farmers also grow tapioca, turmeric, ginger, nutmeg, coconut, cashew, and cardamom.

1.7.3 Climate Change In Wayanad

Wayanad is no longer a chilly, foggy environment; instead, its temperatures have increased dramatically. The amount of warmer days has increased over time, more than double, with early March temperatures above 30 degrees Celsius. This has a detrimental impact on heat-sensitive crops like

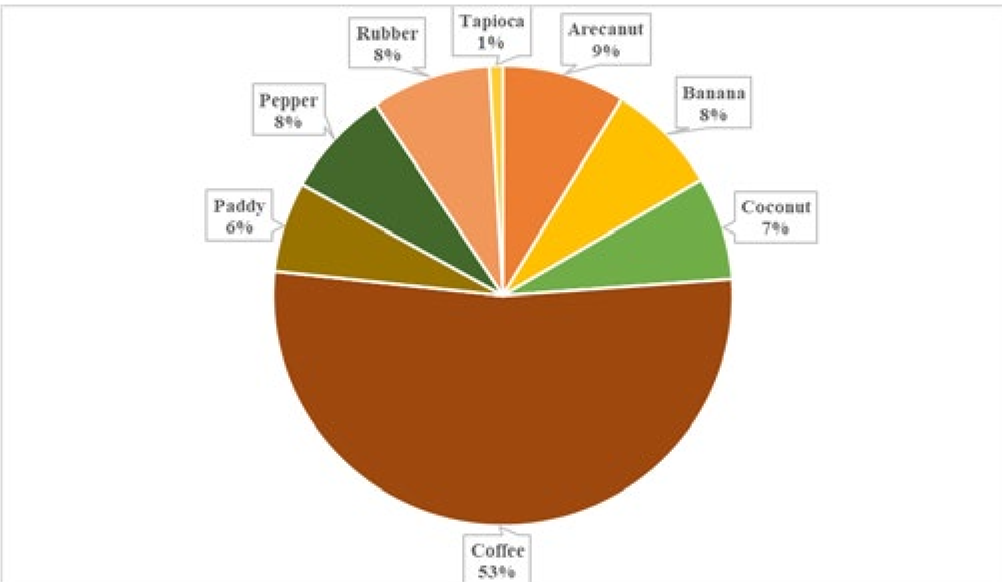

Figure 1.5 Area Under Major Crops In Wayanad District

(Source: Compiled from Agricultural Statistics Report, Government of Kerala (2021-2022))

oranges and peppers. Farmers now face even more difficulties as the once-reliable monsoon season has become unpredictable, resulting in protracted droughts or excessive rains.

Wayanad saw the worst floods in its history since 1924 between 1 June and 18 August 2018, with more rainfall than usual. The damage of the flood was exacerbated by multiple landslides and the forced discharge of extra water from dams due to the excessive rainfall. Floods were caused by the maximum rainfall of 3093 mm, which fell in the Banasura Sagar dam's catchment region, which is located 20 km northwest of Kalpetta, the district capital. According to the Wayanad District Soil Conservation Office's records, from 1 June to 30 August, there were 45 cases of ground subsidence, 155 landslips, and 47 landslides (Deepu Sivadas, P., R. Geethakumary, and B. M. Prakash kumar, 2019)

The red lines in the figure represent the excess amount of rainfall received in Wayanad which led to the devastating floods in 2018 and 2019.

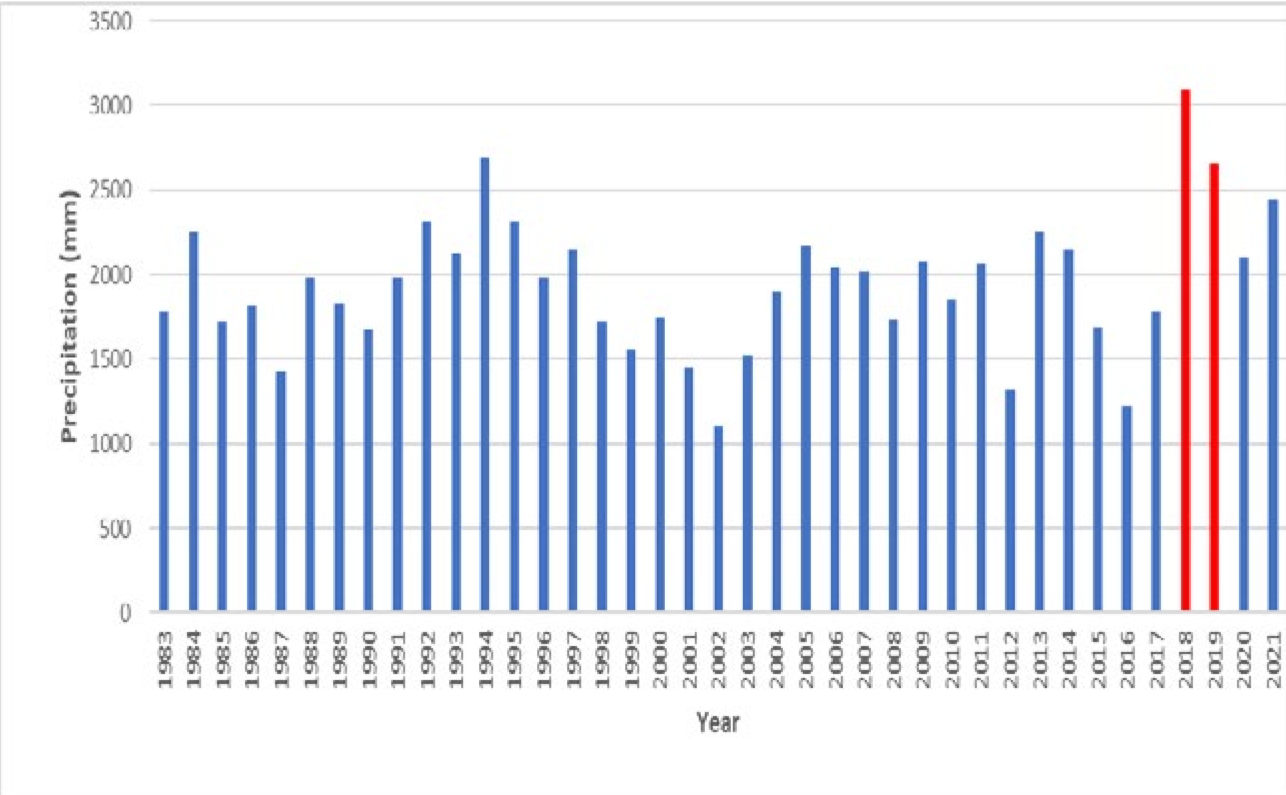

Figure 1.6 Trend of Precipitation in Wayanad from 1983-2021

(Source: Thomas K.S, 2020 and Agricultural Statistics Report, 2022)

Wayanad has been experiencing a periodic drought issue too due to unpredictable monsoons as a result of anthropogenic pressures and climate change. Failing markets, harsh weather conditions, and frequent man-animal confrontations have come to define farming in a district known globally for its coffee, pepper, and spices, as well as one of Kerala's most important agricultural districts (Krishi Jagran, 2019).

1.7.4 The Deadly Floods of 2024

A recent extreme climate event that struck Wayanad rocked the entire nation in addition to these previous occurrences. On 30 July 2024, Punchirimattam, Chooralmala, and Mundakkai of Meppadi Panchayat witnessed one of the worst floods that the nation has ever seen. Meppadi is renowned for its hilly landscape and agricultural land, the majority of which is owned by tea plantations owned by Harrisons Malayalam Limited (HML). Kozhikode and Malappuram districts are next to Mundakkai. The Chaliyar River and the renowned Nilambur forests are located beyond the towering mountains that encircle the region. The surrounding terrain consists of steep slopes, creeks, and thick forests. When it rains a lot, the area is vulnerable to landslides because of its geography. The climate in the region is tropical and the majority of the people living in these settlements are farmers. Many of the locals are employed as plantation or agricultural labourers. Pepper, tea, coffee, and other spices are common crops. Additionally, some households raise livestock on a limited basis.

About 2,000 people lived in Chooralmala, occupying about 470 homes. Of those homes, 39 suffered minor damage and up to 112 were demolished. Over 600 people were relocated. Mundakkai was the most severely impacted location by the landslide, according to the Panchayat's data. Of Mundakkai's 280 homes, up to 200 suffered total devastation, and 50 suffered partial destruction. Forty residences in Attamala suffered full destruction, and another forty suffered minor damage. Heavy rains forced the hillsides to crumble, causing landslides that destroyed the areas below. (The News Minute, 2024)

Data from the Indian Meteorological Department (IMD) indicates that in a few hours on July 30, the landslide-affected areas got 6 per cent of their yearly rainfall. Wayanad barely received 9 millimetres (mm) of rain on July 29, which was almost 73 per cent less than the typical amount of 32.9 mm. Meanwhile, it rained 141.8 mm in a single day on July 30, 493 percent higher than the average of 23.9 mm.

It was recently established by the Kerala State Disaster Management Authority that the Wayanad landslide was the biggest in India's history. The event caused a debris flow of about six million cubic meters, which is enough to fill 2,400 Olympic-sized swimming pools, according to research. The Wayanad tragedy was five times larger than the record for the largest debris flow in the nation, which was previously held by the Malpa landslide in Uttarakhand in 1998. It is also 300 times bigger than the 2020 landslide at Pettimudi, Kerala.

Residents of Wayanad are dealing with the loss of loved ones, houses, and means of subsistence while the area attempts to recover. The extent of the catastrophe will be felt for years to come, even while efforts to return things to normal continue. (Down to Earth, 2024)

1.7.5 Climate change-related financial losses in Kerala

Kerala is paying a heavy price in terms of lost lives and economic losses due to climate change. The State spent more than Rs. 40,000 crores on the 2018 floods alone. Early warning systems are considered essential to accelerating climate adaptation and mitigation efforts. Revenue Minister K. Rajan states that the region is estimated to have suffered a loss of Rs. 1,200 crores, while the Kerala government has not yet finalized an assessment of the loss of property and human lives. According to Kerala's State Action Plan on Climate Change (2023–2030), the state will have to allocate approximately Rs. 90,000 crores on climate change adaptation and mitigation. (Down to Earth, 2024).

Figure 1.7 Images showing the intensity of the Wayanad Landslide- 2024
(Image Sources : The Hindu, 2024, CNN, 2024)

CONTEXT

2.1 Importance of the study

In India, the studies that analyse the total cost of climate impacts including economic and non-economic losses and damages are limited. According to leading research institutions like the International Institute for Environment and Development (IIED) research on non-economic losses and damages at a region or community level is the need of the hour to widen the understanding of non-economic losses and develop standard methodologies to estimate the same. This study attempts to get an understanding of the economic and non-economic losses and damages (ELD and NELD) to agriculture that have occurred as a result of the change in climate patterns in Wayanad.

