Kerala State Disaster Risk Financing Strategy

Design of parametric indices for financial transactions with focus on housing sector and Government Buildings

March 2025

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Acknowledgements

RMSI project team acknowledges the support and guidance provided by the CEO, RKI; Principal Secretary, Revenue, Disaster Management & Housing Department; Joint-Secretary and OSD, Finance; Deputy CEO, RKI; Additional Secretary, RKI; and Dr. Sekhar Lukose Kuriakose, Member Secretary, KSDMA.

We also extend our sincere gratitude to Dr. Krishna Vatsa, Honourable Member, NDMA; Mr. Deepak Singh, Lead DRM Specialist and Mr. Vijay Kalavakonda, Senior Operations Officer, The World Bank; Mr. Rahul Mankotia, Sector Specialist, and Dr. Neils Kemper, KfW Development Bank; Mr. Andreas Bollmann, Technical Reviewer; and Dr. George Thomas, Insurance Institute of India for all the support and guidance provided to ensure that the project will benefit the state in the true spirit of its conception. We also acknowledge the support extended by the officials of the RKI and KSDMA for coordination with various line departments and data sharing.

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Abbreviations Used

Abbreviation/Acronym	Expanded Form
AAL	Annual Average Loss
AEL	Annual Expected Loss
AIC	Akaike Information Criterion
AWS	Automatic Weather Station
CATDDO	Catastrophe Deferred Drawdown Option
CCB	Contingent Credit Bonds
CCRIF	Caribbean Catastrophic Risk Insurance Facility
DRTPS	Disaster Risk Transfer Parametric Insurance Solution
EM-DAT	Emergency Events Database
EQ	Earthquake
EWE	Extreme Weather Event
IMD	India Metrological Department
IRDAI	Insurance Regulatory and Development Authority of India
KS Test	Kolmogorov-Smirnov Test
KSDMA	Kerala State Disaster Management Authority
KSID	Kerala State Insurance Department
LEC	Loss Exceedance Curves
LSG	Local Self Governance
MFI	Micro Finance Members
MMI	Modified Mercalli Intensity
NATCAT	Natural Catastrophe
NDEM	National Database for Emergency Management
NDMIS	National Disaster Management Information System
NRSC	National Remote Sensing Centre
NSDMA	Nagaland State Disaster Risk Management Authority
PDF	Probability Density Function
PDNA	Post Disaster Needs Assessment
SDRP	State Disaster Risk Pool
STFI	Storm, Tempest, Flood, and Inundation
USGS	United State Geological Survey

Executive Summary

Kerala has faced severe socio-economic impacts from floods, landslides, cyclones, storm surges, and droughts over the past three decades, along with threats like coastal erosion, earthquakes, tsunami, soil-piping, and forest fires. This study compiles a comprehensive disaster database, conducts risk assessments using advanced catastrophe modeling, and develops a Kerala State Catastrophic Risk Profile. The goal is to establish a Disaster Risk Financing Strategy with parametric insurance solutions for residential and government buildings, enhancing disaster preparedness, resilience, and response.

A historical disaster database has been created, detailing major events, damages, and losses from sources, such as, Emergency Events Database (EM-DAT), National Database for Emergency Management (NDEM), Central Water Commission (CWC) flood database, and Kerala State Disaster Management Authority (KSDMA). It records dates, locations, physical characteristics, affected areas, and casualties, serving as a benchmark for risk modeling and disaster response planning. Understanding past disasters is crucial for forecasting future risks and developing mitigation strategies.

The study also compiles an economic loss database, analyzing the financial impact of disasters over 30 years. Using 2018 Kerala Flood Post Disaster Needs Assessment (PDNA) Report, insurance records, and disaster memoranda, losses are categorized into direct damages, indirect losses and recovery needs, and insurance claims. A geo-referenced loss database helps map financial impacts across Kerala, aiding governments and financial institutions in designing risk financing solutions and sustainable disaster insurance products, ensuring swift financial relief for affected communities.

State Catastrophic Risk Profile

The State Catastrophic Risk Profile presents a detailed hazard assessment for Kerala using state-of-the-art catastrophe risk modeling techniques. The key components include hazard modeling, which evaluates the probability and severity of floods, landslides, cyclones, storm surges, and droughts; exposure assessment, which identifies at-risk assets such as housing sector (residential buildings), and government buildings; vulnerability analysis, which estimates structural resilience and damage potential for different building types; and risk estimation, which develops Risk outputs such as Probable Maximum Loss (PML) and Average Annual Loss (AAL) figures at State, District, Taluka and LSG levels. A comprehensive risk profile helps policymakers prioritize investments in disaster resilience and insurance coverage, ensuring effective disaster risk reduction (DRR) planning.

Disaster Risk Financing Strategy

The Disaster Risk Financing Strategy proposed in this study aims to ensure rapid financial response post-disasters in Kerala. The strategy includes government-backed insurance for residential and public buildings, risk transfer mechanisms through parametric insurance, potential costs of indemnity-based insurance, the development of a catastrophe reserve fund, and leveraging reinsurance markets for large-scale disaster coverage. A structured financial risk transfer system ensures timely disaster relief, reducing the economic burden on the government while providing swift financial aid to affected communities. By establishing these financial safeguards, the state can enhance disaster resilience and economic stability while minimizing the need for post-disaster emergency funds.

Parametric Risk Transfer Instruments

The study introduces parametric risk transfer instruments, which provide insurance payouts based on predefined disaster thresholds rather than post-event damage assessments. These thresholds include rainfall exceeding 100 mm for flood and landslide, and cyclonic wind speeds above 90 kmph for cyclone and 105 kmph for storm surge for Kerala State. Unlike traditional indemnity insurance, parametric insurance ensures immediate payouts based on real-time weather and hazard data. Key categories of parametric insurance include weather-based crop and livestock insurance, flood and landslide insurance, cyclone and storm surge insurance, and urban resilience insurance for municipalities and critical infrastructure. These innovative insurance mechanisms minimize delays in disaster relief and improve financial resilience for both individuals and the state, ensuring that affected communities receive timely support to recover from natural disasters.

Identification of Risk Zones in Kerala

The identification of risk zones in Kerala has been carried out by categorizing flood, landslide, cyclone, and storm surge risks into low, moderate, high, and very high-risk zones, based on AAL. High-risk zones identified include flood-prone areas such as Alappuzha, Ernakulam, and Thrissur, landslide hotspots such as Idukki, Wayanad, and Palakkad, and cyclone and storm surge- prone coastal cities such as Kochi, Thiruvananthapuram, and Kozhikode. Identifying high-risk areas enables targeted investments in mitigation measures, such as flood barriers, landslide stabilization, and cyclone and storm surge-resistant infrastructure. These measures help reduce disaster impacts and enhance Kerala's resilience against future Extreme Weather Events (EWEs), ensuring that both human lives and economic assets are protected.

Development of Parametric Indices

The study focused on developing parametric indices for disaster risk financing, ensuring quick and efficient payouts for insured losses based on measurable hazard triggers. The approach involved the identification of high-risk locations using historical data, AAL and Loss Exceedance Curves (LEC). The selected locations were categorized based on risk exposure, considering population density, built infrastructure, and economic activity. This allowed for a structured allocation of risk weights, ensuring that financial risk transfer mechanisms were aligned with actual vulnerability levels.

A multi-trigger approach was developed to minimize basis risk, which refers to the difference between model-based payouts and actual losses. The primary index triggers were defined for different perils the: flood index was based on rainfall exceeding 100mm in 24 hours, the landslide index on cumulative rainfall of 200mm in 5 days, and for cyclone index wind speed exceed 90 kmph and storm surge index on wind speeds surpassing 105 kmph. These triggers were validated using India Meteorological Department (IMD) data, Automatic Weather Stations (AWS), and satellite imagery from the National Remote Sensing Centre (NRSC).

The effectiveness of these indices was assessed by comparing historical disaster events with financial losses. The results showed that an 85-90% correlation existed between modeled payouts and real losses, confirming the reliability of the parametric triggers. The study also demonstrated that by integrating satellite flood mapping and on-ground damage reports, financial relief could be expedited, reducing post-disaster economic stress. The use of historical rainfall thresholds, such as the 100 mm cumulative rainfall benchmark, significantly improved flood risk estimation in Kerala.

This development is critical for ensuring objective and rapid insurance payouts. By eliminating the need for manual damage assessments, parametric insurance ensures immediate financial relief, making it more effective than traditional indemnity-based insurance. Additionally, the introduction of multi-source data validation (IMD, AWS, satellite imagery, and loss reports) further enhances the reliability of payouts, making parametric insurance an attractive tool for disaster risk financing.

Prototype Property Catastrophe Insurance Products

To improve financial resilience against natural disasters, prototype property catastrophe insurance products were developed, covering residential and government buildings in Kerala for floods, landslides, cyclones and storm surges. The insurance models were designed based on detailed actuarial risk assessment, ensuring affordability and financial sustainability. Three different risk levels (high, medium, and low) were identified at the Taluka levels, allowing for tailored insurance coverage. The insured perils included floods, landslides, cyclones, and storm surges, while additional coverages for earthquakes and forest fires were also considered.

The policy structure featured customizable coverage options based on exposure levels. Sum insured amounts ranged from ₹5 lakh to ₹12 lakh per building, with corresponding premium rates between ₹1,000 and ₹2,400 per year, depending on the peril and location. Premium calculations were based on a combination of pure premium modeling, burning cost approaches, and loss exceedance probability curves (LEC), ensuring that pricing reflected the actual risk exposure. Policyholders could choose deductibles of 2%, 5%, 10%, or 20% to further customize their premiums.

A tiered payout system was introduced to ensure rapid financial relief based on the intensity of the disaster event. For instance, in case of cyclone, wind speed of 90 kmph in a certain Taluka (vary from Taluka to Taluka) would trigger a 25% payout, with 15% increase in payout for every increase of wind-speed 10 kmph and 140 kmph would result in 100% payout.

in case of storm surge, wind speed of 95 kmph in a certain Taluka (vary from Taluka to Taluka) would trigger a 25% payout, with 15% increase in payout for every increase of wind-speed 10 kmph and 145 kmph would result in 100% payout.

Similarly, for flood risks, the rainfall exceeding 100 mm in 24 hours and for landslide 200 mm cumulative in any 5 rolling days would trigger the payouts, minimizing the delays caused by post-disaster damage assessments.

The performance of the insurance model was tested against historical disaster events, demonstrating its effectiveness. In the case of the 2018 Kerala Floods, the proposed model would have provided ₹1,200 crores in immediate payouts, significantly reducing economic stress. During Cyclone Ockhi (2017), the parametric triggers would have covered ₹250 crores in damages within days. These results indicate that the proposed catastrophe insurance framework can serve as a viable financial risk transfer mechanism for Kerala.

By implementing this prototype property catastrophe insurance, Kerala can significantly enhance disaster preparedness and resilience. The model provides a structured financial safety net for homeowners and government assets, ensuring timely recovery and rebuilding efforts. Furthermore, government subsidies on premiums (ranging from 30-50%) can encourage mass adoption, thereby reducing the state’s financial liability during disasters. Additionally, the integration of public-private partnerships (PPP) and reinsurance markets can further strengthen financial sustainability, making Kerala a model state for disaster risk financing in India.

Risk Profile Development and Visualization

The Risk Profile Development and Visualization section focuses on generating detailed risk heat maps and statistical analyses to assess disaster vulnerability at the Taluka levels in Kerala. Using Python-based automation, data on exposure values, AAL, and loss ratios are processed to create visual risk maps, allowing policymakers to identify high-risk areas quickly. The methodology involved aggregating historical disaster loss data, modeling expected financial losses, and mapping hazard intensities for floods, landslides, cyclones, and storm surges. The heat maps categorized different Talukas based on their relative risk levels, enabling more effective resource allocation for disaster preparedness and risk reduction. Additionally, actuarial simulations were conducted to validate the financial sustainability of insurance schemes, ensuring that premium rates and payouts align with real-world loss probabilities. By leveraging data-driven insights, this section enhances Kerala's ability to prioritize mitigation efforts, optimize insurance coverage, and develop targeted financial risk transfer strategies, ensuring that the state is better prepared for future disasters.

The Conclusion of the study highlights the importance of integrating scientific hazard assessments, exposure development, vulnerability analysis and risk assessment, financial risk transfer mechanisms, and innovative insurance solutions to enhance Kerala's disaster resilience. By combining historical disaster data, advanced catastrophe modeling, and parametric insurance frameworks, the study provides a comprehensive roadmap for disaster risk management. The development of risk zones, economic loss assessments, and catastrophe risk profiles enables policymakers to take proactive measures in disaster preparedness, infrastructure resilience, and financial protection. The proposed Disaster Risk Financing Strategy and parametric insurance solutions ensure that financial relief reaches affected communities swiftly, reducing the post-disaster economic burden on both individuals and the government. This study lays the foundation for sustainable disaster resilience in Kerala, setting a model that can be replicated in other disaster-prone regions. By implementing these strategies, Kerala can significantly reduce economic losses, accelerate recovery efforts, and build a safer future for its residents.

1 Introduction

1.1 Background

Natural disasters, such as floods, landslides, cyclones, storm surges, and droughts, have brought significant economic and human tolls in Kerala over the past three decades. The State is also vulnerable to coastal hazards (erosion and sea level rise), forest fires, earthquakes, tsunamis, soil-piping, and lightning and thunderstorms. Understanding the historical occurrence of these hazards and their financial ramifications is paramount for effective disaster risk reduction strategies.

This study aims to compile comprehensive databases documenting major historical hazard events and the resulting economic losses caused by disasters over the past 30 years in Kerala.

Furthermore, the study endeavors to develop an exposure database, and conduct hazard, vulnerability, and risk assessments based on state-of-the-art NatCAT risk modeling methodology, with the objective of developing Kerala State Catastrophic Risk Profile.

Additionally, it seeks to develop a Kerala State Disaster Risk Financing Strategy and establish a methodology for designing a Prototype for Parametric Risk Transfer Products with a focus on the housing sector (residential building) and Government Buildings. These proposed products are intended to mitigate the financial impact of disasters by providing efficient and timely financial assistance to affected communities and stakeholders.

1.2 Objectives

1.2.1 Database of Major Historical Hazard Events:

The first objective of this study is to construct a database of major historical hazard events in Kerala, focusing on floods, landslides, cyclones, storm surges, and droughts. Data collection involves reviewing existing records and consolidating information from various sources, including the Emergency Events Database (EM-DAT), National Database for Emergency Management (NDEM), National Disaster Management Information System (NDMIS), and other portals. It also involves, identification of the independent reporting/ monitoring agencies for each of the major perils. The data sets are collected from Kerala State Disaster Management Authority (KSDMA) and various other published sources. The information and data regarding the historical events, especially, for the past 30 years have been consolidated.

The database includes (for each of major historical events) at least the following information: occurrence date (start and end date), location (e.g., latitude and longitude of the storm's eye for tropical cyclones), physical characteristics (e.g., central pressure along the track for tropical cyclones), affected area, damage and loss information including causality, etc. It serves to support and calibrate the probabilistic catastrophic risk models., In a nutshell, we aim to improve our understanding of Kerala State Disaster Risk Profile by documenting the occurrence of these hazards. In this study, as part of Component-1 Report (Deliverable -2), we have developed a comprehensive database of major historical disaster events for Floods, Landslides, Cyclones, Storm Surges, and Droughts.

1.2.2 Economic and Financial Loss of Major Disasters

The second objective of this project is to develop a database of Economic and Financial losses caused by major disasters in Kerala over the past 30 years. Key actions but are not limited to review of damage assessment reports, insurance reports, etc. and developing a consolidated database of financial and economic losses caused by natural disasters.

The economic losses are provided in the local currency (INR) and US$, adjusted for inflation and/or currency exchange rate. Datasets are collected from Disaster Memorandums, Post Disaster Need Assessment (PDNA) Reports, Insurance Records, and other relevant sources.

In this study, as part of Component-1 Report (Deliverable -2), we have developed a consolidated database of major natural disasters affecting Kerala over the past 30 years, including specific details about disasters caused by Floods, Landslides, Cyclones, -storm surge, and Droughts. This database also includes details on Economic and Financial Losses in addition to the other details discussed above, which helps in improving the understanding of Kerala State Disaster Risk Profile.

Hence, as part of Component-1 Report (Deliverable -2), a comprehensive Geo-Referenced Catalogue of historical major disaster events has been developed. Key parameters included in this catalogue are the date, location (latitude and longitude), type of event, areas impacted including damages and losses, number of deaths, number of injured, project damages and losses, affected economic sectors, and sources of information, etc.

1.2.3 State Catastrophic Risk Profile:

The third objective of this study is to conduct comprehensive hazard assessment, exposure development, vulnerability, and risk assessment for major hazards in Kerala using state-of-the-art catastrophic risk modeling methodology to develop Kerala State Catastrophic Risk Profile. This involves modeling key hazards (floods, landslides, cyclones, storm surges, and droughts), developing exposure databases, assessing vulnerability of communities and assets, and evaluating potential risks. The Component-2 Report (Deliverable -3) along with a Brochure on Catastrophic Risk Profile of Kerala State caters to the Objective of this Component.

1.2.4 Disaster Risk Financing Strategy

The fourth objective of this study is the development of a Disaster Risk Financing Strategy for Kerala State, with a focus on the Housing sector and Government Building. The Component-3 Report (Deliverable -4) caters to this objective of the study.

1.2.5 Design of Parametric Indices

The fifth objective of this study is the design of parametric indices to be used for financial transactions and design Prototype Parametric Risk Transfer Instruments including indemnity and parametric-based catastrophe (property) insurance products (Component -4 Report, Deliverable -5).

1.3 About This Report

This report (Component -4) is the fifth and last deliverable of the study. It details a prototype Parametric Risk Transfer Instrument, including indemnity and parametric-based catastrophe (property) insurance products.

1.3.1 Concept of Parametric Insurance

Parametric insurance is an index-based insurance wherein the coverage is given for a natural catastrophic event (flood, landslide, cyclone, storm-surge, drought, earthquake etc.) resulting in the breach of the selected parameters on a fixed severity scale or trigger. Parameters can be the weather perils (rainfall/precipitation, temperature, wind speed, etc.) applied over fixed locations during a pre-defined period (May to October, October to January). The loss shall only be admissible if the Nat-Cat event has breached the set parameters covered for a given location. Parametric Insurance provides an immediate payout with a recourse action (% of Sum Insured) on post-loss assessment to the insured population in the affected location.

As per Swiss Re Corporate Solutions, "Parametric Insurance or index-based insurance solutions are a type of Insurance that covers the probability of a predefined event happening instead of indemnifying the actual loss incurred."

Parametric Insurance products function based on two fundamental principles (i) the insurance cover is triggered if the predefined event meets or exceeds the pre-agreed index parameters (triggers) in a given location and (ii) the payout mechanism is also defined based on the pre-agreed loss amount regardless of the actual loss incurred. The trigger events are mainly catastrophic events that arise when the selected proxy weather parameters like rainfall, wind speed, and temperature exceed the specific values measured through an independent agency like the India Meteorological Department (IMD), Automatic Weather Station, or Satellite sources.

1.3.2 Different Types of Parameter Insurance Products

The following are various types of parametric insurance products available globally.

1.3.2.1 Weather-Based Parametric Insurance Products

- **Crop Insurance**: Weather-based crop insurance protects farmers' crop losses against adverse weather conditions like drought, excess rainfall, or frost.
- **Livestock Insurance**: Covers losses related to the mortality of cattle, milk productivity loss, and feed shortages due to weather-related impacts.
- **Tourism Insurance**: Protects against financial losses caused by weather conditions affecting tourist activity, e.g., unseasonal rain during peak tourist periods.
- **Renewable Energy Insurance**: Covers shortfalls in solar or wind energy production due to insufficient sunlight or wind.

The basic triggers of the above types of parametric products are (i) Rainfall (measured by gauges or satellites), (ii) Temperature (heat waves or frost), and (iii) Wind speed (Cyclones and Storm surges), etc.

1.3.2.2 Parametric Insurance for Natural Disasters

- **Earthquake Insurance** provides payouts based on seismic activity intensity or magnitude. The primary trigger is the seismic magnitude of the event (e.g., the Richter scale for earthquakes) causing damage to the property in pre-defined locations.
- **Flood Insurance** covers flooding incidents based on water levels at predefined gauges or satellite observations, and rainfall. The triggers are based on the measured water levels or precipitation volumes correlated with the flood events.
- **Cyclone and Storm Surge Insurance** is triggered when the pre-defined wind speed, pressure levels, or storm category exceeds the specified trigger thresholds (IMD definitions for various categories of Cyclones) in the selected locations.

1.3.2.3 Commodity Price Insurance

- **Agricultural Price Insurance**: Protects farmers against sharp drops in the prices of their crops or livestock products.
- **Energy Price Insurance**: Helps businesses and governments manage risks from volatility in oil, gas, or electricity prices.
- **Mining Industry Insurance**: Covers financial losses due to fluctuations in metal or mineral prices.
- The **Key Triggers** of these products are market price indices and benchmark commodity prices on global exchanges.

1.3.2.4 Business Interruption Insurance

- **Retail Insurance**: Protects retail businesses from revenue losses caused by unusual weather patterns, like snowstorms during holiday seasons.

- **Event Insurance**: Covers event cancellations or reduced attendance due to predefined weather or disaster triggers.
- **Supply Chain Insurance**: Provides coverage for supply chain disruptions caused by weather or natural disasters. The main triggers are predefined thresholds like temperature, rainfall, or catastrophic event parameters.

1.3.2.5 Health and Life Insurance

- **Pandemic Insurance**: Provides payouts based on epidemic triggers, such as the World Health Organization declaring a pandemic based on epidemiological data (e.g., infection rates) of specific locations or countries.
- **Heatwave Insurance**: Protects vulnerable populations, such as the elderly, from heat-related health issues by providing financial support during heat waves. The main triggers are temperature levels or the duration of extreme weather.

1.3.2.6 Marine and Aviation Insurance

- **Marine Cargo Insurance**: Covers cargo losses due to adverse weather conditions affecting shipping operations. The payouts under this insurance get triggered based on wind speeds, wave heights, or port closures for marine insurance.
- **Fishing Insurance**: Provides payouts to fishers affected by cyclones or other weather disruptions.
- **Aviation Insurance**: Covers delays or disruptions in aviation operations due to adverse weather conditions, visibility or wind thresholds for aviation insurance.

1.3.2.7 Microinsurance Products

- Designed for low-income individuals or small businesses, often in developing regions. Commonly include weather-based crop or livestock insurance to protect against climate-related risks. The main triggers are easily measurable parameters like rainfall levels or temperature deviations.

1.3.2.8 Renewable Energy and Carbon Offset Insurance

- **Solar Power Insurance**: Covers loss of income due to insufficient sunlight, measured solar irradiance, or wind speed.
- **Wind Power Insurance**: Provides payouts for below-average wind speeds.
- **Carbon Credit Insurance**: Ensures income from carbon offset projects based on parameters like forest growth or methane reduction. Satellite data for environmental metrics.

1.3.2.9 Urban Resilience Insurance

- **Infrastructure Insurance**: Covers damages to urban infrastructure due to earthquakes, floods, or storms.
- **City-Level Insurance**: Provides financial support to municipalities based on disaster triggers to ensure quicker recovery. The major triggers are Disaster intensity or duration and Economic or infrastructure damage indices.

2 Parametric Indices for Financial Transactions

This chapter covers the design of parametric indices for major perils, detailing the methodologies for creating first- and second-generation indices to ensure financial viability and reduced basis risk.

This section would also discuss the following points.

- Identify homogeneous risk zones in the State for each major peril. The number and characteristics (e.g., size) will be agreed with the client. The risk zones may be different by peril.
- For each risk zone (related to a specific peril), produce the risk profile of the risk zone (e.g., AEL, LEC, etc.). In particular, it will include a table showing the annual frequency of events of given severity occurring in the risk zone.
- For each risk zone, produce at least 50,000 simulated events. (RMSI)

2.1 Basic Principle of Parametric Insurance Products

- Parametric Insurance products are non-conventional insurance products that offer immediate claims payouts on pre-agreed parameters or indices. The payout depends on the occurrence of the selected perils (floods, earthquakes, cyclones, droughts, etc.) in the pre-identified locations when the occurrence of the event breaches a pre-agreed trigger or index.
- It insures a policyholder against the occurrence of a specific event severity (trigger) exceeding a pre-defined trigger threshold or Index. The trigger could be any of the high-severity weather parameters like rainfall, wind speed, temperatures, drought conditions, etc., exceeding a pre-agreed threshold or index.
- The trigger threshold or index is established based on the correlations of the selected disaster events (floods and landslides, cyclones and storm surges) and the cumulative level of the rainfall thresholds wind speed and cyclonic wind thresholds.
- The payout is a pre-agreed amount based on the severity of the event parameter or index value. The payout pattern and limits are defined together based on the possibility or correlations of the pre-defined trigger or index levels getting breached. The payout amount or compensation for each trigger threshold is determined based on the correlations between the trigger levels and the historical losses. Often, the amount of compensation is determined by discussing with the purchaser of this insurance (generally the government officials and the intermediaries).
- Another important principle that we need to be aware of is the ***Basis Risk*** that parametric insurance may contribute. Basis Risk is the deviation between the triggered payouts and the actual loss that occurred due to the selected perils. The basis risk arises when the structured or delivered payouts are either less than or more than the actual loss incurred by the policyholders in the locations. This results in a situation where some customers who did not suffer a loss may receive the payouts, and some may receive a lesser payout than their actual loss.
- The geographical units generally selected are specific locations or units that are vulnerable to specific perils. However, the intensity or severity of the perils may vary from one location to another. Similarly, the parameter trigger threshold or index values may also differ from one location to another depending upon the historical losses

that occurred at the selected trigger points.

- The total sum insured by the parametric insurance policy would be distributed across the selected locations based on their exposure values or population intensity. For instance, if the total sum insured of the policy is 100 crores and five districts have been identified as the most vulnerable for floods, the total sum insured shall be distributed as below, Kottayam district may have a higher sum insured of Rs.30 crores, Kollam Rs.20 crore, Idukki Rs.20 crore, Trivandrum may have Rs.10 crores, and Wayanad may have Rs.10 crores, etc.
- One of the key criteria of Parametric Insurance is that the contract should have an insurable event; (a) the triggers are fortuitous, and (b) the occurrence of the event should be verifiable through an independent and reliable agency like the India Meteorological Department (IMD). And (c) it should be continuously monitored and reported to the insurers. An insured should have an insurable interest to qualify for parametric insurance.
- Another important feature is to ensure timely claim payout and also keep the basis risk at a minimum. This requires a reliable data source that is authentic and transparent. If the selected parameter is rainfall, the reliable data sources would be weather data provided by the IMD, as it is a government institution, all the stakeholders would trust the data source. If the parameter is seismic data, then we may have to rely upon the earthquake monitoring agencies like USGS MMI Shake Maps or similar output by the National Centre of Seismology (NCS), Ministry of Earth Sciences, New Delhi.

The following sample product structure of parametric insurance would help in understanding the basic requirements and data sources required for the successful implementation of Parametric Insurance in Kerala State.

Sample Product Structure
Only for illustration purpose
Munich RE

Perils	Index	Data Source	Coverage	Payout
Earthquake	**EQ Intensity:** Modified Mercalli Intensity (**MMI**) at POI	**USGS** MMI Shake Maps	**Sum Insured:** e.g. 100 Cr. distributed over all the postcode in the state. Distribution of Sum Insured can be based on any proxy e.g. population or a pre-agreed value per tehsil / district	• MMI: 0 to 7 : 0% • MMI: 7 to 8 : 25% • MMI: 8 to 9 : 50% • MMI: 9 & above : 100%
Cyclone	**Wind Speed:** 3-min sustained wind speed at POI	**IMD** Cyclone Tracks		• WS Kmph: 0 to 120 : 0% • WS Kmph: 120 to 160 : 25% • WS Kmph: 160 to 220 : 50% • WS Kmph: 220 & above : 100%
Excess Rain	**Amount of rain:** Amount of rain at POI	**IMD / ERA5** Daily Gridded rainfall data		• Rain Amt: 300 mm & above: 100% (Individual threshold for each Postcode)
Flood	**Inundation**	**NRSC** Flood Inundation Maps		• Non-Inundated : 0% • Inundated : 100%

Figure 2-1: Sample Parametric Insurance Product Structure

Source: Munich Re.

The above diagram explains all the basic principles and the requirements for implementation of Parametric Insurance.

The following section provides an overview of various parametric insurance products that were successful across the world.

2.2 Overview of Parametric Indices

Many countries like the USA, Turkey Mexico, the Philippines, New Zealand, the Caribbean Islands, and Africa, have already implemented Parametric Insurance solutions for Natural Catastrophic Perils like Earthquake, Flood, Cyclone, and Drought, etc. The following paragraphs discuss the type of parametric indices used and also their applications in financial risk transfer.

1. The Caribbean Catastrophic Risk Insurance Facility (CCRIF) is one of the popular Catastrophic Risk Pools supported by a Parametric Insurance solution covering large catastrophic risks exceeding the pre-agreed level of hurricanes or Earthquakes in any of the selected Caribbean islands. On the occurrence of the event breaching the triggers, the claims payouts are made to the affected people immediately within 15 to 30 days. CCRIF uses the parameters and weather data provided by the National Hurricane Centre and the US Geological Survey (USGS) to determine the coverage and claims payouts.
2. Lloyd has developed a parametric insurance solution for large catastrophic perils exceeding the pre-agreed threshold levels. The product covers property damage and also business interruption losses to the corporations and small business traders.
3. Swiss Re has many parametric insurance products with various types of catastrophic and non-catastrophic risks. Most of their products cover catastrophic perils like earthquakes, Cyclones, Storm surges, and water level (river line) exceedance in pre-defined locations. Their Storm coverage perils make a payout when the wind speed exceeds the pre-defined trigger level of 100 mph in the selected locations. The payout includes property replacement, repair costs, business expenses, loss of revenue, and other immediate economic losses. The Parametric water level insurance products cover excess water levels in rivers affecting goods transportation and also pay for indirect costs of business due to business interruption arising out of excess water or storm surge.
4. AXA Introduced Climate Risk Parametric Insurance which covered the airport in Taiwan for a maximum loss of $2 million. This parametric insurance protection was designed under the Cat-in-a-circle concept, wherein the airport with a radius of 100 meters was covered against different types of cyclonic winds ranging from CAT level 2 to 5.
5. Munich Re has designed the parametric Insurance products for the State of Nagaland and currently SBI General Insurance Company has provided cover. Earlier similar scheme was designed by Swiss Re with the support of Tata AIG General Insurance Company. Now Munich Re has made some modifications to the earlier cover and reintroduced it with support from SBI General Insurance Company. The Nagaland State Disaster Risk Management Authority (NSDMA) has been administering the insurance. A brief outline of the excess rainfall coverage is discussed below.

In the year 2024, NSDMA implemented this first sub-sovereign extreme precipitation insurance scheme, the Disaster Risk Transfer Parametric Insurance Solution (DRTPS) to increase the financial capacity of the State and reduce dependency on the financial assistance from National Disaster Response Funds, to provide compensation at a sufficient level and quickly in the event of disaster. *It is a three-year (2024 to 2027) contract with a total sum insured of Rs.150 crores with an annual coverage of Rs.50 crores and a premium payment of Rs.4.20 crores.* The total sum insured is divided among the selected tehsils. The claim payout gets triggered at the Tehsil level when the occurrence of rainfall breaches the set threshold level. It has an annual aggregate deductible of Rs. 1 Crore. It has a two-tiered payout structure covering two seasons – Monsoon season from June to October and Non-Monsoon season from

November to May. The trigger threshold level for the monsoon cover is 1500 mm for 5 months (1st June to 31st October 2024) and the exit threshold is 2220 mm. The threshold for the non-monsoon period (1st November 2024 to 31st May 2025) is 130 mm to 211 mm (Exit Level).

PRODUCT STRUCTURE

Product Structure for High Flood Risk Tehsils- Year 1			
Monsoon Period: 1st June to 31st October 2024			
Excess Seasonal Rainfall *Aggregate Rainfall over Monsoon Period above or equal to Trigger Point*		Strike Point	Payout
	Payout Trigger Level	1500 mm	10% of Tehsil sum insured
	Incremental Payout per additional 80 mm		10% of Tehsil sum insured
	Payout Exit Level	2220 mm	100% of Tehsil sum insured
Non-Monsoon Period: 1st November 2024 to 31st May 2025			
Excess Unseasonal Rainfall *Cumulative Rainfall over 7 Consecutive Days within Phase Period above or equal to trigger point - Single Payout*		Strike Point	Payout
	Payout Trigger Level	130 mm	3% of Tehsil sum insured
	Incremental Payout per additional 9 mm		3% of Tehsil sum insured
	Payout Exit Level	211 mm	30% of Tehsil sum insured

Figure 2-2: Parametric Insurance Product for Flood Risk

Source: NSDMA

The aggregate rainfall over the monsoon period (1st June to 31st October 2024) is equal to or above the trigger threshold of 1500 mm, and 10% of the tehsil sum insured is paid to the insured members in the selected tehsil. For every additional rainfall of 80 mm, an incremental payout of 10% of the Tehsil sum insured is payable. When the total cumulative rainfall exceeds 2220 mm, 100% of the sum insured is payable to the insured population in the selected tehsil.

The parametric insurance also covers excess unseasonal rainfall during the non-monsoon period from 1st November 2024 to 31st May 2025. The trigger threshold starts with a strike point of 130 mm during the period and the payout exit level is 211 mm. if the cumulative rainfall exceeds 130 mm over 7 consecutive days during the non-monsoon season, 3% of the Tehsil sum insured is payable to the insured members in the selected location. Further, for every additional rainfall of 9 mm, an incremental payout of 3% of the tehsil sum insured is paid. The payout exit level is 211 mm. When the cumulative rainfall exceeds the exit level of 211 mm, then 30% of the sum insured is payable.

This study uses both IMD Gridded Rainfall data and Automatic Weather Station (AWS) rainfall data. It has a tiered payout structure that sensitively addresses the distinctions of rainfall events ranging from high to torrential intensities. This system is strategically designed to ensure that the financial compensations are proportionately aligned with the severity of the rainfall and the consequent potential damages and needs.

Further, Munich Re is working on different types of parametric insurance covers for the States of Assam, Gujarat, and Odisha. The following prototype of parametric insurance for various catastrophic risks: Earthquake cover for Assam and Gujarat, Cyclone cover for Odisha, and Flood cover for Assam and Gujarat.

We know that Assam has consistently been impacted by Natural Catastrophic events like flash floods, cyclones, and earthquakes in the past. Munich Re has developed parametric insurance solutions for all three major perils for the state of Assam. The following diagram explains the extreme precipitation cover (excess rainfall cover) for covering flash floods in the state of Assam.

