NATURAL CATASTROPHE MODEL

From Risk to Resilience

NDRMF
MAKING PAKISTAN RESILIENT

Background

The National Disaster Risk Management Fund (NDRMF) has taken a significant step in enhancing Pakistan's resilience against natural hazards by developing the country's first-ever Disaster Risk Financing (DRF) Strategy. This pioneering strategy integrates disaster risk reduction and financing into the national financial management framework, addressing the critical need for financial preparedness in the face of natural disasters.

A key component of the DRF Strategy is the implementation of the Natural Catastrophe (NatCat) Modeling system. Developed by NDRMF in collaboration with M/s SUPARCO, the NatCat Model is a sophisticated probabilistic framework designed specifically for Pakistan to conduct comprehensive multi-hazard risk assessments. This model is integral to the DRF Strategy as it provides detailed insights into the potential impacts of various natural hazards. By accurately quantifying risks and estimating potential losses, the NatCat Model informs the development and deployment of effective DRF instruments, thereby enhancing the country's disaster risk management capabilities.

What is NatCat Model?

The NatCat Model is an advanced tool that utilizes probabilistic modeling to predict the potential impacts of natural disasters such as floods, droughts, cyclones, tsunamis, heatwaves, earthquakes and landslides.

It combines extensive data on natural hazards, exposed assets, structural vulnerabilities, and historical loss records to generate precise loss estimates. This comprehensive approach ensures that the model can provide valuable information on the frequency, severity and volatility of disaster losses over time, making it an essential resource for strategic planning and resource allocation.

The primary purpose of the NatCat Model is to offer a robust risk assessment tool that supports strategic planning and resource allocation for disaster risk management. By evaluating exposure and vulnerability at the sub-district level, the model helps predict where future events are likely to occur and their potential intensity. This predictive capability is crucial for developing targeted risk reduction measures and ensuring efficient deployment of resources before, during, and after disaster events.

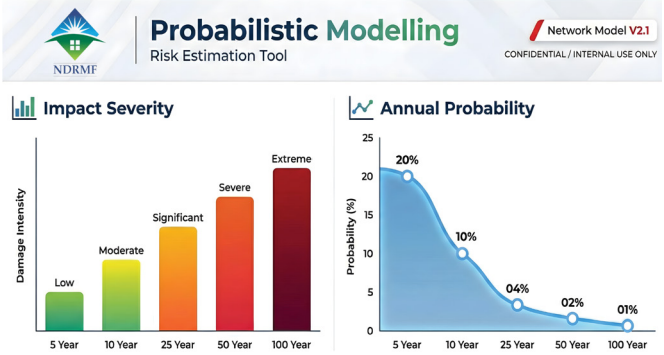
Importance of NatCat for Pakistan

In the context of Pakistan, the NatCat Model plays a pivotal role in strengthening financial resilience against natural hazards. It aids informed decision-making by integrating comprehensive hazard data, thereby enhancing the precision of disaster risk assessments. The model quantifies financial impacts, facilitating effective disaster risk financing and prioritization of mitigation efforts.

By improving disaster preparedness, the NatCat Model helps reduce damage and loss during disasters, protecting critical infrastructure and minimizing economic disruptions. Furthermore, the insights provided by the model guide national disaster management policies and strategies, supporting sustainable development and economic resilience. Through the implementation of the NatCat Model, Pakistan can significantly bolster its ability to anticipate, prepare for and respond to natural disasters, ensuring a more secure and resilient future for its citizens.

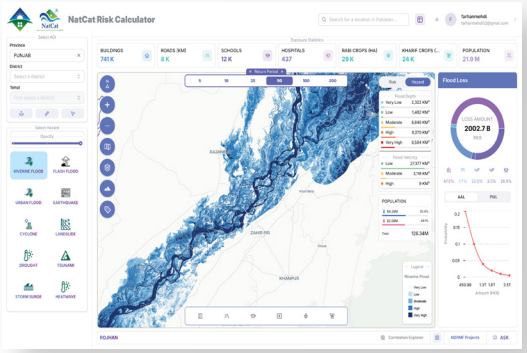
How it works?

The NatCat Risk Calculator evaluates exposure and vulnerability, providing detailed risk assessments. It translates hazard data into monetary losses, guiding strategic planning and resource allocation. Event (Return Period) generation involves simulation of thousands of potential events, detailing their intensity and frequency to cover even the most extreme scenarios. Exposure Analysis then computes hazard intensity for specific locations by considering factors like land use, topography and geological data. Vulnerability Estimation utilizes vulnerability curves to estimate damages, accounting for the variability in property responses. Finally this hazard data is translated into several risk matrixes like Average Annual Loss (AAL), Exceedance Probability (EP) Curves, etc.