2.2 Locale of the Study

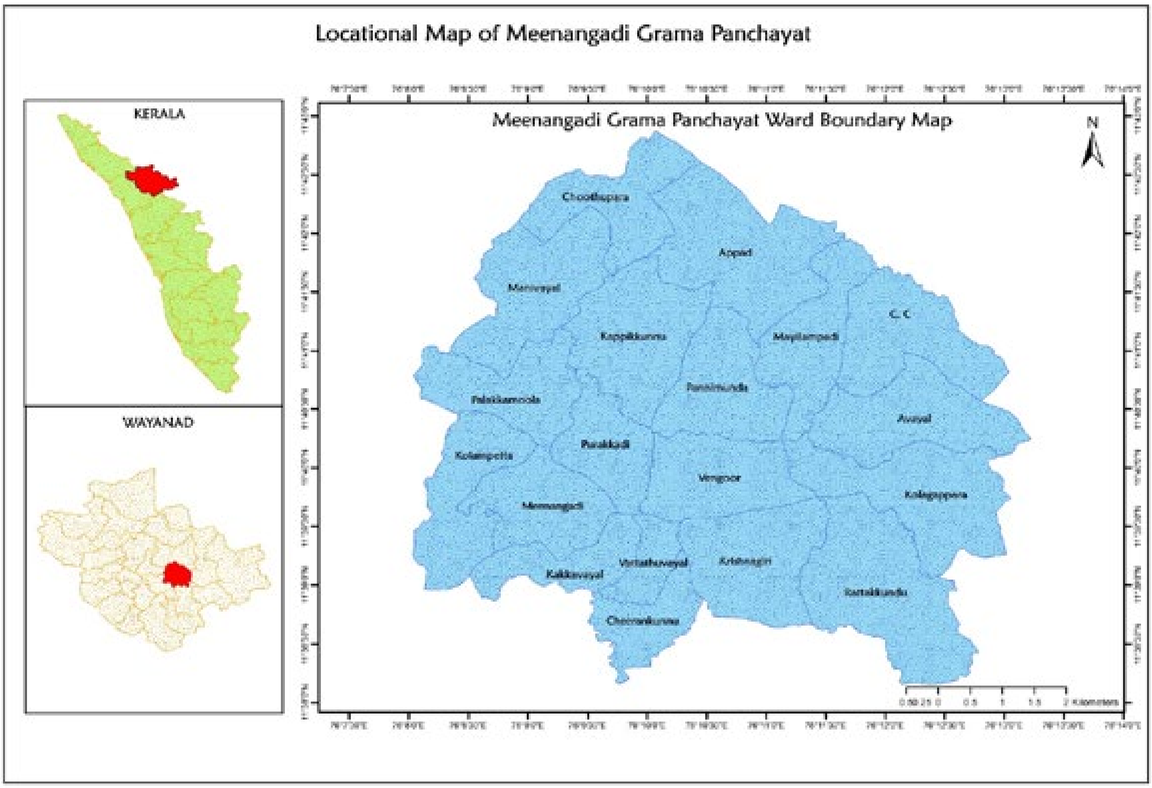

Figure 2.1 Locational Map of Meenangadi Panchayat

Meenangadi, the panchayat selected to conduct this research, is one of the 25 grama panchayats in Wayanad district. Meenangadi Grama panchayat recently bagged the prestigious '**Carbon Neutral Vishesh Panchayat Puraskar'**, the first such award instituted by the Ministry of Panchayati Raj for exemplary work towards achieving net-zero carbon emission (The Hindu, April 18, 2023). The idea of a ***"Carbon Neutral District"*** promotes low-carbon development, environmental preservation, self-sufficiency in food and energy, economic prosperity, and development at local self-government level. Achieving carbon neutrality involves equalizing the measured quantity of carbon released into the atmosphere as a result of human activity with an equivalent amount sequestered in carbon sinks. This results in net zero GHG (Greenhouse Gas) emissions. Meenangadi was chosen as the study area.

2.3 Profile of Meenangadi Grama Panchayat-

Meenangadi Grama Panchayat is situated in the centre of Wayanad District with an area of 53. 51 sq. km. There are 19 wards in Meenangadi Panchayat.

The number and names of the 19 wards in Meenangadi are presented in the following table.

Table 2.1: Wards in Meenangadi Grama Panchayat

Ward Number	Name of the Ward
1	Choothupara
2	Appadu
3	Mylambadi
4	CC
5	Aavayal
6	Kolagappara
7	Rattakundu
8	Krishnagiri
9	Cheeramkunnu
10	Vattathuvayal
11	Kakkavayal
12	Kolambatta
13	Meenangadi
14	Purakkadi
15	Vengoor
16	Pannimunda
17	Kaapikunnu
18	Paalakkamoola
19	Manivayal

Source: Meenangadi Grama Panchayat Development Report 2022-2027

2.3.1 Agriculture in Meenangadi Panchayath

About 76 per cent of the population in Meenangadi has agriculture as their main source of income. Black soil, Alluvial soil, Sandy soil and red soil are the major soil types found in this panchayat. The cultivable land area in Meenangadi is 4919 Hectares.

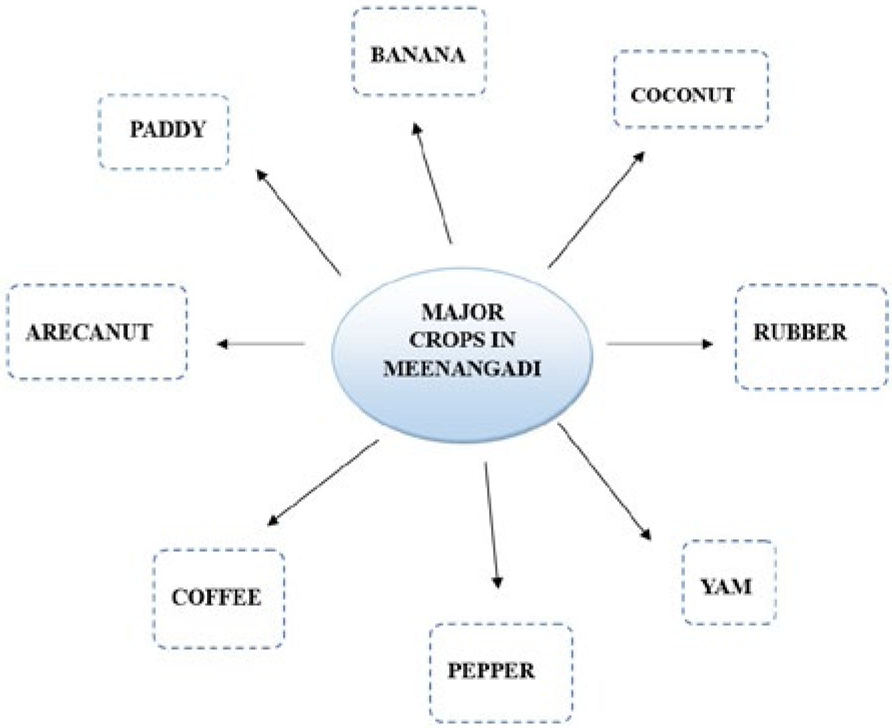

Figure 2.2 Major Crops Grown In Meenangadi Panchayath

(Source: Meenangadi Grama Panchayat Development Document, 2022- 2027)

Paddy, Coffee, Pepper, Banana, Coconut, Rubber, Arecanut, Ginger, Turmeric, Tapioca and Yam are the major crops grown in this region. The Panchayat has 12 *Paadashekhara samitis* (registered organisation of paddy farmers in the locality) and 19 *Samitis* (registered organisation of pepper farmers) in the locality. Roughly 3848 households in this panchayat are dependent on dairy farming for their livelihood with an average milk production of almost 12624.7 litres per day. In addition, 425 farmers are engaged in fish farming in about 16.484 Hectares. (Meenangadi Grama Panchayat Development Document, 2022- 2027).

2.3.2 Impact Of Climate Change on Agriculture in Meenangadi Panchayat

There are 19 wards in Meenangadi Grama Panchayat. One of the important climate disasters that took place in Meenangadi was the floods that happened in 2018 and 2019 which made the lives of people horrible. Athinilam, Kolambatta, Padavayal, Mayilampadi, Puzhamkuni and Cheerakunnu were affected the most by the floods. There was also an incidence of landslides in the Rattakkund ward. Agriculture was the most affected sector by the floods. Nine wards out of nineteen wards were severely affected.

Most of the farmers in Meenangadi are small farmers. They were severely affected by the floods. The major damage was caused when the topsoil of the agricultural fields was dragged away by the water. This led to the loss of essential soil nutrients in the soil. This also led to increased acidity in the soil and reduced the pH of cultivable soil. Coffee plantations prevented soil erosion to an extent but the yield of coffee was affected drastically due to heavy rains which thereby led to increased economic losses. There was also a drastic reduction in the yield of arecanut and coconut.

Short-term crops like rice, ginger and yam were affected the most. Transplanted and directly sown paddy crops were affected. Roughly 20 Hectares of Banana plants were destroyed. Fish farming carried out in the farms was washed away and thus caused huge economic losses to farmers. On the whole, about 60 hectares of cultivable land was affected which caused a loss of more than Rs. 2 Crores in Meenangadi Panchayat.

Furthermore, according to the Meenangadi Krishi Bhavan, about 22.17, 13.23, 1.69, 5.58 Hectares of crop area was affected by the climate extremes like heavy rainfall and high temperature in the years 2019-2020, 2020-2021, 2021-2022, 2022-2023 respectively.

Table 2.2: Preliminary report on natural calamity- Flood

Sl. No	Crops Affected	Total Area Affected (Ha)		Number of plants/trees affected/area	Number of farmers affected	Estimated crop losses (Rs)	Total losses (Rs)
		Irrigated (Ha)	Unirrigated (Ha)				
1	Banana (Bunched)	20		50000 Trees	78	10000000	5000000
2	Banana (Unbunched)	24		60000 Trees	64	9000000	4500000
3	Paddy Nursery	20		20 Hectares	120	150000	270000
4	Paddy Main Field	100		100 Hectares	98	3000000	3000000
5	Ginger	10		10 Hectares	40	2000000	680000
6	Tapioca	5		5 Hectares	17	100000	34000
7	Pepper	15		15 Hectares	35	350000	1125000
8	Vegetable		20	20 Hectares	77	300000	270000
	Total				**452**	**24600000**	**14879000**

Source: Meenangadi Panchayath Development Report, 2022-2027

Figure 2.3 Agricultural Land in Meenangadi Panchayath (Picture Credit: Anju Babu)

2.4 Objectives

As mentioned previously, Studies that examine the entire cost of climate changes, including both non-economic and economic losses and damages, are scarce in India. Hence, we put together a few objectives which formed the foundation of this research. They are as follows

1. To enlist the different crops and the cropping pattern of the study area.
2. To estimate the economic losses and damages (ELD) caused by climate change on the selected crops
3. To understand the non-economic losses and damages (NELD) caused by climate change on the selected crops
4. To suggest countermeasures and recommendations to reduce losses and damages

RESEARCH METHODOLOGY

3.1 Types of Data

This study made use of primary and secondary data.

3.1.1 Primary Data Collection

3.1.1. (a) Survey

The major mode of data collection from farmers was through surveys. After consulting resource persons concerned, an initial interview schedule was prepared for a pilot survey in June 2023. We surveyed almost 30 farmers to learn more about the state of agriculture in the panchayat, the demographics, main crops and furthermore, to see the feasibility of the study. After collecting the necessary information, we made some changes to the initial interview schedule to make the interview schedule efficient. Multi-stage sampling method was followed in the study. Wayanad district was purposely selected, as it is one of the climate change hotspots in Kerala where climate change events are common and has agriculture as one of the major occupations of the residents. Meenangadi panchayat was selected as agriculture was comparatively more prominent here. The 10 most affected wards in which the study was done were selected based on our interactions with the government officials and also based on the reports released by the panchayat of Meenangadi. We surveyed 120 respondents from the panchayat for the main survey, using random sampling. The main survey was carried out by visiting the farmers in their fields and interviewing them. The study period was from mid-July to October 2023.

3.1.2 Secondary Data Collection

Secondary data on variables like demography, rainfall, population, land utilisation pattern, operational land holdings, soil type, and agro-climatic conditions were compiled from government records, yearly reports, and statistical publications by the Government of Kerala. Other essential data was collected from Meenangadi Krishi Bhavan, Regional Agricultural Research Station (RARS), Ambalavayal, Meenangadi panchayat office and available literature.

3.2 Period of Study

In June 2023, a pilot research was conducted to learn about the circumstances in Meenangadi Panchayat and a structured questionnaire was put together as an outcome. The main survey was carried out from mid-July to mid-October, 2023.

3.4 Sampling Design

There are 19 wards in Meenangadi Panchayat. Interviews with resource people, including farmers and Panchayat officials, taught us that the impacts of significant climate events, such as floods, were not uniform throughout the Panchayat. Some areas had been ravaged by the floods, while others had been slightly affected. It was confirmed after reading a report that the Panchayat had been released in the wake of 2018 rains. Hence, we decided to concentrate more on the areas having the worst consequences. We did, however, speak with farmers from the wards where the effects were rather less severe. For the research, farmers were selected from 10 wards (Aavayal, Kolagappara, Cheeramkunnu, Vattathuvayal, Kakkavayal, Kolambatta, Purakkadi, Palakkamoola, Mayilampadi and Manivayal) that were most affected in climate extreme events making a sum of 120 farmers in total.