Extreme Precipitation Cover: Assam
Sample Product

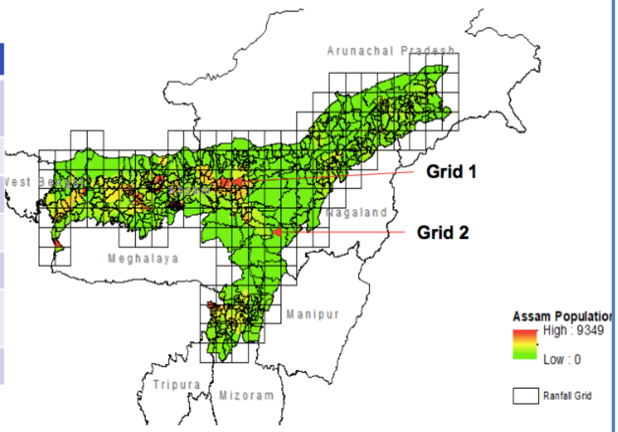
Munich RE

Extreme Precipitation
(IMD gridded data)

Excess Rainfall Cover - Assam	
Index	Maximum of 3 consecutive rainfall during cover period basis IMD Gridded data
Policy Period	365 days
From	Jan 1, 2025
To	Dec 31, 2025
Strike (MM)	250 mm
Sum Insured (INR)	Rs 100 crore per year (To be divided on Tehsil level)
Premium (INR)	Rs 8 crore per year

Trigger mechanism:

Rainfall pay-out structure: If **Cumulative rainfall over 3 consecutive days exceeds** the **threshold** assigned to a particular **IMD grid**, the **pay-out will trigger in proportion to the % population (or Pre-agreed Sum Insured)** in that grid.



Rainfall (mm)	1	2	3	4	5	6	7	8	9	10
At grid 1	0	44	41	83	15	20	160	215	200	85
At grid 2	5	53	34	91	74	21	18	90	129	191

Figure 2-3: Sample Parametric Insurance Product for Extreme precipitation covers for Assam

Source: Munich Re, 2025

This cover provides immediate relief to the insured persons in the selected locations of Assam State in the event of flash floods. The policy period is one year from 1st January 2025 to 31st December 2025. The parameters triggering the defined precipitation/rainfall trigger index exceeding 250 mm cumulatively in consecutive 3 days in any month of the policy period. The total sum insured by the policy is Rs.100 crores, which would be divided among the selected tehsil in proportion to the population of the tehsils. If the cumulative rainfall over 3 consecutive days exceeds the threshold assigned to a particular IMD grid of the selected location, the pay-out will trigger in proportion to the percentage of the population (pre-agreed sum insured) in the location/grid.

Munich Re has also designed a sample or prototype parametric cover for cyclone peril in Odisha. The parametric cover has a total sum insured of Rs. 100 crores which is subdivided into the selected tehsils in the state. The amount of premium payable is Rs 8 crore for the sum insured of Rs. 100 crores. The following diagram provides snapshots of the product structure with pre-agreed triggers and payout levels.

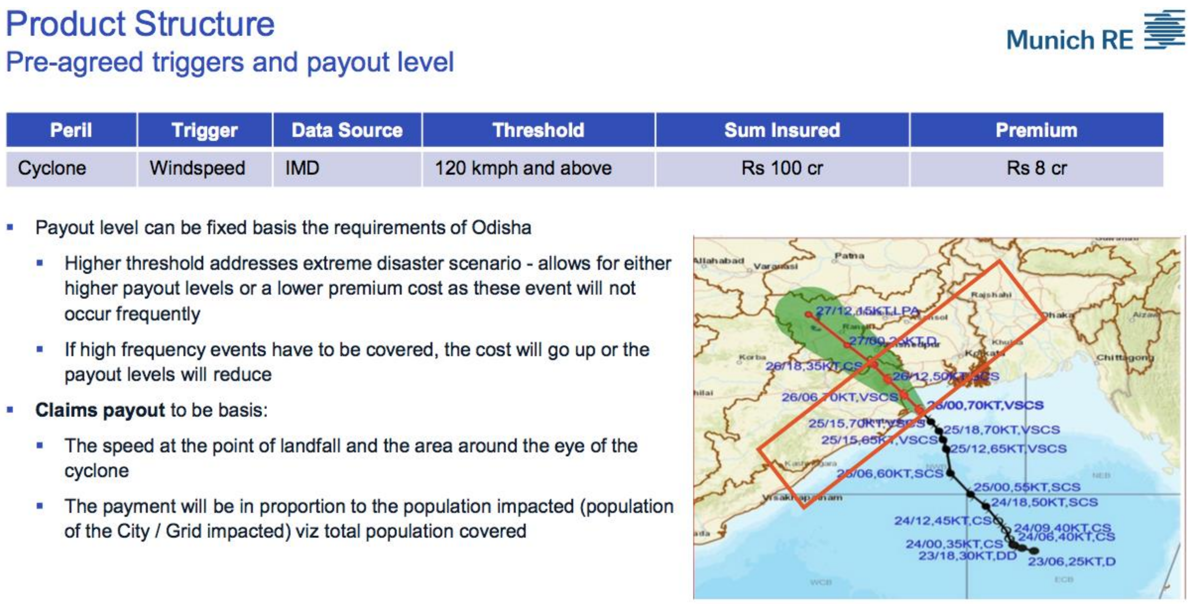


Figure 2-4: Sample Parametric Insurance Product for Cyclone Risk in Odisha

Source: Munich RE, 2025

The selected weather parameter for the cyclone cover is Wind speed. The trigger index level is 120 kmph and above. It will have two circles, one near the point of landfall of the cyclone and another is the outer layer of the landfall. The payout of the cover can be structured based on the requirements of the Odisha government. The payout will be in proportion to the population of the city/grid impacted to the total population covered in the selected region/city.

Munich Re has also designed a prototype Parametric Insurance cover for earthquake peril in the state of Gujarat. The duration of the cover is one year (2025). The total amount of sum insured determined for the cover is Rs. 150 Crore with a gross premium payment of Rs. 8 Crores. The trigger is the ground-shaking parameter MMI provided by USGS.

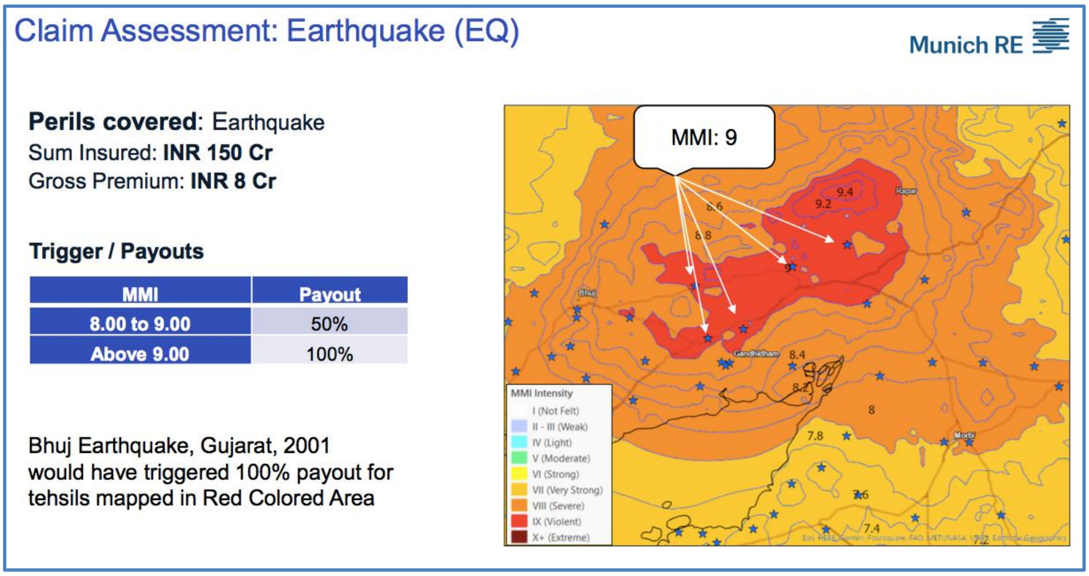


Figure 2-5: Sample Parametric Insurance Product for Earthquake Risk - Gujarat

Source: Munich Re, 2025

The modified Mercalli Intensity (MMI) scale is a measure of the ground shaking severity at a given point, depending primarily on the earthquake's magnitude and distance from where the quake occurred inside the earth (hypocenter). It is a combination of distance from the epicenter and depth. The MMI scale ranges from the value 1 to 12. The scale values higher than 6 to 8 are measures of moderate severity (regions colored yellow in the above diagram) and the values higher than 8indicate a high-severity earthquake event (amber and red color depicted in the above diagram). The trigger threshold set for this cover is an MMI scale value of 8to 9 and Above 9. If the occurrence of an earthquake in the selected zone or region triggers the intensity of 8to 9 points on the MMI scale, then 50% of the sum insured of the zone or region will be paid to all the insured persons in the location. The covered event triggers a high intensity of 9 and above (exit trigger threshold), then 100% of the sum insured is payable.

Further, Munich Re has also developed Parametric Insurance for the customers of Micro Finance Institutions (MFI), which protects their outstanding loan amount on the occurrence of the selected catastrophic events like earthquakes, cyclones, and Floods. The scheme has enrolled over 1 million borrowers in 3 years. The following diagram explains the features of Parametric Insurance for protecting smallholders.

MFI Loan Customer protection program

Munich RE

Parametric Insurance – For Micro Borrowers	Product Specifications:	Current Status:
	• Voluntary basis parametric insurance product to Loan customers of financial institutions • Protecting 3 EMIs of the loan	• Over 1 million borrowers in 3 years • Payout events: Cyclone Yaas, Odisha Floods 2023, Northern Floods and floods in Western India 2023

PERIL	Parameter	Data Source	Trigger	Payout
Earthquake	EQ Intensity (MMI)	USGC (Intensity Map)	MMI: I to VII	0%
			MMI: VII to IX	50%
			MMI: Above IX	100%
Cyclone	Wind Speed (3 min sustained wind speed)	IMD (Best Tracks)	Wind Speed: 0 to 100 kmph	0%
			Wind Speed: 100 to 119 kmph	50%
			Wind Speed: Above 119 kmph	100%
Flood	Inundation	NRSC (Bhuvan Portal)	Non-Inundated	0%
			Inundated	100%

Munich Re launched product along with insurer to offer parametric solution for MFI customers

Insurance for the MFI borrower's home contents against:

- NAT CAT perils on a parametric trigger basis (linked to the location of the property: Lat-Long)
- Offered with all loans offered by MFI for Loan Protection (3 months EMI or SI, whichever is lower)
- The number of settlements per policy is limited to one per individual during the policy period

Figure 2-6: Parametric Insurance product for Micro Finance Members

Source: Munich Re, 2023

The above parametric insurance structure covers the specified catastrophic perils like earthquakes, cyclones, and Floods, protecting the credit risk, especially outstanding loan amounts of the micro borrowers of the particular MFI in the selected regions. The parameter selected for the earthquake is the EQ Intensity measured by MMI provided by USGS. The regions are classified into 3 regions (High – above IX, Medium – VII to IX, and Low intensity – I to VII) by the EQ intensity scale ranging from I to XII. If occurred EQ event triggers the MMI value of VII to IX, 50% of the sum insured is paid to the insured members of the MFI. If it triggers the high intensity of MMI 9 and above, 100% of the sum insured is paid to the members.

The cyclone cover has two trigger threshold levels with a wind Speed of 100 to 119 kmph, 50% of the sum insured, and if the event triggers a wind speed of above 119 kmph, 100% of the sum insured is paid to the member of the MFI.

The flood cover has a single trigger level linked to the inundation of water in the selected regions, then 100% of the sum.

2.2.1 Advantages/Merits of Parametric Insurance

- Simple index-based insurance provides an instant payout to the insured which can be immediate relief in times of crisis.
- Customized parametric products for each risk exposure at a given location can be designed for major perils like floods, cyclones, landslides, etc.
- The payout can be automated on the occurrence of pre-defined events triggering the strike points at the selected location.
- The availability of different types of parametric insurance covering various natural catastrophic events.
- An easy claims settlement process where claims can be directly credited to the insured accounts, without the customers reporting the loss to the insurance company.
- The premium could be comparatively cheaper.

2.3 Methodology for the Development of Parametric Insurance

Developing a parametric Insurance product requires a systematic approach to identify the vulnerable regions/zones, select the perils to protect, design the coverage based on the exposure values or risk profile of the regions, determine the trigger index or thresholds, and the payout amount. The success of the product depends upon the quality and accuracy of the weather data and their correlations with the occurrence of the pre-defined peril. It also requires reliable data sources from a third-party agency like IMD/Automatic Weather Station, and Satellite Data. The methodology for developing parametric insurance has been explained through a step-by-step process.

- The first step is to **identify the most vulnerable locations** or areas at the LSG or Taluka level **for each of the selected perils** (Floods, landslides, Cyclones, and Storm surges). The selected locations should be **based on hazard characteristics** like Annual Expected Loss (AEL/AAL), and Loss Exceedance Curves (LEC) to ensure homogeneity in risk profile.
- **Selection of Appropriate Parameters**: This involves the selection of appropriate and quantifiable weather parameters like rainfall, wind speed, temperature soil type, and topography of the regions (plain, river line areas, hilly regions, coastal regions, etc.). These parameters would serve as the triggers for claims payouts.
- **Determination of Coverages**: The coverages are the sum insured determined for each location. The sum insured or coverage can be determined based on the risk exposures and annual average loss (AAL) of the selected locations. The sum insured can be distributed to each location based on the weights allocated. The coverage weights for the location will be determined based on the underlying exposure data.
- **Determine the index parameters**: The index or trigger parameters are established based on the correlations of the historical losses and the selected weather parameters. The trigger thresholds for the selected parameters set risk profile analyses and correlation of the historical losses, which reflect the point at which the insured is likely to experience a possible loss impact at the

occurrence of the selected peril. Thus, the established trigger thresholds would vary from each location/ area depending upon their exposures and exceedance probability, which would ensure minimization of basis risk.

- **Design of Payout Structure**: The claim payout structure would be designed in consultation with the state government officials which specifies the pre-agreed payout or compensation to be disbursed when a trigger event occurs. This can be a fixed sum (pre-agreed loss amount) or a scaled amount based on the severity of the parameter.
- **Select a Reliable Data Source Agency**: It is important to select a reliable independent data source agency like the Indian Meteorological Department, to provide the required weather data which is fairly accurate and reliable to the key stakeholders such as the state government, affected people or insured public, and insurers. Apart from the IMD data sources, the government can also examine the possibility of using the Automotive Weather Station (AWS) data and Satellite data.
- **Regular Review and Adjustment**: It is important to do a periodical review of the product performance and verify the data quality through multiple data sources. The same should also be validated through ground truthing using a field survey of the affected locations. In accordance with the changes in the weather conditions, the triggers need to be adjusted based on the new data, technological advancements, and changes in the insured risk profile. Regular reviews and trigger adjustments would help maintain the relevance and reliability of the insurance coverage and ensure that the basis risk is kept minimum.
- **Establish the Dispute Mechanism**: Despite the efficiency in delivering faster claims payouts and simplification of the parametric insurance solution, disputes can arise in the area of trigger event confirmation, data accuracy, payout adequacy policy interpretation, etc. Hence, it is necessary to establish a suitable dispute mechanism addressing the policyholder’s grievances directly with the insurers. Similarly, suitable Mediation measures with neutral third-party negotiations resolving through mutually agreeable solutions, Arbitration with the help of a neutral arbitrator can be used to make a binding decision on the dispute.

2.4 First-Generation Parametric Indices

2.4.1 Identifying Homogeneous Risk Zones

2.4.1.1 Flood risk zones in Kerala based on AAL

The project team conducted a comprehensive analysis to identify flood risk zones in Kerala, focusing on flood-induced induced losses in terms of monetary losses. For this study, flood hazard-induced Average Annual Loss (AAL) across the LSGs in Kerala has been considered to delineate the flood hazard risk zones. Based on the AAL values, the LSGs were categorized into three risk zones: high, moderate, and low. This categorization was determined by the degree of financial losses caused by flood conditions in each area. The AAL value serves as a reliable indicator of flood impact, helping to map the region’s most susceptible areas to economic damage from floods. The AAL (residential, govt. buildings, critical facilities, transport infrastructure and agriculture.) across the LSGs in Kerala has been classified into four categories as shown below in Table 2.1.

Figure 2-7 illustrates the flood risk zones in Kerala, based on monetary losses attributed to floods.

Table 2-1: Categorization of drought hazard risk zone based on the AAL

AAL (INR Crores)	Flood hazard Risk Zone
>10	Very High
5-10	High
1-5	Moderate
0.05-1	Low
<0.05	Very Low/Negligible

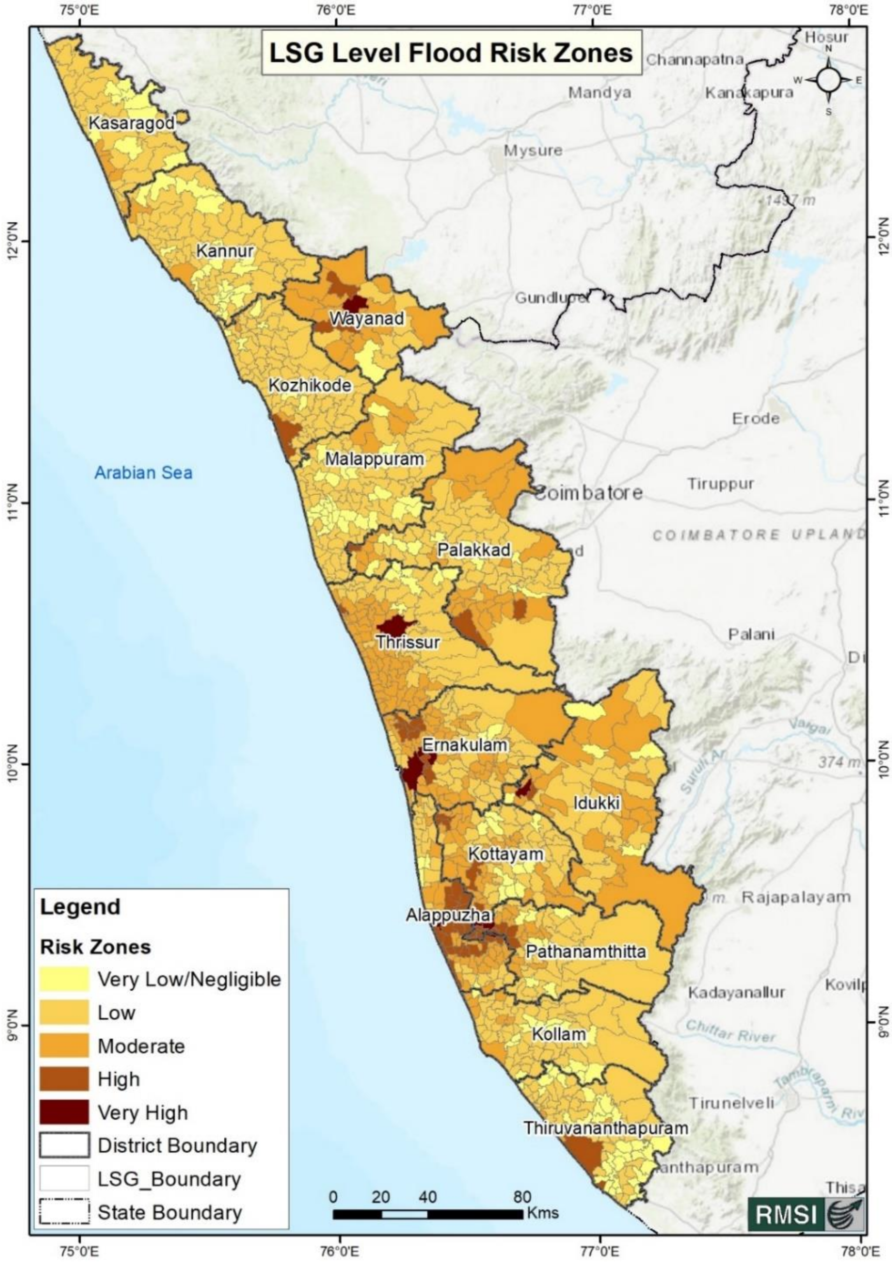


Figure 2-7: LSG wise flood risk zone over Kerala

Table 2-2:List of LSG falling in Very High-Risk zone for flood

LSG Name	Taluka Name	District Name
Ambalapuzha South	Ambalapuzha	Alappuzha
Cochin Corporation	Kochi	Ernakulam
Kalamassery Municipality	Paravur	Ernakulam
Panamaram	Mananthavady	Wayanad
Thiruvanvandoor	Chengannur	Alappuzha
Thodupuzha Municipality	Thodupuzha	Idukki
Thrissur Corporation	Thrissur	Thrissur

Table 2-3: List of LSG falling in High-Risk zone for flood

LSG Name	Taluka Name	District Name
Alangad	Paravur	Ernakulam
Ambalapuzha North	Ambalapuzha	Alappuzha
Anakkara	Pattambi	Palakkad
Arattupuzha	Karthikapally	Alappuzha
Budhanoor	Chengannur	Alappuzha
Changanassery Municipality	Changanassery	Kottayam
Chavakkad Municipality	Chavakkad	Thrissur
Chendamangalam	Paravur	Ernakulam
Chengannur Municipality	Chengannur	Alappuzha
Chennithala-Thripperumthura	Mavelikkara	Alappuzha
Edathua	Kuttanad	Alappuzha
Edavetty	Thodupuzha	Idukki
Eraviperoor	Thiruvalla	Pathanamthitta
Haripad Municipality	Karthikapally	Alappuzha
Kadapra	Thiruvalla	Pathanamthitta
Karumallur	Paravur	Ernakulam
Karuvatta	Karthikapally	Alappuzha
Kizhakkencherry	Alathur	Palakkad
Kollengode	Chittur	Palakkad
Kottathara	Vythiri	Wayanad
Kottayam Municipality	Kottayam	Kottayam
Kottuvally	Paravur	Ernakulam
Kozhikode Corporation	Kozhikode	Kozhikode
Kumarapuram	Karthikapally	Alappuzha
Mananthavady Municipality	Mananthavady	Wayanad
Maravanthuruthu	Vaikkom	Kottayam
Neelamperoor	Kuttanad	Alappuzha
North Paravur Municipality	Paravur	Ernakulam
Padinharathara	Vythiri	Wayanad
Pallippad	Karthikapally	Alappuzha
Pandanad	Chengannur	Alappuzha

Peringara	Thiruvalla	Pathanamthitta
Pulincunnoo	Kuttanad	Alappuzha
Purakkad	Ambalapuzha	Alappuzha
Ramankary	Kuttanad	Alappuzha
Thakazhy	Kuttanad	Alappuzha
Thalavady	Kuttanad	Alappuzha
Thiruvalla Municipality	Thiruvalla	Pathanamthitta
Thiruvananthapuram Corporation	Thiruvananthapuram	Thiruvananthapuram
Thrikkakara Municipality	Kanayannur	Ernakulam
Thrikkunnappuzha	Karthikapally	Alappuzha
Tripunithura Municipality	Kanayannur	Ernakulam
Udayanapuram	Vaikkom	Kottayam
Veliyanad	Kuttanad	Alappuzha

2.4.1.2 Landslide risk zones in Kerala based on AAL

The project team conducted a comprehensive analysis to identify landslide risk zones in Kerala, focusing on landslide-induced losses in terms of monetary losses. For this study, landslide hazard-induced Average Annual Loss (AAL) across the LSGs in Kerala has been considered to delineate the landslide hazard risk zones. Based on the AAL values, the talukas were categorized into four risk zones such as low, moderate, high and very high. This categorization was determined by the degree of financial losses caused by a landslide in each area. The AAL value serves as a reliable indicator of landslide impact, helping to map the region's most susceptible areas to economic damage from landslides. The AAL (combined for all buildings (Residential, Govt offices, Govt Schools and Govt hospitals), roads, railways and agriculture crops including (Coconut, Arecanut, Rice & Banana)) across the LSGs in Kerala has been categorized as shown in

Table 2-4. The landslide risk zone map of the State is depicted in Figure 2-8.

Table 2-4: Categorization of landslide hazard risk zone based on the AAL

AAL (INR Crores)	Landslide Hazard Risk Zone
>1	Very High
0.25-1	High
0.01-0.25	Moderate
0-0.01	Low

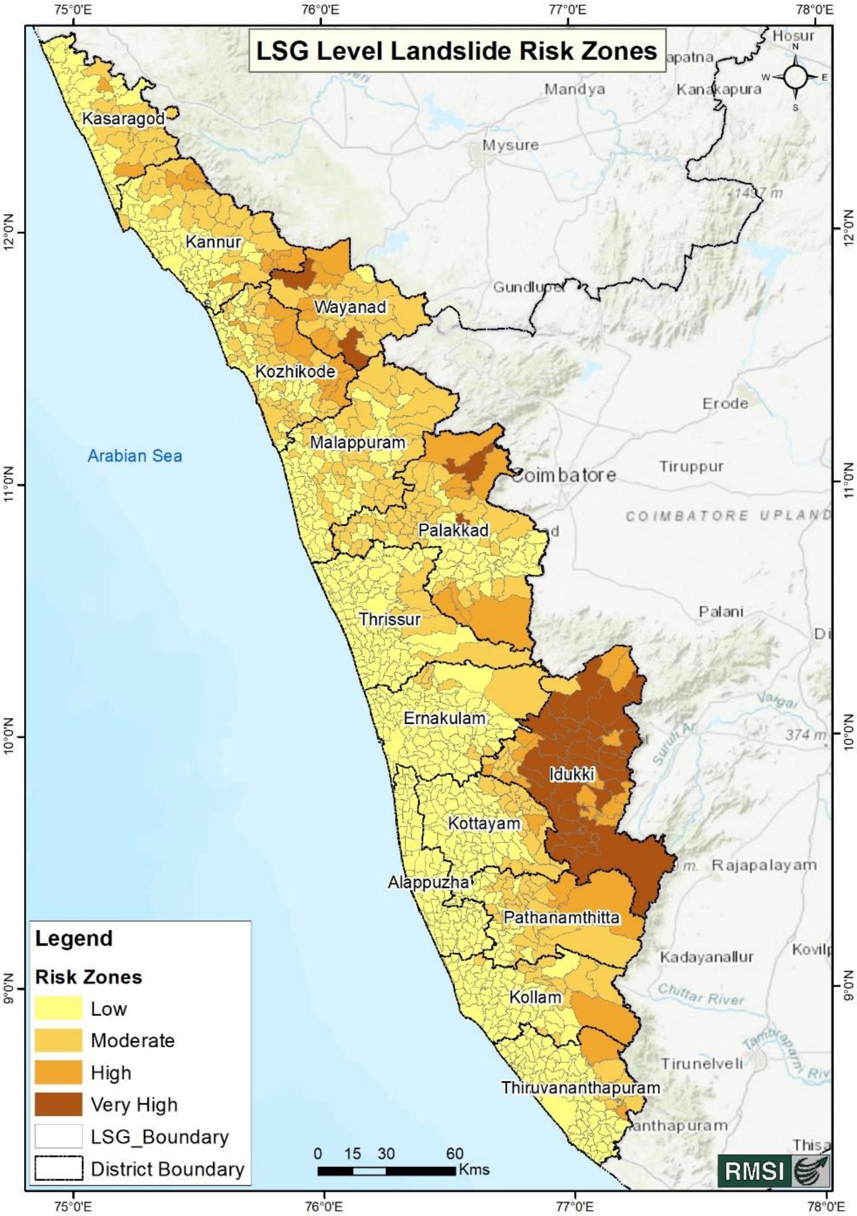


Figure 2-8: LSG-wise Landslide risk zone over Kerala

Table 2-5:List of LSG falling in Very High-Risk zone for landslide

LSG Name	Taluka Name	District Name
Adimaly	Devikulam	Idukki
Arakulam	Thodupuzha	Idukki
BysonValley	Devikulam	Idukki
Devikulam	Devikulam	Idukki
Idukki Kanjikuzhy	Idukki	Idukki
Kattappana Municipality	Idukki	Idukki
Konnathady	Idukki	Idukki
Kumily	Peermade	Idukki
Mariyapuram	Idukki	Idukki
Munnar	Devikulam	Idukki

Nedumkandam	Udumbanchola	Idukki
Udumbanoor	Thodupuzha	Idukki
Vazhathope	Idukki	Idukki
Vellathooval	Devikulam	Idukki
Agali	Attappadi	Palakkad
Meppadi	Vythiri	Wayanad
Thavinhal	Mananthavady	Wayanad
Kokkayar	Peermade	Idukki
Rajakkad	Udumbanchola	Idukki
Mundur	Palakkad	Palakkad
Chinnakanal	Udumbanchola	Idukki
Mankulam	Devikulam	Idukki
Pallivasal	Devikulam	Idukki
Pampadumpara	Udumbanchola	Idukki
Peermade	Peermade	Idukki
Peruvanthanam	Peermade	Idukki
Santhanpara	Udumbanchola	Idukki
Senapathy	Udumbanchola	Idukki
Udumbanchola	Udumbanchola	Idukki
Upputhara	Peermade	Idukki
Vandiperiyar	Peermade	Idukki
Vathikudy	Idukki	Idukki
Vattavada	Devikulam	Idukki
Velliyamattom	Thodupuzha	Idukki
Elappara	Peermade	Idukki

Table 2-6: List of LSG falling in High-Risk zone for landslide

LSG Name	Taluka Name	District Name
Amboori	Kattakada	Thiruvananthapuram
Chittar	Ranni	Pathanamthitta
Seethathodu	Konni	Pathanamthitta
Vannappuram	Thodupuzha	Idukki
Kizhakkencherry	Alathur	Palakkad
Pudur	Attappadi	Palakkad
Sholayoor	Attappadi	Palakkad
Ayancheri	Vadakara	Kozhikode
Kodanchery	Thamarassery	Kozhikode
Thiruvambadi	Thamarassery	Kozhikode
Pozhuthana	Vythiri	Wayanad
Thirunelly	Mananthavady	Wayanad
Pattiam	Thalassery	Kannur
Kayyur Cheemeni	Hosdurg	Kasaragod
Kumbadaje	Kasaragod	Kasaragod
Peringammala	Nedumangad	Thiruvananthapuram
Kulathupuzha	Punalur	Kollam

Poonjar Thekkekara	Meenachil	Kottayam
Chakkupallam	Udumbanchola	Idukki
Kanchiyar	Idukki	Idukki
Kudayathoor	Thodupuzha	Idukki
Muttom	Thodupuzha	Idukki
Purapuzha	Thodupuzha	Idukki
Tachampara	Mannarkkad	Palakkad
Vandazhy	Alathur	Palakkad
Kanhirapuzha	Mannarkkad	Palakkad
Nelliyampathy	Chittur	Palakkad
Chakkittapara	Quilandy	Kozhikode
Kavilumpara	Vadakara	Kozhikode
Koorachundu	Quilandy	Kozhikode
Koodaranhi	Thamarassery	Kozhikode
Vellamunda	Mananthavady	Wayanad
Vythiri	Vythiri	Wayanad
Mananthavady Municipality	Mananthavady	Wayanad
Padinharathara	Vythiri	Wayanad
Kottiyoor	Iritty	Kannur
Udayagiri	Taliparamba	Kannur
Alakode Knr	Taliparamba	Kannur
AyyappanCoil	Idukki	Idukki
Kamakshy	Idukki	Idukki
Kanthalloor	Devikulam	Idukki
Karimannoor	Thodupuzha	Idukki
Karunapuram	Udumbanchola	Idukki
Marayoor	Devikulam	Idukki
Rajakumary	Udumbanchola	Idukki
Vandanmedu	Udumbanchola	Idukki
Erattayar	Idukki	Idukki
Kattippara	Thamarassery	Kozhikode
Kanichar	Iritty	Kannur
Kelakam	Iritty	Kannur

2.4.1.3 Cyclonic Wind Risk Zones in Kerala based on AAL

The project team conducted a comprehensive analysis to identify cyclonic wind risk zones in Kerala, focusing on the associated monetary losses. For this study, the Average Annual Loss (AAL) due to cyclonic wind hazard across the LSGs in Kerala was analyzed to delineate risk zones. Based on the AAL values, the LSGs were categorized into three risk levels: high, moderate, and low (

Table 2-7). This classification reflects the extent of financial losses caused by cyclonic wind events in each area. The AAL value serves as a reliable indicator of the economic impact of cyclonic winds, helping to map the region's most vulnerable areas to such damage.

The combined AAL (including residential buildings, critical facilities, government buildings, transport infrastructure, and agriculture) across the talukas in Kerala ranged from INR 0.11 crore to INR 2.93 crores.

Figure 2-9 illustrates the Cyclonic wind risk zones in Kerala, categorized based on monetary losses attributed to cyclonic wind.

Table 2-7: Categorization of cyclonic wind hazard risk zone based on the AAL

Cyclonic Wind Risk Zone Range (INR Crore)	
High	>0.25
Moderate	>0.10 - 0.25
Low	<0.10

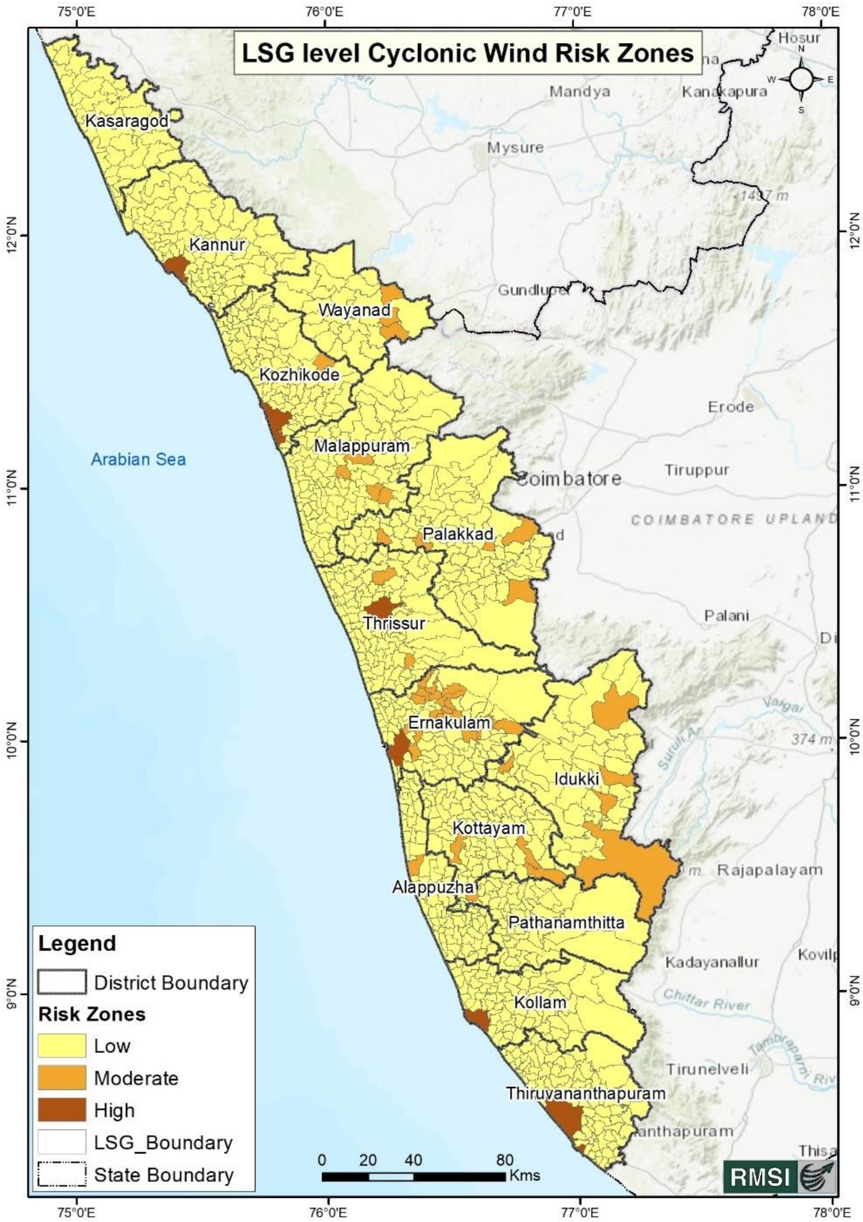


Figure 2-9: LSG-wise cyclonic wind risk zone over Kerala

Table 2-8: List of LSG falling in High-Risk zone for Cyclonic Wind

LSG Name	Taluka Name	District Name
Cochin Corporation	Kochi	Ernakulam
Kannur Corporation	Kannur	Kannur
Kollam Corporation	Kollam	Kollam
Kozhikode Corporation	Kozhikode	Kozhikode
Thiruvananthapuram Corporation	Thiruvananthapuram	Thiruvananthapuram
Thrissur Corporation	Thrissur	Thrissur

2.4.1.4 Storm Surge Risk Zones in Kerala based on AAL

The project team conducted a comprehensive analysis to identify storm surge risk zones in Kerala, focusing on the associated monetary losses. For this study, the Average Annual Loss (AAL) due to storm surge hazard across the talukas in Kerala was analyzed to delineate risk zones. Based on the AAL values, the talukas were categorized into three risk levels: high, moderate, and low (

Table 2-9). This classification reflects the extent of financial losses caused by storm surge events in each area. The AAL value serves as a reliable indicator of the economic impact of storm surges, helping to map the region's most vulnerable areas to such damage.