NatCat developed by NDRMF

NatCat (Natural Catastrophe) Modeling system, developed by the National Disaster Risk Management Fund (NDRMF) in collaboration with M/s SUPARCO, is Pakistan's first national-level Natural Catastrophe Model - a revolutionary probabilistic framework that transforms how we understand, prepare for and respond to natural disasters.



A probabilistic framework for multi-hazard risk assessments, from hydro meteorological and geophysical hazards. It aims to provide a scientific knowledge base and a loss estimation module crucial for developing disaster risk financing instruments.

Comprehensive Hazard Coverage

This model is the first of its kind at the national level in the region, addresses the risk and loss estimations posed by nine different types of natural hazards:

10 Natural Hazards, 1 Integrated Platform

Hydro-Meteorological Hazards

Riverine Floods
River overflow modeling with return periods 5-250 years

Urban Floods
City drainage capacity and inundation mapping

Flash Floods
Rapid onset flood prediction and impact zones

Drought
Agricultural and water stress indicators

Cyclone Wind
Wind speed analysis and structural impact assessment

Storm Surge
Coastal inundation from cyclonic storm systems

Heat Waves
Temperature extremes and health impact zones

Geo-Physical Hazards

Earthquakes
Seismic hazard maps with magnitude-distance analysis

Tsunamis
Coastal inundation and wave height modeling

Landslides
Slope stability and susceptibility mapping

By evaluating exposure and vulnerability at the Tehsil level, NatCat quantifies risks and their financial impacts, informing users where future events are likely to occur and how intense they might be. This framework is comprised of several simulation models and data sets that are calibrated for quantifying potential impacts of hazards in Pakistan in collaboration with M/s SUPARCO. By accurately estimating location-based risks and losses, the NatCat Model informs the development and deployment of effective DRF instruments, thereby enhancing financial resilience and disaster management against natural hazards.

Key Capabilities:

Multi-Hazard Assessment:
10 disaster types analyzed simultaneously

Ultra-High Resolution:
Hazard modeling down to 5-meter spatial resolution

Tehsil-Level Statistics:
Granular risk analytics at sub-district level

Real-Time Analytics:
Interactive web-based risk calculator

Financial Impact Modeling:
Precise loss estimation in monetary terms

Evidence-Based Planning:
Scientific foundation for policy decisions

Powered by Advanced Technology:

- Probabilistic modeling engines
- High-resolution satellite imagery (5m precision)
- Historical disaster databases
- GIS-integrated exposure analysis
- Vulnerability assessment algorithms

From Reactive Response to Poractive Resilience

REACTIVE
Pre-2020
Crisis response
$24B losses
Post-disaster focus

BUILDING
2020-2023
NDRMF created
NatCat development
Scientific approach

PROACTIVE
2024-Present
10hazards modeled
5m resolution
prevention-focused

Technical Architecture & Data Foundation

Robust Database Infrastructure:

Core Components

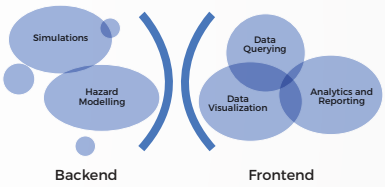
Hazard Module
Probabilistic simulation engines

Vulnerability Analysis
Physical, social, economic risk factors

National Georeferenced Database
Tehsil-level spatial data layers

Exposure Assessment
Asset inventory and classification

Loss Estimation Engine
Financial impact calculations



Data Sources Integration

Ultra-high resolution satellite imagery

Historical disaster records (30+ years)

Demographics and socio-economic data

Infrastructure and asset inventories

Topographic and geological datasets

Technical Specifications

Coverage:
Entire Pakistan territory

Hazard Resolution:
5-meter spatial precision

Statistical Granularity:
Tehsil level (sub-district)
Continuously improving

Update Frequency:
Real-time hazard monitoring

Data Layers:
200+ exposure and vulnerability datasets

Processing:
Cloud-based parallel computing

API Integration:
Restful services enable integration with existing government systems and third-party applications.

Future Enhancements:
Working toward finer administrative resolution for even more precise local-level planning.

Risk Metrics & Decision Support

Actionable Intelligence for Strategic Planning

National Georeferenced Database: A layered Tehsil-level Geo-database contains all the spatial and non-spatial data sets required to simulate the NatCat Models, including Satellite Imagery, DEM, sector-specific GIS data.

Hazard Module: Probabilistic Simulation Models that quantify risks against each return period of a geo-physical or hydrological hazard.