3.5 Analyses of Data

3.5.1 Conventional Analysis

Simple Average and Percentage Analyses were used to investigate socio-economic variables such as age, education, and family size as well as farm-related variables such as the size of the operation holding, cropping pattern, inputs used, yield, prices etc.

3.5.2 Trend Analysis

3.5.2.(a) Compound Annual Growth Rate

The growth rate is useful for analysing the trend of any variable under consideration. The Compound Annual Growth Rate (CAGR) was used to determine the trend in area, production, and productivity of main crops in the Wayanad district from 1980- 2022. For this analysis, an exponential function of the following form was used (Patil and Yeledhalli, 2016).

$$Y = ab^{t}e^{Ut}$$

Where,

Y = area/ production/ productivity

a= intercept term

b = regression coefficient

U_t = disturbance term for the year 't'

When this is transformed to logarithmic form, it becomes:

$$\log Y = \log a + t \log b + U_t$$

The equation's log-linear form has been estimated using Ordinary Least Squares (OLS) technique

From the estimate, CAGR (r) was computed as

$$r = (\text{Antilog } b - 1) \times 100$$

The significance of the CAGR was tested using the 't' statistic:

$$t = r / SE(r)$$

Where,

SE(r) is the Standard Error of the CAGR

3.5.3 Economic Losses and Damages to Agriculture

The Damage and Loss Assessment (DaLa) approach, as provided by the FAO in its guidance note on "Post-disaster damage, loss and needs assessment in agriculture (2012)," was used to compute the damages and losses to agriculture, with the requisite modifications.

Initially developed by the United Nations Economic Commission for Latin America and the Caribbean (UN-ECLAC) in 1972, the approach is sometimes known as the UN-ECLAC methodology (GFDRR, 2010). Since then, the United Nations Educational, Scientific, and Cultural Organisation (UNESCO), the Pan-American Health Organisation (PAHO), the World Bank, the Inter-American Development Bank (IADB), and the International Labour Organisation (ILO) have worked closely together to improve it in order to estimate damage and losses from disaster events as closely as possible. The analyses made by the DaLA method are based on the impacted nation's overall economy. For the purpose of estimating damage and loss, it makes use of national records and statistics. The approach takes into account the impact of the disaster on jobs and livelihoods in order to fully describe the needs for recovery and reconstruction. This approach can be used to estimate

a. Natural disasters with sudden onsets, such as flash typhoons, floods, earthquakes, and;

b. Natural disasters with slow onsets, such as saline water intrusions, droughts, and other phenomena related to climate change;

c. Epidemics, such as COVID-19, Avian flu and SARS; and

d. The civil unrest that may interrupt or temporarily halt regular economic activity.

According to FAO's guidance note, the agriculture sector is divided into the following sub-sectors

1. **Seasonal crops**- These are the crops that are cultivated and harvested at specific times of the year. Examples are Vegetables, Rice, maize and other similar crops.

2. **Permanent crops** - These need to mature for a while before produce can be routinely gathered. Examples of these include Coffee, Rubber, Coconut, Fruit trees and others.

3. **Forestry**- Forest goods like timber

4. **Livestock**- Animals like cattle and poultry

5. **Fisheries-** consist of both marine and freshwater fisheries.

6. **Infrastructure**- This covers the physical assets associated with agriculture. Examples include fish cages, livestock shelters, mills, warehouses, and irrigation systems.

3.5.3.(a) Definitions of Losses and Damages (FAO, 2012)

i. **Losses-** Losses are the equivalent of lost revenue, lost investments, increased manufacturing costs, and other unforeseen expenses.

ii. **Damages -**The expenses incurred to replace completely destroyed assets or repair partially damaged assets to their pre-disaster state are known as damages.

Damages and losses should be valued at what they were prior to the incident. The inflation that follows a calamity shouldn't have an impact on them.

3.5.3.(b) Procedure for conducting post-disaster damage and loss assessments in the agricultural sector

The procedure to assess the post-disaster damages and losses can be put together in simple terms as follows

Step 1 - Compile baseline data prior to the disaster.

Establishing a baseline is crucial for post-disaster damage and loss assessment since a fair estimate of damage and loss should be based on prior conditions. A baseline from which damage and loss will be evaluated must be established. Key data that must be obtained include

Figure 3.1 Steps to conduct post-disaster damage and loss assessments in the agricultural sector
Source: FAO, 2012

1. Population and Income
2. Perennial and Seasonal Crops
3. Livestock and Poultry
4. Fisheries
5. Irrigation Assets
6. Other Agricultural Assets
7. Other Agriculture-Related Assets and Industries

Step 2: Assess Damages

Damages are the consequences on stocks or assets, and their worth is determined by:

1. Repairing partially damaged assets
2. Replacing completely destroyed assets

Replacement cost is the asset's worth immediately prior to entire destruction, whereas repair cost is the sum needed to restore the item to its state just prior to partial destruction. Nonetheless, the cost of repairing the damaged asset is considered the replacement cost in the current study.

Damages in the context of agriculture include the whole or partial loss of assets like livestock shelters, farm machinery, irrigation systems, fertilisers, seed supplies, etc. In addition to this, crops that were in the harvesting stage when they were damaged by natural disasters and completely devastated perennial crops are also included in the damages. While disaster-damaged harvest-stage crops are valued at the farm gate pricing at the time of the disaster, completely devastated perennial crops are evaluated at the cost of replacing trees of that kind. The amount needed to replant each completely destroyed perennial crop is known as the average replanting cost per crop.

On the other hand, the cost of replanting is reduced if a destroyed tree has a salvage value (for example, a felled coconut tree may be sold for a specific sum). Nevertheless, the crops that were killed during the harvest stage are valued at the market wholesale price in the current study.

Assessment of Damages:

1. Agricultural Asset Damages (D_A)

$$D_A = \text{(Number/Quantity of partially damaged Assets X Average Repair Cost)} + \text{(Number/Quantity of totally destroyed assets X Average replacement cost)}$$

2. Damages to Crops (D_C)

a. Damages to Seasonal Crops (D_{SC})

$$D_{SC} = \text{Production loss X Market wholesale price}$$

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 trees totally destroyed X Average Replanting Cost

3. Damages to Livestock (D_L)

$$D_L = \text{(Number of dead animals X Respective values}$$

Total Damages = $D_A + D_C + D_L$

Step 3: Estimate losses

Losses represent the value of lost output or income and have an impact on economic flows. Macroeconomic effects can result from losses that continue for years after a disaster occurs, up until the point at which production returns to its pre-disaster level.

Agricultural losses include:

a. Lost investments or increased production costs;

b. Lost revenue or production losses and

c. Extra costs associated with clearing debris.

Investment loss is a significant kind of loss in agriculture. The amount invested in the lost crops will be regarded as a loss rather than the value of the anticipated production in the event that a calamity completely destroys the standing crops and the farmers are unable to replant. Production losses in agriculture are a significant kind of loss as well. Production loss is the expected cost of the reduced harvest as a result of the disaster. This will be the anticipated yield prior to the tragedy less the estimated yield (if any) following it.

The additional costs incurred for asset recovery, waste cleanup, etc. are the third category of losses in agriculture.

The losses component of this study just addresses crop losses. Both losses from entirely destroyed and losses from partially destroyed perennial crops are included in the category of losses from perennial crops. Distinct attention in assessment is necessary for losses resulting from seasonal and perennial crops. Therefore, among the losses in the study are:

1.Losses from Seasonal Crops (L_{SC})

$L_{SC} =$ **Production loss + Higher production cost + Other Losses**

Where,

Production Loss = Expected Pre-disaster yield - Post-disaster Yield

The loss is regarded as being equal to an investment loss for seasonal crops that were completely destroyed at the harvest stage (costs involved in bringing the perished seasonal crops to that level when they got destroyed).

2. Losses from Perennial Crops (L_{PC})

a. Losses from Completely Destroyed Perennial Crops (L_{PC1})

$$L_{PC1} = \textbf{Production loss + Investment Loss}$$

The expenses paid to bring the completely destroyed crop to this point of destruction (including establishment and maintenance costs) are considered an investment loss in this case. With the understanding that the replanted crop will begin to yield in the following seven years, production loss is calculated using a method of discounting expenses and returns over the next seven years.

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

$$L_{PC2} = \textbf{Production loss X Market Wholesale Price}$$

Where,

Production Loss = Expected Pre-disaster yield - Realized Post-disaster Yield

Total Lossess = L_{SC} + L_{PC}

3. Losses from Fisheries

$$\textit{Total Loss } (L_P) = \textbf{Production loss + Higher production cost + Other Losses}$$

Where,

Production Loss = Expected Pre-disaster yield - Post-disaster Estimated Yield

Higher production costs result from the original investment made in the fingerlings before their destruction by the calamity and the additional cost incurred by the fish farmers if they restock in time for the harvest that year.

Step 4: Summarize the Losses and Damages

The anticipated losses and damages from steps two and three are tallied, and the overall impact of the disaster is calculated using direct summation. So,

Total Disaster Effect = $D_A + D_C + D_L$ $L_{SC} + L_{PC} + L_F$

The total damage and losses resulting from climate change events were assessed in the current study by extrapolating the damages and losses determined for a single farmer.

3.5.4 Non-Economic Losses and Damages (NELD)

Generally, different categories of non-economic losses and damages include

- Loss of Life
- Biodiversity/ ecosystem services
- Productive Land
- Loss of Traditional Knowledge
- Social Cohesion
- Identity/ Mobility
- Mental and physical Health

I. Loss of Life

Loss of life is an NELD since it violates the right to life.

II. Loss of Biodiversity and ecosystem services

Living beings have inherent value, and species have the right to exist; ecosystems provide a variety of functions, including food and water, aesthetics, culturally valued goods, and regulatory services.

III. Loss of Traditional Knowledge

Traditional knowledge can be truly unique and have practical, cultural, and societal significance.

IV. Loss of Social Cohesion

Cooperation, human security, and peace are all dependent on social cohesion. Therefore, loss of social cohesion is considered as NELD.

V. Loss of Identity/Mobility

Identity/home is linked to the concepts of knowing and belonging, and it provides orientation and freedom. Hence it is defined as an NELD.

VI. Loss of Mental/ Physical Health

Loss of physical and mental health is considered as the loss of core values and basic huma rights.

Institutions like IIED (International Institute for Environment and Development) have suggested using qualitative methods to analyse non-economic losses and damages at a community level since there is unavailability of proper reliable methodologies to evaluate non-economic losses. For this study, after the pilot survey, four important indicators were selected that were specific to Meenangadi Panchayat (loss of traditional knowledge, loss of mental health, loss of biodiversity and loss of identity) the respondents were asked to rank them based on the severity of the non-economic losses and damages that they experienced. This data was then analysed using Garrett's Ranking Method.

3.5.4.(a) Garrett Ranking Method

The Garret ranking technique was used to rank the major non-economic impacts of climate change that the farmers face in Agriculture, which were identified initially through a literature review and pilot survey. Farmers were asked to rank the challenges in terms of how important they were to them. The following Garrett's ranking approach formula was used to quantify the rankings provided:

$$\textbf{Percentage position} = \frac{(R_{ij}-0.5)}{N_j}$$

Where

R_{ij} represents the rank of an i^{th} factor given by j^{th} individual

N_j represents the number of factors ranked by j^{th} individual

After determining the per cent positions, they were transformed into scores on a scale of 100 using the table provided by Garret and Woodworth (1969). The mean score of each risk was then calculated from the above score, and they were ordered appropriately.

3.4.5 Limitations of the Study

Data was gathered through personal interviews with a set of sample respondents from different wards of Meenangadi Panchayat. Hence, the results obtained may contain recall bias. However, extra efforts were made during the design of the interview schedule to avoid recollection bias by employing cross-check questions. Furthermore, the data acquired is exclusive to the Meenangadi Panchayat. As a result, while extending the conclusions of this study, utmost caution should be exercised.