The combined AAL (including residential buildings, critical facilities, government buildings, transport infrastructure, and agriculture) across the talukas in Kerala ranged from INR 0.000001 crore to INR 1.84 crores. Figure 2-9 illustrates the storm surge risk zones in Kerala, categorized based on monetary losses attributed to storm surge. The analysis indicates that 50 talukas are in the low-risk zone, as determined by the Average Annual Loss (AAL).

Table 2-9: Categorization of storm surge hazard risk zone based on the AAL

Surge Risk Zone Range (INR Crore)	
High	>0.25
Moderate	>0.05 - 0.25
Low	<0.05

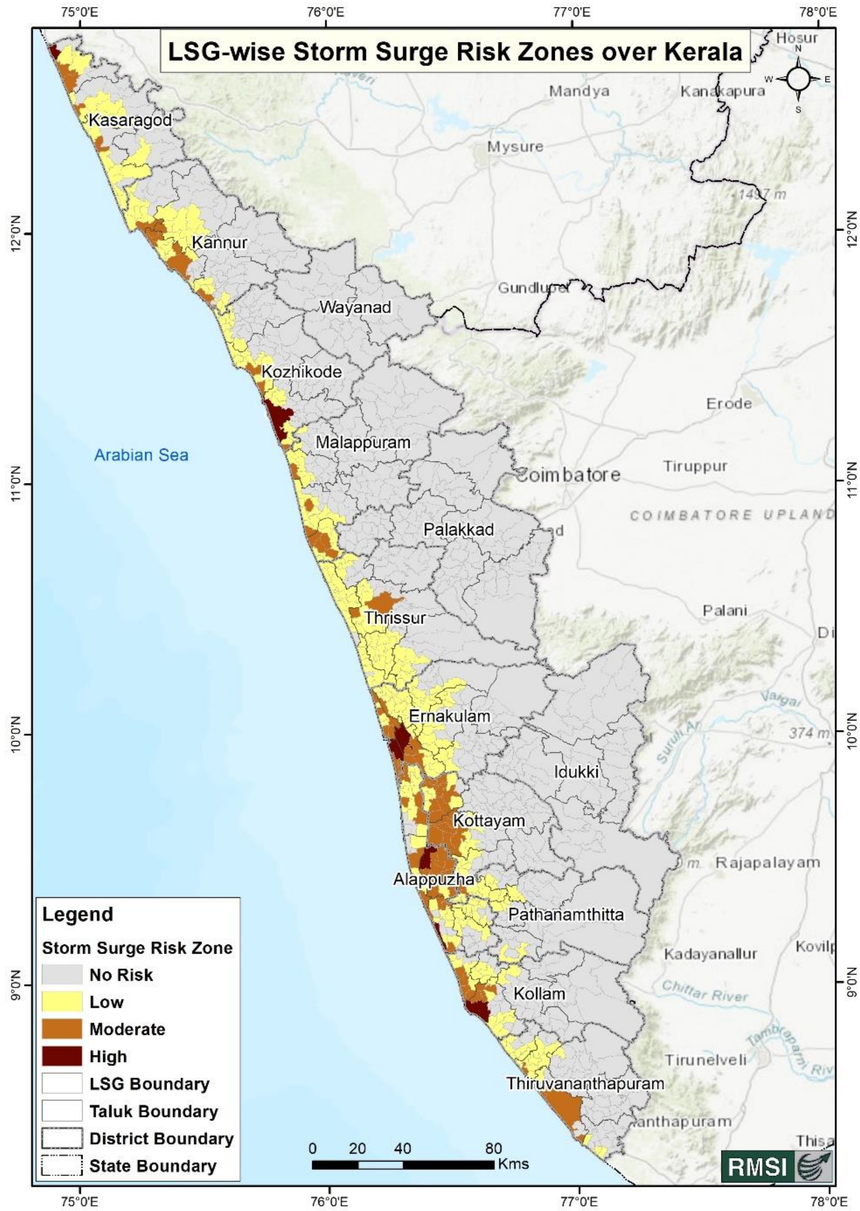


Figure 2-10: LSG-wise storm surge risk zone over Kerala

Table 2-10: List of LSG falling in High-Risk zone for Storm Surge

LSG Name	Taluka Name	District Name
Alappad	Karunagapally	Kollam
Arattupuzha	Karthikapally	Alappuzha
Cochin Corporation	Kochi	Ernakulam
Kainakary	Kuttanad	Alappuzha
Kollam Corporation	Kollam	Kollam
Kozhikode Corporation	Kozhikode	Kozhikode
Manjeshwar	Manjeswaram	Kasaragod

2.4.2 RISK PROFILE DEVELOPMENT

2.4.2.1 Flood and Landslide

Kerala State estimated AAL of INR 1,332 Crores due to floods is primarily from residential buildings, transport infrastructure and agriculture. The estimated AAL for the districts of Ernakulam and Alappuzha are INR 265.3, and 251 Crores, respectively. From Landslides, Kerala State estimated AAL is of INR 143 Crores. The major contributors to landslide damage/ losses are residential buildings, roads and agriculture.

2.4.2.2 Cyclonic Wind

Kerala State estimated AAL from cyclonic winds is INR 84 Crores, with residential buildings and agriculture crops being major contributors. The estimated AAL for the districts of Palakkad, Malappuram, and Ernakulam are INR 13.5, 9.66, and 8.87 Crores, respectively. For a 250-year return period, the estimated damage/losses are highest in Palakkad district (INR 758.84 Crores) followed by Malappuram (INR 638.19 Crores).

2.4.2.3 Storm Surge

Kerala's State estimated AAL from storm surge is INR 15 Crores, with residential buildings, transport infrastructure, and agriculture as major contributors. The estimated AALs for the districts of Alappuzha and Ernakulum are INR 3.4, and 2.5 Crores, respectively. For a 250-year return period, the estimated PMLs for the districts of Alappuzha and Ernakulum are INR 67.3, 34.8 Crores, respectively.

Table 2-11: State-level combined PML&AAL (INR Crore) for major perils

Exceedance Probability (EP)	10%	4%	2%	1%	0.4%	0.2%	
Return Period (in Years)	**10**	**25**	**50**	**100**	**250**	**500**	**AAL**
Flood	3,752	6,760	7,718	12,498	21,002	23,355	1,332
Landslide	372	599	813	1,109	3,112	6,531	143
Cyclonic Wind	161	492	1,281	2,589	5,739	9,884	84
Storm Surge	51	62	102	156	233	296	15

2.5 Second Generation Parametric Indices

Second Generation Parametric Insurance covers are based on multi-trigger coverages, wherein the primary index or threshold triggers are validated further through direct reporting of the losses or weather data using multiple sources like IMD, Satellite Images, and AWS, etc. These data which are collected from the field or other sources are used to validate the index or threshold triggers set in the primary indices. For instance, Swiss Re has developed second-generation parametric insurance covers such as intensity-based covers using advanced data analytics like Machine Learning algorithms with satellite images. The intensity-based covers are structured based on the reported intensity of the selected weather parameters (temperatures, wind speed, precipitation) that occur at specific locations defined under the policy. These data are used to validate the primary index thresholds set under the policy. Such multi-peril or multi-data sources help in reducing the basis risk of the primary index covers.

The second-generation parametric indices for each selected location were developed for the specified natural catastrophic perils such as Floods, Landslides, Cyclones and Storm Surges. The following methodology was used to develop parametric Indices for the selected perils and locations.

2.5.1 Identification of Locations:

For each peril, the three locations were selected based on their risk profiles - Risk Exposures, Annual Expected Loss / AAL, and Loss Exceedance Curve. Ideally, the selected location will represent one with high-risk exposures, one from moderate, and one from low-risk exposures for each selected peril. For example, we have selected the 'Kuttanad 'or 'Ambalappuzha' Taluka from Alappuzha District representing a high-risk location, Idukki for moderate exposure, and Tirur from Malappuram District as the low-risk exposure areas for Flood Risk.

Similarly, Landslide, Idukki, Devikulam and Peermade from Idukki District are considered to be high-risk exposure areas. Thodupuzha from Kottayam District has moderate exposure and Mannarkadu or Vythiri are considered low-risk areas for Landslide risks.

2.5.2 Allocation of Weights:

Appropriate weights are allocated to the selected location based on its property risk exposure, vulnerability, or hazard risk exposures. Allocation of weights also depends upon the number of locations that the State wishes to cover. Generally, the weights are allocated based on the exposure values of the residential property and or the population of the selected locations.

Under this parametric insurance coverage, the sum insured shall be based on the exposure values of the underlying assets (residential property/government buildings) in the selected locations at the Taluka or District level. If the state prefers to cover the residential properties in six preferred locations in the State and the total sum insured that the state determines to cover is Rs. 200 crores. The total sum insured by the Parametric insurance cover shall be distributed across the selected locations in the State in accordance with their residential property asset exposure values. For instance, if the state selects 5 districts namely, Alappuzha, Kottayam, Idukki, Ernakulam, and Thiruvananthapuram to be covered under Parametric Insurance for the Flood risks. Based on the given asset exposure values of the selected districts, Ernakulam district will have 30% of the sum insured, followed by Kottayam – 25%, Alappuzha – 20%, Idukki 15% and Thiruvananthapuram (10%) respectively. Similarly, the sum insured of Landslide coverage shall have the sum insured distributed in accordance with the vulnerability hazard profile of the selected districts.

2.5.3 Development of Parametric Indices for the Selected Perils:

The first step in computing the parametric trigger index is to identify the appropriate weather parameter as the proxy indicator for the claim's payouts. The selection of the weather parameter largely depends on the type of perils that the State wants to cover. The appropriate weather parameter for Flood Risk is the rainfall or precipitation rate. The trigger threshold is established at a particular rainfall threshold i.e., 100 mm or 200 mm, which is expected to trigger the insured peril event like a flood, cyclone, landslide, etc. The set trigger threshold is determined based on the historical analysis of weather data – rainfall and or precipitation data, risk analysis or identification of the peak or observed trends/patterns of the weather data, and correlation of these data with the financial loss of the covered event (flood, cyclone, landslide, etc.) as stated below; The trigger threshold is the value that must be reached or exceeded for a payout to occur. The said analysis would involve the following.

1. **Aggregating data:** Summing up or cumulative weather data i.e. rainfall, or precipitation, etc. over a selected season – Monsoon, Winter, Spring, etc.
2. **Averaging the parameter values:** Calculating average values of the selected weather parameters; rainfall, humidity, and over a specific period (one week/month/quarter).

3. **Design a Threshold Index:** It involves finding out the parameter threshold value that has triggered the insured peril in the past. The Index is designed based on the analysis of historical weather data over the last 20 or 30 years examining the selected risk pattern. For example, as given in the following diagram, it can be observed that a cut-off value of historical average or cumulative rainfall of 2100 mm has triggered the flood event in 6 out of 43 years. Accordingly, the following flood program has a threshold trigger index value of 2100 mm.

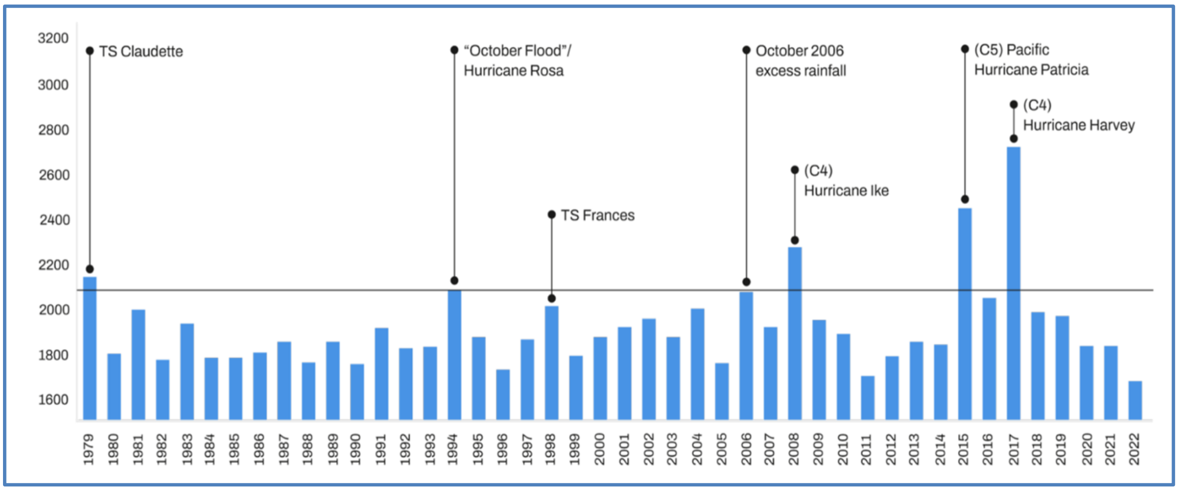


Figure 2-11: Historical weather data Analysis- for Parametric Insurance

Source: FloodBase.com

1. Further, a third-party agency like Floodbase in the US maps the selected region geographically (latitude and Longitude) by historical flood risk data for each relevant peril (Flood) and it measures the extent or magnitude and depth of the flood water using Satellite images and weather data. Based on these analyses, the insurance company can determine the trigger index and claims payout structure. The third-party agency regularly monitors the weather conditions of the selected regions to determine if any flooding surpasses the predefined trigger index. If the occurrence of any of the insured events breaches the pre-defined trigger index, the agency automatically alerts the insurance company and also the clients (government) via API, emails, or other channels preferred by the stakeholders.
2. **Validation of the weather parameters:** Verifying the occurrence of a single event such as floods, cyclones, earthquakes, etc., through spot checks, field-level data through AWS or Satellite Images, by third-party agencies such as the Indian Metrological Department (IMD), NRSC, US-GIS, etc. Example: For a parametric cyclone policy, Data from meteorological agencies (IMD) tracks wind speeds during a storm. The trigger is activated if speeds exceed 120 kmph (threshold).

2.5.4 SCALING THE CLAIM PAYOUT:

The claim payout structure under the parametric insurance can be determined either as a pre-agreed fixed payout amount i.e. Rs. 10,000 or a certain percentage (10% or 20%) of the selected sum insured amount on the occurrence of the insured event which has breached the set index or trigger threshold level. The payout can also be structured proportionately based on the intensity levels of the weather parameter. For example, in the case of a Storm Surge cover, the payout can be structured based on the intensity of the wind speed. If the insured peril (storm surge) breaches the set threshold range of 120 kmph, then a certain fixed percentage (20% or 30% of the sum insured is paid as the payout to all the insured members in the covered location. If the wind speed ranges from 130 to 140 kmph, 50% payout, and if it is within 140 to 150 kmph, 75% payout and if the wind speed exceeds 150 kmph, 100% of the sum insured is payable to all the insured members in the covered location.

2.5.5 Index Formula Development and Optimization (Basis Risk Minimization)

As discussed in 2.5.1 to 2.5.4, the development of a parametric trigger index involves multiple stages, right from identifying the appropriate weather parameter as the proxy indicator for the index threshold to validation of the set index with the actual weather data from the field. The set trigger threshold is determined based on the historical analysis of weather data – rainfall and perspiration data, risk analysis, or identification of the peak or observed trends/patterns of the weather data, and correlation of these data with the financial loss of the selected perils - flood, cyclone, landslide, etc. The trigger threshold is the value that must be reached or exceeded for a payout to occur. Development of the Index formula involves the following process.

For index development, we first took daily IMD gridded rainfall over two distinct periods: the Monsoon period (June to Nov), and the non-monsoon period (Dec to May). Then, we have carried out 3-days, 5-days and 7-days rolling averages of the rainfall data for each location for Floods, Landslides, over a historical period. Since the 5-days and 7-days rolling average represented the data better, we have used 5-days and 7-days rolling average rainfall data for developing the trigger index for the selected perils. For cyclonic wind and storm surge, we have used cyclonic wind speed data.

After calculating the average values of the cumulative rainfall over a specific period (Monsoon & Non-monsoon), we defined the threshold trigger index.

Designing a Threshold Index involves finding out the parameter threshold value that has triggered the insured peril in the past. The Index is designed based on the analysis of historical weather data over the last 25 years (2000 to 2024), examining the selected risk pattern. Then, we compared the rolling average (mean/median) values with the historical accumulated weather data that triggered the selected catastrophic perils (floods, landslides, storm surges, and cyclonic winds) during the calamity periods. After this analysis, we have selected the appropriate rolling day's average values (5-day) as the starting trigger index value for each selected location for the selected perils.

A detailed methodology of the trigger Index development has been explained through a step-by-step process as below.

2.5.5.1 Methodology for Trigger Index Development

The development of the Trigger Index was based on a structured approach, integrating historical data collected during the last 25 years (2000 to 2024) and rainfall analysis to establish event-triggering thresholds along with information from historical floods data. The process was applied for both Flood, and Landslide, using data from affected districts and talukas. The following outlines the detailed methodology employed:

1. Data Collection of historical weather data

The first step involved compiling historical event data, with key columns in the dataset including:

- **Year**: The year in which the selected catastrophic event (flood/ landslide/ cyclone/ storm surge) occurred.
- **Taluka & Districts**: The specific administrative divisions where the event was recorded, ensuring a granular level of analysis.
- **Type of weather parameter selected**: Rainfall data for flood, storm surge, and landslide risks in each selected location.

- **Type of Peril**: Identification of the hazard type (Flood, Landslide, Cyclone, Storm surge).
- **Start Date & End Date**: The start date and end date of the entire (flood/landslide) event duration were recorded for the analysis.

This information was used to categorize and filter relevant events for analysis.

2. Rolling Rainfall Analysis

To determine the impact of rainfall on hazard events, cumulative rainfall data were analyzed over different time windows. Key columns utilized in this analysis included:

- **Rolling Days**: The period over which cumulative rainfall was computed.
- **Total 5-Day Cumulative Rainfall**: The total recorded rainfall over a consecutive 5-day window.
- **Average of 5-Day Rainfall**: The mean rainfall calculated over a rolling average of consecutive 5 days.
- **Total 7-Day Cumulative Rainfall**: Similar to the 5-day analysis but considering a 7-day rolling period.
- **Average of 7-Day Rainfall**: The mean rainfall calculated over a rolling average of consecutive 7 days.

These rolling periods were chosen to assess short-term rainfall accumulation trends, which are critical indicators for triggering flood and landslide events.

3. Threshold Identification and Exceedance Analysis

To establish rainfall thresholds that indicate high-risk conditions, the following metrics were evaluated:

- **No. of Days Exceeding Average Rainfall**: The number of days within the rolling window where rainfall exceeded the calculated average.
- **Minimum Exceeding Rainfall**: The lowest recorded rainfall that surpassed the average.
- **Maximum Exceeding Rainfall**: The highest recorded rainfall that exceeded the average threshold.

These metrics were crucial in understanding variability in rainfall patterns and determining the significance of exceedance events.

4. Comparative Assessment and Validation

To ensure robustness in trigger identification, a comparative assessment was conducted across multiple years and locations:

- Patterns of rainfall accumulation were analyzed to detect consistent trends.
- Taluka-wise and district-wise comparisons were made to validate consistency in hazard triggers.
- Data gaps and anomalies were reviewed and addressed to refine the analysis.

5. Trigger Index Development and Finalization

The insights derived from the data analysis were synthesized into a structured Trigger Index. This index serves as a decision-support tool by:

- Identifying key rainfall thresholds based on the historical weather data analysis and trend lines associated with disaster events.
- Establishing standardized conditions (based on mean & standard deviation of the selected weather parameters under which a hazard event (flood/landslide/storm surge) is likely to be triggered.
- Providing a framework for proactive disaster preparedness and early warning systems.

6. Visualization and Illustration through Rainfall Plots

To further refine the trigger index and illustrate trends effectively, rainfall plots were created for selected talukas over multiple years:

- **5-Day and 7-Day Average Rainfall Trends**: Graphical representations were generated to visualize fluctuations and detect critical thresholds.
- **Taluka-Specific Rainfall Comparisons**: This helped in determining location-specific thresholds and validating the trigger conditions.
    - **Annual Variability Analysis**: Time series plots were used to assess changes in rainfall intensity and their correlation with hazard events.

These visualizations played a crucial role in better understanding the relationship between extreme rainfall and disaster occurrences, ultimately strengthening the reliability of the Trigger Index.

Through this methodical approach, the Trigger Index was developed to provide a data-driven basis for assessing flood, landslide, storm, and cyclone risks, ensuring a structured and reliable mechanism for disaster response.

The following sections discuss the Index triggers for the selected risks – Flood, Landslide, Storm Surge, and Cyclonic Winds in each selected location (taluka).

2.5.5.2 Index Triggers for Flood Risk:

The following table presents the historical weather data analysis with mean and standard deviation of the 5-day and 7-day rolling averages of cumulative rainfall values, including minimum and maximum rainfall exceeding the overall historical average for the Ambalapuzha talukas in Alappuzha district for flood risk parametric insurance.

Table 2-12: Historical Weather Data Analysis for Flood Risk in Ambalapuzha Taluka

Year	Taluka	5-Day Average Rainfall	Minimum Exceeding Rainfall	Maximum Exceeding Rainfall	7-Day Average Rainfall	Minimum Exceeding Rainfall	Maximum Exceeding Rainfall
2013	Ambalapuzha	141.62	144	280	199.25	205	357
2014	Ambalapuzha	74.38	76	262	103.99	106	288
2018	Ambalapuzha	101.81	102	277	143.56	146	345
2018	Ambalapuzha	162.87	216	322	217.40	220	342
2019	Ambalapuzha	92.10	94	278	124.19	127	362
2021	Ambalapuzha	80.44	83	116	113.69	125	163
	Mean	**108.87**		**Mean**	**150.35**		
	STDEV	**35.55**		**STDEV**	**47.14**		

The above historical analysis of the rainfall data indicates that the overall mean of the 5-day rolling average is 108.87 mm with a standard deviation of 35.55, the minimum exceeding rainfall in Ambalapuzha is 76 mm in 2014, and the maximum is 162 mm in 2018. The overall mean of the 7-day rolling average is 150.35 mm with a standard deviation of 47.14 mm, with the minimum exceeding rainfall ranges from 106 mm in 2014 to a maximum of 362 mm in 2019.

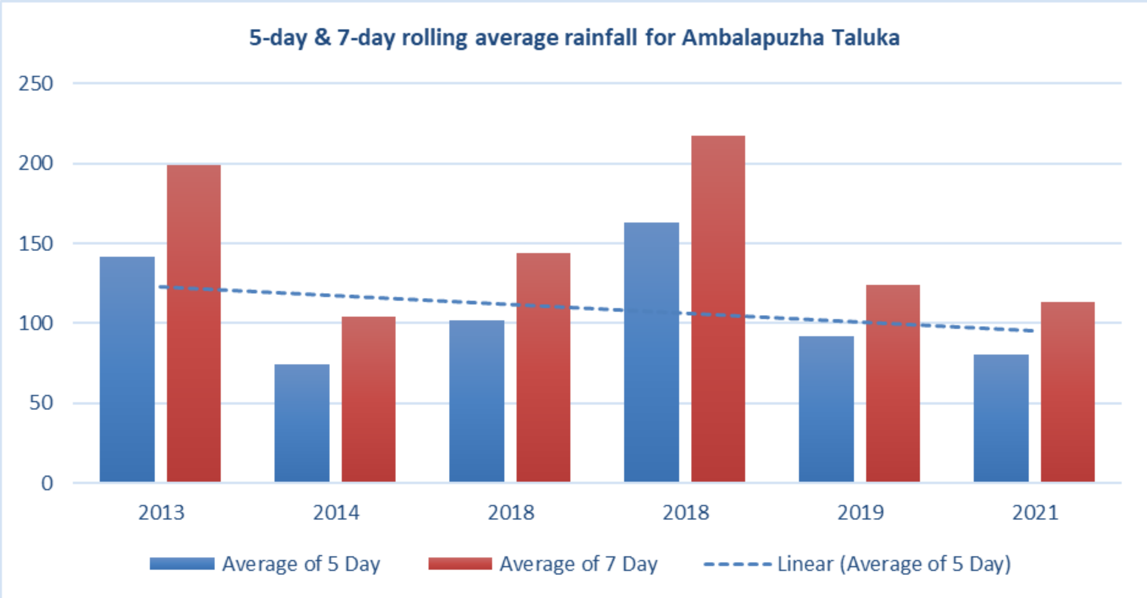


Figure 2-12: Historical Trend Analysis for Flood Risk in Ambalapuzha Taluka

For example, as given in the above diagram, it can be observed that a cut-off value of historical average or cumulative rainfall of 100 mm has triggered the flood event in 4 out of 6 years in a 5-day rolling average, while it has triggered 6 out of 6 times in 7-day rolling averages. Considering the historical mean and standard deviations of the cumulative rainfall in the Ambalapuzha taluka in Alappuzha District, **we have selected a cumulative rainfall of 100 mm as the starting trigger value and can exit at 300 mm during any 5 consecutive days for the monsoon season from June to November**. The overall mean value from the above-mentioned historical events for the Ambalapuzha taluka is 108.87 mm with a standard deviation of 35.55 mm. The index trigger can start with **75 mm and exit at 150 mm during 5 consecutive days in the non-monsoon period**.

Index Development for Flood Risk in Kochi Taluka:

The following table presents the historical weather data analysis for developing a parametric index for flood risk in Kochi Taluka.

Table 2-13: Historical weather data Analysis for Parametric Index - Kochi Taluka

Year	Taluka	5-Day Average	Minimum Exceeding Rainfall	Maximum Exceeding Rainfall	7-Day Average	Minimum Exceeding Rainfall	Maximum Exceeding Rainfall
2013	Kochi	165.43	170	322	231.33	233	402
2014	Kochi	109.84	112	321	153.70	157	418
2018	Kochi	140.55	150	354	196.83	212	419
2018	Kochi	173.87	180	405	234.27	293	431
2019	Kochi	147.81	149	469	200.32	205	550

2021	Kochi	117.75	119	195	165.13	170	251
	Mean	**142.54**		**Mean**	**196.93**		
	STDEV	**25.38**		**STDEV**	**33.07**		

It can be observed from the above historical weather data analysis that the overall mean and standard deviation of the 5-day rolling average of rainfall data are 142.54 mm with a standard deviation of 25.38. while the same for the 7-day rolling average is 196.93 mm with a standard deviation of 33.07. The minimum exceeding rainfall during the flood event is 112 mm in 2014, and the maximum was 469 mm in 2019 for the 5-day rolling average, while the minimum exceeding rainfall was 157 mm in 2014, and the maximum was 550 mm in 2019 for the 7-day rolling average.

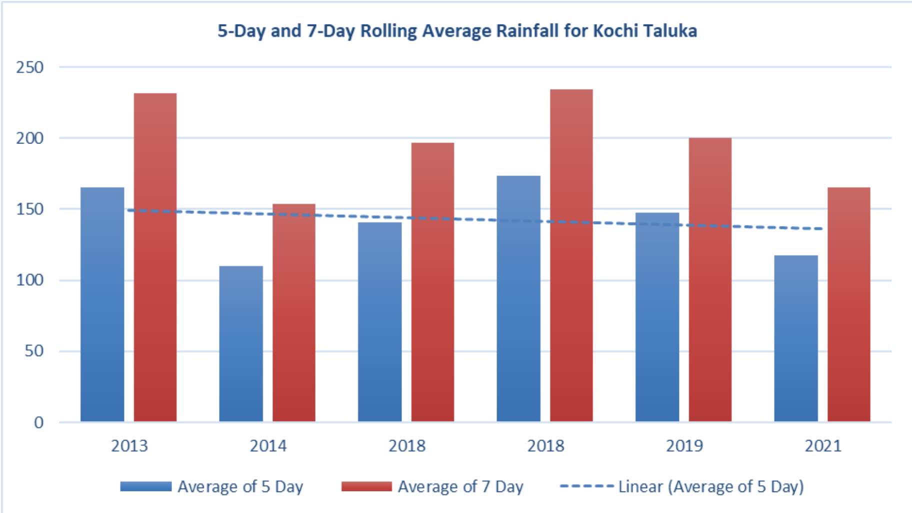


Figure 2-13: Historical Trend Analysis for Flood Risk in Kochi Taluka

The historical trend analysis of the rainfall data indicates that the average cumulative rainfall is trending toward 150 mm, as there has been an increase in cumulative rainfall over the last 10 years. Hence, considering the historical average rainfall and also the trend line, the **cut value for the starting trigger index can be 150 mm and can exit at 400 mm for the flood risk in Kochi Taluka during the monsoon period. The starting index trigger for the non-monsoon period can be 100 mm, and the same can exit at 300 mm.**

*2.5.5.3 **Index Triggers for Flood and Landslide Risks:***

The following historical weather data analysis covers a 5-day and 7-day rolling averages of cumulative rainfall analysis, including the mean and standard deviation, minimum and maximum cumulative rainfall during the flood and Landslide risk events that occurred in the last 10 years in Idukki Taluka. The following table 2.13 presents the historical weather data analysis for flood and Landslide risks in Idukki Taluka.

Table 2-14: Historical Weather Data Analysis for Flood and Landslide Risks in Idukki Taluka

Year	Taluka	5-Day Average	Minimum Exceeding Rainfall	Maximum Exceeding Rainfall	7-Day Average	Minimum Exceeding Rainfall	Maximum Exceeding Rainfall
2012	Idukki	56.18	58	141	72.95	86	145
2013	Idukki	72.67	74	151	101.20	102	172
2018	Idukki	122.47	127	347	170.39	174	399
2018	Idukki	363.33	377	607	489.80	527	694
2019	Idukki	103.10	107	388	142.26	206	428
2021	Idukki	120.63	127	174	163.88	166	250
		143.55		**Mean**	**195.32**		
		125.54		**STDEV**	**168.81**		

The overall historical mean for the 5-day rolling average rainfall is 143.55 with a standard deviation of 125.54 mm, while the same for the 7-day rolling average rainfall is 195.32 with a standard deviation of 168.81. The minimum exceeding (5-day) rolling rainfall is 58 mm in 2012, and the maximum is 607 mm in 2018. The minimum exceeding rolling average rainfall for a 7-day consecutive period is 86 mm in 2012, and the maximum is 694 mm in 2018.

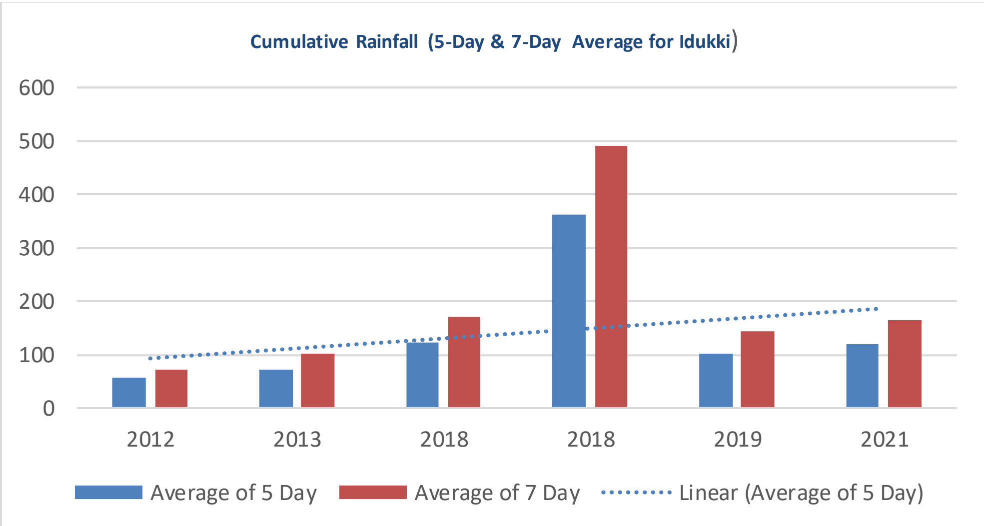


Table 2-15: Historical Trend Analysis for Rainfall and Landslide Risks in Idukki Taluka

The historical trend analysis indicates that the rolling rainfall average of both 5-day and 7-day periods exceeds 100 mm in almost 5 out of 7 landslide events. The mean is 127.52 mm with a standard deviation of 118.96 mm, suggesting that **a minimum index trigger cut-off value of 150 mm and a maximum (exit) of 250 mm during the monsoon season. Similarly, the starting trigger of 100 mm, which can exit at 200 mm in the non-monsoon periods, is used for the flood and landslide risks in Idukki**.

Index Development for Flood and Landslide Risks in Devikulam Taluka:

The historical weather data analysis presented in the following Table 2.14 exhibits the historical weather data analysis for floods and landslide risks in Devikulam taluka from Idukki district.

Table 2-16: Historical weather data Analysis for Flood and Landslide Risks in Devikulam

Year	Taluka	5-Day Average	Minimum Exceeding Rainfall	Maximum Exceeding Rainfall	7-Day Average	Minimum Rainfall	Maximum Exceeding Rainfall
2013	Devikulam	144.97	151	397	201.34	213	442
2014	Devikulam	101.98	104	276	142.86	145	356
2018	Devikulam	120.20	123	315	167.53	168	435
2018	Devikulam	326.00	332	555	436.27	439	661
2019	Devikulam	167.42	204	636	230.10	237	729
2020	Devikulam	351.00	351	351	400.00	400	400
2021	Devikulam	104.50	105	168	146.00	149	224
2022	Devikulam	317.00	317	317	411.00	411	411
		Mean	**204.13**		**Mean**	**266.89**	
		STDEV	**107.85**		**STDEV**	**126.88**	

From the above historical data analysis, it can be observed that most of the years during which floods and landslides occurred in Devikulam taluka, the historical rainfall average has been around 150 mm to 300 mm, with the highest 5-day rolling average value of 351 mm in 2020 and 7-day rolling average value of 729 mm in 2019. The overall mean value of the 5-day rolling rainfall average is 204.13 with a standard deviation of 107.85, while the overall mean of the 7-day rolling rainfall average is 266.89 with a standard deviation of 126.88.

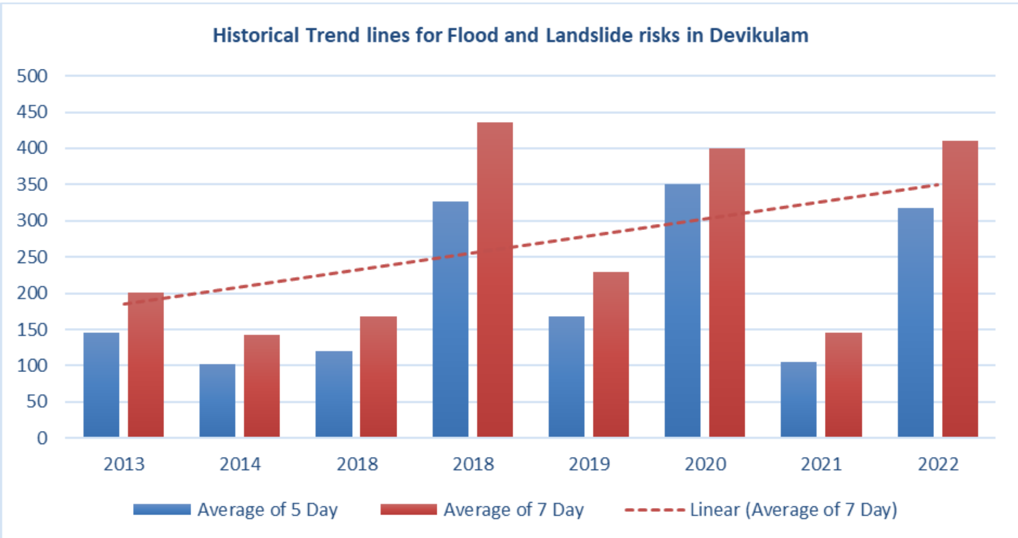


Figure 2-14: Historical Trend Analysis for Rainfall and Landslide Risks in Devikulam Taluka

The above analysis indicates that the Devikulam taluka experienced floods or landslides on almost 6 out of 8 occasions when the trigger index exceeded 100 mm, while there is almost 37% probability that 3 out of 8 occasions, where both floods and landslides occurred at the 5-day cumulative index of 200 mm and above. While it is almost 62% probability that such events occur at an index value exceeding 200 mm at a 7-day rolling average rainfall.

Considering the historical trend line and the mean & standard deviation of the 5-day and 7-day rolling average rainfall data, we suggest **a starting trigger cut-off value of 200 mm and an exit trigger of 350 mm during the monsoon period for flood and landslide risks in Devikulam taluka in Idukki District**. The index trigger for the non-monsoon period can be 100 mm for flood and landslide risks in Devikulam taluka.

2.5.5.4 Prototype Parametric Insurance Products

This section focuses on the development of prototype parametric insurance products tailored to the risk profiles and needs of the housing sector and government buildings. Based on the above historical weather data analysis, and also the index triggers selected (starting index as well as the exit trigger values), for the selected perils and the regions (Talukas) for each peril, we have developed the prototype parametric insurance products for each selected peril.

The design covers the coverage period, - monsoon period and non-monsoon period, Cyclonic and Non-Cyclonic Period, the starting index trigger and exit trigger values for the specified period, and the perils (flood/landslide/storm surge). The product also specifies the sum insured or the coverage amount (Exposure Value) and the different levels of claims payouts, which shall be paid to the insured person if the event triggers the specified index.

2.5.5.4.1 Product Structure for Flood Risk- Ambalapuzha Taluka

The following table presents the product devised for Ambalapuzha Taluka for Flood risk. The total exposure value of all the properties, i.e. Residences and Government buildings is to be considered as the Sum insured. The Annual average loss for all the Government building in the Ambalapuzha Taluka, as derived from the CAT Modelling is only Rs 18.13 lakhs, but considering the current exposure and market value, we determine the above exposure value of Rs 35 Lakhs as an appropriate sum insured value for the Government building. For residential property the average exposure value per unit estimated by the CAT model is Rs 22 lakhs, the state government can decide to fix the individual sum @insured either 5 lakhs, 8 lakhs, 10 lakhs, or 12 lakhs for individual Residential properties.

The following table exhibits the parametric insurance product structure for Flood risk in Ambalapuzha Taluka.

Table 2-17: Product devised for Ambalapuzha taluka for flood risk

Peril	Flood
Taluka	Ambalapuzha
Government Exposure per unit	₹ 35 Lakhs
Residential average Exposure per unit	₹ 22 lakhs

Table 2-18: Product structure for Flood Risk for 2025-26

Product Structure for Flood Risk – 2025-26		
Monsoon Period:1st June to 30th November		
Ambalapuzha Taluka	**Strike Point**	**Payout**

Excess Seasonal Rainfall		
Payout Trigger Level	100 mm	20% of the sum insured
Incremental Payout per additional 25 mm		10% of the sum insured
Payout Exit Level	300mm	100% of the sum insured
Non-Monsoon Period: 1st December to 31st May		
	Strike Point	**Payout**
Excess Unseasonal Rainfall		
Payout Trigger Level	75 mm	25% of the sum insured
Incremental Payout per additional 15 mm		15% of the sum insured
Payout Exit Level	150 mm	100% of the sum insured

The aggregate rainfall over the monsoon period (1st June to 30th November) is equal to or above the trigger threshold of 100 mm, and 20% of the sum insured i.e total exposure mentioned under the policy is paid to the insured members in the selected Taluka. For every additional rainfall of 25 mm, an incremental payout of 10% of the sum insured (Total Exposure) is payable. When the total cumulative rainfall in the identified Taluka exceeds 300 mm, 100% of the sum insured is payable to the insured population in the selected Taluka due to the operation of the peril

The parametric insurance also covers excess unseasonal rainfall during the non-monsoon period from 1st December to 31st May. The trigger threshold starts with a strike point of 75 mm of unseasonal rainfall during the above stated period and the payout exit level is 150 mm if the cumulative rainfall exceeds 75 mm over 5 consecutive days during the non-monsoon season, 25% of the sum insured is payable to the insured members in the selected location of Amabalapuzha. Further, for every additional rainfall of 15 mm, an incremental payout of 15% of the sum insured is paid. The payout exit level is 150 mm. When the cumulative rainfall exceeds the exit level of 150 mm, then 100% of the sum insured is payable (Annexure-1).

2.5.5.4.2 Product Structure for Landslide Risk – Devikulam Taluka

The following table presents the product devised for Devikulam Taluka for Landslide risk. The total exposure value of all the properties, i.e, Residencial and Government buildings is to be considered as the Sum insured.

Table 2-19: Product devised for Devikulam taluka for landslide risk

Peril	Landslide (Flood & Landslide)
Taluka	Devikulam
Government Exposure Per unit	₹ 35 Lakhs
Residential average Exposure per unit	₹ 37.89 Lakhs

The Annual average loss for all the Government building in the Devikulam Taluka, as derived from the CAT Modelling is only Rs 25.16 lakhs, but considering the current exposure and market value, we determine the above exposure value of Rs 35 Lakhs as appropriate sum insured value for the Government building.

For residential property the average exposure value per unit as estimated by the CAT model is Rs 37.89 lakhs. The state government can decide to fix the individual sum insured @ either 5 lakhs, 8 lakhs, 10 lakhs and 12 lakhs for individual Residential properties.

The following table exhibits the parametric insurance product structure for Flood risk in Devikulam Taluka.

Table 2-20: Product structure for Landslide Risk for 2025-26

Product Structure for Landslide Risk – 2025-26		
Monsoon Period:1st June to 30st November		
Devikulam Taluka	**Strike Point**	**Payout**
Excess Seasonal Rainfall		
Payout Trigger Level	200 mm	25% of sum insured
Incremental Payout per additional 30 mm		15% of sum insured
Payout Exit Level	350 mm	100% of sum insured
Non-Monsoon Period: 1st December to 31st May		
	Strike Point	**Payout**
Excess Unseasonal Rainfall		
Payout Trigger Level	100 mm	25% of sum insured
Incremental Payout per additional 30 mm		15% of sum insured
Payout Exit Level	250 mm	100% of sum insured

The above product is devised for Devikulam Taluka of Idukki District where Landslide is a major peril bringing about huge catastrophic loss to the properties in this case the trigger points are set for both Monsoon as well as Non monsoon season which is based on Historic Rain fall data and landslide data (Weather loss Data)

The aggregate rainfall over the monsoon period (1st June to 30th November) in Devikulam Taluka is equal to or above the trigger threshold of 200 mm, and the payout structure starts from 25% of the sum insured (total exposure value) The amount is paid to the insured members in the above selected Taluka on event breaching the starting trigger value of 200 mm

For every additional rainfall of 30 mm, an incremental payout of 15% of the sum insured (Total Exposure) is payable. When the total cumulative rainfall in the identified Taluka exceeds 350 mm, 100% of the sum insured becomes payable to the insured population in the selected Taluka due to the operation of the peril

The parametric insurance also covers excess unseasonal rainfall during the non-monsoon period from i.e. 1st December to 31st May. The trigger threshold starts with a strike point of 100 mm of unseasonal rainfall during the above stated period and the payout exit level is fixed at 250 mm. if the cumulative rainfall exceeds 100 mm over 5 consecutive days during the non-monsoon season, 25% of the sum insured is payable to the insured members in the selected location of Devikulam. Further, for every additional rainfall of 30 mm, an incremental payout of 15% of the sum insured is paid. The payout exit level is 250 mm, i.e. When the cumulative rainfall exceeds the exit level of 250 mm, then 100% of the sum insured is payable (Annexure-1).

2.5.5.4.3 Product Structure for Flood & Landslide Risk Idukki Taluka

The following table presents the product devised for Idukki Taluka for Flood and Landslide risk. The total exposure value of all the properties, i.e, Residencial and Government buildings are to be considered as Sum insured

Table 2-21: Product devised for Idukki taluka for flood and landslide risk

Peril	Landslide (Flood & Landslide)
Taluka	Idukki
Government Exposure Per unit	₹ 35 lakhs
Residential average Exposure per unit	₹ 38.71 lakhs

The Annual average loss for all the Government building in the Idukki Taluka, as derived from the CAT Modelling is only Rs 20.42 lakhs, but considering the current exposure and market value, we determine the above exposure value of Rs 35 Lakhs as appropriate sum insured value for the Government building.

For residential property the average exposure value per unit as estimated by the CAT model is Rs 38.71 lakhs, the state government can decide to fix the individual sum insured @ either 5 lakhs, 8 lakhs, 10 lakhs and 12 lakhs for individual Residential properties.

The following table exhibits the parametric insurance product structure for Flood risk in Idukki Taluka.

Table 2-22: Product structure for Flood and Landslide Risk for 2025-26

Product Structure for Flood& Landslide Risk – 2025-26		
Monsoon Period:1st June to 30st November		
Idukki Taluka	**Strike Point**	**Payout**
Excess Seasonal Rainfall		
Payout Trigger Level	150 mm	25% of the sum insured
Incremental Payout per additional 20 mm		15% of the sum insured
Payout Exit Level	250 mm	100 % of the sum insured
Non-Monsoon Period: 1st December to 31st May		
	Strike Point	**Payout**
Excess Unseasonal Rainfall		
Payout Trigger Level	100 mm	25% of sum insured

Incremental Payout per additional 20 mm		15% of sum insured
Payout Exit Level	200 mm	100% of sum insured

The above parametric insurance product is devised for Idukki Taluka of Idukki District where Flood and Landslide are the most hazardous peril bringing about huge loss to the properties. Heavy rainfall in Idukki district has triggered landslides, causing damage to property and infrastructure. Thus, we have taken cognisance of rainfall as well and landslide records from the historical data and finalised the trigger points for Monsoon as well as Non monsoon season.

The aggregate rainfall over the monsoon period (1st June to 30th November) in Idukki Taluka is equal to or above the trigger threshold of 150 mm, and the payout structure starts from 25% of the sum insured (total exposure value) The amount is paid to the insured members in the above selected Taluka once their Threshold limit of 150 mm of rainfall is reached.

For every additional rainfall of 20 mm, an incremental payout of 15% of the sum insured (Total Exposure) is payable. When the total cumulative rainfall in the identified Idukki Taluka exceeds 250 mm, 100% of the sum insured becomes payable to the insured population in the selected Taluka.

The above product can also be formulated for the non-monsoon period i.e. 1st December to 31st May. This insurance covers excess unseasonal rainfall and resultant landslides during the non-monsoon period with the following set trigger points. The trigger threshold starts with a strike point of 100 mm of unseasonal rainfall during the above-stated period and the payout exit level is fixed at 200 mm. In case the cumulative rainfall exceeds 100 mm over 5 consecutive days during the non-monsoon season, 25% of the sum insured is payable to the insured members in the selected location of Idukki. Further, for every additional rainfall of 20 mm, an incremental payout of 15% of the sum insured is paid. The payout exit level is 200 mm, i.e when the cumulative rainfall exceeds the exit level of 200 mm, then 100% of the sum insured is payable (Annexure-1).

2.5.5.4.4 Product Structure for Cyclonic Wind and Storm Surge Risk – Kollam Taluka

Kerala State experiences Cyclones from both Bay of Bengal and Arabia Sea during pre- and post- monsoon months (April to May and Oct to Dec). The Storm Surge is experienced in its coastal areas, experiences storm surges, with events like "*kallakkadal*" (sudden, high waves) causing flooding. Generally, Storm-Surge starts generating at a Cyclonic Wind of 90 kmph and above and it starts noticeable damage to housing sector in Kerala at about 95 kmph.

The below parametric insurance products are devised for Kollam Taluka of Kollam District because of its susceptibility to the cyclones and storm surges. For these perils, we have taken cognisance of Cyclonic Wind records from the historical data and finalised the trigger points for Cyclone and Storm Surge for the Cyclone season.

The following tables (Table 2-23, Table 2-24) present the products devised for Kollam Taluka for Cyclone and Storm Surge risk. The total exposure value of all the properties, i.e., Residencial and Government buildings are considered as the Sum insured.

Table 2-23: Product devised for Kollam taluka for cyclone risk

Product Structure for Cyclone Risk		
Cyclonic Period: April 1 to May 31 and Oct 1 to Jan 15		
Kollam Taluka	**Strike Point**	**Payout**

Excess Seasonal Wind Speed		
Payout Trigger Level	90 kmph	25% of the sum insured
Incremental Payout per additional 10 kmph		15% of the sum insured
Payout Exit Level	140 kmph	100% of the sum insured

Table 2-24: Product devised for Kollam taluka for storm surge risk

Product Structure for Storm Surge Risk		
Cyclonic Period: April 1 to May 31 and Oct 1 to Jan 15		
Kollam Taluka	**Strike Point**	**Payout**
Excess Seasonal Wind Speed		
Payout Trigger Level	95 kmph	25% of the sum insured
Incremental Payout per additional 10kmph		15% of the sum insured
Payout Exit Level	145 kmph	100% of the sum insured

Considering the current exposure and market value, we determine the above average value of Rs 25 Lakhs as appropriate sum insured value for the Government buildings in Kollam Taluka.

For residential property the average exposure per unit estimated by the NatCAT model is Rs 36 Lakhs, the state government can decide to fix the individual sum insured @ either 5 lakhs, 8 lakhs, 10 lakhs and 12 lakhs for individual Residential housing unit.

The Cyclonic Wind speed for Cyclone and Storm surges during the cyclone period in Kollam Taluka is equal to or above the trigger threshold of 90 kmph and 105 kmph respectively, and the payout structure starts from 25% of the sum insured (total exposure value) The amount is paid to the insured members in the above selected Taluka once their lower threshold trigger point of 90 kmph is reached for Cyclone and 105 kmph for Storm surge.

For every additional cyclonic wind of 10 kmph, an incremental payout of 15% of the sum insured (Total Exposure) is payable. When the cyclonic wind speed in the identified Kollam Taluka exceeds 140 kmph, 100% of the sum insured becomes payable to the insured population in the selected Taluka for Cyclone and 155 kmph for Storm Surge.

The above prototype products are applicable for both high risk Talukas for Cyclone and for Storm Surges in high-risk coastal Talukas in the state (Annexure-1).

3 Prototype Property Catastrophe Insurance Products

3.1 Design Methodology:

Details the approach to developing insurance products, including the identification of policy features, risks covered, and customization for different stakeholders.

To develop region-specific customized (Prototype) property catastrophe insurance products, we studied the various catastrophic insurance products available in developed markets like the USA, UK, Europe, Mexico, etc. Most of these products have the most prominent perils like earthquakes, floods, and cyclones, as compulsory cover and other secondary perils such as lightning, storm surges, and landslides as the add-on cover.

The development of catastrophic insurance products requires a sound actuarial methodology approach. First, the risk exposures of residential property and government assets need to be ascertained. Second, vulnerability and hazard probability are estimated using CAT Risk Modeling, yielding outputs like risk exposure values, Expected Loss / AAL, and Loss Exceedance Probability Curves for each major peril.

Based on these values, the risk profile of regions with different levels of loss exposures (High, Medium, and Low) for each major peril selected for the State, is developed (as given in Component 2 of the report). Using these values, insurance coverages at different sums insured are determined at the LSG/Taluka level. Then, for each sum insured or coverages, appropriate premium rates including burning cost, expected loss value, and the total amount of premium payable for the residential properties at LSG/Taluka level have been estimated. These estimates were done considering the loss exceedance probability of all the possible natural catastrophic perils like floods, landslides, cyclonic winds, and storm surges, occurring at the LSG/Taluka level. Similar risk profiles were also developed for each district level by aggregating the estimate values derived at the LSG/Taluka level.

After determining the risk profile along with the estimated values of risk exposures, expected loss value/ AAL, the burning cost or pure premium rates were estimated for each major peril for the residential property at LSG/Taluka level. Using the pure premium rate, the actuarial premium rates were estimated after loading for the necessary administrative and marketing expenses and profit margin.

Finally, the performance of the catastrophic risk insurance was also evaluated by comparing the expected loss value and the premium rates at different loss probability levels (1%, 5%, 10%, and 20% with return years (1/10, 1/25, 1/50, and 1/100 years) respectively.). The actuarial performance of these products including the financial viability was estimated using simulation, through 'as if' scenario analysis.

3.2 Policy Features and Coverage Options

This section explores the range of options available for policyholders, including coverage limits, deductibles, and peril-specific protections.

The risk from Nat Cat events is increasing, partly due to climate change, which is contributing to more extreme weather events like Storms, Flood, hurricanes, earthquakes, and Land slide. These events can cause significant damage to property, infrastructure, and lives, resulting in large financial losses. The insurance industry, particularly in India, has been heavily impacted by these events.

Natural catastrophe (NatCAT) insurance covers damage from natural disasters such as earthquakes, floods, landslides, cyclones, storm surges and Drought. It can be included in property insurance policies.

Natural catastrophes in India have led to uninsured economic losses of $32.94 billion (Rs 273,500 crore) during the five period of 2018-22, indicating the low insurance penetration in the country. Insured economic losses during the period were just $1.10 billion (Rs 9,130 crore) as 93 per cent of exposures were uninsured (SwissRe, 2023).

Alongside the expanding economy and growing insurance market, India is exposed to many natural catastrophes, including earthquakes, floods, tropical cyclones, storm surges, drought and wildfires (Forest Fire) etc. It is also observed that the insurance protection against natural catastrophe risks is low and as per the resilience analysis carried out by Swiss Re indicates that 93% of the exposures are uninsured.

Since then, the State of Kerala has witnessed frequent floods, storm surges, landslides and Drought during the last 10 years which have resulted in huge financial liability to the State Government. One of the reasons for the heavy financial burden to the State Government is that nearly 95% of the properties were uninsured, based on our analysis of insurance penetration in the state highlighted in component 3. This suggests that the state needs to have a region-specific Catastrophic property insurance mainly for residences and Government Buildings.

Catastrophic insurance plays a key role in helping the Government, property owners and business houses in mitigating their financial losses resulting from the above catastrophic events. This allows them to make more informed decisions regarding risk selection and risk financing.

The following sections of this chapter discuss the salient features of the catastrophic insurance products including coverages, exclusions, deductibles and peril-specific protection.

Risks Covered Under Catastrophic Insurance

1. **Flood and Inundation**: It can be defined arising out of heavy rains and subsequent inundation. Floods are also classified as a *force majeure* event (also known as a *"vis major"*), meaning that they are unexpected and beyond the control of the property owner.

Storms and heavy rainfall can lead to overflowing of rivers, dams, and even the sea which can result in flooding in the nearby areas. On the other hand, inundation is a type of flood resulting from the overflow of water.

Properties situated in flood-prone areas, such as near rivers, coastlines, or low-lying regions, are considered to be at higher risk and will attract higher premiums. Conversely, properties in areas less susceptible to flooding may attract lower premiums.

In the event of a flood caused by external factors (like heavy rainfall & storms and coastal storm surge), the policy will cover the cost of repairs or rebuilding the damaged property. Property owners can receive financial compensation up to the policy limit specified in the policy, which is typically based on the value of the property and the contents covered (if specifically mentioned in the policy). This ensures that the property owner is protected from the financial burden of flood damage.

Exclusion: *This policy excludes damage from flooding due to bursting of pipes, overflowing of overhead tanks and all types of flooding not resulting from NatCAT event*.

2. **Storm and Tempest**: The catastrophic insurance covers different types of Storms; Cyclonic Storm, Severe Cyclonic Storm, Storm Surge etc. The definitions of various cyclonic disturbances, as per the IMD are given below:

Table 3-1: Classification cyclones based on Wind Speed

Sl. No.	Storm category	Wind speed in knots	Wind speed in kmph
1	Low Pressure Area (L)	<17	<31
2	Depression (D)	17-27	31-49
3	Deep Depression (DD)	28-33	50-61
4	Cyclonic Storm (CS)	34-47	62-88
5	Severe Cyclonic Storm (SCS)	48-63	89-117
6	Very Severe Cyclonic Storm (VSCS)	64-89	118-166
7	Extremely Severe Cyclonic Storm (ESCS)	90-119	167-221
8	Super Cyclonic Storm (SuCS)	120 or more	222 or more

Cyclonic Storm is an Intense low-pressure system represented on a synoptic chart by more than four closed isobars at 2 hPa interval and in which the wind speed on the surface level is between 34 – 47 Kts (equivalent to the wind speed of 62 kmph to 88 kmph).

Severe Cyclonic Storm is referred to Intense low-pressure system represented on a synoptic chart by more than four closed isobars at 2 hPa interval and in which the wind speed on the surface level is between 48 – 63 Kts. (equivalent to the wind speed of 89 kmph to 117 kmph). If the wind speed on surface level is between 118 kph to 166 kmph), it is considered a Very Severe Cyclonic Storm (VSCS). Cyclonic wind speed between 167 to 221 kmph is considered as an Extremely Severe Cyclonic Storm (ESCS). The cyclonic wind speed above 222 kmph is classified as a Super Cyclonic Storm (SuCS).

The storm generally results in atmospheric disturbances that lead to powerful winds, rains, thunderstorms, hailstorms, and sometimes even snow. Storm is a common occurrence that may lead to damage to the property and goods for which the catastrophic policy provides compensation.

3. **Hurricanes and Typhoons**: Hurricane is a tropical cyclone with winds of 74 Mph or greater, that is usually accompanied by rain, thunder, and lightning, and that sometimes moves into temperate latitudes. Hurricanes and typhoons are types of dangerous storms that are formed in different regions. A hurricane is a storm that commonly forms over hot or warm water and can result in heavy destruction of property. On the other hand, typhoons are prevalent in tropical atmospheres, leading to massive destruction.

4. **Tornado**: It is another natural calamity that can result in subsequent damage to the property and goods insured. A tornado usually forms a vortex on the surface of the Earth.

5. **Earthquake**: The catastrophic insurance policy covers earthquakes resulting in a sudden shaking of the Earth's surface caused by the release of energy in the Earth's crust. The policy protects the property of residential buildings (Housing Sector) and Government buildings from damage caused by an earthquakes and volcanic eruptions. This Insurance covers loss or damage (including loss or damage by fire) to the property insured by this Policy occasioned by earthquake including Landslide / Rockslide resulting from earthquake *but excluding flood or overflow of the sea, lakes, reservoirs and rivers caused by earthquake*.

6. **Landslide and Rockslide**: The catastrophic policy covers Loss, destruction or damage directly caused by Subsidence of a part of the site on which the property stands or Land slide/Rockslide *but excludes the following:*

a. The normal cracking, settlement or bedding down of new structures

b. The settlement or movement of made-up ground.

c. Coastal or river erosion

d. Defective design or workmanship or use of defective materials e. Demolition, construction, structural alterations or repair of any property or groundworks or excavations

Landslides/Rockslides are not directly considered under Catastrophic insurance policy but the resultant damages from any of the above insured Catastrophic perils are covered under the policy though it is a localized calamity.

Sum Insured.

To arrive at the Sum insured for each property, we have taken the total exposure value and arrived at the *average exposure value for per property*. The same is used to calculate the *premium per unit*, *i.e., liability to the State Government*. However as per the discussions with the Kerala State Disaster Management Authority (KSDMA), we are considering the sum insured of Rs 5 lacs, Rs 8 lacs, Rs 10 lacs and Rs 12 lacs per unit towards residential property for arriving at the total premium liability for the State.

Premium Rates.

Natural catastrophe premium rates have been increasing during the last few years due to climate change, which is leading to more frequent and severe weather events. This has resulted in higher insured losses; which insurers are passing on to policyholders through higher premium rates. The STFI rates for property catastrophe insurance have risen by 20-22% since December 15, 2023. As of 2024 in India, the premium rates for add-on natural catastrophe (NatCAT) perils on insurance policies vary significantly depending on the specific location, type of property, and the severity of the natural disaster risk in that area. The other factors influencing the premium rates are Impact of climate change, Policy conditions and coverages and Regulatory influence (setting up minimum premium).

As of April 1, 2024, the Insurance Regulatory and Development Authority of India (IRDAI) has *scrapped tariff wordings* for General Insurance policies, except for motor third party (TP) allowing insurers to devise their own policy wordings and structures. The above change enables the insurers to introduce customized (region-specific) catastrophic insurance products in the market.

It must be noted that there was peril-specific rates for Catastrophic perils, However the current revision/scenario allows the insurance company to offer a consolidated package rate for all the Catastrophic perils including Earthquake, STFI, Landslide and Rockslide etc. depending on the risk exposure of the regions/ State. Considering the above market dynamics, we have worked out the actuarial premium rate based on the catastrophic risk exposures at the Taluka Level for the State.

Deductibles:

Excess is that amount which is borne by the insured/ policyholder in case of any Catastrophic event arising out of the NatCAT perils. It is usually 2% of the claim amount subject to a minimum of Rs 10,000/- per event. The policyholder can also have a choice of increasing the limit of excess to 5%, 10% and 20% of the claim amount and accordingly also increase the minimum limit to Rs 25,000/-, Rs 50,000/- and Rs 1.0 lakh respectively. This will allow a reduction in premium payable amount.

Add-on Cover:

Some of the perils like*, Bush Fire and Forest Fire* which even though are out of control of the insured, *cannot be considered as the Catastrophic perils* and have to be taken as an *add-on under Property Insurance*.

3.3 Risk Profile Development:

This section describes the process of generating risk profiles for the proposed policies, including their associated risk exposures, pure premium rates, expected loss cost, and loss ratio (Annexure-3).

To generate the risk profiles for the catastrophic risk insurance products, we have used expected loss cost, annual average loss, and exposure values derived from the catastrophic risk model. In addition, we have used the average loss cost and loss ratio estimated based on the pure premium rates generated for the catastrophic risk insurance products. To understand the risk, vulnerability and loss experience of the selected regions, we have generated a Risk Heat Map for each of the selected perils: Flood, Landslide, Cyclone and Storm Surge. The Heat map is developed using the expected loss ratio and average annual loss data derived at the Taluka Level for each peril and Taluka. *The loss ratio represents the ratio of premiums charged to the expected loss or claims experience*. This can help in identifying the high, medium, and low vulnerable Talukas as compared to their risk exposures for residential properties and public assets. The following paragraph discusses the development of Heat Map and its data points & visualization.

3.3.1 Overview of Python-Based Excel Automation and Heat Map Generation

This particular python implementation effectively utilizes pandas, seaborn, and matplotlib to extract, process, and visualize disaster risk data, specifically focusing on Exposure Values, Average Annual Loss (AAL), and Loss Ratios. The goal of this automation is to identify and represent vulnerability levels across different risk segments, across certain categorized regions of the state, providing insights into potential losses due to various perils such as floods, landslides, cyclones and Storm Surge.

This structured approach not only automates data handling but also generates heat maps that serve as intuitive visual aids for assessing risk exposure. By categorizing the data values into meaningful bins and applying custom colour coding, the outputs offer a clear, data-driven representation of risk distribution across different parameters.

3.3.2 Key Steps and Logic Adopted

1. **Data Transformation for Visualization**
   - A pivot table is created to organize data into a two-dimensional matrix where risk metrics (AAL, exposure values, and loss ratios) are aligned into structured rows and columns.
   - This ensures that the final heat-map effectively represents the relationship between exposure levels and risk categories, highlighting areas of higher vulnerability.
   - The x-axis represents the Average Annual Loss (AAL) or Risk Exposures.
   - The y-axis (risk values such as expected loss cost or loss ratio) is reversed to ensure that the highest-risk values appear at the top of the Heat-Map rather than the default bottom-up approach.
   - This logical ordering improves interpretability by maintaining a natural risk progression from low to high, making it easier to analyse critical risk zones immediately.
2. **Colour Mapping and Interpretation**
   - A custom vulnerability scale is implemented, mapping risk levels to intuitive colour codes:
     - Green – Very Low risk
     - Light Green – Low risk
     - Yellow/Amber – Moderate risk
     - Orange – High risk
     - Red – Very High / Extreme risk

- This gradient-based colour mapping enhances interpretability, making it easy to spot critical risk zones immediately.

3. Graphical Representation and Final Output

- The final heat maps are plotted using matplotlib, with clear labelling for both axes to denote financial exposure categories and risk values.
- Annotations are included inside heat-map cells to display actual numerical values, ensuring that data insights are immediately accessible without requiring further reference.
- The y-axis is reversed to align risk values logically from low to high, ensuring the heat-map's structure reflects an intuitive understanding of increasing financial vulnerability.

4. Significance of the Outputs

- Enhanced Decision-Making for Risk Assessment
  The generated heat-maps allow for quick visual identification of high-risk zones, making it easier for financial analysts, insurance providers, and risk assessors to focus on areas requiring immediate attention. The structured categorization of risk provides an objective and data-driven foundation for decision-making.
- Automation and Efficiency

Manual risk classification and heat-map generation can be time-consuming and prone to human errors. By leveraging Python for automation, your workflow ensures speed, accuracy, and consistency across different datasets, reducing manual effort and improving overall efficiency.

- Scalability and Adaptability

  The methodology implemented can be easily adapted to different datasets. Whether analyzing risk across different perils (floods, landslides, or windstorms) or adjusting financial exposure brackets, the scripts allow easy customization to accommodate evolving data requirements.

- Data Integrity and Consistency
- The use of structured data binning, pivot tables, and custom colour mapping ensures that the heat-map representations remain consistent and reliable across multiple datasets. This prevents biases or misinterpretations that may arise from automatic scaling methods used in conventional heat maps.
- Visual Clarity and Interpretability

  Unlike raw numerical reports, which require extensive analysis, the heat maps provide a clear and immediate snapshot of risk distributions. The combination of numerical annotations, structured binning, and intuitive colour coding makes the outputs highly reliable for both technical analysts and non-technical stakeholders.

This specific Python-based automation pipeline successfully transforms raw risk exposure-loss data into actionable insights, streamlining risk assessment and vulnerability analysis. By effectively integrating Excel processing with customized heat-map visualization, this approach provides a highly scalable, efficient, and visually intuitive method for identifying financial exposure and associated risks. This framework can be further enhanced by incorporating interactive dashboards, real-time data updates, making it an even more powerful tool for analysis.

3.3.3 Taluka Level Risk Profile Analysis for All Risks (Flood, Landslide, Cyclones and Storm Surges:

The following Heat Map presents nine different risk segments having low loss ratio and low expected loss, medium loss ratio and low expected loss, and high loss ratio and low expected loss, to high loss ratio and high expected loss (AAL).

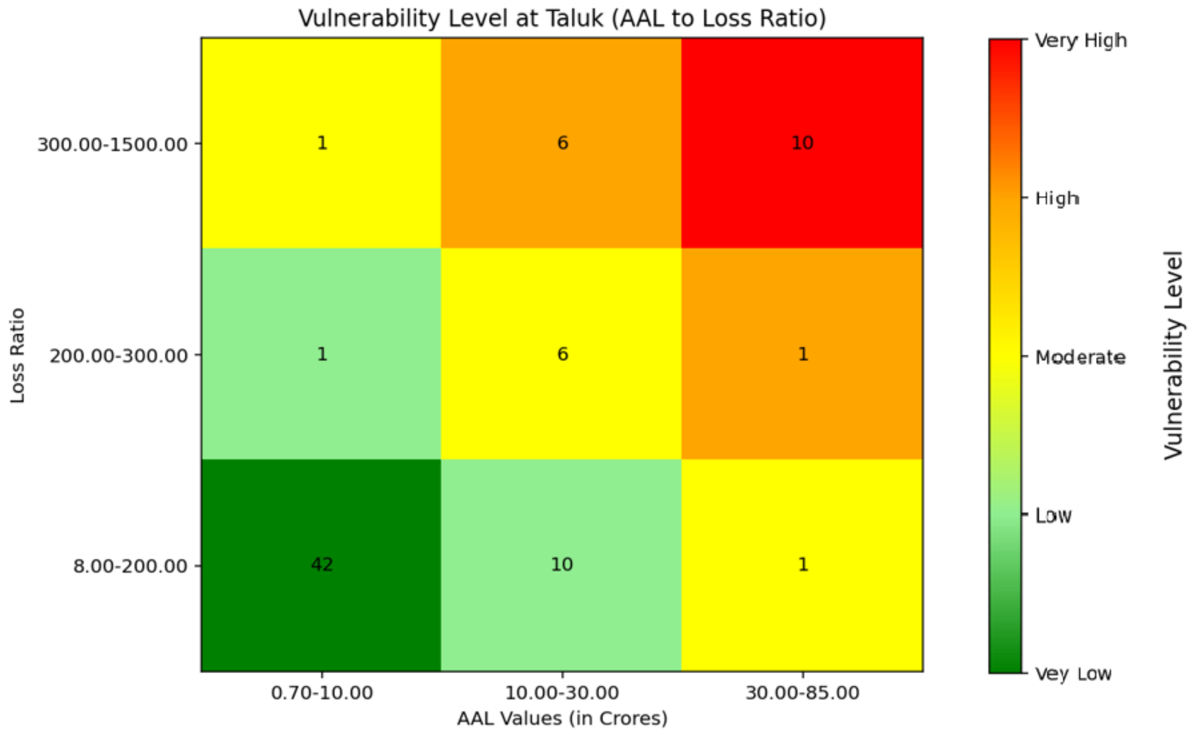


Figure 3-1: Heat-Map exhibiting Taluka-wise Risk Areas for All Perils – AAL and Loss Ratio

The top quadrants Heat-Map with red or amber colour highlights the most vulnerable areas where the expected losses are likely to exceed the insurance coverage and needs drastic risk mitigation measures to be undertaken to keep them under control. Some of the Talukas which fall under high loss ratios with extreme average losses are Kochi, Paravur, Aluva and Kanayannur from Ernakulam district, Kuttand, Karthikapally, Chengannur, Ambalapuzha from Alappuzha district, and thodupuzha, Peermadu, Idukki, and Udumbanchola from Idukki district and Trissur, Chavakkad from Trissur district, vaikkom, Kottayam, changanassery from Kottayam district and mananthavady, vythiri from Wayanad district are highly vulnerable for all the catastrophic perils like floods, cyclonic winds, landslide and storm surges.