FINDINGS OF THE STUDY

The methodological approach outlined in the previous chapter was used to analyse the primary and secondary data that were gathered for the study. Estimating the economic losses and damages as well as comprehending the non-economic losses and damages that climate change is causing to farmers in Meenangadi was the primary goal of the study. Finding significant results and deriving practical conclusions required the application of the analytical techniques covered in the methodology chapter. This chapter explains the conclusions drawn from the examination of primary and secondary data, as well as their interpretations.

4.1 Shifts in area, production and productivity of different crops in Wayanad

The shifts in area, production and productivity of selected major crops like Rice, Coffee, Pepper, Arecanut, Banana, Cardamom, Rubber, Coconut and Tea in Wayanad were estimated using CAGR. The years 1981 through 2022 were the time frame used to compute the CAGR. The years under consideration were split into four sub-periods for computation: 1981-1990, 1991-2000, 2001-2010, and 2011-2022.

4.1.1 Compound Annual Growth Rate in the Area of Selected Crops in Wayanad District

The table shows the change in the growth of nine selected crops in the Wayanad district. The only crop that demonstrated positive growth throughout the four sub-periods was arecanut. The only crop, however, to have a negative CAGR throughout all four sub-periods was paddy. During the third sub-period (2000-2001 to 2009-2010), six out of the nine crops selected were found to be declining in terms of area. This district had about 30,000 hectares of paddy fields in 1980. In 2001, this was downsized to just 7000 hectares. One potential explanation for the decline in the area used for paddy agriculture is the widespread conversion of wetlands and paddy fields into dry areas for construction and dry land cultivation. The years of the district's greatest agrarian crisis fell within this sub-period. A key contributing cause to the anguish was the emergence of crop disease and the frequency of drought conditions (George, Jose, and P. Krishnaprasad, 2006). Due to crop disease and drought in recent years, the district has seen a reduction in pepper planting of 31,157 hectares during the past 15 years. Over time, the farmed cardamom area had shrunk to one-fourth of its former size (Department of Economics and Statistics, 2021). Crops like Paddy, Black pepper, Cardamom, Banana and Coconut reported a negative growth rate in the area under cultivation during the last two sub-periods.

Table 4.1: Compound Annual Growth Rate (CAGR) in the area of selected major crops in Wayanad (per cent per annum- from 1981-2022)

Sl. No	Major Crops	1981- 82 to 1989-1990	1990-91 to 1999-2000	2000-2001 to 2009-2010	2010-2011 to 2021-2022
1	Paddy	-0.0435	-0.0178	-0.0158	-3.222
2	Coffee	0.0245	0.0139	-0.0003	0.0502
3	Black Pepper	0.1541	0.0599	-0.1049	-0.6149
4	Arecanut	0.006	0.1438	0.0675	0.5914
5	Banana	0.0898	0.1952	-0.0079	-1.2937
6	Cardamom	0.0162	-0.0063	-0.0001	-0.0377
7	Rubber	-0.1994	0.0348	0.047	6.3697
8	Coconut	0.017	0.1024	-0.0083	-0.228
9	Tea	0.0283	0.0132	-0.0328	1.66831

Source: Department of Economics and Statistics, Government of Kerala

4.1.2 Compound Annual Growth Rate in the Production of Selected Crops in Wayanad District

The CAGR in the production of eight different crops grown in Wayanad is shown in Table. Of all the eight crops, Coconut was the only crop with a positive growth rate in production throughout all the four sub-periods. Although there was an increase in the area under rubber cultivation, the production showed a declining growth rate. Furthermore, despite the negative growth rate in the area under pepper cultivation, the production of Pepper shows an increasing trend. Bananas, which had a positive growth rate in the first three sub-periods, had a decline in growth rate during the last sub-period. One potential reason for this decline could be the floods in 2018 and other extreme climate events that took place in the last sub-period. Arecanut, despite having a positive growth rate in the area in all the sub-periods, had a decreasing growth rate in production. Due to an increase in illnesses such as fruit rot, also known as Mahali, bud rot, and yellow leaf disease, as well as adverse weather occurrences, production has decreased by more than 70 per cent in 2022 (The Hindu, 2022)

Table 4.2 Compound Annual Growth Rate (CAGR) in the production of selected major crops in Wayanad (per cent per annum- from 1981-2022)

Sl. No	Major Crops	1981- 82 to 1989-1990	1990-91 to 1999-2000	2000-2001 to 2009-2010	2010-2011 to 2021-2022
1	Paddy	-0.0307	0.0072	-0.0021	-1.892
2	Coffee	-0.0606	0.1298	-0.0174	0.072
3	Black Pepper	0.1464	0.0963	-0.1424	3.4657
4	Arecanut	0.0844	0.0805	0.0798	-0.7066
5	Banana	0.0877	0.1548	0.0065	-0.0749
6	Cardamom	-0.0078	-0.0009	0.0461	-5.0046
7	Rubber	-0.1958	0.0469	0.0873	-4.0471
8	Coconut	0.0283	0.1819	0.0075	1.4135
9	Tea	0.0283	0.0132	-0.0328	0.332788

Source: Department of Economics and Statistics, Government of Kerala

4.1.3 Compound Annual Growth Rate (CAGR) in the productivity of selected major crops in Wayanad

The Compound Annual Growth Rate in productivity of selected major crops in Wayanad is given in Table. Paddy and Coconut are the only crops to have positive growth rates in all the four sub-periods. A positive compound annual growth rate (CAGR) in coconut and paddy productivity overall decades indicated that any productive steps adopted to enhance the acreage under crop may produce beneficial outcomes. Although the area used for rubber cultivation has increased, the productivity of the crop has plummeted. It was noted that while the productivity of certain crops improved in the third sub-period, it declined in the fourth. These crops included rubber, arecanut, and cardamom. This suggests that better policies should be implemented to improve the productivity of the mentioned crops.

Table 4.3 Compound Annual Growth Rate (CAGR) in the productivity of selected major crops in Wayanad (per cent per annum- from 1981-2022)

Sl. No	Major Crops	1981- 82 to 1989-1990	1990-91 to 1999-2000	2000-2001 to 2009-2010	2020-2011 to 2021-2022
1	Paddy	0.0134	0.0254	0.0139	3.1977
2	Coffee	-0.083	0.1144	-0.0171	0.0222
3	Black Pepper	-0.0067	0.0344	-0.0419	4.1069
4	Arecanut	0.0779	-0.0553	0.0115	-1.3155
5	Banana	-0.0067	0.0344	-0.0419	1.2347
6	Cardamom	-0.0237	0.0055	0.0461	-4.9687
7	Rubber	0.0044	0.0117	0.0385	-9.7931
8	Coconut	0.0111	0.0721	0.016	2.2728
9	Tea	0.029	0.0107	-0.0382	-1.3313

Source: Department of Economics and Statistics, Government of Kerala

The two graphs given below could assist in illustrating how serious the agricultural collapse in Wayanad is.

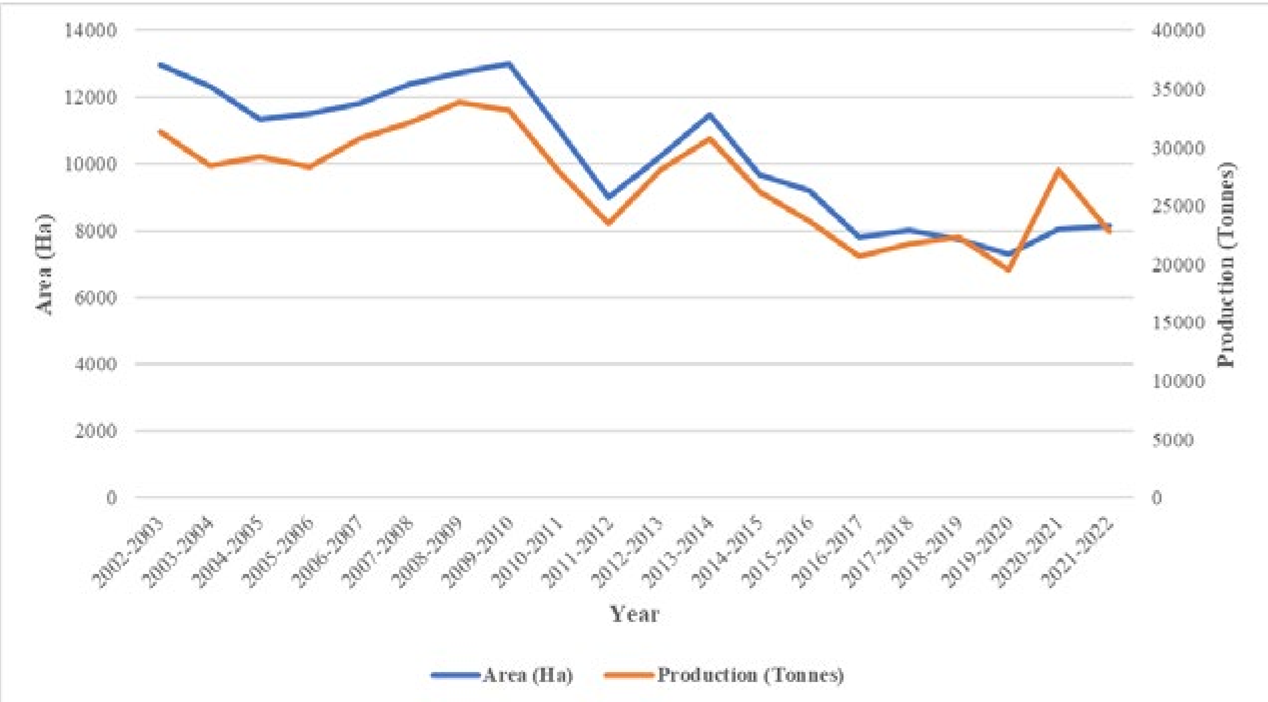

Figure 4.1 Trend of Area and Production of Rice in Wayanad (2002-2022)

Source: Department of Economics and Statistics, Government of Kerala

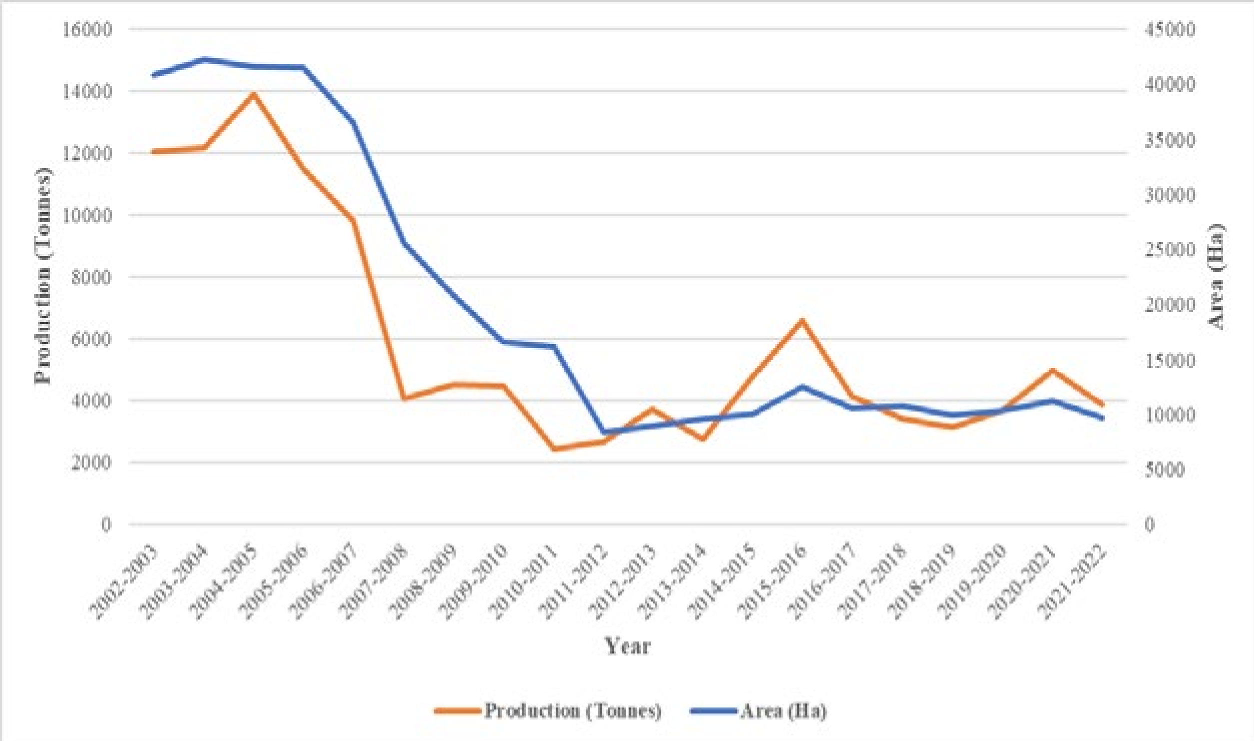

Figure 4.2 Trend of Area and Production of Black Pepper in Wayanad District (2002-2022)

Source: Department of Economics and Statistics, Government of Kerala.