The line chart of loss ratio vs annual average loss, given below in Figure 3-1, also represents the same pattern. Further, the results derived from the line chart and the heat-map above confirm that the risk vulnerabilities of these Talukas have a similar loss experience pattern highlighting the reliability of the catastrophic modeling results. The line chart presents the Taluka-wise loss trends for all risks (floods, landslides, cyclone and storm surge) with AAL and Loss Ratio values. There are almost 17 Taluka areas which are highly vulnerable for all the risks in terms of both higher AAL values and greater loss ratios, indicating these areas need to be given prime importance for risk mitigation and insurance coverages.

Similarly, there are about 8 Taluka areas that have moderate risk vulnerability with either higher AAL and moderate loss ratio or moderate AAL values. Some of these Talukas are Attappadi, Chittur from Palakkad, Kanayannur from Ernakulam, Kodungallur, Mukundapuram, from Thrissur, Thiruvalla, Kozhencherry, Ranni from Pathanamthitta, Mavalikkara from Alappuzha, and Mananthavady, Suthan Bathery from Wayanad. Though most of them have moderate AAL, but they are likely to contribute to higher loss ratio as their vulnerability to floods, landslide, cyclone and storm surge is increasing.

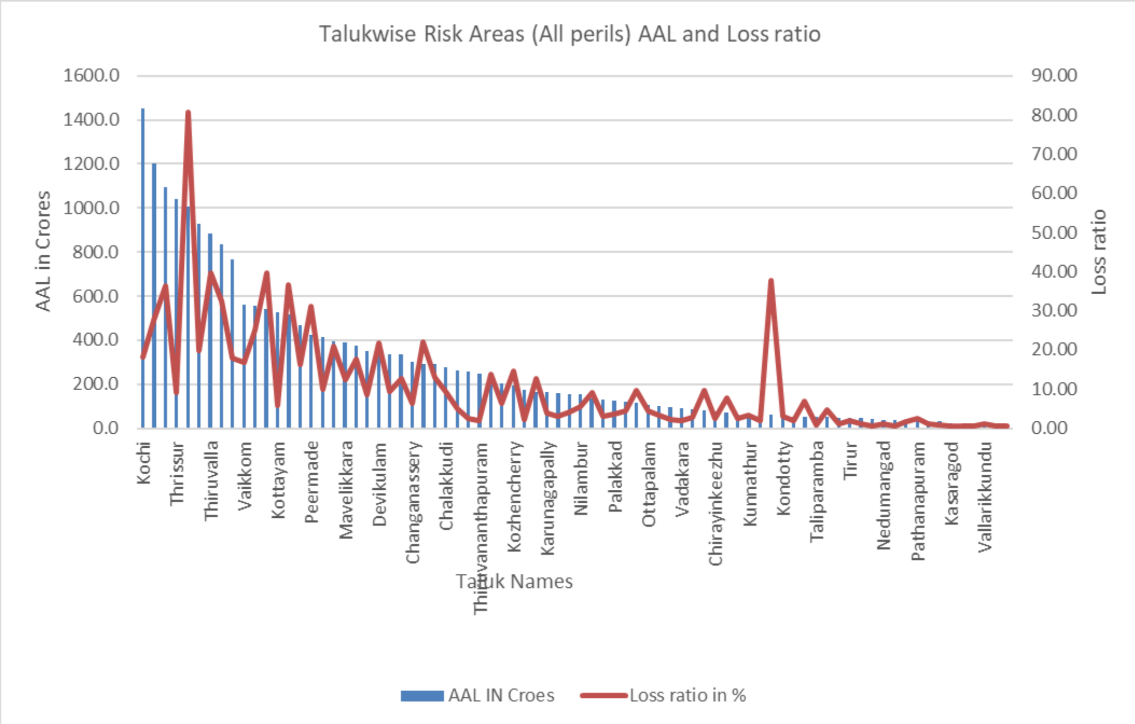


Figure 3-2: Taluka-wise Risk Areas for All Perils – AAL and Loss Ratio Trends

Some of the low-risk areas highlighted by the analysis are (53), Karunagapally, Kollam, Kottarakara from Kollam district, Thalassery, Iritty, Taliparamba from Kannur district and Kasaragod, Manjeswaram, Vallarikkundu from Kasaragod district, and Kondotty, Perinthalamanna, Thirurangadi, Ponnani, Eranad, from Malappuram district.

3.3.3.1 Taluka level Risk Profile Analysis for Flood Risk:

This analysis presents the Taluka-level risk profile analysis for Flood risk using Heat Map as well as Exposure & ALL Trend analysis for the State. The heat-map provides the risk profile of flood risk areas in terms of both exposure values of the residential property and expected loss values (AAL), which helps to identify the most flood vulnerable Taluka areas with different risk profiles – High, Medium and Low risks.

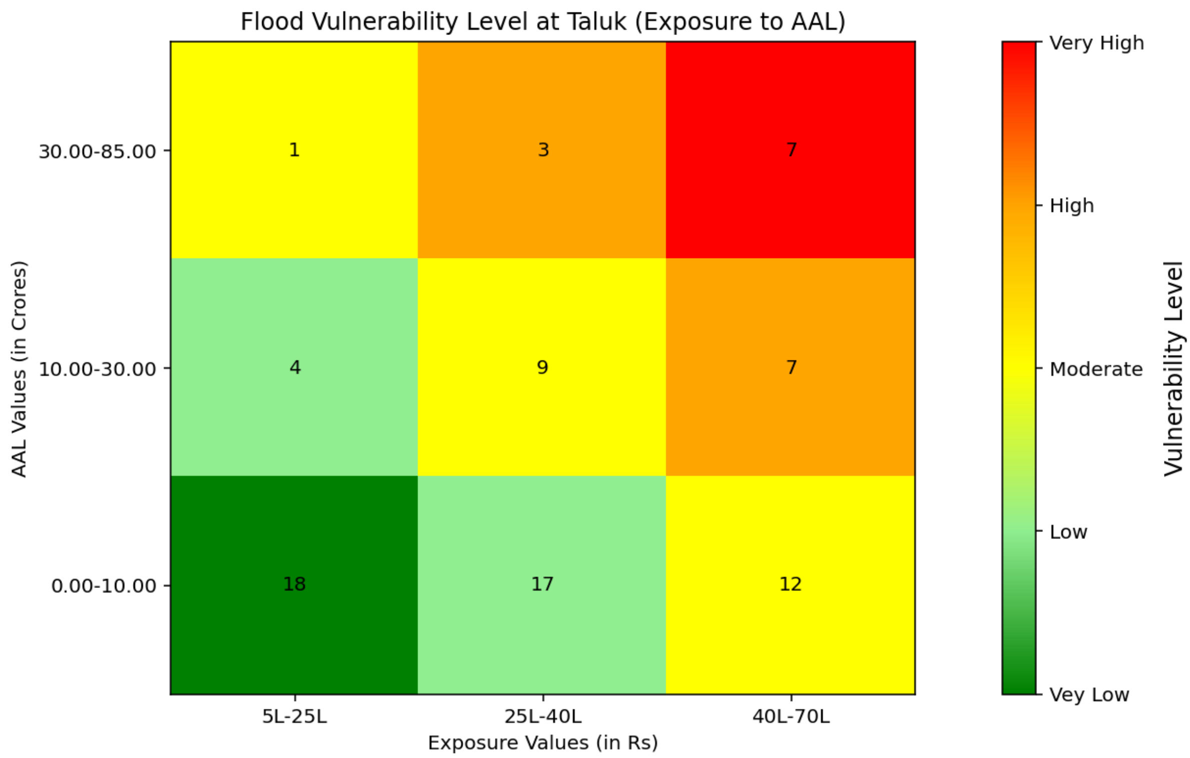


Figure 3-3: Heat-map exhibiting Risk Areas for Flood Perils – AAL and Exposures

The above heat map demonstrates the vulnerability of certain Talukas to flood risks. As observed in the state hazard map, flood is one of the most significant risks for the state, the heat map exhibits that nearly 17 Talukas are highly vulnerable for the flood risk in terms of both with higher AAL and also greater asset exposure values.

Some of the high-risk areas with high flood risk vulnerabilities, with higher exposure values and AAL are Kochi, Paravur, Aluva, Muvattupuzha and Kanayannur, from Ernakulam district, Chengannur and Karthikapally from Alappuzha district, Kottayam and Vaikkum from Kottayam district, Chavakkad, and Thrissur from Thrissur district, Thiruvananthapuram, Kozhikode, Pattambi, Alathur and Chittur from Palakkad district.

The Table given below exhibits the top 10 Flood high risk area in terms of both vulnerability (AAL) as well as Exposure.

Table 3-2: Top ten Flood high risk area in terms of both vulnerability (AAL) as well as Exposure

Flood High Risk Areas			
Name of Talukas	**District**	**AAL in Rs Crores**	**Exp Value in Crores**
Kochi	Ernakulam	80.1	1,00,402
Paravur	Ernakulam	67.1	55,386
Thrissur	Thrissur	56.91	1,42,830
Kuttanad	Alappuzha	55.47	15,498

Thodupuzha	idukki	53.68	38,213
Karthikapally	Alappuzha	51.5	58,613
Thiruvalla	Pathanamthitta	49.13	28,099
Chengannur	Alappuzha	46.66	32,437
Chavakkad	Thrissur	42.63	53,845
Vaikkom	Kottayam	30.92	41,932
Ambalapuzha	Alappuzha	30.88	27,908

Similarly, there are about 20 Talukas which has very high exposure values with moderate AAL, like Kottayam, Thiruvananthapuram, Kozhikode, Patambhi, Chenganassery, kanayannur, Alathur, Muvattupuzha and Mavelikkara are also observed to be high vulnerable areas to Flood risk. Hence, these areas which high exposures are to be given priority in terms of Disaster Risk protection and Mitigation.

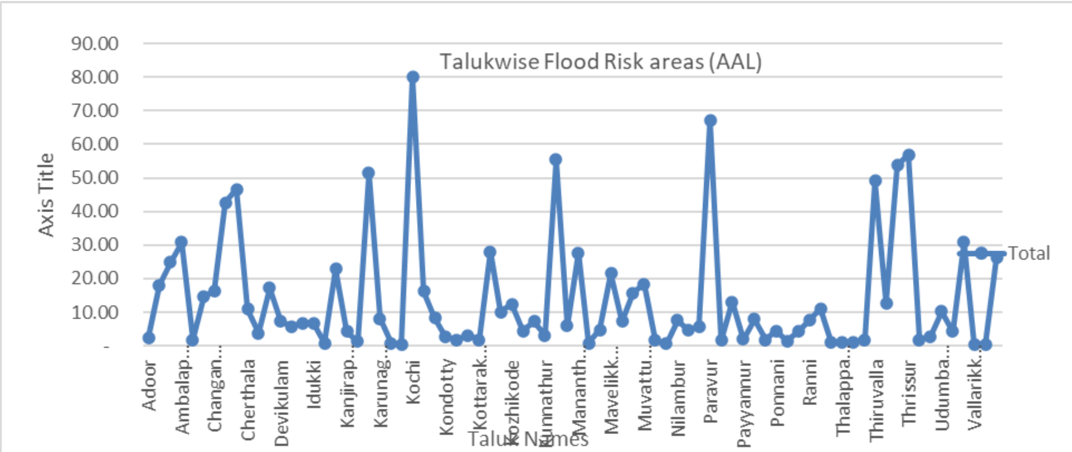


Figure 3-4: Taluka-wise Risk Areas for Flood Perils – AAL and Exposure Trends

The above chart-2.3.4 exhibits the flood risk trends – AAL and Exposure values. This also almost reflects the same high and moderate flood risk areas for the state. Some of the low-risk areas are Cherthala from Thrissur district, Kondotty, Kottarakara, Ponnani from Malappuram district, Ranni, Mallapally, Kozhancherry, and Vallarikkundu from Pathanamthitta district, Udumbanchola and Peermade from Idukki district.

3.3.3.2 Taluka Level Risk Profile Analysis for Landslide Risk:

Landslides are one of the most significant catastrophic risk factors impacting the regions of Wayanad and Idukki districts. The Heat-Map analysis highlights the locations or Taluka areas which have significant risk exposures as well as vulnerability to landslide risk.

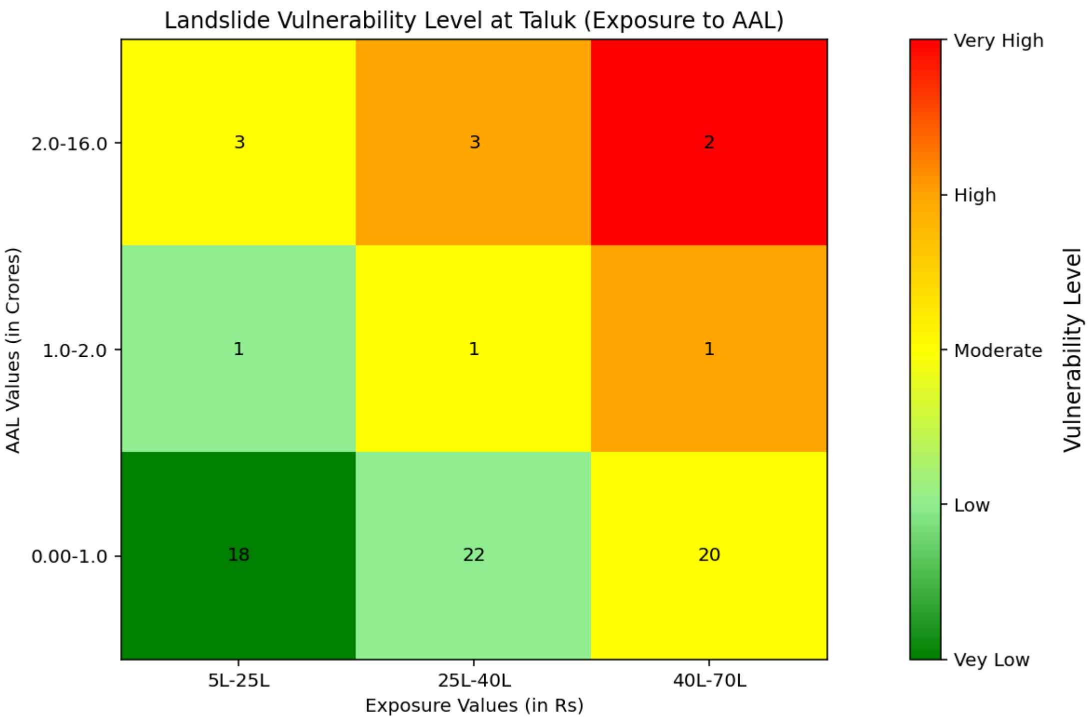


Figure 3-5: Heat-map exhibiting Landslide Risk Areas – AAL and Exposures

As per this analysis, there are 6 Taluka areas like Peermade, Idukki, Devikulam, Udumbanchola from Idukki district, and Vythiri, and Mananthavady from Wayanad district have very high exposures and also large AAL values to landslide risks. The following table highlights highly vulnerable areas to Land slide risk.

Table 3-3: Top ten Landslide high risk area in terms of both vulnerability (AAL) as well as Exposure

Top Landslide Risk Talukas			
Name of Talukas	District	AAL in Crores	Exposure Values in Rs Crores
Peermade	Idukki	15.54	17,186.27
Idukki	Idukki	14.92	24,093.51
Devikulam	Idukki	11.55	20,041.24
Udumbanchola	Idukki	10.00	26,801.09
Thodupuzha	Idukki	7.41	38,212.94
Mananthavady	Wayanad	2.41	17,370.04
Vythiri	Wayanad	2.28	17,840.92
Mannarkkad	Palakkad	2.22	18,575.48

While Mannarkkad Taluka from Palakkad, Ranni from Pathanamthitta, and Taliparamba from Kannur district have a moderate risk vulnerability to landslide with high to moderate values of AAL and asset exposures.

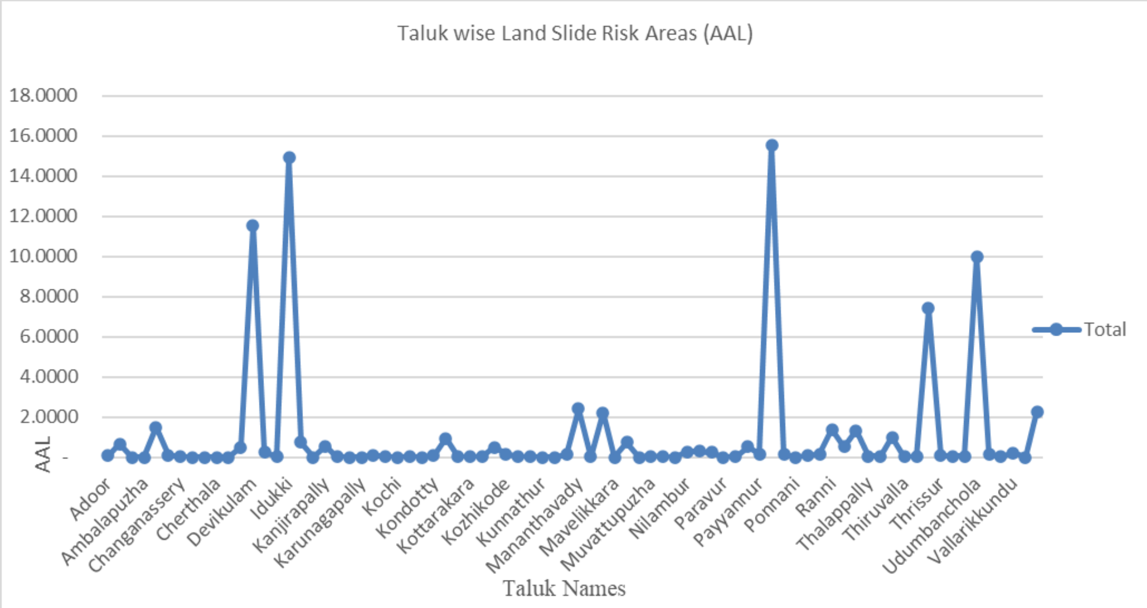


Figure 3-6: Trendline exhibiting Landslide Risk Areas – AAL and Exposures

The above AAL of the Talukas also indicates more or less similar exposures of certain Talukas which have greater vulnerability to Landslide risks. The areas that have greater exposure to landslide are Devikulam, Idukki, Peermade, Thodupuzha and Udumbanchola. Similarly, the Talukas with low-risk areas are Konni, Attappadi, Thalassery, Thiruvalla, and Vaikkom, etc.

3.3.3.3 Cyclonic Wind Risk Talukas Vulnerability Profile:

There are nearly 21 Talukas that have a high to very high vulnerability to the risks of high Cyclonic winds. Out of them, there are 6 of them that are in very high vulnerability exposures both in terms of high value of AAL and Exposures; Kozhikode, Thrissur, Thiruvanathapuram, Kottayam, Palakkad, Pattambi, Thalassery, Alathur, and Kollam.

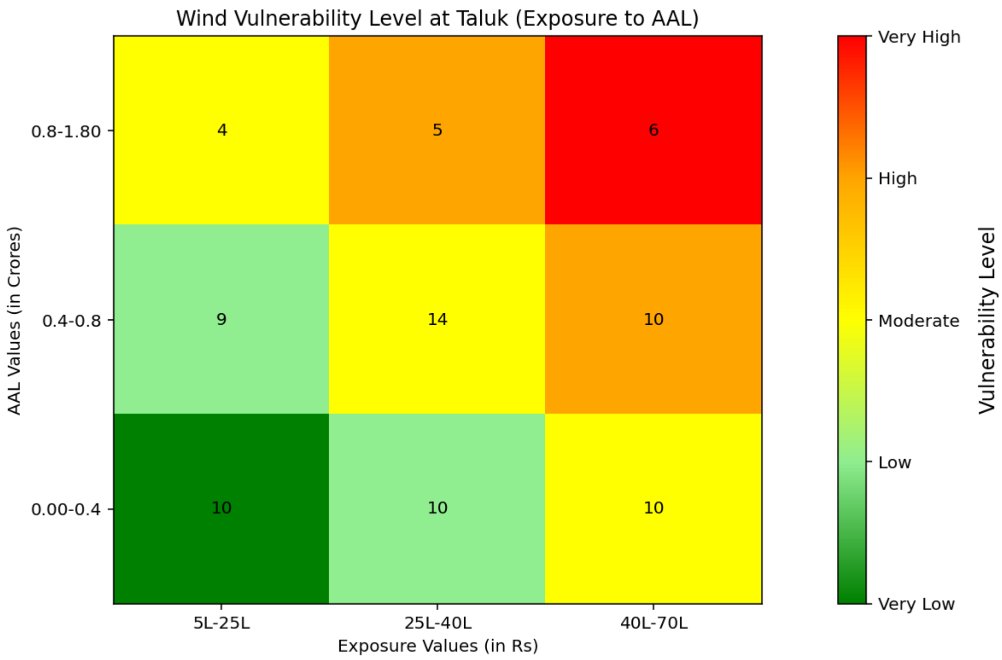


Figure 3-7: Heat-map exhibiting High Wind Risk Areas – AAL and Exposures

The moderate risk areas are Kothamangalam, Ottapalam, Ernad, Udumbanchola, Quilandy, Kannur and Changanassery Kochi, Vadakara and Thalappally. The following table highlights highly vulnerable areas to Heavy Cyclonic wind risk.

Table 3-4: Top ten Cyclonic Wind high risk area in terms of both vulnerability (AAL) as well as Exposure

High Cyclonic Wind Risk Areas		
Name of Taluka	**AAL in Rs Crores**	**Exposure Values in Rs Crores**
Kozhikode	1.59	132,473.95
Thrissur	1.53	142,829.60
Aluva	1.48	36,535.34
Kunnathunad	1.40	45,542.45
Palakkad	1.16	45,477.67
Pattambi	1.15	66,023.13
Perinthalmanna	1.10	35,895.37
Chittur	1.10	33,550.22
Thiruvananthapuram	1.02	166,418.35
Kottayam	1.00	110,327.55
Alathur	0.92	52,088.35
Meenachil	0.90	67,560.03
Kothamangalam	0.89	11,776.93

Ottapalam	0.86	29,861.11
Thalassery	0.84	97,239.68

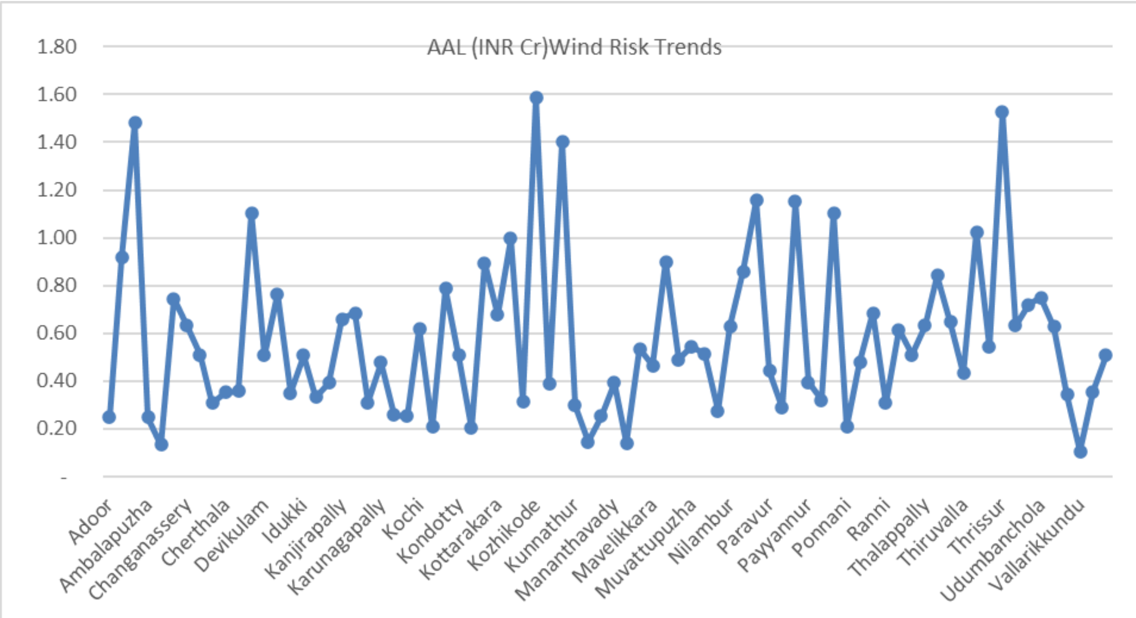


Figure 3-8: Trendline exhibiting Heavy Cyclonic Wind Risk Areas – AAL and Exposures

The low-risk areas are Paravur, Payyannur, Kanayannur, Kunnamkulam, Cherthala, and Hosdurg, Kozhencherry, and Karthikapally, etc.

3.3.3.4 Storm Surge Risk Talukas Vulnerability Profile:

As highlighted in the Heat-Map below, nearly 17 high-risk areas in terms of both high-value AAL and greater exposure value are Kuttanad, Karungapally, Kottayam, Cherthala, Ambalapuzha, Quilandy, Kannur, Majeswaream, Thalasery, and Tirur, etc.

The moderate risk areas are Chirayinkeezhu, Chavakkad, Chengannu, Kasaragod, Ponnani, Taliparamba, Neyyatinkara, and Mukundapuram Talukas.

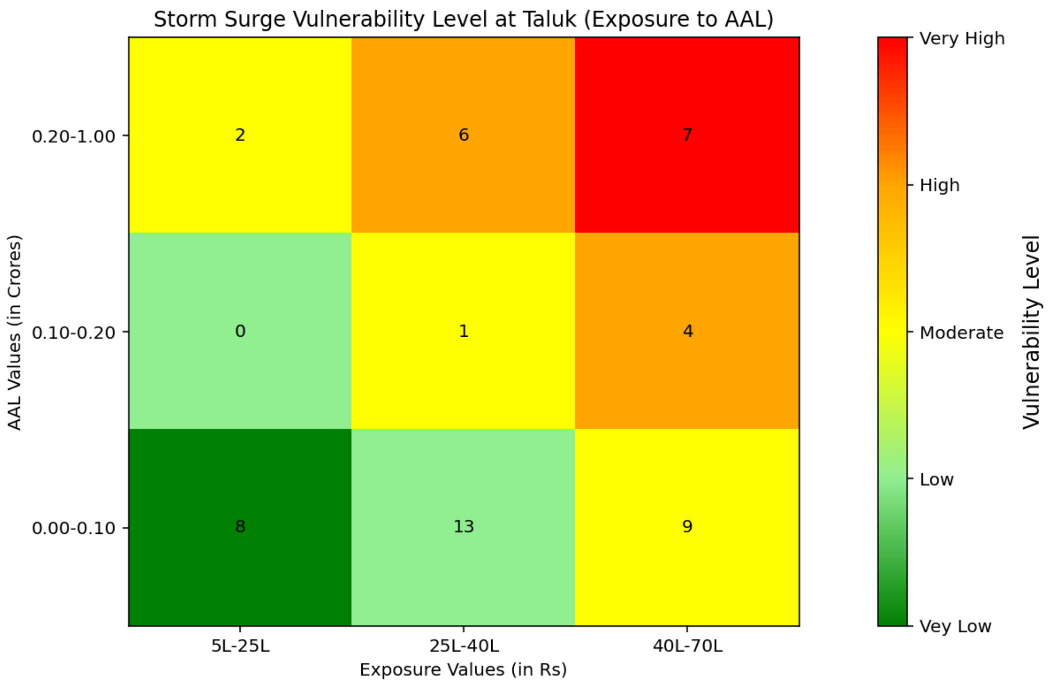


Figure 3-9: Heat-map exhibiting Storm Surge Risk Areas – AAL and Exposures

The above heat map analysis exhibits that most of the coastal regions from Alappuzha, Kottayam and Ernakulam districts in Kerala state are the most vulnerable areas for storm surge.

The table given below highlights the Talukas with high-risk exposure as well as high vulnerability to Storm surge.

Table 3-5: Top ten Storm Surge high risk area in terms of both vulnerability (AAL) as well as Exposure

High Storm Surge Risk Area		
Name of Taluka	AAL in Rs Crores	Exposure Value in Rs Crores
Kuttanad	0.90	15,498
Kochi	0.88	1,00,402
Karunagapally	0.63	48,997
Kollam	0.60	97,898
Kottayam	0.46	1,10,328
Karthikapally	0.40	58,613
Cherthala	0.34	39,010
Vaikkom	0.33	41,932

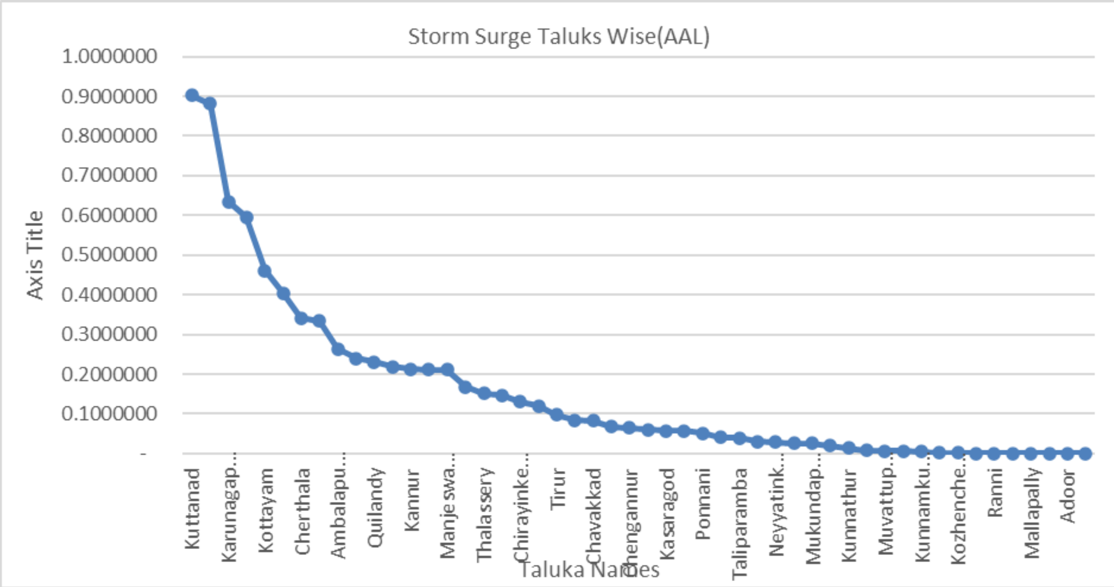


Figure 3-10: Trendline exhibiting Storm Surge Risk Areas – AAL and Exposures

The low-risk areas are Kunnathur, Muvattupuzha, Kunnamkulam, Kozhencherry, Ranni, Mallapally, Adoor, and Mannarkkad.

Thus, these risk analyses helped in identifying the vulnerable areas and also classify homogeneous areas into High, Medium, and Low risk Talukas for each of the selected catastrophic perils (Floods, Landslides, Heavy Cyclonic winds and Storm Surges) for the state. Further, the risk profile analysis compared the exposures of the residential and government building in comparison to the AAL and Loss Ratios generated from the analysis. It also calculated the loss cost / pure premium rates for each of the 78 Talukas of the state. These analyses would help the state government to understand the risk exposures, expected loss values (AAL), loss cost (pure premium rates) and loss experience (loss ratio) of the regions for each catastrophic perils (Flood, Landslide, Storm Surge and Cyclonic Winds) and their financial implications for the State.

The next section presents the product experience at various "what if" scenarios at different exceedance loss probability of 1 in 25 years, 1 in 50 years and 1 in 100 years events. We will present the financial implications or expected loss experiences at different as if scenarios for the state for each of the selected catastrophic perils (Flood, Landslide, Storm Surge, and Cyclonic Winds).

3.3.4 Historical Event Scenario Analysis:

This section presents "as if" scenarios using historical data to demonstrate the performance and viability of the proposed insurance products. Various "as if "scenarios under 1 out of 25 years, 50 years, and 100 years for each selected perils- Estimation of exposures, expected loss, Pure premium, adjusted premium, and deductibles (optional and mandatory) for different Sum insured options.

3.3.4.1 Introduction

This section presents various 'As If' scenario analyses using the historical data of the selected parameters, such as average annual loss, count of properties, and exposure values, to demonstrate the performance of catastrophic insurance products. The product performance analysis was carried out using simulation of the insurance parameters including premium rates, loss cost, and loss ratio. For this purpose, a comprehensive methodology was used first to analyse the distribution of the selected parameters: AAL, count of residential and government building, and exposure values, to conduct a simulation based on the best-fitting probability distribution. The primary objective of this analysis is to identify the most suitable statistical distribution that best represents the dataset, ensuring accurate modelling of the underlying patterns. This process involves multiple steps, including data extraction and cleaning, fitting various statistical distributions, assessing the goodness of fit, selecting the optimal distribution, and generating a large-scale simulation to evaluate potential real-world scenarios. This methodology enables the obtaining of simulated results of the catastrophic risk insurance products under different scenarios with one-in 25-year event, one in 50 years and one-in-100-year event with robust statistical techniques.

3.3.4.2 Fitting and Comparing Probability Distributions

With a cleaned dataset, the next phase involves determining which probability distribution best represents the selected data sets of AAL, building counts, and Exposure values. For this purpose, various theoretical distributions were considered, including Normal (Gaussian), Exponential, Lognormal, Gamma, Beta, Weibull (both minimum and maximum), Pearson Type III, Triangular, and Uniform distributions. Each distribution is fitted to the dataset, and its parameters are estimated using established statistical methods. The fitting process involves calculating key distribution-specific parameters such as shape, scale, and location, which define the characteristics of each probability function. The following table presents the goodness-of-fit values of the fitted distributions of the selected parameters – count of building, AAL, and exposure values of the residential and government buildings.

Table 3-6: Distribution Analysis of Historical Data

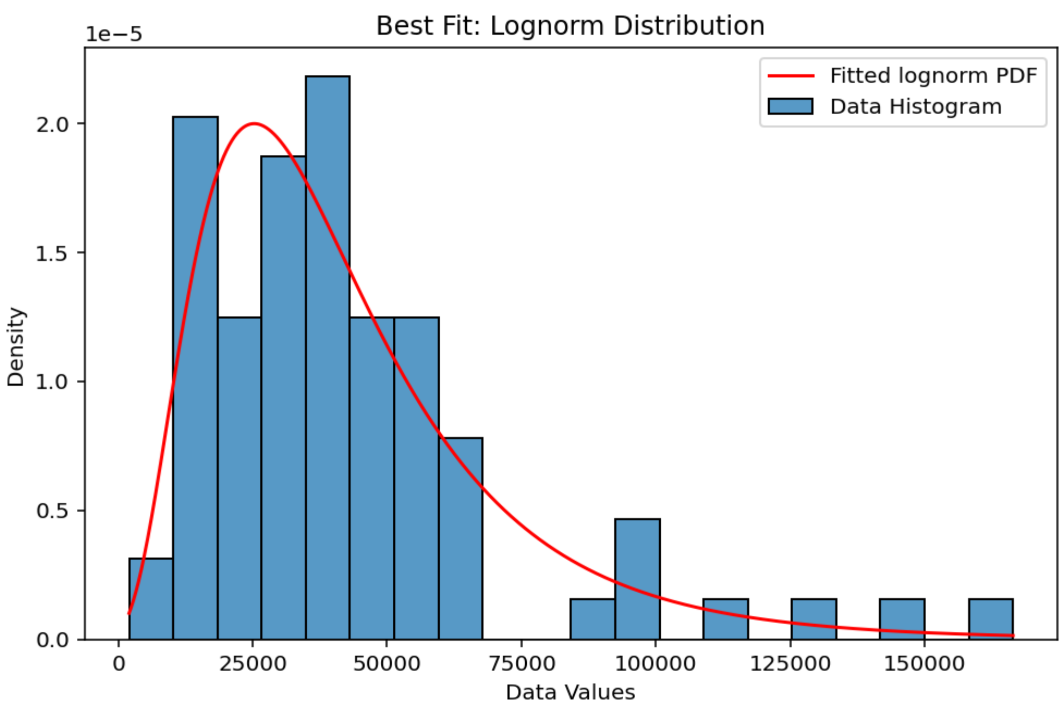
Category	Distribution	Mean	Standard Deviation	KS Test p-value	AIC
Residential Buildings					
Count of Buildings	Pearson3	1,20,832.00	61,182.00	0.04	1,921.37
Total Exposure	Lognorm	49,338.14	28,903.85	0.07	1,794.94
AAL	Gamma	13.62	15.97	0.06	555.91
Government Buildings					
Count of Buildings	Lognorm	716.00	394.00	0.06	1,111.51
Total Exposure	Lognorm	369.19	265.90	0.07	3,472.07
AAL	Gamma	0.12	0.15	0.07	2,269.39

Two primary criteria were used to assess and compare distributions: the Kolmogorov-Smirnov (KS) test and the Akaike Information Criterion (AIC). The KS test is a non-parametric test that measures the degree of agreement between empirical data distribution and theoretical distribution. A lower p-value in the KS test indicates a better fit. As we can find from the above table, almost all the distributions that we have selected have a lower p-value of 0.061 to 0.069, suggesting that the sample data does not significantly deviate from the expected distribution. On the other hand, the AIC is used to compare multiple distributions by considering both model accuracy and complexity. AIC penalizes overfitting while favoring distributions that strike an optimal balance between complexity and goodness-of-fit. Here again, most of the distributions that we have used have the lower AIC score (555 to 3472) while maintaining an acceptable KS test p-value (< 0.07) is selected as the best representation of the dataset.

3.3.4.3 Visualizing the Best-Fitting Distribution

Once the most suitable distribution is identified, a visual representation is created to further validate the selection. A histogram of the dataset is plotted alongside the probability density function (PDF) of the best-fitting distribution. This visualization allows for a direct comparison between the observed data and the expected behaviour of the chosen distribution. The histogram given below illustrates the frequency distribution of the selected parameters, while the superimposed PDF curve provides insight into how well the theoretical distribution aligns with the empirical data. A well-fitting distribution should closely follow the shape and spread of the histogram, reinforcing the accuracy of the selection process. The following diagrams represent the histograms and best fit of the selected distributions for the residential and government buildings.

Residential:



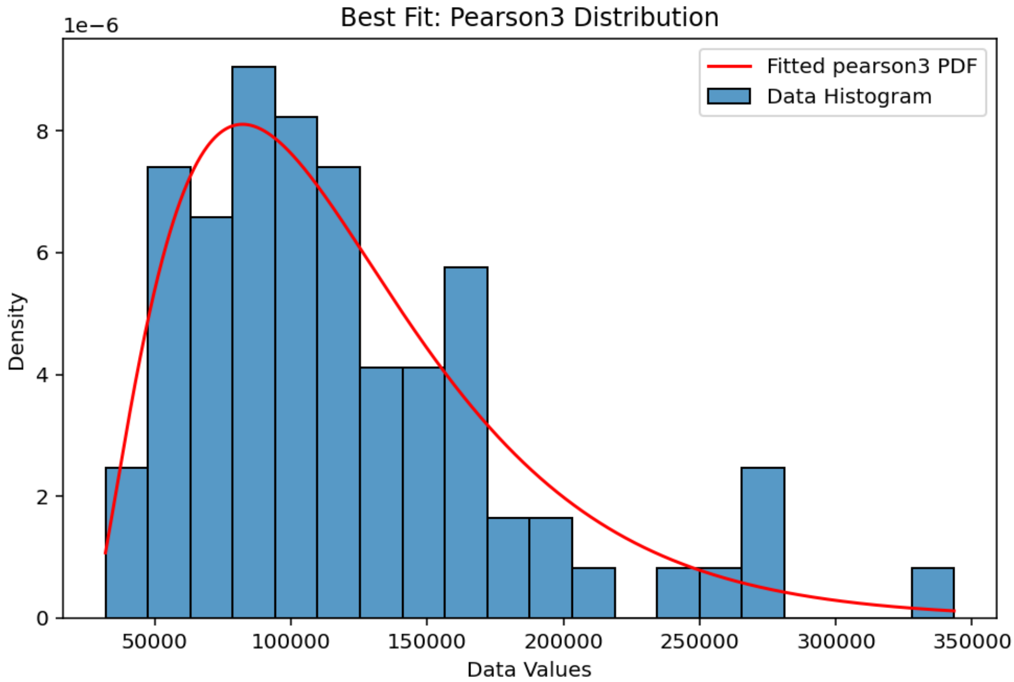


Figure 3-11: Distribution of Total Exposure Values for Residential Building

Government:

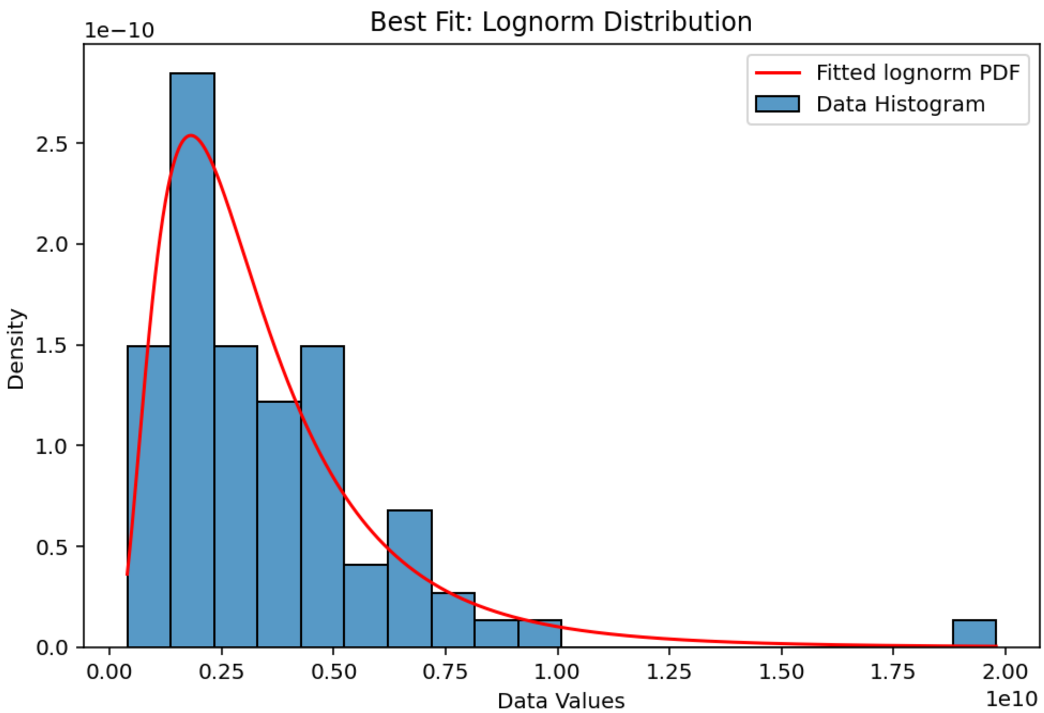


Figure 3-12: Distribution of Total Exposure Values for Government Building

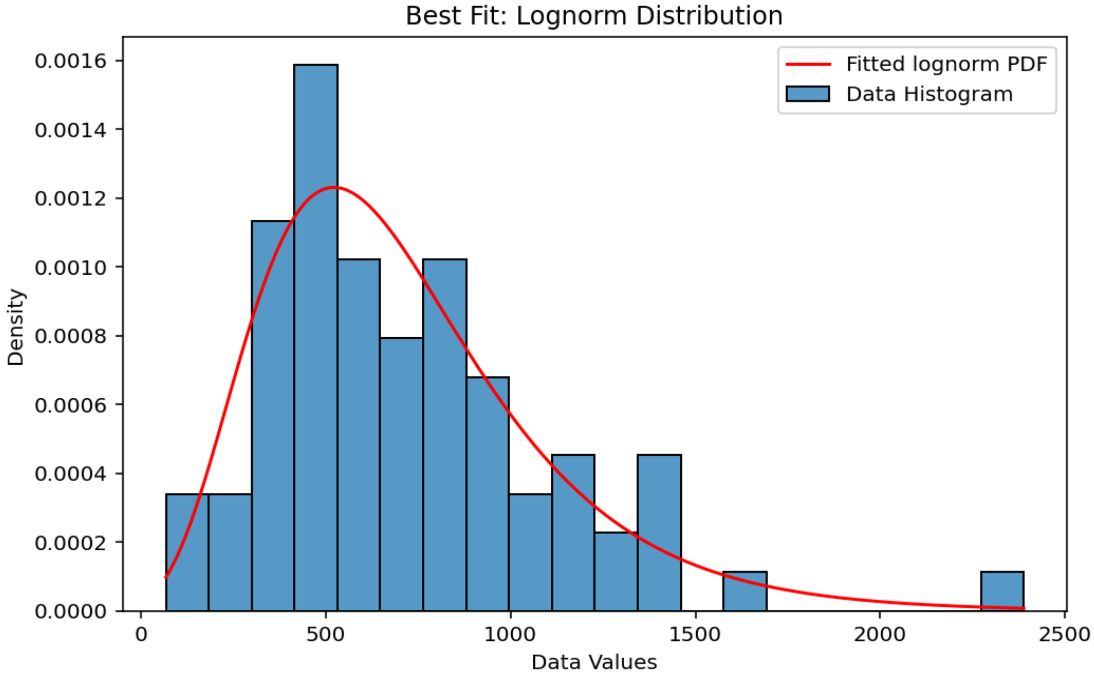


Figure 3-13: Distribution of Total Count of Government Buildings

The diagrams exhibit the goodness of fit of the distributions for all the selected parameters. IT can be observed from the above diagrams that almost all the fitted distributions represent the identified statistical distributions fairly well. Hence, based on the above fitted distributions along with their goodness of fit indices i.e. KS test p values and AIC values, we have finalized the distributions for carrying out the simulations.

3.3.4.4 Simulation of Large-Scale Data Samples

Following the identification of the best-fitting probability distribution, a large-scale Monte Carlo simulation is conducted to generate 50,000 simulations. The purpose of this simulation is to model potential real-world scenarios based on the statistical properties of the dataset. By leveraging the estimated parameters of the selected distribution, random values are generated to mimic the natural variability observed in the original data. This simulation provides valuable insights into possible outcomes, risk assessment, and predictive modelling. The following table presents the results of the simulated values of the selected parameters.

Table 3-7: Results of 50000 Simulated values of the selected parameters

Results of 50000 Simulated values of the selected parameters								
Statistics	**AAL in Rs crores**	**Total Exposure (Rs. Crores)**	**Building Count**	**Avg. Exposure (Rs. crores)**	**Per Unit AAL**	**Premium (Rs.)**	**Loss Ratio %**	**Loss Cost %o**
Residential Buildings								
Mean	13.62	49,338.14	1,20,831	1.03	3,612.24	2,583.65	376.65	0.94
STDV	15.97	28,903.84	61,182	8.99	31,080.95	22,488.50	1,947.67	4.87
Government Buildings								
Mean	0.12	369.19	980	0.67	2,679.35	3,689.58	357.27	1.97
STDV	0.37	269.89	389	7.69	25,560.59	42,327.39	9,485.92	52.17

After generating the simulated data samples, key statistical measures such as the mean and standard deviation are calculated for all the selected parameters: AAL, Exposures, premium rates, Loss cost, and Loss ratio, to analyse the characteristics of the simulated dataset. These statistics were then compared to the original datasets to verify the consistency of the simulation.

Table 3-8: Comparison of Historic and 50000 Simulated Data for Residential and Government Buildings

Comparison of Historic and Simulated Data				
Category	**Mean Historical**	**Mean Simulated**	**Standard Deviation HD**	**Standard Deviation Simulated Data**
Residential				
Count of Buildings	1,20,832	1,21,903	61,182	59,103
Total Exposure	49,338	50,514	28,904	27,209
AAL	14	17	16	12
Government Building				
Count of Buildings	716.00	982.00	394.00	388.00
Total Exposure	369.19	389.29	265.90	236.09
AAL	0.12	0.16	0.15	0.11

We can observe that almost all the parameter values of the simulated distributions, are very close to the original parameter values of mean and standard deviations. For Instance, it can be observed that the historical mean value of AAL for Residential buildings is 13.62 while the simulated value is 17.38. Similarly, the historical Exposure value is Rs 49338.14 Crores while the simulated Exposure value is 50,513.6 Crores.

It can also be noted that the simulated results of AAL and Exposure Values for the Government buildings are closer to the historical values. The main reason for such smaller deviation in this section is mainly due to the smaller number of buildings, with an average of 716 and the lower range of exposure values.

Similarly, a comparison of historical Loss ratio and Loss cost with simulated results was done. Table 3-9given below presents the results.

Table 3-9: Comparison of 50000 Simulated Results with Historical Data

Comparison of 50000 Simulated results with Historical Data				
	Historical Loss Ratio %	**Simulated Loss Ratio %**	**Historical Loss Cost % o**	**Simulated Loss Cost % o**
	Residential Buildings			
Mean	190	377	0.5	0.94
Standard Deviation	237	1947	0.6	4.87
	Government Buildings			
Mean	129	357	0.65	1.97
Standard Deviation	181	9485	0.91	52.17

The historical mean loss ratio for Residential buildings is 190% while the simulated loss ratio is 377%, which indicates a highly volatile loss experience with a standard deviation of 1947 % under one-in-25-year return period. This also further indicates that the current rate of premium (@0.25%o) charged for residential property is not sustainable.

This comparison ensures that the simulation accurately reflects the behaviour of the real-world dataset and provides reliable estimates for decision-making purposes.

3.3.4.5 Results of Scenario Analysis with 50000 Simulation

To facilitate further analysis and documentation, all results are systematically recorded. The results include detailed information about the best-fitting distribution, its estimated parameters, goodness-of-fit test results, and summary statistics of the simulation. This structured storage of results allows for easy reference, integration into reports, and subsequent analysis. The inclusion of graphical representations, such as histograms and fitted distribution plots, further enhances the interpretability of the findings.

	Mean	S.D
AAL	**13.6**	**16.0**
Total Exposure	**49338.1**	**28903.8**
Count of Build	**120832**	**61182**

Index	AAL	Total Exposure (in Cr)	Count of Buildings	Average Exposure (in Rs)	Per Unit AAL	Premium	Loss Ratio	Loss Cost
1	2.4	18429.1	146800	1255637.3	165.8	313.9	52.8	0.1
2	8.5	27320.1	42800	6376767.7	1992.8	1594.2	125.0	0.3
3	23.1	18561.3	14500	12833555.6	15968.3	3208.4	497.7	1.2
4	16.2	18510.2	79700	2321428.8	2032.0	580.4	350.1	0.9
5	4.7	72903.3	16500	44212420.2	2848.5	11053.1	25.8	0.1
6	39.6	73498.3	121600	6042283.8	3254.9	1510.6	215.5	0.5
7	35.0	58520.2	229400	2551173.8	1525.2	637.8	239.1	0.6
8	20.2	61842.6	164600	3756745.4	1225.7	939.2	130.5	0.3
9	12.9	37698.2	136800	2755576.8	940.3	688.9	136.5	0.3
10	0.9	4590.8	181900	252406.6	46.9	63.1	74.3	0.2
49990.0	6.7	41398.2	76000	5445035.0	881.0	1361.3	64.7	0.2
49991.0	5.0	60795.9	38700	15713179.8	1287.2	3928.3	32.8	0.1
49992.0	24.5	49804.4	89700	5550401.6	2725.7	1387.6	196.4	0.5
49993.0	19.7	9573.7	22000	4360706.7	8972.6	1090.2	823.0	2.1
49994.0	26.5	19568.3	132500	1477121.3	2002.0	369.3	542.1	1.4
49995.0	37.3	27177.6	205400	1322992.3	1817.5	330.7	549.5	1.4
49996.0	8.8	80113.0	177700	4507439.6	495.6	1126.9	44.0	0.1
49997.0	40.6	29132.8	18400	15828763.8	22045.9	3957.2	557.1	1.4
49998.0	48.9	65651.5	77300	8497654.3	6333.6	2124.4	298.1	0.7
49999.0	29.0	74095.2	31400	23577097.0	9212.6	5894.3	156.3	0.4
50000.0	6.7	48037.6	196700	2441979.0	338.2	610.5	55.4	0.1
Mean	**17.22**	**50452.65**	**121900**	**10334588.35**	**3612.67**	**2583.74**	**377.55**	**0.94**
STDV	**12.21**	**27046.17**	**58888**	**89954009.15**	**31080.72**	**22488.33**	**1948.00**	**4.36**

Figure 3-14: 50000 Simulated Results (25 RP) of Selected Parameters for Residential Buildings

It can be observed from the results of the above simulated worksheet for Residential buildings, the average loss ratio for all perils is 377%, which indicates a highly volatile loss experience with a standard deviation of 1948 % under one-in-25-year return period. This also further indicates that the current rate of premium (@0.25%o) charged for residential property is not sustainable. Hence, considering the increasing risk exposure of NATCAT perils for the residential buildings, the applicable premium rate should **be at least @0.50% o.**

	Mean	S.D
AAL	1227268.6	1484417.4
Total Exp	3691902086.2	2658979169.1
Count of Build	980	389

Index	AAL	Total Exposure (in Rs)	Count of Buildings	Average Exposure (i	Per Unit AAL	Premium	Loss Ratio	Loss Cost
1	406967.2	1274290465.2	500.0	2780918.3	888.1	1390.5	63.9	0.3
2	469516.7	4547573061.9	700.0	6722572.5	694.1	3361.3	20.6	0.1
3	2529439.0	6951414352.3	1400.0	4948672.0	1800.7	2474.3	72.8	0.4
4	648467.8	3520691502.7	800.0	4520317.8	832.6	2260.2	36.8	0.2
5	2522756.1	4896897162.9	1500.0	3288479.8	1694.1	1644.2	103.0	0.5
6	588976.1	1285641537.6	900.0	1435317.4	657.5	717.7	91.6	0.5
7	1358502.4	3682547339.2	1900.0	1944127.6	717.2	972.1	73.8	0.4
8	71976.6	589161766.8	1000.0	584310.0	71.4	292.2	24.4	0.1
9	301862.3	2317493453.3	1100.0	2048892.5	266.9	1024.4	26.1	0.1
10	2048294.2	1512072305.9	600.0	2361655.3	3199.2	1180.8	270.9	1.4
49990	1943793.0	3765084563.2	700.0	5049773.6	2607.0	2524.9	103.3	0.5
49991	1437704.4	692379406.6	200.0	3622122.1	7521.2	1811.1	415.3	2.1
49992	2171880.2	6286510025.3	700.0	8561853.2	2958.0	4280.9	69.1	0.3
49993	734191.7	4486151563.9	1300.0	3376728.7	552.6	1688.4	32.7	0.2
49994	1630727.3	378627656.5	1300.0	300370.6	1293.7	150.2	861.4	4.3
49995	2273676.8	7848772578.5	900.0	8541802.2	2474.4	4270.9	57.9	0.3
49996	3310906.9	2388362142.6	900.0	2561977.2	3551.6	1281.0	277.3	1.4
49997	573429.5	586780940.3	800.0	714649.9	698.4	357.3	195.4	1.0
49998	2495000.6	5411073454.8	400.0	13090610.6	6036.0	6545.3	92.2	0.5
49999	2017681.8	5696801662.8	800.0	7078623.8	2507.1	3539.3	70.8	0.4
50000	1278607.9	2418681868.8	1000.0	2539303.8	1342.4	1269.7	105.7	0.5
Mean	1568904.96	3897926972.25	1000	9764007.37	3411.14	4882.00	404.87	2.02
STDV	1116973.73	2367881258.60	388	395863628.94	82515.98	197931.81	9959.00	49.79

Figure 3-15: 50000 Simulated Results (25 RP) of Selected Parameters for Government Buildings

The above tables exhibit the working sheet of a 50000-simulation carried out with the parameters of AAL, Exposure Values and the number of buildings under one-in-25-year return period scenario for residential as well as Government Buildings.

It can be observed from the results of than above simulated worksheet for Government buildings, the average loss ratio for all perils is 404%, which indicates a highly volatile loss experience with a standard deviation of 9959 % under one-in-25-year return period. The simulated loss cost for the above extreme distribution stands at 2.02%o with a standard deviation of 49.79 %o. This also further indicates that the current rate of premium (@0.50%o) charged for Government property is not sustainable. Hence, considering the increasing risk exposure of NatCAT perils for the Government buildings, the applicable premium rate should **be at least @2.00%o.**

	Mean	S.D
AAL 50RP (in Crore)	27.1	35.1
Total Exposure (in crore)	49338.1	28903.8
Count of Build	120832	61182

Index	AAL (in Crore)	Total Exposure (in Cr)	Count of Buildings	Average Exposure (in Rs)	Per Unit AAL	Premium	Loss Ratio	Loss Cost
1	82.2	4334.7	104900	413427.5	7842.9	206.7	3794.1	19.0
2	6.9	23266.4	125900	1848237.3	549.8	924.1	59.5	0.3
3	21.1	84716.5	95400	8877307.9	2206.6	4438.7	49.7	0.2
4	2.5	28439.9	84600	3363712.0	290.3	1681.9	17.3	0.1
5	6.9	84920.9	88500	9597543.6	778.7	4798.8	16.2	0.1
6	68.1	83037.8	178600	4649596.1	3812.0	2324.8	164.0	0.8
7	18.2	100859.3	75700	13316623.9	2407.6	6658.3	36.2	0.2
8	1.5	89479.0	134100	6675675.3	112.8	3337.8	3.4	0.0
9	40.5	36910.4	18200	20327423.7	22294.0	10163.7	219.3	1.1
10	10.6	72357.9	131800	5489682.0	801.3	2744.8	29.2	0.1
49990	54.5	34827.0	177300	1964553.5	3077.0	982.3	313.2	1.6
49991	48.8	56977.3	193900	2939239.0	2519.9	1469.6	171.5	0.9
49992	73.5	34894.0	87800	3973226.7	8367.6	1986.6	421.2	2.1
49993	80.0	20934.2	80300	2608303.2	9964.5	1304.2	764.1	3.8
49994	16.1	110496.9	1431000	7675524.4	1119.6	3837.8	29.2	0.1
49995	87.1	99075.9	195400	5071381.0	4457.9	2535.7	175.8	0.9
49996	6.3	26025.2	184100	1413372.4	343.6	706.7	48.6	0.2
49997	13.9	7118.9	99100	718929.0	1400.6	359.5	389.6	1.9
49998	22.6	50467.4	56600	8913683.1	3986.4	4456.8	89.4	0.4
49999	31.1	37422.3	100100	3739329.8	3104.1	1869.7	166.0	0.8
50000	2.0	54616.4	95700	5704732.8	210.4	2852.4	7.4	0.0
Mean	36.39	50610.98	121701	10450432.69	6687.49	5225.22	611.05	3.06
STDV	26.19	26981.07	58995	63175552.29	31308.44	31590.94	8389.85	41.95

Figure 3-16: 50000 Simulated Results (50 RP) of Selected Parameters for Residential Buildings

The results of the above simulated worksheet for Residential buildings, under one-in-50-year return period, the average loss ratio for all perils is 611%, with a standard deviation of 8389%. This exhibits a highly volatile loss experience under an extreme scenario. The simulated average loss cost for the above distribution is 3.05%o with a standard deviation of 41.94%o. This indicates that the current rate of premium (@0.50%o) charged for Residential property is not sustainable. Hence, in view of the increasing risk exposure of NATCAT perils for the residential buildings, the applicable premium rate should **be at least @3.05%o.**

	Mean	S.D
AAL 50RP (in Crore)	50.7	65.1
Total Exp (in Rs.)	3691902086.2	2658979169.1
Count of Build	980	389

Index	AAL (in Crores)	Total Exposure (inRs)	Count of Buildings	Average Exposure (in Rs)	Per Unit AAL	Premium	Loss Ratio	Loss Cost
1	98.5	2934390976.0	700	4370630.1	14671.2	3933.6	373.0	3.4
2	11.4	3613691874.4	1300	2718759.8	857.4	2446.9	35.0	0.3
3	101.3	3815160082.7	1200	3123070.2	8290.1	2810.8	294.9	2.7
4	27.9	5564475448.3	1600	3584731.9	1798.1	3226.3	55.7	0.5
5	51.5	4230990418.8	1000	4007892.5	4878.1	3607.1	135.2	1.2
6	89.7	960700930.6	1100	849894.6	7939.7	764.9	1038.0	9.3
7	129.6	2702179643.4	1300	2009301.3	9636.4	1808.4	532.9	4.8
8	39.4	4545135945.3	1400	3254376.7	2823.2	2928.9	96.4	0.9
9	143.9	3185840465.8	250	12946125.8	58491.1	11651.5	502.0	4.5
10	15.8	4714378857.3	1500	3169650.6	1062.6	2852.7	37.2	0.3
49990	32.7	122422860.1	1100	115022.1	3072.7	103.5	2968.2	26.7
49991	166.8	3773674230.9	400	9500428.1	41983.8	8550.4	491.0	4.4
49992	9.8	4462282644.3	600	7432372.6	1624.5	6689.1	24.3	0.2
49993	130.5	7700867058.5	400	17968884.7	30455.2	16172.0	188.3	1.7
49994	90.0	2921164582.7	1100	2644381.0	8146.9	2379.9	342.3	3.1
49995	54.7	1780928119.4	1600	1101453.3	3381.0	991.3	341.1	3.1
49996	19.7	1751039753.1	850	2064090.4	2324.8	1857.7	125.1	1.1
49997	45.4	6788046848.7	900	7267002.9	4862.3	6540.3	74.3	0.7
49998	63.7	5315999116.9	1100	5006642.7	5995.5	4506.0	133.1	1.2
49999	5.8	7519536973.0	800	9126449.7	709.4	8213.8	8.6	0.1
50000	26.4	4822014101.5	700	6996472.1	3837.1	6296.8	60.9	0.5
Mean	67.01	3903710883.51	1000	6833484.04	12091.73	6150.09	767.58	6.91
STDV	48.22	2373491388.78	387	82026889.73	164819.37	73824.94	8370.18	75.33

Figure 3-17: 50000 Simulated Results (50 RP) of Selected Parameters for Government Buildings

The above analysis for Government buildings, highlights the average loss ratio for all perils to be around 768%, with a standard deviation of 8370 %. This indicates a highly volatile loss experience under one-in-50-year return period. The simulated loss cost for the above extreme distribution stands at 6.9%o with a standard deviation of 75.33 %o. This also further indicate that the current rate of premium (@0.90%o) charged for Government property is not sustainable. Hence, considering the increasing risk exposure of NATCAT perils for the Government buildings, the applicable premium rate should **be at least @6.90%o.**

	Mean	S.D
AAL 100 RP (in Crore)	**69.8**	**81.1**
Total Exposure (in Crore)	**49338.1**	**28903.8**
Count of Build	**120832**	**61182**

Index	AAL (in Crore)	Total Exposure (in Cr)	Count of Buildings	Average Exposure	Per Unit AAL	Premium	Loss Ratio	Loss Cost
1	69.0	69742.5	74800	9326563.8	9232.8	6994.9	132.0	1.0
2	84.9	77937.9	143800	5420686.5	5904.9	4065.5	145.2	1.1
3	25.6	39886.9	113100	3529334.1	2268.5	2647.0	85.7	0.6
4	23.6	24543.2	204100	1202937.3	1158.9	902.2	128.4	1.0
5	40.8	28140.6	18700	15065615.4	21840.4	11299.2	193.3	1.4
6	153.8	88271.9	193700	4556995.5	7941.0	3417.7	232.3	1.7
7	46.1	39266.6	128500	3055677.4	3585.4	2291.8	156.4	1.2
8	2.0	54025.2	107600	5019698.5	188.7	3764.8	5.0	0.0
9	57.7	45336.6	198600	2282969.7	2907.6	1712.2	169.8	1.3
10	158.0	63967.9	175600	3642241.3	8994.7	2731.7	329.3	2.5
49990	143.4	111152.0	135800	8186721.9	10565.4	6140.0	172.1	1.3
49991	156.6	41784.1	64400	6488068.2	24321.7	4866.1	499.8	3.7
49992	23.5	49092.3	134600	3646809.5	1742.4	2735.1	63.7	0.5
49993	9.8	92277.0	112100	8228924.6	870.7	6171.7	14.1	0.1
49994	17.6	106212.9	121100	8773256.9	1455.7	6579.9	22.1	0.2
49995	56.1	8972.8	145500	616603.1	3852.7	462.5	833.1	6.2
49996	93.9	25363.3	85400	2970269.6	10993.3	2227.7	493.5	3.7
49997	12.5	26480.7	88300	3000430.2	1417.4	2250.3	63.0	0.5
49998	175.3	30578.8	74800	4085597.9	23417.2	3064.2	764.2	5.7
49999	197.3	28860.7	1041000	2750252.5	18803.1	2062.7	911.6	6.8
50000	28.3	53903.3	84800	6353458.4	3331.0	4765.1	69.9	0.5
Mean	**86.23**	**50914.45**	**121200**	**10371001.93**	**17779.47**	**7778.25**	**619.91**	**4.65**
STDV	**61.55**	**27342.70**	**58438**	**68264008.58**	**126141.51**	**51198.00**	**4036.87**	**30.28**

Figure 3-18: 50000 Simulated Results (100 RP) of Selected Parameters for Residential Buildings

The results of the above simulated worksheet for Residential buildings, under one-in-100-year return period, the average loss ratio for all perils is 619%, with a standard deviation of 4036%. This exhibits a highly volatile loss experience under an extreme scenario. The simulated average loss cost for the above distribution is 4.64%o with a standard deviation of 30.27%o. This indicates that the current rate of premium (@0.75%o) charged for Residential property is not sustainable. Hence, in view of the increasing risk exposure of NATCAT perils for the residential buildings, the applicable premium rate should **be at least @4.65%o.**

	Mean	S.D
AAL 100RP (in Crore)	85.5	109.9
Total Expoure (in Rs.)	3691902086.2	2658979169.1
Count of Build	980	389

Index	AAL (in Crore)	Total Exposure (inRs)	Count of Buildings	Average Exposure (i	Per Unit AAL	Premium	Loss Ratio	Loss Cost
1	211.6	1797547285.5	1100	1625965.5	19144.6	2032.5	941.9	11.8
2	46.3	2000606042.4	1400	1470930.3	3407.5	1838.7	185.3	2.3
3	120.7	2652793838.6	1400	1937412.0	8817.7	2421.8	364.1	4.6
4	39.0	2534887855.8	1100	2216459.4	3408.8	2770.6	123.0	1.5
5	227.2	3641036207.6	1000	3672729.7	22922.3	4590.9	499.3	6.2
6	112.5	1244578269.7	1300	947706.3	8562.9	1184.6	722.8	9.0
7	152.2	3040511256.8	1000	2876403.4	14402.8	3595.5	400.6	5.0
8	36.8	5889764428.8	700	8371727.9	5227.2	10464.7	50.0	0.6
9	50.1	5364188900.1	300	20864403.0	19475.0	26080.5	74.7	0.9
10	108.4	2812271765.8	800	3527238.2	13590.3	4409.0	308.2	3.9
49990	25.1	1279849156.3	800	1579303.4	3098.2	1974.1	156.9	2.0
49991	275.8	3158338056.2	1400	2201028.7	19222.9	2751.3	698.7	8.7
49992	56.0	582941212.1	1000	531669.3	5104.8	664.6	768.1	9.6
49993	19.2	4101162992.5	800	5189392.2	2435.7	6486.7	37.5	0.5
49994	92.6	811800444.3	1300	625400.5	7135.5	781.8	912.8	11.4
49995	161.5	3366138036.5	800	3982149.7	19101.8	4977.7	383.7	4.8
49996	177.7	2365656795.8	800	2968270.1	22299.4	3710.3	601.0	7.5
49997	360.8	3952016738.7	800	4864664.0	44417.8	6080.8	730.5	9.1
49998	139.5	3385114009.0	2100	1608000.3	6626.6	2010.0	329.7	4.1
49999	112.3	1601559857.8	800	1910728.3	13401.9	2388.4	561.1	7.0
50000	93.3	11215117692.7	1100	10360047.4	8622.4	12950.1	66.6	0.8
Mean	**112.97**	**3900450974.56**	**1000**	**7160287.32**	**20847.90**	**8950.36**	**883.39**	**11.04**
STDV	**81.28**	**2351384781.65**	**385**	**85106914.04**	**278511.86**	**106384.71**	**10211.36**	**127.64**

Figure 3-19: 50000 Simulated Results (100 RP) of Selected Parameters for Government Buildings

The above simulation worksheet under one-in-100-year return period for Government buildings, highlights the average loss ratio for all perils to be around 883%, with a standard deviation of 10211%. The simulated loss cost for the above extreme distribution is 11.04%o with a standard deviation of 127.64%o. This suggests that the current rate of premium (@1.25%o) charged for Government property is not sustainable under this highly volatile loss experience. Hence, considering the increasing risk exposure of NATCAT perils for the Government buildings, the applicable premium rate should **be at least @11.04%o.**

The next section presents the simulation analysis of loss experience with different deductible limits.