4.2 Economic Losses and Damages to Farmers Caused by Climate Change (ELD) in Meenangadi Panchayath

4.2.1 Socio-Economic Characteristics of Farmers Interviewed

An individual's or a group's socioeconomic status is their place on the socioeconomic scale. It is based on a variety of social and economic factors, including their income, their type and level of education, their type and prestige of occupation, and where they live among others. The socio-economic status of the respondents like their gender, age, size of the family, size of farm holding, education, primary occupation, annual income and their experience in farming are furnished in Table 4.4.

4.2.1.1 Distribution of Farmers Based on Gender

Men made up the majority of the farmers that answered the survey. Of the respondents, women made up only approximately 21 per cent. The data indicates that males engage in farming activities at a higher rate than women. However, it is important to remember that women do contribute to farming activities in some capacity.

4.2.1.2 Distribution of Farmers Based on Age

A fair share of respondents (77 per cent) were above 50 years of age. The majority of survey participants fell into the 51–60 age group, followed by the 61–70 age category. The relatively low percentage of young responses suggests that there is a high aversion among youngsters to choosing agriculture as a career. Further details on the distribution of farmers based on their age are presented in the following figure.

4.2.1.3 Distribution of Farmers Based on the Size of Family

Most of the farmers who participated in the survey had nuclear families. About 72 per cent of the respondents had a four-member family. Only about eight per cent of the respondents had more than four members in their family.

4.2.1.4 Distribution of Farmers Based on Land Holdings

A lion's share of farmers in Meenangadi were marginal and small farmers. About 43 per cent of the respondents were marginal farmers and 43 per cent of the respondents were small farmers. In total, about 79.16 per cent of the farmers had a land holding of less than 2 hectares.

Table 4.4: Socio-economic Profile of the Respondent Farmers in Meenangadi

Sl. No	Particulars	Values
1	**Gender**	
a	Male	99 (82.5)
b	Female	21 (17.5)
2	**Age**	
a	30-40 years	7 (5.83)
b	41-50 years	20 (16.66)
c	51-60 years	40 (33.33)
d	61-70 years	38 (31.66)
e	>70 years	15 (12.5)
3	**Family Size**	
a	2 members	7 (5.83)
b	3 members	31 (25.83)
c	4 members	72 (60.00)
d	>4 members	10 (8.33)

Sl. No	Particulars	Values
4	**Land Holding**	
a	Marginal (0-1 Hectare)	52 (43.33)
b	Small (1-2 Hectares)	43 (35.83)
c	Medium (2-4 Hectares)	21 (17.5)
d	Semi- Medium (4-10 Hectares)	4 (3.33)
5	**Primary Occupation**	
a	Agriculture	107(89.16)
b	Others	13 (10.83)
6	**Education**	
a	<SSLC	24 (20)
b	SSLC	38 (31.66)
c	Higher Secondary	43 (35.83)
d	Graduation	13 (10.83)
e	Post-Graduation	2 (1.66)
7	**Annual Income (₹)**	
a	<2,00,000	30 (25)
b	2,00,000-4,00,000	62 (51.66)
c	4,00,000-10,00,000	23 (19.16)
d	>10,00,000	5 (4.16)
8	**Experience in Farming**	
a	10-20 Years	3(2.5)
b	21-30 Years	16(13.33)
c	31-40 Years	43(35.83)
d	> 40 Years	58(48.33)

Total Sample = 120
Figures in parentheses represent the percentage of the sample population

4.2.1.5 Distribution of Respondents Based on Occupation

The majority of people (about 89.7 per cent) who took part in the survey had agriculture as their primary source of income. Approximately 10 per cent of the participants in the survey earn their primary income from other sources, with agriculture serving as their secondary source.

4.2.1.6 Distribution of Respondents Based on Education

About one-third of the respondent farmers had a higher secondary level education while 31 per cent of the respondents had an SSLC level of education. About 11 per cent of the farmers were graduates and 2 per cent of the respondents were post-graduates.

4.2.1.7 Distribution of Respondents Based on Annual Income

The majority of the respondents in Meenangadi who took part in the survey were marginal and small farmers. These farmers raised livestock as well as crops to supplement their income. About 62 per cent of the respondent farmers had income ranging from Rs. 2,00,000-4,00,00 per year. About 4 per cent of the farmers had an income of more than 10,00,000 while 30 per cent of the farmers make less than 2,00,000 and 23 per cent of the farmers have an income level of 4 to 10 lakhs per annum.

4.2.1.8 Distribution of Respondents Based on Experience

Approximately 50 per cent of the population that took part in the survey had more than 40 years of experience, and the majority of these people had been farmers since their early years. Farmers with less than 20 years of experience made up only 2.5 per cent of the respondents.

4.2.2 Extreme Climate Events in Meenangadi and Their Impacts On Agriculture

Meenangadi, the first carbon-neutral Panchayat of Wayanad is no exception to experiencing the devastating impacts of climate change. Being an agrarian region, Meenangadi has witnessed it all; agriculture flourishing in its golden glory to the crops being destroyed by the negative impacts of Agriculture. Meenangadi has been witnessing the negative impacts of climate change on its farming sector for quite some time now and it got worse in 2018 when the panchayat was hit by the catastrophic floods that wrecked various districts of Kerala. Crops were destroyed, cattle sheds, irrigation pumps and farm assets were damaged, and fish grown on farms were washed away. It was so destructive that it took a toll on the lives of farmers. Before the farmers could heal from the destruction that the 2018 floods caused them, they were hit by another flood in 2019. This added to their misery and it took a while for them to recover from these extreme climate events. Due to their uncertainty about the earnings from agriculture, farmers' interest in continuing farming was gradually fading.

This section of the study examined in detail the economic losses and damages (ELD) resulting from severe climate events as well as other related phenomena. The FAO-recommended approach was utilised to quantify the losses and damages resulting from extreme climate factors in the agriculture sector with suitable modifications as done in a study conducted by KAU, 2020 to assess the losses to agriculture due to the 2018 floods to farm households in the flood plains of Chalakudy.

This study attempted to examine how climate change affected Meenangadi over four agricultural years and caused losses and damages to livestock, agricultural assets, fishery, perennial crops and seasonal crops beginning with the first flood in 2018–19 and ending in 2021–2022. The average value of the disaster effect per family is indicated by mean values throughout this section.

Table 4.5: Major Climate Change Events in Meenangadi during the Years Considered

Sl. No	Year	Climate Change Event
1	2018-2019	Flood
2	2019-2020	Flood
3	2020-2021	Erratic rainfall and rise in temperature
4	2021-2022	Erratic rainfall and rise in temperature

Source: Compiled from agricultural reports and field survey

The major climate event that occurred in Meenangadi during the years considered, was flood. Two catastrophic floods hit the farms of Meenangadi Panchayath in 2018 and 2019 in August causing considerable losses and damages to Agriculture and subsidiary sectors. After these floods, in 2020-2021 and 2021-2022, the weather patterns were unusual, as farmers reported that they did not get the right amount of rainfall at the right time. There was an uneven distribution of rainfall. It was either meagre rainfall throughout the year or too much rainfall downpouring within a few days. Both of these conditions were fatal to the crops thereby affecting the farming community of Meenangadi in a bad way. The farmers pointed out that the yield of the major cash crops in Meenangadi significantly declined as a result of the unusual weather patterns. The farmers also reported to have had a drastic increase in temperature in the years considered.

4.2.3 Losses and Damages to Agricultural Implements and Other Assets

The floods in 2018 and 2019 caused damage to agricultural assets and implements. The affected assets included animal shelters or sheds, agricultural tools, implements, irrigation pumps and motor sheds. The losses and damages ranged from slight damages to the total collapse of agricultural assets and implements. The aggregate amount of losses and damages from agricultural assets to the sample population selected was Rs. 80,000 in 2018 whereas in 2019 it was Rs 37,000. The following years did not cause any significant losses or damages to agricultural assets in Meenangadi Panchayat.

4.2.4 Damages to Livestock and Poultry

The farmers in Meenangadi consider livestock as an integral part of their livelihood. About 70 per cent of the farmers who participated in the survey had some kind of livestock in their household.

These livestock significantly included cattle, goats and buffaloes, along with pigs, quails and ducks.

Farmers who owned cows, goats and buffaloes sold their milk and meat to earn subsidiary income. On the other hand, most poultry farmers used the eggs for household consumption while only a handful sold eggs in the market.

Farmers who owned pigs revealed that pig farming was a great way to diversify farmers' income and thus build risk-bearing ability among farmers against extreme climate events. A farmer who had pig farming as a significant source of income revealed that he had 130 pigs which were estimated to yield around Rs. 5,00,000 per annum which was an excellent source of subsidiary income.

The major life damage to livestock was due to floods. Two cows were killed in the floods of 2018 in Meenangadi Panchayath as reported by the respondents of the survey. The damages to livestock due to climate change were estimated to be around Rs 80,000 for the sample population considered. There was no damage to livestock reported by farmers in the floods of 2019. Increasing temperatures and erratic rainfall did not seem to cause damage to livestock in the region during 2020-2021 and 2021- 2022.

The one major problem with possession of livestock in a hill station like Wayanad, which has a significant share of its area under forests, was the attack of wild animals like tigers. 18 per cent of the respondents revealed that there was an occasional wild animal attack in their locality.

4.2.4 Losses from Fishery

Farmers in Meenanagadi cultivated fish in ponds to earn a subsidiary income. The major varieties of fish grown on their farms included tilapia and grass carp. Cultivation of fish earned them an annual income of up to a sum of Rs 5,00,000. In most of the farms, the locals went fishing, weighed their catch, and bought it from the farmer. They were also used for consumption in farmers' households and sometimes sold in Markets. During the floods of 2018 and 2019, a part of fishes grown in some farms was washed away causing an aggregate loss of about Rs 2,75,000 per year.

Figure 4.3 Tilapia- A common type of fish reared in Meenangadi

4.2.5 Losses and Damages from Perennial Crops

In Meenangadi Panchayath, an extensive range of perennial crops are grown. Among the most prominent perennial crops farmed in Meenangadi are Coffee, Cocoa, Avocado, Cashew, Arecanut, Black Pepper, Cardamom, Vanilla, Nutmeg, and Coconut. Additionally, they cultivate Mango, Mahogany, Jack, and Eeti trees. Like in other regions of Wayanad, mixed farming is practised by the farmers in Meenangadi. The varieties of major perennial crops grown in Meenangadi are given in Table 4.6.

Table 4.6 Major Perennial Crops Grown in Meenangadi and their Varieties

Sl. No	Major Perennial Crops	Common Varieties
1	Black Pepper	*Karimunda, Panniyoor 1, Panniyoor 3, Panniyoor 5*
2	Coffee	Robusta, Arabica, *Chandragiri,* CXR
3	Coconut	*Kutyadi,* TXD
4	Arecanut	*Kasargodan, Mangala*

Source: Primary Survey

The perennial crops that underwent significant losses and damages in 2018 and 2019 floods are Black Pepper, Coconut, Arecanut, Rubber, Nutmeg, and Cardamom. The losses and damages incurred by these crops are compared in Table 4.7.