3.3.4.6 Deductible Limits

The main objective of determining suitable deductible limits is to eliminate high-frequency small-value claims which results in a reduction in premium for the policyholders (Government or Individual property owners). For this purpose, we have plotted the frequency distribution of the simulated values of AAL across different frequency intervals which helped to identify the suitable deductible limits for the proposed catastrophic insurance products.

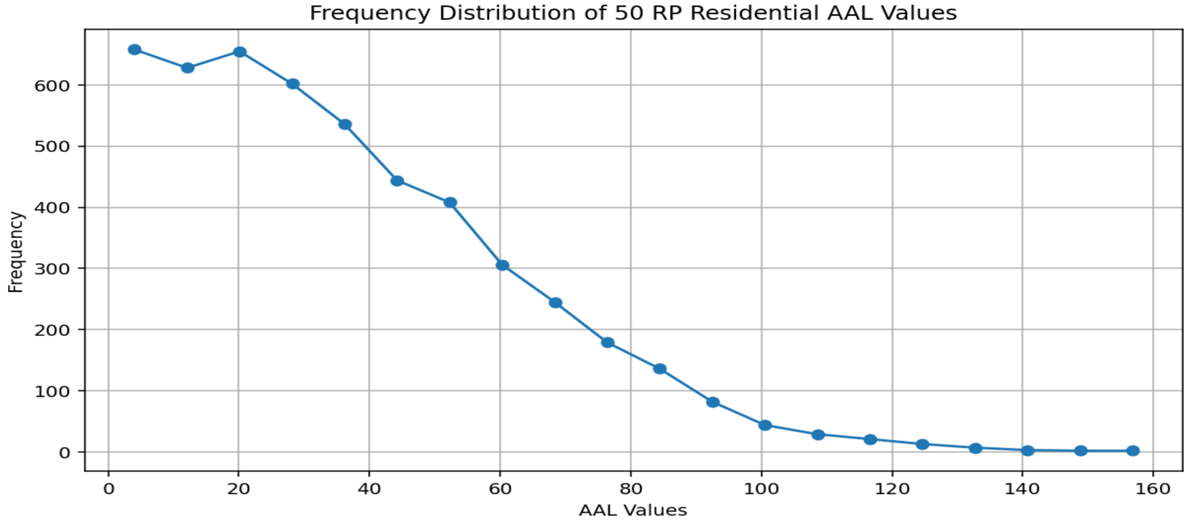


Figure 3-20: Frequency Distribution of 50 RP AAL Values with 50000 Simulations - Residential building

Based on the above analysis of the frequency distribution of AAL values for Residential Buildings, we suggest a deductible limit of Rs 20 Crores AAL in case of the occurrence of a single event at the severity level of 1 out of 50 years Return period event. Accordingly, there will be a suitable premium discount offered by the Insurance company.

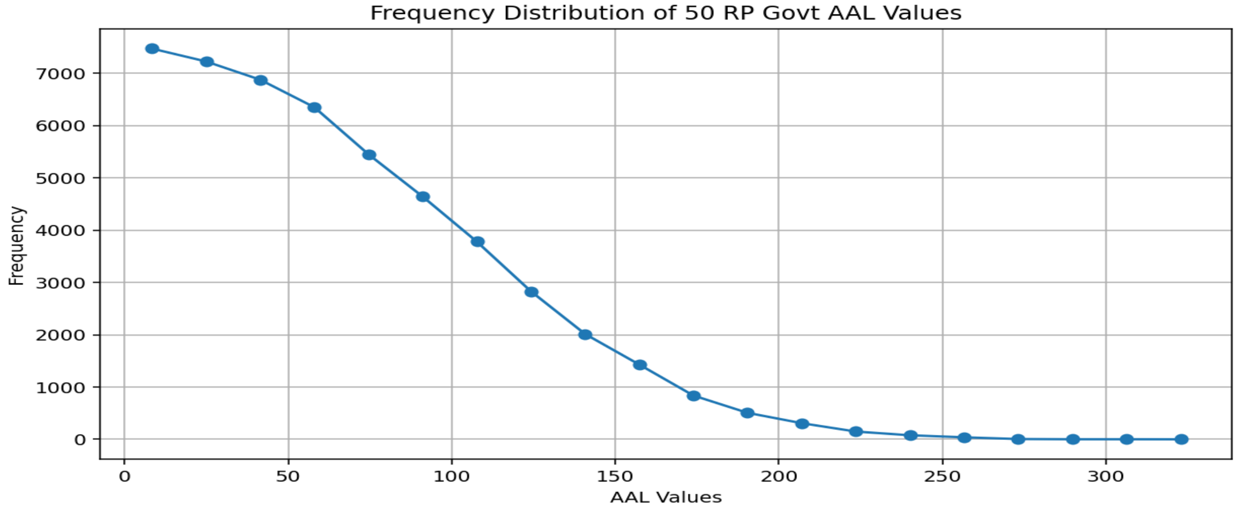


Figure 3-21: Frequency Distribution of 50 RP AAL Values with 50000 Simulations - Government building

Based on the above frequency distribution analysis of the AAL values for Government Buildings, we suggest a deductible limit of Rs 40 Crores AAL in case of the occurrence of a single event at the severity level of 1 out of 50 years Return period event.

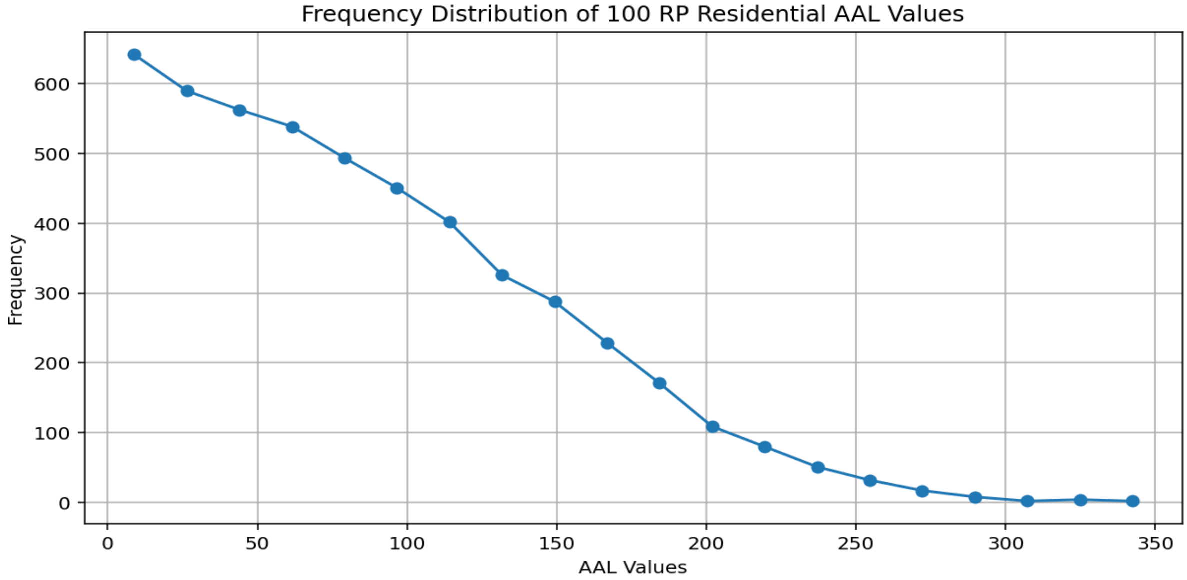


Figure 3-22: Frequency Distribution of 100 RP AAL Values with 50000 Simulations - Residential building

Based on the above frequency distribution analysis of the AAL values for Residential Buildings, we suggest a deductible limit of Rs 40 Crores AAL in case of the occurrence of a single event at the severity level of 1 out of 100 years Return period event.

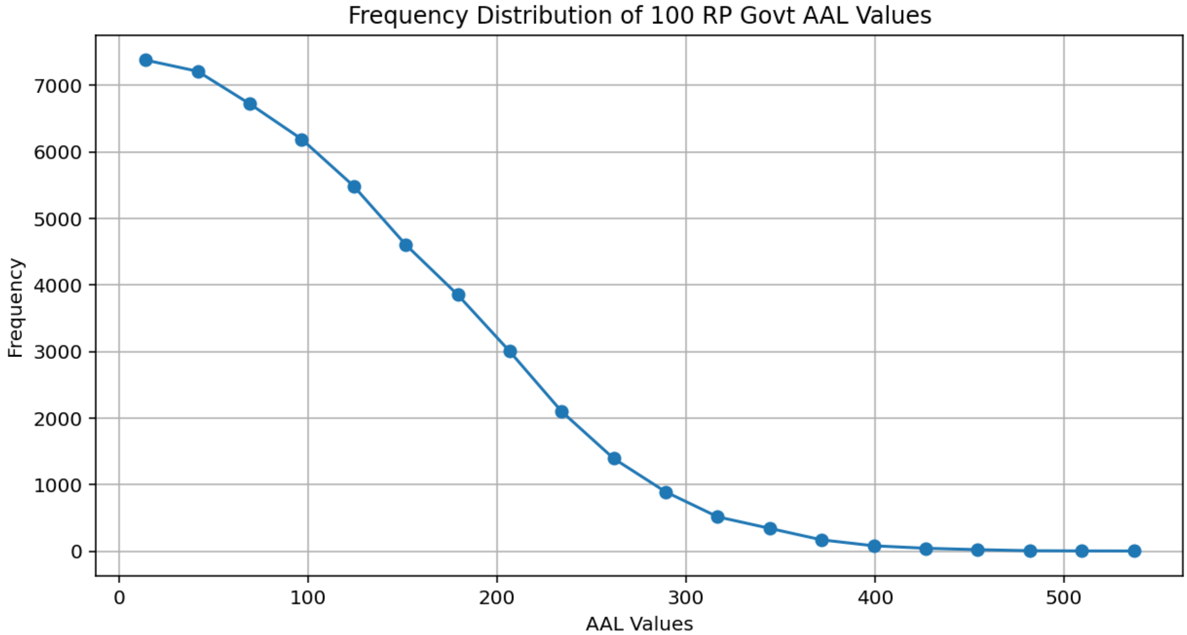


Figure 3-23: Frequency Distribution of 100 RP AAL Values with 50000 Simulations - Government building

Based on the above frequency distribution analysis of the AAL values for Government Buildings, we suggest a deductible limit of Rs 75 Crores AAL in case of the occurrence of a single event at the severity level of 1 out of 100 years Return period event.

3.3.4.7 Conclusion

The methodology outlined in this document presents a structured approach to statistical distribution analysis and Monte Carlo simulation. By systematically evaluating the various loss scenarios with the selected risk parameters, helps us to understand the viability and the variation of the proposed catastrophic insurance products. This analysis also helps us in understanding the implications of different premium rates and their associated loss experiences, like loss ratios and loss costs to determine the adequacy of exposure values and AAL and premium rates.

This approach ensures accurate and reliable predictive modelling. The ability to simulate thousands of potential outcomes provides a powerful tool for assessing uncertainties, making data-driven decisions, and optimizing strategies in various applications.

4 Institutional Mechanisms for Implementation

4.1 Mechanisms for Housing Insurance

This section of the report discusses the Institutional Role of the Department of Insurance in Implementing Parametric and Indemnity-Based Housing Insurance Products.

The Department of Insurance plays a crucial role in the implementation and administration of both parametric and indemnity-based housing insurance products. These two types of insurance serve as essential financial tools for property owners, particularly in regions prone to natural disasters. Traditional indemnity-based insurance compensates policyholders for disasters, after assessing actual damage through loss assessment (survey). This process is time-consuming and complex, while parametric insurance ensures swift financial support by triggering payouts when predefined parameters, for perils like flood or earthquake are met. This mechanism enables property owners to receive immediate payouts.

Seamless implementation of Catastrophic Insurance arrangements requires multiple stakeholders, such as Insurance companies, the Government Department relating to Finance, and the Directorate of Insurance at the State Level. The primary objective of establishing a robust Institutional mechanism for housing insurance is to ensure transparency, fairness, and operational efficiency.

As discussed in the administrative structure for DRF Pool under Component 3, we suggest that the Directorate of Insurance Department be the Nodal office for the Administration of the Catastrophic Insurance Scheme in the State.

4.1.1 Mechanism for Implementation of Catastrophic Insurance Scheme (Indemnity Based)

The implementation process for the successful administration of catastrophic insurance products involves various activities; Selection of appropriate Insurance companies, determining suitable coverages in accordance with the risk profile defined for each district of the state (as discussed in Section 3.3 under Chapter 3), discussion the policy terms and conditions, Sum insured, Exclusions and appropriate deductibles limit.

KSDMA will perform the necessary risk analysis including generating risk profiles with hazard probability and exposures of all the residential and Government Buildings along with location addresses to the Directorate of Insurance department to enable them to determine suitable coverage. Alternatively, KSDMA can directly determine the coverages in accordance with the risk profile and provide necessary input to the Directorate of Insurance.

The Insurance department should take the initiative to negotiate with the insurance company to obtain fair premium rates for the selected coverages. This can be done based on the risk profile analysis of the Talukas / Districts provided by KSDMA. While negotiating the premium rates, due consideration should be allowed for various inputs like: various safety measures undertaken by the property owners towards risk improvement (as instructed by KSDMA), good feature discounts, and selected optional deductible limits. All the above-suggested insurance considerations should be done by the Insurance Department with due consultation with KSDMA and the State Finance Department.

The insurance department must further provide details about the type of residential properties proposed for insurance along with the ownership details, types of construction, and location with area pin code to the selected insurance company and get the master policy issued for one year. Any additions or changes in the policy should be communicated to the insurance company to get endorsement for any such changes.

At the time of the occurrence of a Catastrophic loss, KSDMA is to provide the necessary loss details along with the post-disaster damage assessment (PDDA) report (as discussed in section 3.3.1 under component 3) to the insurance department. The State insurance department should provide timely intimation to the insurance company along with the PDDA report with details of the type of loss and extent/ amount of loss etc. They should also proactively support the surveyors by providing all the required information for carrying out the loss assessment and actively participating in the claims settlement process. Furthermore, the insurance department collaborates with various independent agencies and stakeholders, including meteorological agencies (IMD, AWS), to obtain accurate data necessary for the settlement of such claims.

The stakeholders (Government, KSDMA, Insurance Department, Insurance companies & intermediaries) must create necessary public awareness, and information sharing for a better understanding of these insurance options. The department (Insurance department & KSDMA) educates the property owners to make informed decisions about their coverage and necessary disaster risk mitigation. Additionally, the department monitors the insurance market to ensure that both parametric and indemnity-based products are accessible to the property owners and meet the diverse needs of the state government, thereby fostering a resilient housing sector capable of withstanding and recovering from natural disasters.

4.1.2 Mechanism for Implementation of Parametric Insurance for Catastrophic Risks:

Successful implementation of parametric Insurance requires an understanding of risk exposures and hazard vulnerability factors of various regions (Talukas/Districts) for selected catastrophic perils. Secondly, it also requires the selection of appropriate locations, determination of suitable coverages, and estimation of triggers / Index thresholds for the selected perils.

As discussed in the earlier section 4.1.1, KSDMA will provide the necessary risk profile analysis, selection of location, coverage options including Sum insured, other policy features, estimation of weather index trigger and the appropriate amount of claim payouts for selected perils as well as location to the insurance department.

The insurance department in consultation with Insurance/ Reinsurance companies determines suitable coverages, and sets guidelines for policy terms, based on the triggers and claim payouts for parametric policies. The selection of the Insurance / Reinsurance companies should be done based on eligibility conditions like Solvency, ratings, claims settlement performance, and credibility in the market. The insurance department also negotiates the premium rates, coverages, and claim payouts with the selected insurance/ Reinsurance companies and ensures that the policy is issued in accordance with the proposal given.

Simultaneously, the department in consultation with KSDMA and the insurance companies should select reliable third-party agencies preferably the Indian Meteorological Department (IMD) for providing the necessary weather data for performing the risk analysis as well as setting up the trigger/ index threshold to ensure availability of reliable and accurate data and also for the transparent and fair claims payout mechanism.

In the context of Kerala, the Kerala State Insurance Department (KSID) will play a pivotal role in implementing both parametric and indemnity-based housing insurance products. As a state-run entity, KSID is responsible for underwriting various insurance policies, including those related to property and housing. The department's mandate includes ensuring that insurance products are accessible, affordable, and tailored to the specific needs of property owners, considering the state's unique geographical and climatic challenges. This involves developing policies that provide comprehensive coverage against natural disasters such as floods and landslides, which are prevalent in the region.

By offering indemnity-based and parametric insurance, KSID ensures that an appropriate amount of compensation for actual losses incurred by property owners is provided by the insurance companies, ensuring financial support for reconstruction and repair. Additionally, the department is exploring the integration of parametric insurance models, which offer predefined payouts based on specific triggers like rainfall levels or wind speeds, enabling quicker disbursement of funds to the affected individuals. This dual approach not only enhances the resilience of communities but also ensures a more efficient and responsive insurance framework. Furthermore, KSID is responsible for regulatory oversight, ensuring that all insurance products comply with regulatory norms set by the Insurance Regulatory and Development Authority of India (IRDAI). This includes maintaining transparency in policy terms, ensuring fair pricing, and protecting consumer interests.

The institutional role of all the key stakeholders (Government, KSDMA, KSID, Insurance companies, and intermediaries) in implementing these products is crucial in ensuring that the housing insurance sector remains robust, accessible, and capable of supporting disaster recovery efficiently. This approach not only expedites financial relief for affected homeowners but also contributes to the overall stability and resilience of communities in disaster-prone areas.

4.2 Mechanisms for Government Risk Transfer

This section outlines strategies for government risk transfer, including the use of catastrophe bonds, corpus funds, and market-linked financial instruments.

Considering the disaster risk exposures and vulnerability of the state to the various types and nature of catastrophe risk, we suggest the state set up an ex-ante disaster risk pool model as suggested in section 4.5.2 under component 3. Depending on the loss exposures, the state can determine various types of risk transfer mechanisms -Captives, Insurance (Indemnity catastrophic risk insurance and parametric insurance), Reinsurance, CAT Bonds, and market-linked financial instruments like Catastrophe Deferred Drawdown Option (CATDDO) and Contingent Credit Bonds (CCB).

The administration of captives and other insurance / Reinsurance requirements can be done by the Directorate of Insurance Department. The captives can finance the cost of disaster relief and response expenditure up to Rs 1000 crores on the occurrence of a disaster. The above-suggested parametric insurance can be used as a risk transfer mechanism to meet the state Government's financial needs for relief and response measures.

The Government can use indemnity-based catastrophic risk insurance products suggested in section 3 for any losses up to Rs 4000 crores covering residential property and Government buildings.

Further, the Government can obtain direct Reinsurance support from National as well as International Reinsurance companies for any losses beyond the risk appetite of the Government/Insurance companies. Reinsurance support can be obtained for any of the above-suggested risk transfer mechanisms- Captives, Catastrophic Risk Insurance, and Parametric Insurance. As suggested earlier in section 4.1.1, KSID in consultation with the Government and insurance companies can select suitable Reinsurance companies based on their solvency, financial rating, claims settlement performance, and international experience subject to their regulatory compliance.

It is a known fact that the state of Kerala is highly vulnerable to a large NATCAT event with a severity occurrence probability of one in 50 years / one in 100 years causing huge financial losses and having a devastating impact on properties, critical infrastructure, and the lives of the people in the state. To effectively mitigate such large losses, the Government can use catastrophe bonds (CAT bonds), which are risk-linked securities that transfer the financial risk of disasters to the capital markets. Cat bonds allow governments to raise funds upfront, with investors receiving regular premiums but losing their principal if a predefined catastrophe occurs. This mechanism diversifies risk and reduces the burden on public budgets. CAT bonds are particularly useful for governments because they provide a non-debt source of funding, which is critical for maintaining fiscal stability in the aftermath of disasters.

Another critical instrument in government risk transfer strategies is the establishment of dedicated corpus funds which are available through the ex-ante state disaster risk pool (SDRP). These are pre-funded reserves specifically earmarked for disaster response and recovery. Corpus funds can be replenished through parametric insurance payouts, ensuring a sustainable financial buffer. This approach ensures that governments have immediate access to resources without relying on external aid or diverting funds from other critical sectors. Corpus funds also provide a platform for pooling risks across regions, reducing the cost of coverage and enhancing the overall efficiency of risk transfer mechanisms.

In addition to CAT bonds and corpus funds, governments can leverage market-linked financial instruments such as CATDDOs, and Contingent Credit Bonds offered by International Financial Institutions like the World Bank, KFW, ADB, etc. These instruments are particularly useful for managing risks associated with agricultural losses, disaster relief and response measures, and rebuilding or reconstruction of critical infrastructures in the state.

The integration of these instruments—cat bonds, corpus funds, and market-linked financial tools—creates a robust framework for parametric insurance-based risk transfer. By combining these tools, governments can diversify their risk exposure, reduce dependency on post-disaster borrowing, and ensure rapid access to funds when disasters strike. Moreover, the use of such multi-faceted risk transfer mechanisms encourages the development of risk models and data analytics, which are essential for designing effective risk transfer strategies.

In conclusion, all the above risk transfer mechanisms offer governments a powerful mechanism for transferring catastrophic risks, ensuring financial stability, and protecting vulnerable populations. By leveraging instruments such as cat bonds, corpus funds, and market-linked financial tools, governments can build a comprehensive risk transfer framework that addresses the growing challenges posed by climate change and natural disasters. This approach not only enhances fiscal resilience but also fosters sustainable development by promoting proactive risk management and investment in disaster preparedness.

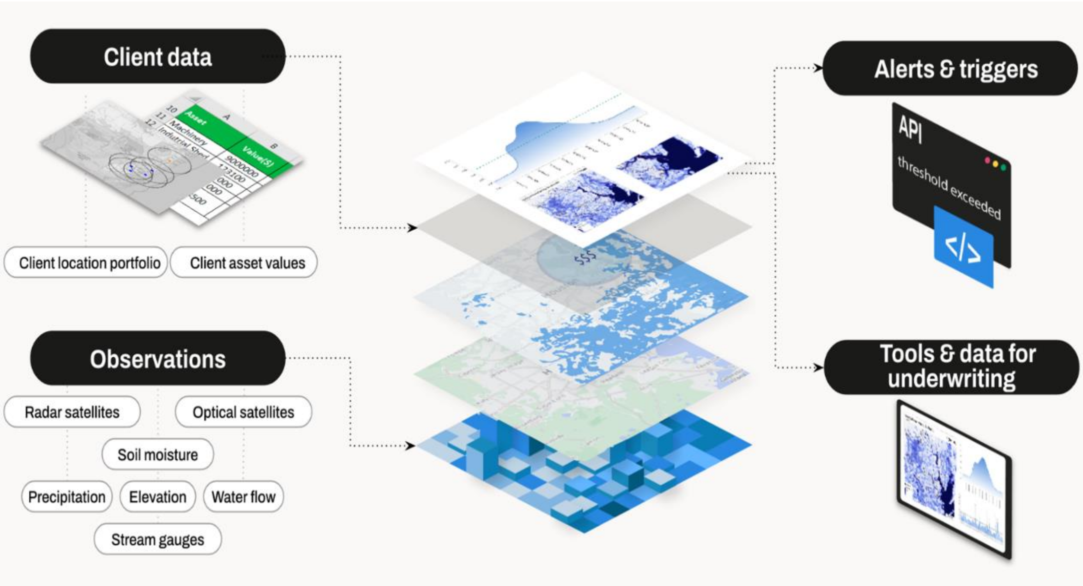
4.3 Triggering and Field Verification Mechanisms

This section describes mechanisms to operationalize parametric triggers, including field verification processes to ensure fair claim settlements.

Parametric insurance relies on predefined triggers to determine payouts, making the design and operationalization of these triggers critical to the effectiveness and fairness of the mechanism. Triggers are typically based on objective, measurable parameters such as rainfall, Temperatures, wind speed and precipitation or all other relevant parameters that correlate with the occurrence and severity of a catastrophic event. These triggers must be carefully calibrated to ensure they accurately reflect the losses incurred, minimizing basis risk which arises due to the discrepancy between the payout and the actual damage. For instance, in the case of hurricane insurance, wind speed measured by meteorological stations or satellite data can serve as a reliable trigger. Similarly, for drought insurance, rainfall levels measured over a specific period can be used. The selection of suitable parameters for each peril is often done by analyzing historical data, scientific models, and risk assessments, to ensure they are both robust and transparent. Advanced technologies such as remote sensing, satellite imagery, and IoT-enabled devices are increasingly being used to enhance the accuracy and reliability of parametric triggers.

Flood-base, a weather management company in the USA uses Satellite observations with hydrological and other relevant weather data for continuous monitoring of the parametric insurance loss experience. They leverage machine learning models to map flooding regardless of cloud cover or terrain.

Table 4-1: Parametric Insurance process structure



Source: Flood-base, USA

Flood base uses decades of historical weather and flood loss data including flood occurrences, magnitude, and damage assessments along with satellite observations, client location profiles, and asset values/exposures. It maps each area with the hazard, risk, vulnerability and exposure. It also continuously monitors the weather conditions and sends automatic risk alerts through API, email, and SMS, to the government and policyholders when the insured peril breaches the triggers in the selected locations.

We suggest that the State Government select an independent third-party agency, preferably government institutions like IMD or NRSC that can provide reliable and accurate weather data on the selected parameters and regions. Historical analysis of disaster loss exposure along with satellite images, can help in identifying the affected residential and government building properties in the vulnerable areas. Secondly, KSDMA, in consultation with weather management service providers (IMD), can run a correlation analysis of the selected weather parameters with the historical loss events which can help establish the triggers or index thresholds for the selected perils.

While parametric insurance is designed to minimize the need for traditional claims assessment, field verification mechanisms play a complementary role in ensuring the integrity and fairness of the process. Field verification is particularly important in cases where there is a dispute or where the parametric trigger may not fully capture the extent of the loss or damage. For example, in agricultural insurance, a drought index might trigger a payout, but field verification can confirm the actual impact on crops and livelihoods. This process typically involves on-ground surveys, drone inspections, and collaboration with local authorities and community representatives to assess the loss or damage.

Field verification can also help refine parametric index threshold triggers over time, ensuring they remain aligned with ground realities. For instance, after a flood event, field teams might collect data on water levels, property damage, and affected populations, which can then be used to adjust future triggers and improve the accuracy of the model.

Additionally, third-party auditors and independent experts are often engaged to oversee the verification process, ensuring transparency and building trust among stakeholders. By combining parametric triggers with robust field verification mechanisms, governments and insurers can strike a balance between speed and accuracy, ensuring that payouts are both timely and fair.

4.4 Dispute Resolution

This section proposes a framework to address disputes arising from overpayments or underpayments in risk transfer products.

Parametric insurance, while efficient and transparent, is not immune to disputes, particularly when payouts do not align with the actual losses incurred. Disputes often arise due to basis risk, i.e the gap between the parametric trigger and the real-world impact and disagreements over the accuracy of the data used to determine payouts. For instance, a hurricane might trigger a payout based on wind speed, but the actual damage might be less severe than anticipated, leading to overpayment. Conversely, a drought index might not fully capture the extent of agricultural losses, resulting in underpayment.

To address these challenges, a robust dispute resolution framework is essential. This framework should begin with clear contractual terms that define the parametric triggers, data sources, and payout mechanisms in detail. Transparency in the design of the parametric model is critical, as it ensures that all parties understand how payouts are determined. Additionally, the use of independent third-party data providers, such as IMD -Meteorological agencies or NRSC- Satellite data source, can enhance the credibility of the triggers and reduce the likelihood of disputes.

When disputes do arise, a framework or plan of action that can be proposed is a multi-tiered resolution process that can ensure fairness and efficiency. The first tier should involve an internal review by the selected Insurance Company or the Directorate of Insurance department (KSID), where the claimant can present evidence to support their case, such as field verification reports or alternative data sources to the insurance company and to KSID.

If the dispute remains unresolved, the second tier could involve mediation by an independent expert or panel consisting of members from KSDMA, the State revenue Department, KSID, the Selected Insurance company & Customer representative. The panel can obtain independent technical opinions from agencies like the Central Water Commission (CWC) and similar other reputed research institutions. This panel can oversee the resolution process, provide guidance on complex cases, and recommend improvements to the parametric model to reduce future disputes. By combining clear contractual terms, independent oversight, and a structured resolution process, this framework can address overpayments and underpayments effectively, ensuring the long-term viability and credibility of parametric insurance as a risk transfer tool.

In case if the dispute is still not resolved by the above-stated options, the last resort for the dispute redressal mechanism is legal recourse with clear guidelines on jurisdiction and applicable laws.

5 Dissemination Material

5.1 Summary of Prototype Insurance Policies

Summarizes the features, benefits, and operational aspects of the proposed property catastrophe insurance products.

5.2 Presentation Material

Presents key findings and recommendations in a stakeholder-friendly format, including visual aids and concise summaries.

Detailed presentation has been prepared and shared along with this Report.

6 Conclusions and Recommendations

6.1 Summary of Findings

Recaps the major insights from the study, linking them back to the objectives and demonstrating how they were achieved.

The primary objective of this study was to assess the adequacy of existing disaster risk financing available in the state and suggest appropriate risk transfer and financing mechanisms to reduce the financial liability of the state arising from the increasing catastrophic risk exposures and climate change vulnerabilities.

Considering the above objectives, the study evaluated the adequacy of the existing disaster funds, both SDRF and SDMF, considering the financial implications arising from a large catastrophic event (1 in 100-year return period).

- The study finds that both SDRF and SDMF are highly inadequate to cover the financial liability arising from a large one-in-100-year event, as we find that the SDRF funding gap for relief and response measures is almost 86%, and the funding gap for recovery and rebuilding costs is 89%. While we compare the total fund size (both SDRF & SDMF) with the uninsured AAL of Rs. 1162 crore, the overall funding gap is 66%.
- To mitigate the disaster financial liability for the state, we proposed various risk transfer and financing options instruments such as direct property insurance, reinsurance options, parametric insurance, CATDDOs, Catastrophic Bonds, Contingent Credit Bonds (CCB) from international financial institutions like the World Bank, ADB, KfW, etc. (Annexure-2).
- Further, we suggested that the government consider providing 100% protection to the most vulnerable segments – BPL segments (yellow and pink card holders) and the vulnerable people like fishermen, living in the disaster-prone regions. While the State can provide a premium subsidy to the non-priority subsidy households (blue card holders) and can encourage the non-priority households to buy property insurance with only catastrophic cover, with adequate coverage.
- The total cost of the premium shall be Rs. 62.91 crore with sum insured coverage of Rs. 5,00,000 (at a premium rate of Rs. 31 for Rs. 100000 Sum Insured) for covering BPL segments of yellow and pink card holders, 41.94 lakh households. The cost of the premium for the coverage amount of Rs 8 lakhs is Rs 100.66 crore. For the coverage of Rs 10 lakhs and Rs 12 lakhs sum insured, it will be around Rs 125.82 crore and Rs 150.98 crore, respectively.
- We have also estimated the cost of insurance for various types of public buildings, including government buildings, schools, hospitals, bus stations, and fire stations etc. The total cost of the premium for covering the government buildings is estimated to be around Rs. 18.713 crores.
- While suggesting the disaster risk insurance for protecting the property risks from various catastrophic risks, including fire and allied perils, and landslide, we have estimated the cost of insurance for the state government for insuring the properties belonging to various categories of population segments (BPL, APL, and Affluent economic segments).

- We have also estimated the cost of insurance for every type of property – residential property, and government buildings, including schools, hospitals, police stations, bus stops, etc. This would help the state determine the financial liability relating to insuring the various segments of the population, as well as the types of properties. While working out the insurance estimates, we have also considered the cost of repair and rebuilding through the reinstatement value clause.
- We have suggested an exclusive catastrophic risk insurance covering all the important catastrophic perils like floods, inundation, cyclones, storms, landslides, and forest fires. We have estimated the burning cost or pure premium rate for covering the residential and government buildings with the different coverage amounts, sum insured of Rs 5 lakhs, Rs 8 lakhs, Rs 10 lakhs, and Rs 12 lakhs.
- Like most of the developed countries, including Southeast Asian countries, which have well-established ex-ante catastrophic risk pools (Caribbean Catastrophic Risk Pool – CCRP, African Risk Capacity (ARC), Fondon, we have suggested that the state establish an ex-ante catastrophic risk pool with different risk layers.
- We suggested that the state must have a minimum of Rs. 1000 crore as the bottom layer for protecting the residential property damages of various segments of the people through a parametric insurance solution. This would also cover the relief and response costs that the State has to provide as the post-disaster relief and response measures.
- For any losses above Rs. 1000 crore and up to Rs. 4000 crores, the State can take the direct property insurance cover from the insurance companies. We have also given the details about catastrophic risk insurance, its features, coverages, add-on covers, exclusions, and deductibles.
- For the large catastrophic losses with a sum insured of over Rs. 4000 crores to Rs. 10,000 crores, the state can cover its critical infrastructures, including Airports, Railways, Roads, Bridges, Water reservoirs, PSU undertakings – Power, Telecom, Oil and Energy industries, through reinsurance arrangements like Facultative, Surplus Treaty and Excess of Loss reinsurance.
- Further, the State can also approach international reinsurance companies to develop Catastrophic Bonds for protecting the supernatural catastrophic events causing an economic loss of over Rs. 10,000 crores.
- Financing sources and fund flow of the State Disaster Risk Pool (SDRP) have been suggested to include the following sources.
    - Initial budgetary contributions of Rs. 100 crores can be made to the pool to start its initial operations.
    - Local State Government contributions to the pool would help the LSG to understand the importance of the pool and also provide them a vital stake in the pool.
    - PSU and Commercial organizations, including state-owned, to contribute a certain percentage of their CSR Contribution to the Pool.
    - A certain minimum percentage of tax can be levied on the Luxury Goods and Services, Land revenue, Stamp Duty, and Registration of Properties.
    - Contribution from PACS/Agriculture/Rural Banks

would help in sourcing additional funding for the Pool.

- A certain minimum percentage of the net profit earned by the PSU and Commercial organizations would help them contribute to climate change, disaster risk insurance, and disaster risk mitigation in the State.
- Every new house may pay an additional premium of Rs 1 as a contribution to the pool.
- Investment in SDRMF should be as permitted as per MHA guidelines should be encouraged as an additional contribution to the pool
- New Investors in the state may be requested to contribute 1% of their investment value to the pool.
- Allocation from CMDRF may also be considered as an additional contribution to the pool as permitted by the State.

The above contributions would enable the Pool should start with a fund size of about Rs 750-1000 Crores, to be self-sufficient to meet the initial relief and response expenditure, and to take care of the administrative fees for pool management

The surplus fund is suggested to be invested in state-owned financial institutions like Kerala State Finance Corporation (KSFC), Kerala Bank for investment, re-investment, and other purposes, so that the interest and dividend can be attained, making it a self-financing account in the next 5 years. This would help augment the fund from the initial investment of Rs. 1000 to reach a self-sufficient fund size of Rs. 5000 crores in the 5th Year.