Table 4.7 Total Losses and Damages incurred by Perennial Crops Caused by Floods in Meenangadi in 2018 and 2019

Sl. No	Crops	Total Losses and Damages (₹)	
		2018-19	2019-20
1	Rubber	13,17,214	1,94,833
2	Coconut	3,90,156	3,31,656
3	Arecanut	4,48,331	2,73,262
4	Coffee	3,11,920	1,37,086
5	Pepper	30,10,394	27,20,594
6	Nutmeg	2,81,358	3,12,287
7	Cardamom	10,49,130	16,38,880

Sample n= 120, *Source: Primary Survey*

The crop that incurred the most amount of losses and damages in the floods of 2018 and 2019 was Black Pepper followed by Cardamom. The aggregate amount of losses and damages in 2018 to Pepper was about Rs. 30,10,394 while in 2019 it was Rs 27,20,594. The aggregate amount of losses and damages to Arecanut was Rs. 4,48,331 in 2019 it was 2,73,262. The aggregate amount of losses and damages to nutmeg were Rs. 2,81,358 in 2018 and Rs 3,12,287 in 2019 respectively. A comparison of these losses and damages is given in Figure 4.4.

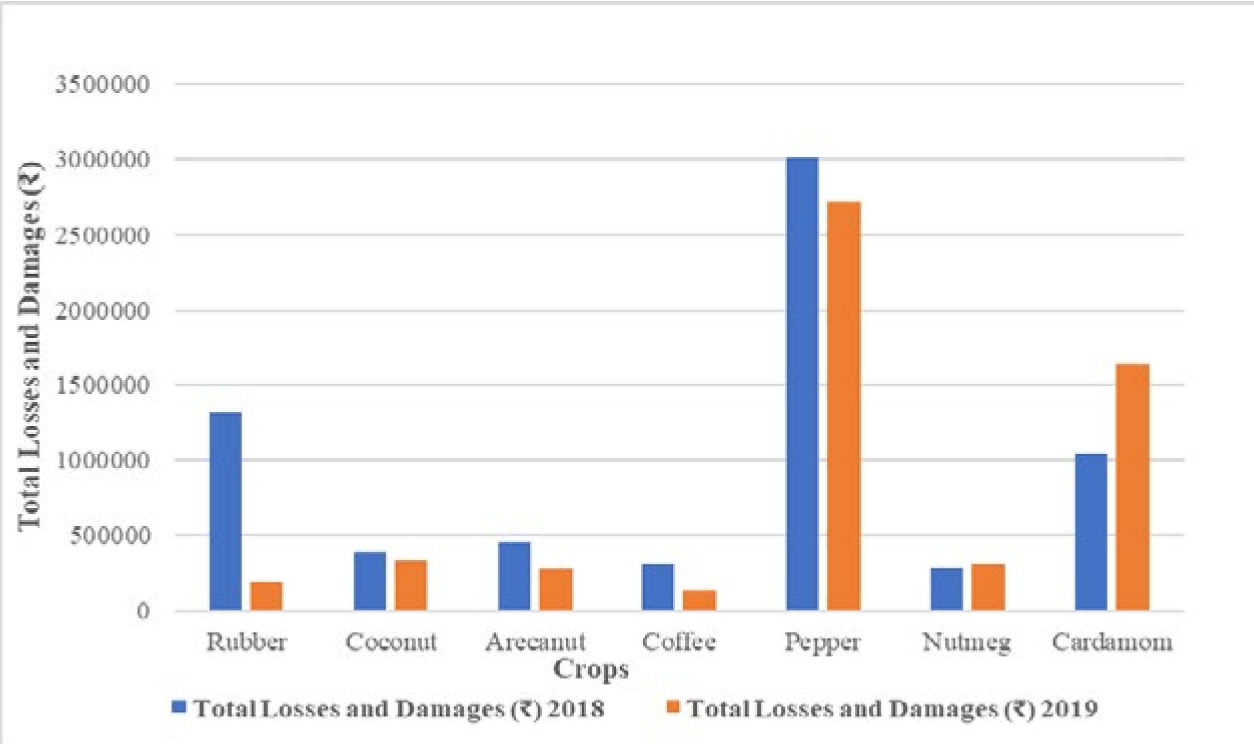

Figure 4.4 Comparison of the Total Losses and Damages Incurred by Perennial Crops during the Floods in 2018 and 2019

Table 4.8 Losses and Damages to Perennial Crops in 2020-2021 and 2021-2022

Sl. No	Crops	Losses and Damages (Rs)	
		2020-2021	2021-22
1	Coffee	57,358	16,587
2	Pepper	5,51,069	6,42,642
3	Nutmeg	1,37,010	87,564
4	Cardamom	262780	738548
5	Arecanut	88932	98452

Source: Primary Data

Like the losses and damages illustrated for perennial crops in 2018-2019 and 2019-2020, Black Pepper was the most affected followed by Cardamom, Nutmeg, Coffee and Arecanut. Almost every farmer grows pepper in their farms indicating the significance of pepper in the agriculture sector of Wayanad. *Karimunda, Panniyoor 1* and *Panniyoor 3* were some of the widely grown pepper varieties in Meenangadi.

Figure 4.5 Mr T K Thomas, in his farmland (Kakkavayal)

Most of the respondents had an opinion that the yield of Black Pepper showed a declining trend for a few years. Thomas T K, a respondent who cultivated Black pepper for almost 30 years in Meenangadi said that the yield of Black pepper has reduced to one-third of what it was 10 years ago. A few years ago, he used to get about 3 Quintals from 100 vines of pepper but last year he got a yield of only 20 kilos. He also added that this year (in 2023) the yield would be much lower due to the absence of *Karkidaka Mazha* and quick wilt.

Figure 4.6 Coffee Wilt

The other important crop grown in Meenangadi is Coffee. Erratic rainfall affected the yield of coffee greatly. Kanaran, a farmer who had an experience of 40 years in farming revealed that not receiving rain at the right time and receiving excessive rainfall at the wrong time has affected the pollination of coffee significantly. He also added that a large amount of coffee beans dropped off from the coffee plants on his farms last year as unexpected heavy rains occurred when the coffee beans were mature and almost ready to harvest.

4.2.5.(a) Increase in Drying or Wilting in Crops due to Extreme Climate Patterns

Figure 4.7 Cocoa Wilt

Field survey showcased extensive drying of coffee berries (wilting) which contributed to a significant quantity of losses in Coffee. Some respondents had an opinion that repetitive occurrence of floods resulted in the removal of the top layer of soil which might have caused widespread drying of coffee berries. Research has proven that higher temperature has a significant role in increasing the severity of the wilting disease. Wilt not only occurs in coffee, it affects crops like pepper and Cocoa. There is also a considerable decrease in the number of Arecanut plants in the respondents' farm. Most of the Arecanut trees in their farm had no crown and the trees were left with just their trunks. This was due to Mahali disease. Mahali or the fruit rot is also known to get severe depending upon the pattern of rain. Uneven rain patterns and intermittent high sunshine hours aided in increasing the disease outbreak and spread. This was one of the major concerns of the farmers in Meenangadi Panchayath. Some farmers said that the outbreak of Mahali had increased several fold after floods. According to them, the loss of crowns due to this disease appeared so evidently initially in the Vythiri region of Wayanad initially, after which it spread to almost all regions in Wayanad. This was a major concern revealed by farmers and they said that they weren't able to get proper yields from Arecanut and sold the tree trunks to get at least some kind of income.

Figure 4.8 Quick Wilt in Pepper

Figure 4.9 Mahali in Arecanut

A few perennial crops like Jack and Mango were destroyed by lightning and thunder in Meenangadi Panchayath. As the wood struck by lightning did not fetch a good price, they were used as firewood at the farmers' home.

4.2.6 Losses and Damages to Seasonal Crops

The farmers in Meenangadi Panchayath also cultivated Paddy. The major rice varieties cultivated here were *Kunjanthondi, Chomala, Aathira* and *Valichoori.* The farmers here preferred hybrid rice varieties like *Jaya* for cultivation since the traditional varieties require more days to attain maturity and also they need a timely supply of water to survive and to give the best yield, fetching higher prices in the market. *Jeerakashala* and *Gandhakashala* are two premium-scented rice varieties Wayanad is well known for, whose area is constantly decreasing in Meenangadi according to the respondents. A fair share of farmers shared their concerns regarding the declining area under rice cultivation. The rice farmers in Meenangadi used to cultivate rice in two seasons (*Nanja* and *Punja*) in the past years but limited water availability forced farmers to cultivate paddy just for one season.

Other seasonal crops grown significantly by farmers in Meenangadi were Tapioca, Banana and Ginger. Ginger was sold both in fresh and dried forms while tapioca was mostly sold as fresh produce. Some farmers also cultivated vegetables in their home garden which were taken for household consumption.

Table 4.9 Seasonal Crops Cultivated by the Respondents and Their Varieties

Sl. No	Major Seasonal Crops	Common Varieties
1	Paddy	*Jaya, Aathira, Gandhakashala, Jeerakashala, Valichoo-ri, Kunjanthondi, Uma, Jyothi*
2	Ginger	*Maaran, Regodi, Calcutta, Varada*
3	Banana	*Njalipoovan, Nendran, Poovan*
4	Tapioca	*Ambakkadan*

Source: Primary Survey

The floods that occurred in 2018 and 2019 destroyed the banana cultivation in Meenangadi. To quote an example, the hope of a respondent farmer who had planted almost 2000 bananas in his field was shattered by the floods in 2018. The banana bunches which could have earned him a considerable amount of income were sold as second-quality bunches that yielded not even 10 per cent of what he had estimated.

The most affected seasonal crop in the floods of 2018-19 and 2019-20 was Banana. The total losses and damages incurred by the banana plants were Rs 58,99,180 in 2018-19 while it was 62,95,000 in 2019-20. The losses and damages incurred by tapioca were Rs 33,14,086 in 2018-19 and Rs 2835569 in 2019-20. The aggregate loss incurred by Paddy was Rs 4,67,860 in 2018-19 and Rs 7,95,594 in 2019-20. Ginger incurred a total loss and damage of about Rs. 26,03,000 in 2018-19 and Rs 28,91,000 in 2019-20.

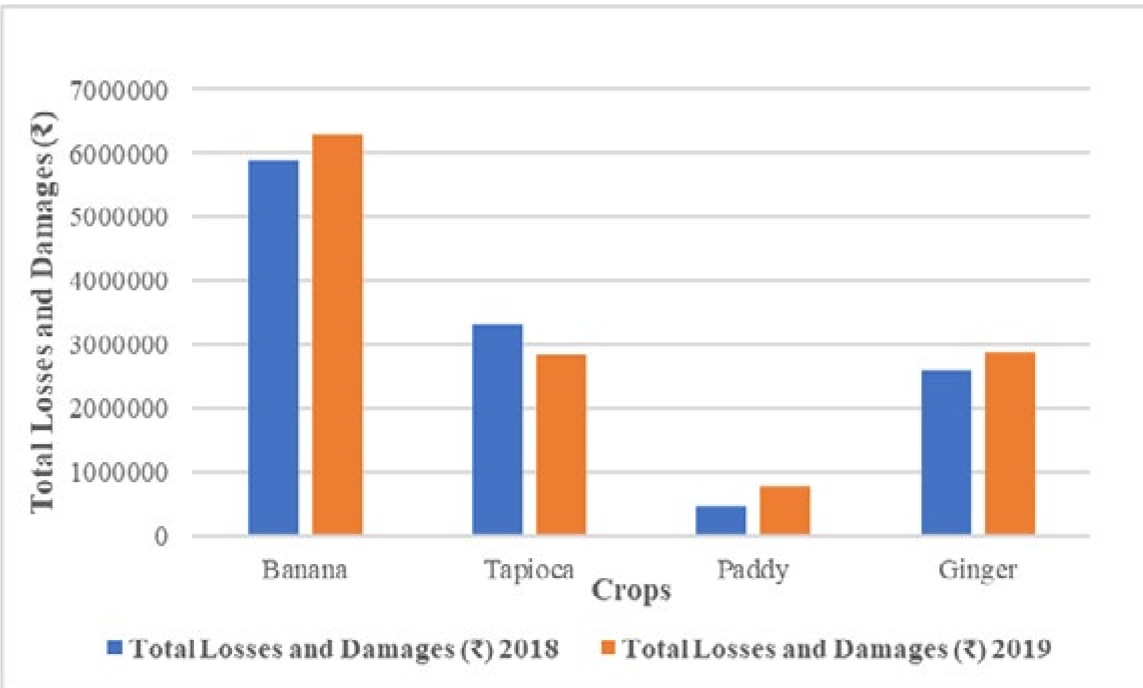

Figure 4.10 Comparison of Total Losses and Damages Incurred by Seasonal Crops in the Floods of 2018-2019 and 2019-2020

Number of Samples= 120, Source: Primary Data

Table 4.10 Losses and Damages Incurred by Major Seasonal Crops in 2020-2021 and 2021- 2022

S1 No	Crops	Losses and Damages (Rs)	
		2020-2021	2021-22
1	Paddy	4,32,118	3,49,140
2	Ginger	1,28,531	50,350
3	Banana	2,57,843	1,86,233

Source: Primary Data

The major crops that got damaged in 2020-2021 and 2021-2022 were Paddy, Banana and Ginger. Unavailability of water and having less facilities to store available water were the major reasons for the losses and damages. Unavailability of sufficient water also led to the reduction of yield in ginger. Since, the vegetables cultivated were lesser in area, the farmers could manage the irrigation of the vegetable crops with the water available at home.