First year, 70% of the fund is suggested to be kept in Liquid Investments like fixed deposits, treasury bills, Collateralized Borrowing and Lending Institutions (CBLI). The remaining 30% of the fund is to be invested in the Government Securities.

The Liquid Investments of the fund size should gradually be reduced on a sliding scale basis: Second year 50%, 3rd Year 40%, and 5th year 30% respectively.

The Pool should have a small Margin or Contribution ranging from 1% to 2% towards the administrative cost of the pool management.

6.2 Recommendations for Implementation

Offers practical steps and strategies for deploying the proposed parametric indices and insurance products effectively.

6.2.1 Suggestions for Successful Implementation of Catastrophic Risk Insurance

The following are the various suggestions the state government can consider for the successful implementation of the proposed catastrophic risk insurance in the state.

- **Key Stakeholders**: Insurance Companies, KSDMA, State Finance Department, Directorate of Insurance Department are suggested to be the key stakeholders for implementing the above proposed insurance scheme.
- **Implementation Process:** The State Insurance Department, in coordination with KSDMA and the Finance Department, should implement the proposed Catastrophic Risk Insurance. The primary responsibility of this department is to manage the insurance and other risk financing instruments proposed in our study. The department shall be assisted by technical experts in the areas of Insurance, Public and Risk Financing, and Data Analytics. The financial decisions relating to Insurance/ Reinsurance/ Parametric Insurance shall be made in consultation with the Apex Committee. The Insurance Department negotiates premium rates based on risk mitigation efforts. The department can get a Master Policy issued for one year, updated with endorsements for new properties.
- **Administration of Insurance Schemes**: The Director of State

Insurance Department (DSID), in coordination with insurance and reinsurance companies, shall be involved in the administration of various insurance/ reinsurance/ parametric-insurance schemes, including a selection of suitable disaster insurance products for specified categories of residential buildings and public assets/ Life/ Accidents /Health/ Agriculture, including crops & livestock.

- **Risk inspection**: Experts from the insurance companies can also assist in risk assessment at the time of insurance, and post-disaster loss assessment in coordination with the state damage assessment team. They can also suggest suitable risk mitigation/improvement measures for the existing properties in coordination with KSDMA.
- **Data Analysis**: Technical experts with Data analytical and IT skills shall perform the necessary data analysis based on the historical loss and financial information available with the pool for periodical validation of the pool performance and the insurance requirements. The KSID, in collaboration with KSDMA, can generate the risk profile analysis, which would help in determining the appropriate coverage and premium rates.
- **Financial Institutions**: Banks and financial institutions may offer loans and financial products for post-disaster recovery, such as funding for rebuilding infrastructure and restoring businesses over and above the compensation payable by the proposed risk pool (SDRP).
- **Product Design and customization: Insurance Companies** should customize the coverage according to the risk profile of the location and requirements of the homeowners, business and governments with flexible limits and deductibles. Insurance companies should also offer a combination of parametric and traditional indemnity insurance for comprehensive coverage as well as faster claim settlement.
- **Post-Disaster Process**: KSDMA provides damage assessment reports (PDDA) to the Insurance Department.
- **Claims settlement** to be managed collaboratively with surveyors, Structural Engineers, insurance companies, and third-party data sources (IMD, AWS) in order to have a transparent and faster claims settlement
- **Public Awareness & Education**: Stakeholders conduct awareness programs to improve understanding & adoption of insurance solutions
- **Capacity Building:** All the stakeholders should sensitize the homeowners to understand the importance of adequate coverage and knowledge about risk prevention and building resilience.

6.2.2 IMPLEMENTATION OF PARAMETRIC INSURANCE FOR CATASTROPHIC RISKS

The following are the various measures to be taken for the successful implementation of the proposed parametric insurance in the Kerala State.

1. Identification of Vulnerable Regions

- Select high-risk areas at the Taluka level for floods, cyclones, storm surges, landslides, and droughts.
- Use hazard assessment metrics like Annual Average Loss (AAL) and Loss Exceedance Curves (LEC) for risk profiling.

2. Selection of Parameters

- Identify measurable weather and environmental parameters (e.g.,

rainfall, wind speed, , soil type, topography).
- Ensure selected parameters serve as reliable claim triggers.

3. Determination of Coverage
- Establish the sum insured for each location based on risk exposure and AAL.
- Allocate coverage weights proportional to regional risk profiles.

4. Definition of Trigger Thresholds
- Set disaster-specific index parameters (e.g., rainfall exceeding 300 mm in 24 hours for floods).
- Standard thresholds on historical loss correlations to minimize basis risk.

5. Design of Payout Structure
- Define pre-agreed payout mechanisms (fixed or scaled) based on disaster severity.
- Align payout structures with government policies for rapid disbursement.

6. Reliable Data Sources
- Utilize data from the India Meteorological Department (IMD), Automatic Weather Stations (AWS), and Satellite imagery.
- Ensure independent, verifiable, and transparent data for claims processing.

7. Regular Review & Adjustments
- Conduct periodic assessments of policy effectiveness using updated data.
- Validate models with ground surveys and historical event analysis.

8. Dispute Resolution Mechanism
- Implement grievance redressal mechanisms for policyholders.
- Use mediation, arbitration, or third-party reviews for dispute resolution.

6.2.2.1 Role of Kerala State Insurance Department (KSID), Insurance and Reinsurance Companies

- **Risk analysis & Selection of locations:** The insurance department, in collaboration with KSDMA, should identify suitable locations based on hazard vulnerability (Taluka/District level).
- **Determination of triggers & coverage options:** The department should determine the triggers and coverage options in consultation with KSDMA and insurance companies using the methodology proposed in the report.
- **Data Validation & Claims Processing:**

  Third-party agencies (IMD, AWS, satellite data) verify weather data & trigger thresholds. This validation ensures transparent & fair payout mechanisms for policyholders.

  Calibrate threshold triggers that closely match the historical losses and selected weather parameters.
- Underwrites & administers both parametric & indemnity-based housing insurance.
- Ensures affordable & accessible coverage for property owners.
- Selection of Insurance/Reinsurance companies based on credibility, solvency & claim settlement history.
- Develop policies tailored to Kerala's unique climate & disaster risks (Floods, Landslides, Cyclones).
- Integrates predefined payouts (parametric model) with actual loss compensation (indemnity model) for rapid disaster response.

6.2.2.2 Regulatory Oversight & Stakeholder Collaboration

- Regulated by IRDAI to ensure transparency, fair pricing & consumer protection.

- KSID collaborates with the Government, KSDMA, insurance companies & intermediaries to strengthen the housing insurance sector.
- Ensures faster financial relief & enhances community resilience against future disasters.

6.2.2.3 *Continues monitoring and Adoption*

- Regular Back-Testing and Model updates are to be performed periodically to adjust trigger parameters based on the changes in weather conditions, disaster exposures and loss data.
- Policyholders feedback and iteration to be taken regularly and the same to be incorporated after reviewing to refine the existing parametric insurance product.
- Adopt Global best practices and learn from the use cases of successful implementation in other regions, states and countries.

7 Annexure 1

7.1 Parametric insurance Prototype product:

Parametric insurance Prototype product for selected perils (Flood, Landslide, Cyclonic Wind, and Storm-Surge)

7.1.1 Product Prototype for Flood Risk Talukas:

Product Structure for Flood Risk – 2025-26		
Monsoon Period:1st June to 30th November		
Peril	**Flood**	
Taluka	**Kochi**	
Government Exposure Per unit	₹ 19 lakhs	
Residential Exposure per unit	₹ 37 lakhs	
	Strike Point	**Payout**
Excess Seasonal Rainfall		
Payout Trigger Level	150 mm	20% of sum insured
Incremental Payout per additional **25** mm		10% of sum insured
Payout Exit Level	350mm	100% of sum insured
Non-Monsoon Period: 1st December to 30th May		
	Strike Point	**Payout**
Excess Unseasonal Rainfall		
Payout Trigger Level	60 mm	25% of sum insured
Incremental Payout per additional 15 mm		15% of sum insured
Payout Exit Level	120 mm	100% of sum insured

Product Structure for Flood Risk – 2025-26		
Monsoon Period:1st June to 30th November		
Peril	**Flood**	
Taluka	**Paravur**	
Government Exposure Per unit	₹ 24 lakhs	
Residential Exposure per unit	₹ 37 lakhs	
	Strike Point	**Payout**
Excess Seasonal Rainfall		
Payout Trigger Level	150 mm	20% of sum insured
Incremental Payout per additional **25** mm		10% of sum insured
Payout Exit Level	350mm	100% of sum insured
Non-Monsoon Period: 1st December to 30th May		
	Strike Point	**Payout**
Excess Unseasonal Rainfall		
Payout Trigger Level	75 mm	25% of sum insured
Incremental Payout per additional 15 mm		15% of sum insured
Payout Exit Level	150 mm	100% of sum insured
Product Structure for Flood Risk – 2025-26		
Monsoon Period:1st June to 30th November		
Peril	**Flood**	
Taluka	**Thrissur**	
Government Exposure Per unit	₹ 54 lakhs	
Residential Exposure per unit	₹ 55 lakhs	
	Strike Point	**Payout**
Excess Seasonal Rainfall		
Payout Trigger Level	150 mm	25% of sum insured
Incremental Payout per additional **30** mm		15% of sum insured
Payout Exit Level	300mm	100% of sum insured
Non-Monsoon Period: 1st December to 30th May		
	Strike Point	**Payout**
Excess Unseasonal Rainfall		
Payout Trigger Level	75 mm	25% of sum insured
Incremental Payout per additional 15 mm		15% of sum insured
Payout Exit Level	150 mm	100% of sum insured

Product Structure for Flood Risk – 2025-26		
Monsoon Period:1st June to 30th November		
Peril	**Flood**	
Taluka	**Kuttanad**	
Government Exposure Per unit	₹ 59 lakhs	
Residential Exposure per unit	₹ 28 lakhs	
	Strike Point	**Payout**
Excess Seasonal Rainfall		
Payout Trigger Level	125 mm	25% of sum insured
Incremental Payout per additional **25** mm		15% of sum insured
Payout Exit Level	250 mm	100% of sum insured
Non-Monsoon Period: 1st December to 30th May		
	Strike Point	**Payout**
Excess Unseasonal Rainfall		
Payout Trigger Level	60 mm	25% of sum insured
Incremental Payout per additional 15 mm		15% of sum insured
Payout Exit Level	120 mm	100% of sum insured
Product Structure for Flood Risk – 2025-26		
Monsoon Period:1st June to 30th November		
Peril	**Flood**	
Taluka	**Thodupuzha**	
Government Exposure Per unit	₹ 65 lakhs	
Residential Exposure per unit	₹ 52 lakhs	
	Strike Point	**Payout**
Excess Seasonal Rainfall		
Payout Trigger Level	150 mm	25% of sum insured
Incremental Payout per additional **30** mm		15% of sum insured
Payout Exit Level	300 mm	100% of sum insured
Non-Monsoon Period: 1st December to 30th May		
	Strike Point	**Payout**
Excess Unseasonal Rainfall		
Payout Trigger Level	100 mm	25% of sum insured
Incremental Payout per additional 20 mm		15% of sum insured
Payout Exit Level	200 mm	100% of sum insured

Product Structure for Flood Risk – 2025-26		
Monsoon Period:1st June to 30th November		
Peril	**Flood**	
Taluka	**Karthikapally**	
Government Exposure Per unit	₹ 85 lakhs	
Residential Exposure per unit	₹ 49 lakhs	
	Strike Point	**Payout**
Excess Seasonal Rainfall		
Payout Trigger Level	125 mm	25% of sum insured
Incremental Payout per additional **25** mm		15% of sum insured
Payout Exit Level	250mm	100% of sum insured
Non-Monsoon Period: 1st December to 30th May		
	Strike Point	**Payout**
Excess Unseasonal Rainfall		
Payout Trigger Level	75 mm	25% of sum insured
Incremental Payout per additional 15 mm		15% of sum insured
Payout Exit Level	150 mm	100% of sum insured
Product Structure for Flood Risk – 2025-26		
Monsoon Period:1st June to 30th November		
Peril	**Flood**	
Taluka	**Thiruvalla**	
Government Exposure Per unit	₹ 52 lakhs	
Residential Exposure per unit	₹ 42 lakhs	
	Strike Point	**Payout**
Excess Seasonal Rainfall		
Payout Trigger Level	150 mm	25% of sum insured
Incremental Payout per additional **30** mm		15% of sum insured
Payout Exit Level	300 mm	100% of sum insured
Non-Monsoon Period: 1st December to 30th May		
	Strike Point	**Payout**
Excess Unseasonal Rainfall		
Payout Trigger Level	100 mm	25% of sum insured
Incremental Payout per additional 20 mm		15% of sum insured
Payout Exit Level	200 mm	100% of sum insured

Product Structure for Flood Risk – 2025-26		
Monsoon Period:1st June to 30th November		
Peril	**Flood**	
Taluka	**Chengannur**	
Government Exposure Per unit	₹ 61 lakhs	
Residential Exposure per unit	₹ 53 lakhs	
	Strike Point	**Payout**
Excess Seasonal Rainfall		
Payout Trigger Level	150 mm	25% of sum insured
Incremental Payout per additional **20** mm		15% of sum insured
Payout Exit Level	250 mm	100% of sum insured
Non-Monsoon Period: 1st December to 30th May		
	Strike Point	**Payout**
Excess Unseasonal Rainfall		
Payout Trigger Level	100 mm	25% of sum insured
Incremental Payout per additional 20 mm		15% of sum insured
Payout Exit Level	200 mm	100% of sum insured
Product Structure for Flood Risk – 2025-26		
Monsoon Period:1st June to 30th November		
Peril	**Flood**	
Taluka	**Chavakkad**	
Government Exposure Per unit	₹ 33 lakhs	
Residential Exposure per unit	₹ 44 lakhs	
	Strike Point	**Payout**
Excess Seasonal Rainfall		
Payout Trigger Level	150 mm	20% of sum insured
Incremental Payout per additional **25** mm		10% of sum insured
Payout Exit Level	350mm	100% of sum insured
Non-Monsoon Period: 1st December to 30th May		
	Strike Point	**Payout**
Excess Unseasonal Rainfall		
Payout Trigger Level	75 mm	25% of sum insured
Incremental Payout per additional 15 mm		15% of sum insured
Payout Exit Level	150 mm	100% of sum insured

Product Structure for Flood Risk – 2025-26		
Monsoon Period:1st June to 30th November		
Peril	**Flood**	
Taluka	**Vaikkom**	
Government Exposure Per unit	₹ 69 lakhs	
Residential Exposure per unit	₹ 47 lakhs	
	Strike Point	**Payout**
Excess Seasonal Rainfall		
Payout Trigger Level	150 mm	20% of sum insured
Incremental Payout per additional **25** mm		10% of sum insured
Payout Exit Level	350mm	100% of sum insured
Non-Monsoon Period: 1st December to 30th May		
	Strike Point	**Payout**
Excess Unseasonal Rainfall		
Payout Trigger Level	75 mm	25% of sum insured
Incremental Payout per additional 15 mm		15% of sum insured
Payout Exit Level	150 mm	100% of sum insured
Product Structure for Flood Risk – 2025-26		
Monsoon Period:1st June to 30th November		
Peril	**Flood**	
Taluka	**Ambalapuzha**	
Government Exposure Per unit	₹ 64 lakhs	
Residential Exposure per unit	₹ 22 lakhs	
	Strike Point	**Payout**
Excess Seasonal Rainfall		
Payout Trigger Level	100 mm	20% of sum insured
Incremental Payout per additional **25** mm		10% of sum insured
Payout Exit Level	300mm	100% of sum insured
Non-Monsoon Period: 1st December to 30th May		
	Strike Point	**Payout**
Excess Unseasonal Rainfall		
Payout Trigger Level	75 mm	25% of sum insured
Incremental Payout per additional 15 mm		15% of sum insured
Payout Exit Level	150 mm	100% of sum insured

7.1.2 PRODUCT PROTOTYPE FOR LANDSLIDE RISK TALUKAS:

Product Structure for Landslide Risk – 2025-26		
Monsoon Period:1st June to 30th November		
Peril	**Landslide**	
Taluka	**Peermade**	
Government Exposure Per unit	₹ 61 lakhs	
Residential Exposure per unit	₹ 36 lakhs	
	Strike Point	**Payout**
Excess Seasonal Rainfall		
Payout Trigger Level	125 mm	25% of sum insured
Incremental Payout per additional **30** mm		15% of sum insured
Payout Exit Level	275 mm	100% of sum insured
Non-Monsoon Period: 1st November to 31st May		
	Strike Point	**Payout**
Excess Unseasonal Rainfall		
Payout Trigger Level	100 mm	25% of sum insured
Incremental Payout per additional 20 mm		15% of sum insured
Payout Exit Level	200 mm	100% of sum insured

Product Structure for Landslide Risk – 2025-26		
Monsoon Period:1st June to 30th November		
Peril	**Landslide**	
Taluka	**Idukki**	
Government Exposure Per unit	₹ 57 lakhs	
Residential Exposure per unit	₹ 38 lakhs	
	Strike Point	**Payout**
Excess Seasonal Rainfall		
Payout Trigger Level	150 mm	25% of sum insured
Incremental Payout per additional **20** mm		15% of sum insured
Payout Exit Level	250 mm	100% of sum insured
Non-Monsoon Period: 1st December to 30th May		
	Strike Point	**Payout**
Excess Unseasonal Rainfall		
Payout Trigger Level	100 mm	25% of sum insured
Incremental Payout per additional 20 mm		15% of sum insured
Payout Exit Level	200 mm	100% of sum insured
Product Structure for Landslide Risk – 2025-26		
Monsoon Period:1st June to 30th November		
Peril	**Landslide**	
Taluka	**Devikulam**	
Government Exposure Per unit	₹ 61 lakhs	
Residential Exposure per unit	₹ 37 lakhs	
	Strike Point	**Payout**
Excess Seasonal Rainfall		
Payout Trigger Level	200 mm	25% of sum insured
Incremental Payout per additional **30** mm		15% of sum insured
Payout Exit Level	350 mm	100% of sum insured
Non-Monsoon Period: 1st December to 31st May		
	Strike Point	**Payout**
Excess Unseasonal Rainfall		
Payout Trigger Level	100 mm	25% of sum insured
Incremental Payout per additional 30 mm		15% of sum insured
Payout Exit Level	250 mm	100% of sum insured

Product Structure for Landslide Risk – 2025-26		
Monsoon Period:1st June to 30th November		
Peril	**Landslide**	
Taluka	**Udumbanchola**	
Government Exposure Per unit	₹ 67 lakhs	
Residential Exposure per unit	₹ 42 lakhs	
	Strike Point	**Payout**
Excess Seasonal Rainfall		
Payout Trigger Level	75 mm	25% of sum insured
Incremental Payout per additional **15** mm		15% of sum insured
Payout Exit Level	150 mm	100% of sum insured
Non-Monsoon Period: 1st December to 30th May		
	Strike Point	**Payout**
Excess Unseasonal Rainfall		
Payout Trigger Level	40 mm	25% of sum insured
Incremental Payout per additional 8 mm		15% of sum insured
Payout Exit Level	80 mm	100% of sum insured
Product Structure for Landslide Risk – 2025-26		
Monsoon Period:1st June to 30th November		
Peril	**Landslide**	
Taluka	**Thodupuzha**	
Government Exposure Per unit	₹ 65 lakhs	
Residential Exposure per unit	₹ 52 lakhs	
	Strike Point	**Payout**
Excess Seasonal Rainfall		
Payout Trigger Level	200 mm	25% of sum insured
Incremental Payout per additional **30** mm		15% of sum insured
Payout Exit Level	350 mm	100% of sum insured
Non-Monsoon Period: 1st December to 30th May		
	Strike Point	**Payout**
Excess Unseasonal Rainfall		
Payout Trigger Level	100 mm	25% of sum insured
Incremental Payout per additional 20 mm		15% of sum insured
Payout Exit Level	200 mm	100% of sum insured

Product Structure for Landslide Risk – 2025-26		
Monsoon Period:1st June to 30th November		
Peril	**Landslide**	
Taluka	**Mananthavady**	
Government Exposure Per unit	₹ 113 lakhs	
Residential Exposure per unit	₹ 24 lakhs	
	Strike Point	**Payout**
Excess Seasonal Rainfall		
Payout Trigger Level	150 mm	25% of sum insured
Incremental Payout per additional **30** mm		15% of sum insured
Payout Exit Level	300 mm	100% of sum insured
Non-Monsoon Period: 1st December to 30th May		
	Strike Point	**Payout**
Excess Unseasonal Rainfall		
Payout Trigger Level	75 mm	25% of sum insured
Incremental Payout per additional 15 mm		15% of sum insured
Payout Exit Level	150 mm	100% of sum insured
Product Structure for Landslide Risk – 2025-26		
Monsoon Period:1st June to 30th November		
Peril	**Landslide**	
Taluka	**Vythiri**	
Government Exposure Per unit	₹ 106 lakhs	
Residential Exposure per unit	₹ 24 lakhs	
	Strike Point	**Payout**
Excess Seasonal Rainfall		
Payout Trigger Level	225 mm	30% of sum insured
Incremental Payout per additional **25** mm		10% of sum insured
Payout Exit Level	400 mm	100% of sum insured
Non-Monsoon Period: 1st December to 30th May		
	Strike Point	**Payout**
Excess Unseasonal Rainfall		
Payout Trigger Level	100 mm	25% of sum insured
Incremental Payout per additional 20 mm		15% of sum insured
Payout Exit Level	200 mm	100% of sum insured

Product Structure for Landslide Risk – 2025-26		
Monsoon Period:1st June to 30th November		
Peril	**Landslide**	
Taluka	**Mannarkkad**	
Government Exposure Per unit	Data not available	
Residential Exposure per unit	₹ 22 lakhs	
	Strike Point	**Payout**
Excess Seasonal Rainfall		
Payout Trigger Level	150 mm	25% of sum insured
Incremental Payout per additional **30** mm		15% of sum insured
Payout Exit Level	300 mm	100% of sum insured
Non-Monsoon Period: 1st December to 30th May		
	Strike Point	**Payout**
Excess Unseasonal Rainfall		
Payout Trigger Level	75 mm	25% of sum insured
Incremental Payout per additional 15 mm		15% of sum insured
Payout Exit Level	150 mm	100% of sum insured
Product Structure for Landslide Risk – 2025-26		
Monsoon Period:1st June to 30th November		
Peril	**Landslide**	
Taluka	**Nilambur**	
Government Exposure Per unit	₹ 33 lakhs	
Residential Exposure per unit	₹ 20 lakhs	
	Strike Point	**Payout**
Excess Seasonal Rainfall		
Payout Trigger Level	200 mm	25% of sum insured
Incremental Payout per additional **30** mm		15% of sum insured
Payout Exit Level	350 mm	100% of sum insured
Non-Monsoon Period: 1st December to 30th May		
	Strike Point	**Payout**
Excess Unseasonal Rainfall		
Payout Trigger Level	100 mm	25% of sum insured
Incremental Payout per additional 20 mm		15% of sum insured
Payout Exit Level	200mm	100% of sum insured

7.1.3 Product Prototype for Cyclonic Wind Risk Talukas:

Product Structure for Cyclonic Wind Risk – 2025-26		
Cyclonic Period: 1st April to 31st May and 1st Oct to 15th Jan		
Peril	**Cyclonic Winds**	
Taluka	**Kozhikode**	
Government Exposure per unit	₹ 82 lakhs	
Residential Exposure per unit	₹ 38 lakhs	
	Strike Point	**Payout**
Cyclonic Wind speed		
Payout Trigger Level	95 Km/h	25% of the sum insured
Incremental Payout per additional 10 Km/h	15% of the sum insured	
Payout Exit Level	145 Km/h	100% of the sum insured

Product Structure for Cyclonic Wind Risk – 2025-26		
Cyclonic Period: 1st April to 31st May and 1st Oct to 15th Jan		
Peril	**Cyclonic Winds**	
Taluka	**Thrissur**	
Government Exposure per unit	₹ 54 lakhs	
Residential Exposure per unit	₹ 55 lakhs	
	Strike Point	**Payout**
Cyclonic Wind speed		
Payout Trigger Level	80 Km/h	25% of the sum insured
Incremental Payout per additional 10 Km/h	15% of the sum insured	
Payout Exit Level	130 Km/h	100% of the sum insured

Product Structure for Cyclonic Wind Risk – 2025-26		
Cyclonic Period: 1st April to 31st May and 1st Oct to 15th Jan		
Peril	**Cyclonic Winds**	
Taluka	**Pattambi**	
Government Exposure per unit	₹ 38 lakhs	
Residential Exposure per unit	₹ 53 lakhs	
	Strike Point	**Payout**
Cyclonic Wind speed		
Payout Trigger Level	80 Km/h	25% of the sum insured
Incremental Payout per additional 10 Km/h		15% of the sum insured
Payout Exit Level	130 Km/h	100% of the sum insured
Product Structure for Cyclonic Wind Risk – 2025-26		
Cyclonic Period: 1st April to 31st May and 1st Oct to 15th Jan		
Peril	**Cyclonic Winds**	
Taluka	**Thiruvananthapuram**	
Government Exposure per unit	₹ 72 lakhs	
Residential Exposure per unit	₹ 61 lakhs	
	Strike Point	**Payout**
Cyclonic Wind speed		
Payout Trigger Level	95 Km/h	25% of the sum insured
Incremental Payout per additional 10 Km/h		15% of the sum insured
Payout Exit Level	145 Km/h	100% of the sum insured

Product Structure for Cyclonic Wind Risk – 2025-26		
Cyclonic Period: 1st April to 31st May and 1st Oct to 15th Jan		
Peril	**Cyclonic Winds**	
Taluka	**Kottayam**	
Government Exposure per unit	₹ 78 lakhs	
Residential Exposure per unit	₹ 69 lakhs	
	Strike Point	**Payout**
Cyclonic Wind speed		
Payout Trigger Level	80 Km/h	25% of the sum insured
Incremental Payout per additional 10 Km/h		15% of the sum insured
Payout Exit Level	130 Km/h	100% of the sum insured

Product Structure for Cyclonic Wind Risk – 2025-26		
Cyclonic Period: 1st April to 31st May and 1st Oct to 15th Jan		
Peril	**Cyclonic Winds**	
Taluka	**Thalassery**	
Government Exposure per unit	₹ 66 lakhs	
Residential Exposure per unit	₹ 49 lakhs	
	Strike Point	**Payout**
Cyclonic Wind speed		
Payout Trigger Level	95 Km/h	25% of the sum insured
Incremental Payout per additional 10 Km/h	15% of the sum insured	
Payout Exit Level	145 Km/h	100% of the sum insured

7.1.4 Product Prototype for Storm Surge Risk Talukas:

Product Structure for Storm Risk – 2025-26		
Cyclonic Period: 1st April to 31st May and 1st Oct to 15th Jan		
Peril	**Storm Surge**	
Taluka	**Kochi**	
Government Exposure per unit	₹ 19 lakhs	
Residential Exposure per unit	₹ 37 lakhs	
	Strike Point	**Payout**
Cyclonic Wind speed		
Payout Trigger Level	100 Km/h	25% of the sum insured
Incremental Payout per additional 10 Km/h		15% of the sum insured
Payout Exit Level	150 Km/h	100% of the sum insured

Product Structure for Storm Risk – 2025-26		
Cyclonic Period: 1st April to 31st May and 1st Oct to 15th Jan		
Peril	**Storm Surge**	
Taluka	**Karunagapally**	
Government Exposure per unit	₹ 45 lakhs	
Residential Exposure per unit	₹ 39 lakhs	
	Strike Point	**Payout**
Cyclonic Wind speed		
Payout Trigger Level	80 Km/h	25% of the sum insured
Incremental Payout per additional 10 Km/h		15% of the sum insured
Payout Exit Level	130 Km/h	100% of the sum insured

Product Structure for Storm Risk – 2025-26		
Cyclonic Period: 1st April to 31st May and 1st Oct to 15th Jan		
Peril	**Storm Surge**	
Taluka	**Kollam**	
Government Exposure per unit	₹ 93 lakhs	
Residential Exposure per unit	₹ 36 lakhs	
	Strike Point	**Payout**
Cyclonic Wind speed		
Payout Trigger Level	95 Km/h	25% of the sum insured
Incremental Payout per additional 10 Km/h		15% of the sum insured
Payout Exit Level	145 Km/h	100% of the sum insured

Product Structure for Storm Risk – 2025-26		
Cyclonic Period: 1st April to 31st May and 1st Oct to 15th Jan		
Peril	**Storm Surge**	
Taluka	**Kottayam**	
Government Exposure per unit	₹ 78 lakhs	
Residential Exposure per unit	₹ 69 lakhs	
	Strike Point	**Payout**
Cyclonic Wind speed		
Payout Trigger Level	90 Km/h	25% of the sum insured
Incremental Payout per additional 10 Km/h		15% of the sum insured
Payout Exit Level	140 Km/h	100% of the sum insured

Product Structure for Storm Risk – 2025-26		
Cyclonic Period: 1st April to 31st May and 1st Oct to 15th Jan		
Peril	**Storm Surge**	
Taluka	**Karthikapally**	
Government Exposure per unit	₹ 20 lakhs	
Residential Exposure per unit	₹ 10 lakhs	
	Strike Point	**Payout**
Cyclonic Wind speed		
Payout Trigger Level	90 Km/h	25% of the sum insured
Incremental Payout per additional 10 Km/h	15% of the sum insured	
Payout Exit Level	140 Km/h	100% of the sum insured

Product Structure for Storm Risk – 2025-26		
Cyclonic Period: 1st April to 31st May and 1st Oct to 15th Jan		
Peril	**Storm Surge**	
Taluka	**Vaikkom**	
Government Exposure per unit	₹ 20 lakhs	
Residential Exposure per unit	₹ 10 lakhs	
	Strike Point	**Payout**
Cyclonic Wind speed		
Payout Trigger Level	95 Km/h	25% of the sum insured
Incremental Payout per additional 10 Km/h	15% of the sum insured	
Payout Exit Level	145 Km/h	100% of the sum insured

8 Annexure 2

8.1 Alternative Risk Transfer solution through CAT Bonds / Insurance-Linked Securities:

Cat bonds are securities that transfer the risk of a natural disaster or other event from the sponsoring entities, i.e., State Government, an insurance company, or a reinsurer, to the investors in the Capital Market. They are issued by a special purpose vehicle (SPV) and pay high-interest rates to investors. The bond principal is at risk if the specified event occurs and the issuer receives payment from the collateral account. Cat bonds are not correlated with other economic risks and can diversify a portfolio. They are securitizations of reinsurance contracts and can only be purchased by qualified institutional buyers like insurers.

As CAT bonds and Insurance-Linked Securities (ILS) are usually multi-year risk hedging instruments, they are highly suitable to cover large catastrophic risks, i.e., floods, cyclones, pandemics, forest fires, earthquakes, etc. They can help raise huge capital as it attracts large institutional investors, including FDI around the globe, to finance the risk. It helps diversify the risks across a wider geographical area, spanning multiple countries and regions. The ART is one of the highly innovative risk financing instruments offering attractive returns and less volatility. It has become the fastest-growing market globally, with a growth rate of more than 20%.

8.2 Catastrophic Drop-Down Option (CATDDO)

CATDDO is a pre-arranged loan that gives a country or state immediate access to funds in the aftermath of disasters like Earthquakes, Floods, Hurricanes, and Pandemics (COVID-19). It is one of the popular contingent credit bonds offered by the International Financial Institutions like the World Bank, ADB, KfW, etc. This instrument provides financial support or quick funding liquidity to the State Governments for meeting their immediate financial liability arising from the high-frequency, but medium-severity events, which often hit the state with low or medium severity of loss. It offers a financial bridge between the reserves and risk transfer instruments, which helps the State to mitigate such medium-scale losses and strengthen its capacity to manage such natural disasters. Such CATDDOs can be used as additional financial support that can complement parametric insurance products. It enables the State government to have a pre-arranged credit, which can reduce reliance on post-disaster aid or borrowing. It encourages proactive disaster risk management and helps maintain good fiscal stability during emergencies.

The main eligibility criteria for the state are that it should have an adequate economic policy framework and a satisfactory disaster risk financing strategy in place to manage the natural disaster risks and public health emergencies. Once this eligibility is met, the state or country negotiates and signs the CATDDO agreement in Advance, alongside their disaster risk management plan. The funds can be drawn down once a state of emergency is declared due to any natural disaster or health emergency.

9 Annexure 3

9.1 Instructions For Insurance Calculations

This workbook contains an analysis of potential losses for Government and Residential property portfolios, evaluated over different return periods (25-year, 50-year, and 100-year events). This analysis helps to estimate the burning cost or pure premium rates, loss ratio, and loss cost for each taluk along with the simulated data. This analysis helps in estimating the financial resilience of the proposed catastrophic insurance products under different return period conditions

9.1.1 Structure of the Workbook

The workbook consists of the following working sheets illustrating the calculations of pure premium rates, loss ratio, and loss cost for both residential and government buildings:

- **25 RP Resid**: Loss analysis for Residential properties under a 25-year return period event.
- **25 RP Govt**: Loss analysis for Government properties under a 25-year return period event.
- **50 RP Resid**: Loss analysis for Residential properties under a 50-year return period event.
- **50 RP Govt**: Loss analysis for Government properties under a 50-year return period event.
- **100 RP Resid**: Loss analysis for Residential properties under a 100-year return period event.
- **100 RP Govt**: Loss analysis for Government properties under a 100-year return period event.

9.1.2 Key Concepts Explained

- **Loss Ratio**:
  - Defined as **Per Unit AAL divided by Premium**.
  - For instance, in reference to the sheets, it would be calculated as **(F11/G11) *100**.
  - Indicates the proportion of premium used to cover losses — a measure of portfolio profitability.
- **Loss Cost**:
  - Calculated as **Per Unit AAL multiplied by 1000 and then whole divided by Average Exposure**.
  - For instance, in reference to the sheets, it would be calculated as **F11 *1000/E11.**
  - Represents the expected cost of claims per unit of exposure (such as insured value).
- **Premium Calculation**:
  - Typically, Premium is the **Average Exposure multiplied by the premium rate and divided by 1000,** factoring in underwriting margin and administrative costs.
  - For instance, in reference to the sheets, it would be calculated as **E11 *(premium/1000).**

9.1.3 Inclusion of Monte Carlo Simulation

- Monte Carlo simulation is used to model **uncertainty** and **variability** in loss outcomes.

- Thousands of random simulations (50,000) are run to project a **distribution of possible loss scenarios**.
- Outputs include a range of loss estimates, mean expected losses, and risk percentiles (e.g., 90th or 99th percentile losses).
- Helps in **risk-based pricing** and **capital adequacy planning**.

9.1.4 KEY TAKEAWAYS

- **Comparative Analysis**: The different sheets allow for comparison between 25-year, 50-year, and 100-year risk scenarios, between the Government and Residential buildings.
- **Risk Insight**: Through loss ratio, loss cost, and premium analysis, stakeholders can evaluate the financial resilience of the property (residential and government buildings).
- **Advanced Risk Modelling**: Monte Carlo simulation adds depth by accounting for variability, offering a more comprehensive view of risk exposure

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