Figure 4.11: Dry and Cracked Paddy fields due to Lack of Water

Picture Credit: Krishi Bhavan, Meenangadi

4.2.7 Total Economic Losses and Damages Incurred by Agriculture in Meenangadi during the Study Period

The total economic losses and damages incurred by all the agricultural sectors as a whole is represented in Table 4.11. The total losses and damages in 2018-2019, 2019-2020, 2020-2021, 2021-2022 were Rs 19527629, Rs 18462761, Rs 1915641 and Rs 2169516 respectively. From the table it is clear that the year with the most damage is 2018-2019 followed by 2019-2020, 2021-2022 and 2020-2021.

Table 4.11 Total Economic Losses and Damages Incurred by Agriculture in Meenangadi

Sl. No	Year	Total Damages and Losses (Rs)
1	2018-2019	19527629
2	2019-2020	18462761
3	2020-2021	1915641
4	2021-2022	2169516

Sample Respondents n= 120, Source: Primary Survey

4.3 Significant Non-economic Losses and Damages Brought in by Climate Change to Farmers

During the pilot survey, the sample farmers in Meenangadi were asked to identify the major non-economic losses and damages they experienced due to the extreme climate events that occurred in the past years. Based on their responses, a few non-economic losses and damages were listed in the questionnaire designed for the main questionnaire and the farmers were asked to rank these losses and damages that they had undergone. The major economic losses that took place in Meenangadi according to the respondents were loss of traditional knowledge, loss of identity, problems in mental health and the loss of biodiversity.

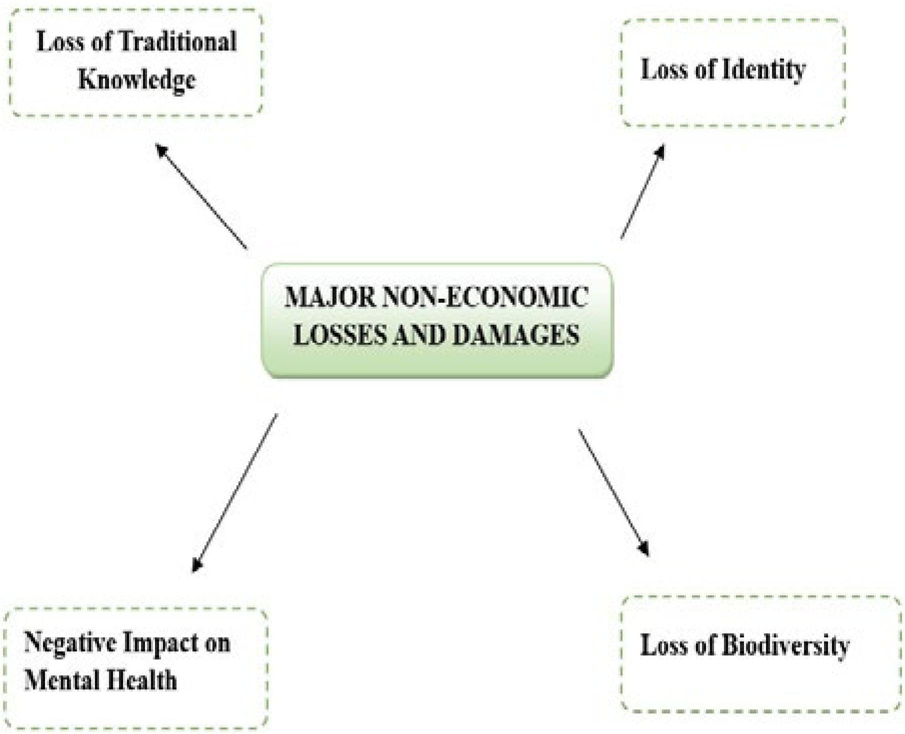

Figure 4.12 Major Non-Economic Losses and Damages Caused by Climate Change To Farmers

Source: Primary Survey

Table 4.12 Respondent Ranking of the major non-economic losses and damages in Meenangadi

SL. No	Major non-economic losses and damages	Ranking 1-4 based on the severity			
		1	2	3	4
1	Mental Health	24	20	31	45
2	Loss of Identity	26	34	40	20
3	Loss of Biodiversity	16	28	33	43
4	Loss of Traditional Knowledge	54	38	16	12

Source: Primary Data

Table 4.13: Per cent position and Garrett score

Rank	Formula	Per cent Position	Garrett Score
1	100*(1-0.5)/4	12.5	73
2	100*(2-0.5)/4	37.5	56
3	100*(3-0.5)/4	62.5	44
4	100*(4-0.5)/4	87.5	27

Source: Primary Data

Figure 4.13 Mr Sabu Oromali, in his Farmland (Kolagappara)

4.3.1 Ranking According to the Score Obtained from the Respondents

The four main non-economic losses that the farmers were able to explain were assigned final rankings based on the mean value that was found. Based on Garrett's Ranking technique, loss of traditional knowledge was the major non-economic loss associated with climate change extremes with a mean value of 59.15. Loss of identity was ranked second, with a mean score of 50.85 followed by mental ill-health and loss of bio-diversity with mean scores of 45.42 and 44.57 respectively.

Table 4.14 Ranking according to the score obtained by multiplying with Garrett value

Sl. No	Factors	Mean Value	Rank
1	Loss of Traditional Knowledge	59.15	I
2	Loss of Identity	50.85	II
3	Negative Impact on Mental Health	45.42	III
4	Loss of Biodiversity	44.57	IV

Source: Primary Data

4.3.2 Understanding the major non-economic losses and damages as explained by the respondents

4.3.2.1 Loss of Traditional Knowledge

The survey respondents prioritised the loss of traditional knowledge as the primary non-economic impact of climate change. The majority of survey participants expressed that they could no longer accurately anticipate the climate as they once could. They believe that Meenangadi, a region of Wayanad that was formerly renowned for its cold climate, has lost its charm. The monsoon is unpredictable and the temperature is higher. They also mentioned how irregular rainfall has impacted coffee pruning activities and negatively impacted the production of crops like pepper.

Figure 4.14 Mr. Paulose Thombrayil in his field (Manivayal)

Mr. Paulose Thombrayil, a farmer with more than 40 years of farming experience, said that he wasn't able to predict the monsoon and plan cultivation practices accordingly. He also felt that the traditional knowledge he had about climate patterns was gradually becoming irrelevant as the monsoon and temperature patterns were changing in Meenangadi and Wayanad as a whole. This also led to confusion regarding the sowing dates and other cultivation practices like pruning in Coffee.

4.3.2.2 Loss of Identity

Climate change has affected the respondents' sense of self as farmers. In the event that the erratic weather patterns continue, some farmers aren't even sure if they want to keep farming. Also, a majority of the farmers do not want their children to get into the farm due to the uncertainty.

4.3.2.3 Negative Impact on Mental Health

Climate change and its impact on agriculture had a toll on the mental health of farmers in Meenangadi. Uncertainty about weather conditions, climate patterns and the measures to tackle these complex situations have put them in a difficult situation. Most of the respondents were anxious about the difficulties that climate change could bring to them In crops like bananas, extreme climate events like floods resulted in the loss of produce, decrease in prices, increase in costs and damages in assets owned by the farmers. Significant problems with water supply were mentioned by a few small coffee growers. They claimed that it was challenging for them to obtain water to irrigate the coffee plants during periods of unpredictable rainfall. Big farmers on the other hand had installed sprinklers in their fields and it was a difficult task for small farmers to find water to irrigate their fields which potentially reduced the yield of coffee. Another issue that concerned the coffee farmers of Meenanagadi panchayath was the drying of coffee beans. A fair share of the expected coffee yield was substantially reduced due to the drying of coffee berries. In addition, some farmers expressed concern that the Mahali disease in Arecanut had become much more prevalent following the 2018 floods, drying up the majority of the farm's trees and that despite taking the necessary management steps, the illness was still harder to contain. A few farmers also reported that wild animals destroyed their farms and this was also an important factor that contributed to their mental ill-health. All these factors resulted in psychological stress for farmers.

4.3.2.4 Loss of biodiversity

The biodiversity of Wayanad has not been spared by climate change. Meenangadi's paddy farmers disclosed that the traditional kinds aren't being farmed as much as they once were due to the emergence of erratic weather patterns. Traditional cultivars including *Kunjanthondi, Chomala, and Valichoori* were frequently used until just a few years ago. Additionally, scented rice varieties like *Gandhakashala and Jeerakashala*, which were premium types and earned much greater prices, were widely cultivated by farmers in the past. But because of Meenangadi's unpredictable rainfall pattern, that isn't the situation these days. The farmers who responded also stressed how, just a few years ago, Meenangadi used to receive enough rainfall at the appropriate times, meaning they never had to worry about running out of water.

However, farmers these days are switching to hybrid cultivars, such as *Aswathy and Jaya*, which mature in a relatively shorter amount of time. They also mentioned that, as a result of the lack of water, they only grow paddy in their fields for a single season rather than the two that they formerly did. A few farmers brought up the fact that, despite occasionally experiencing intense downpours, they lack the infrastructure necessary to retain the water for use on their farms in the future.

Figure 4.15 Chomala and Jeerakashala, traditional rice varieties

Picture Credit: Anju Babu

CONCLUSION AND RECOMMENDATIONS

5.1 Information At a Glance

- The major crops grown in Meenangadi Panchayath are Coffee, Tea Black Pepper, Banana, Coconut, Arecanut, Tapioca, Rubber, Avocado, Turmeric, Ginger, Nutmeg and Cardamom.

- The only crop that demonstrated positive growth in area throughout the four sub-periods (1981-1990, 1991-2000, 2001-2010, 2011- 2022) was Arecanut. The only crop, however, to have a negative CAGR in area throughout all four sub-periods was Paddy.

- Coconut was the only crop with a positive growth rate in production throughout all the four sub-periods (1981-1990, 1991-2000, 2001-2010, 2011- 2022). The trend also showed that even though there was a decrease in area in Pepper, the production showed a declining trend.

- Paddy and Coconut are the only crops to have positive growth rates in productivity in all the four sub-periods considered (1981-1990, 1991-2000, 2001-2010, 2011- 2022).

- The major climate extreme events that occurred in the four years considered (2018-2019, 2019-2020, 2020-2021, 2021-2022) were floods, erratic rainfall and high temperatures. The economic losses and damages were found using the methodology suggested by FAO.

- The aggregate amount of economic losses and damages from agricultural assets to the sample population selected was Rs. 80,000 in 2018-2019 whereas in 2019-2020, it was Rs 37,000. The following years (2020-2021 and 2021-2022) did not cause any significant losses or damages to agricultural assets in Meenangadi.

- During the floods of 2018 and 2019, a part of fishes grown in some farms was washed away causing an aggregate loss of about Rs 2,75,000 per year.

- The most prominent perennial crops farmed in Meenangadi are Coffee, Cocoa, Avocado, Cashew, Arecanut, Black Pepper, Cardamom, Vanilla, Nutmeg, and Coconut. Additionally, they grow Mango, Mahogany, Jack, and Eeti trees in their farms.

- The total economic losses and damages to perennial crops in Meenangadi in 2018- 2019, 2019-2020, 2020-2021 and 2021-2022 were Rs 6808503, Rs 5608590, Rs 1097149 and Rs 1583793 respectively.

- The major seasonal crops in Meenangadi are Paddy, Tapioca, Ginger and Banana. Bananas were the most affected seasonal crop during floods. Some farmers also cultivated vegetables for household consumption.

- The total losses and damages to seasonal crops in Meenangadi in 2018- 2019, 2019-2020, 2020-2021 and 2021-2022 were Rs 1,22,84,126, Rs 1583793, Rs 8,18,492 and Rs 5,85,723 respectively.

- The total economic losses and damages from various sectors of agriculture in 2018- 2019, 2019-2020, 2020-2021 and 2021-2022 were Rs 19527629, Rs 18462761, Rs 1915641 and Rs 2169516 respectively. The year 2018-2019 had the most amount of losses and damages.

- The major non-economic losses and damages were ranked by the farmers as a result of which loss of traditional knowledge was ranked first, loss of identity was ranked second, losses to mental health and losses to biodiversity was ranked third and fourth with the help of Garrett's ranking.

5.2 Conclusion

Climate change has taken a toll on Meenangadi pachayat. Area under crop cultivation has reduced to one-third of what it used to be. Land under paddy cultivation is decreasing at a faster rate and the traditional varieties are on the point of extinction. If the same condition prevails, it would be hard to find paddy fields in a district that was once known for its paddy fields. Arecanut is one of the crops that's undergoing destruction at a faster rate. Significant number of Arecanut plants in the panchayat do not have crowns and inflorescence. They are just logs with no yield. Most of the farmers feel that this phenomenon has increased since the incidence of floods in 2018 and they have no idea about what can be done to rectify the situation. Most of the crops that one used to rule the farming lands are now facing a decrease in yield and area. Destruction of farm lands by converting them to construction sites has also destroyed agriculture. Hence, it is important to take necessary measures to reduce the negative impacts of climate change on agriculture.

5.3 Recommendations

It is important to adopt new practices that would help in reducing the impacts of agriculture.

- **Better Institutional Support**

Better institutional support could be given to farmers to help them reduce the negative impacts of climate change. The government bodies like Coffee Board had organised training programs in Meenangadi panchayat. Meenangadi Panchayath and Krishi Bhavan together organised programmes for farmers day to motivate farmers and to appreciate them for their efforts in agriculture. However, with a little more help, the farmers may overcome their current issues. For instance, farmers in Meenangadi feel that the wilting and drying in several crops have been increasing after floods. Furthermore, the Mahali disease in Arecanut was also in an upward trend. Since they are unaware of effective management techniques that could stop Mahali from spreading throughout Arecanut, they believe that government support is crucial. Hence, providing better training could improve the yield and income from arecanut and other crops. Other organisations like NGOs could also join hands together with Meenangadi Panchayath to provide training to farmers.

- **Better Marketing of Avocado**

In Meenangadi almost all houses have avocado trees that yield a good amount of Avocado per tree per annum. It's clear, though, that these fruits are not being used to their maximum potential and could be a great source of revenue for farmers. It's a loss, definitely. Research could be conducted to explore the possibility of establishing an avocado processing factory in Meenangadi Panchayath in order to fully realise this potential. Avocados that are wasted might be effectively reduced by using this, which can also be a great source of cash for the farmers. It's a good notion to look for effective marketing techniques that could aid in achieving the potential of this crop in the event that a processing facility is not feasible.

- **Giving importance to subsidiary and allied sectors of Agriculture**

Although farmers in Meenangadi follow mixed farming and most of them rear animals as a secondary source of income. Hence, they have a better understanding of having subsidiary sources of income. However, extensive adoption of high- income yielding subsidiary practices like pig farming and fish rearing etc can help farmers to get more income. More farmers should be encouraged to take up pig farming and fish cultivation if they have enough resources. The government could also give assistance and motivate them to start such farming practices.

- **Insuring the Crops**

As they go about their farming operations, farmers frequently overlook crop insurance. It is high time to educate the farmers on the positive sides of insuring crops. Motivating farmers to insure their crops and making sure that they have insured their crops could help to build risk- bearing ability among farmers.

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APPENDIX

Sources of Secondary Data with their time period

Sl. No	Particulars	Period	Sources
1	Area, Production and Productivity of Crops in Wayanad District	1981-82 to 2021-2022	Directorate of Economics and Statistics, Government of Kerala and other miscellaneous sources
2	Prices of Major Agricultural Crops	2017-2022	Directorate of Economics and Statistics, Government of Kerala.
3	Rainfall Data of Wayanad District	1982-2021	Thomas, K. S. "Risk analysis of agricultural economy of Wayanad." PhD diss., Department of Agricultural Economics, College of Horticulture, Vellanikkara, 2020.
4	Temperature Data of Wayanad District	2017-2022	Regional Agricultural Research Station, Ambalavayal, Wayanad

GARRETT RANKING CONVERSION TABLE

Percent	Score	Percent	Score	Percent	Score
0.09	99	22.32	65	83.31	31
0.20	98	23.88	64	84.56	30
0.32	97	25.48	63	85.75	29
0.45	96	27.15	62	86.89	28
0.61	95	28.86	61	87.96	27
0.78	94	30.61	60	88.97	26
0.97	93	32.42	59	89.94	25
1.18	92	34.25	58	90.83	24
1.42	91	36.15	57	91.67	23
1.68	90	38.06	56	92.45	22
1.96	89	40.01	55	93.19	21
2.28	88	41.97	54	93.86	20
2.69	87	43.97	53	94.49	19
3.01	86	45.97	52	95.08	18
3.43	85	47.98	51	95.62	17
3.89	84	50.00	50	96.11	16
4.38	83	52.02	49	96.57	15
4.92	82	54.03	48	96.99	14
5.51	81	56.03	47	97.37	13
6.14	80	58.03	46	97.72	12
6.81	79	59.99	45	98.04	11
7.55	78	61.94	44	98.32	10
8.33	77	63.85	43	98.58	9
9.17	76	65.75	42	98.82	8
10.06	75	67.48	41	99.03	7
11.03	74	69.39	40	99.22	6
12.04	73	71.14	39	99.39	5
13.11	72	72.85	38	99.55	4
14.25	71	74.52	37	99.68	3
15.44	70	76.12	36	99.80	2
16.69	69	77.68	35	99.91	1
18.01	68	79.17	34	100.00	0
19.39	67	80.61	33		
20.93	66	81.99	32		

DATA ON PRECIPITATION IN WAYANAD DISTRICT

Year	Precipitation(mm)
1983	1781.6
1984	2251.6
1985	1728.3
1986	1818.6
1987	1426.5
1988	1985.7
1989	1822.6
1990	1681.4
1991	1986.4
1992	2318.2
1993	2133.2
1994	2690.8
1995	2317.6
1996	1982.4
1997	2151.4
1998	1728.5
1999	1558.8
2000	1743.8
2001	1446.1
2002	1108.5

Year	Precipitation(mm)
2003	1520.6
2004	1899.8
2005	2168.2
2006	2047.8
2007	2023.2
2008	1731
2009	2077.4
2010	1851.8
2011	2069.4
2012	1320.8
2013	2247.4
2014	2151
2015	1689.9
2016	1229.8
2017	1780.6
2018	3093
2019	2654
2020	2098
2021	2441.7

INTERVIEW QUESTIONNAIRE

An empirical analysis of the losses incurred by farmers due to climate change: A case study in Meenangadi

a. Sample No:
b. Date of survey
c. District: Wayanad
d. Village:
e. Block:
f. Mobile:

1. General information

i. Name of the respondent:
ii. Age:
iii. Sex: Male/ Female
iv. Marital Status: Married/ Unmarried
v. Details of family:

Number of Adults:	Number of Children:
Number of Males:	Number of females:

vi. Educational status:

Uneducated	Primary	Higher Secondary	Degree	Post-graduation

vii. Size of land holding (Ha):

Marginal:	Small:	Medium:	Large:

viii. Experience in farming (Years):

0-5	5-10	10-15	15-20	>20

ix. Nature of farming:

Organic	Conventional

x. Sources of income (Rs/ Annum):

Income from farm:	Off-farm Income:	Non-farm income:

xi. Possession of livestock and poultry

Sl. No	Livestock owned	Units	By- products obtained	Income obtained (Rs/ annum)	Remarks
1	Cow				
2	Buffalo				
3	Goat/ Sheep				
4	Poultry				
5	Others (Specify)				

2. Incidence of extreme weather events in the past five years:

Sl. No	Type of extreme weather events	Year & frequency					
		(2021-2022)	(2020-2021)	(2019-2020)	(2018-2019)	(2017-2018)	Remarks
1	High Temperature						
2	Flood						
3	Drought						
4	Cyclone						
5	Unseasonal Rainfall						
6	Others (Specify)						

3. Crop Details

a. Paddy based cropping system

Sl. No	Year	Cropping pattern	Varieties grown	Area under cultivation (acres)	Damages caused due to extreme climate events, if any	Yield (Kg)	Income obtained (Rs)	Delays in sowing of second crop, if any and the reason	Losses incurred due to delayed sowing
1	2021-2022								
2	2020-2021								
3	2019-2020								
4	2018-2019								
5	2017-2018								

b. Mixed cropping system (Annual and perennial crops)

S. No	Year	Major crops grown	Variety	Number of plants grown	Extreme climate conditions, if any	Number of plants damaged	Associated losses incurred (Rs)	Yield obtained (Kg)	Income obtained (Rs/year)
1	2021-22								
2	2020-21								
3	2019-20								
4	2018-19								
5	2017-18								

4. Impact of climate change on timber in the past five years

Sl. No	Year	Name of the timber species grown	Name of the timber tree species affected	Climate events that caused the damage	Associated losses (Rs)	Compensation obtained from Government or other organisations, if any
1	2021-22					
2	2020-21					
3	2019-20					
4	2018-19					
5	2017-18					

5. Losses caused due to damages in farm assets, other structures and the associated costs

Sl. No	Year	Farm asset damaged	Extreme climate events that caused the damage	Losses incurred (Rs)	Measures taken to tackle the losses	Replacement costs (Rs)	Assistance from government or other organizations if any	Remarks
1	2021-22							
2	2020-21							
3	2019-20							
4	2018-19							
5	2017-18							

6. Irrigation

Sl. No	Year	Crop	Irrigation regime followed	Unavailability of irrigation water, if any and the reason	Were there any damages to irrigation pumps or canals due to natural calamities	Costs associated with repairing or replacing the damaged (Rs)	Remarks
1	2021-22						
2	2020-21						
3	2019-20						
4	2018-19						
5	2017-18						

7. Major losses caused by diseases and pests

Sl. No	Year	Crop	Major pests and diseases	Growth stage in which the plant gets affected	Has the incidence been increased due to climate change?	Associated losses (Kg)	Losses (Rs)	Compensations received, if any
1	2021-22							
2	2020-21							
3	2019-20							
4	2018-19							
5	2017-18							

8.Harvest

Sl. No	Year	Crop	Time of Harvest	Delay in harvest by extreme climatic conditions, if any	Did the delayed harvest have an impact on the second crop	Losses incurred (Kg)	Losses in-curred (Rs)	Remarks
1	2021-22							
2	2020-21							
3	2019-20							
4	2018-19							
5	2017-18							

9.Marketing

Sl. No	Year	Crop	Price ob-tained for the product (Rs/ Kg)	Did the extreme climatic conditions affect mar-keting of the prod-uct?	Did you experience distress sale?	Assistance received from organisations, if any	Remarks
1	2021-22						
2	2020-21						
3	2019-20						
4	2018-19						
5	2017-18						

10. Non- economic losses and damage

Sl. No	Parameter	Yes	No	Remarks
1	Loss of life			
2	Shift in crops cultivated			
3	Bio-diversity/ Ecosystem Services			
4	Productive land			
5	Knowledge			
6	Social Cohesion			
7	Identity/ mobility			
8	Mental & Physical health			

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