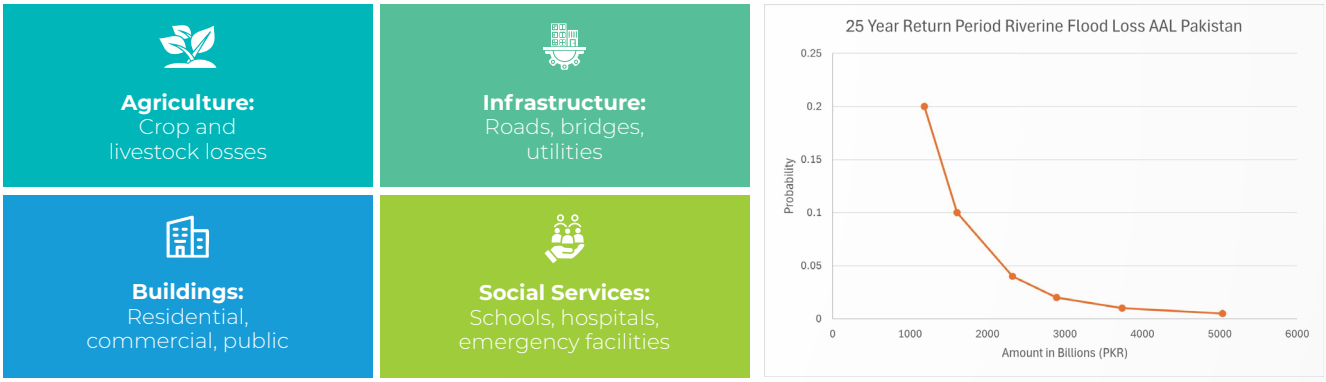
Exposure Assessment: This module computes the hazard's intensity and assists under risk, e.g. crops, roads, schools for all locations

Vulnerability Assessment: Not all assets are at same risk under a specific hazard's exposure. This module estimates different levels of risks associated with different physical, social, economic and environmental vulnerabilities of assets.

Risk/Loss Estimation: This module estimates risk and losses associated with a hazard's return period are translated up to the Tehsil level. It generates a complete risk profile for an administrative level/ project location in the form of a comprehensive risk report. The accumulated losses in terms of monetary values are translated into several statistics required for DRR and DRF actions, including:

Key Risk Indicators:

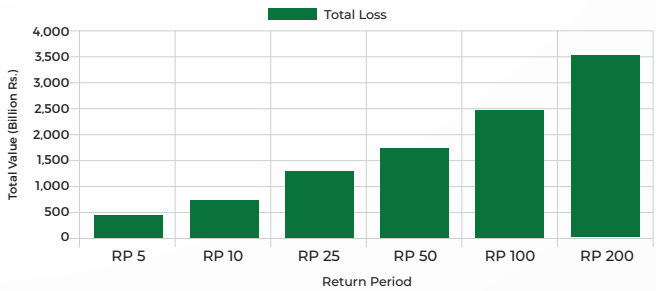
Average Annual Loss (AAL) Expected economic loss per year from natural hazards



Exceedance Probability (EP) Curves Probability analysis for different loss thresholds

- 1-in-10 year event impacts
- 1-in-100 year catastrophic scenarios
- Extreme event tail risk analysis
- **Tail Value at Risk (TVaR)** Expected losses beyond specific thresholds for extreme planning scenarios

Punjab Flood Loss and Risk



- Probabilistic Integrated risk assessment and the ability to carry out scenario-based loss estimation up to Tehsil level for respective hazards. This component will also include the development and deployment of a web-based information system/ platform as a central repository to host the database.

The deliverables of Probabilistic Hazard Modelling and quantification of risk for all 09 Perils

Overall the modelling covered aspects of catastrophic event for severity and frequency of hazard, exposure of assets, vulnerability of locations and estimated maximum probable loss due to a particular hazard in a particular location of the country.

Earthquake	Flood	Urban Floods	Flash Floods
i. hazard maps on desired return basis, ii. Peak Ground Acceleration (PGA), iii. Spectral Acceleration (SA), iv. Disaggregation (Magnitude-distance), v. Most Probable Earthquake (Size/ Magnitude), vi. Maximum Considered Earthquake (MCE), vii. Probable Loss Frequency Curves	i. Flood zonation Maps (Based on Model results), ii. Flood Extent Maps (Based on Historical Inundation and storm surge) iii. Flood Depth maps iv. Flood Duration and Velocity v. Flood Risk Maps and vi. Flood probable loss scenarios on selected return periods (5, 10, 25, 50, 100 and 250).	i. Urban hazard assessment carried out of major cities like Karachi, Lahore, Islamabad/ Rawalpindi, Peshawar and Quetta cities. The major outputs of this model are; ii. Urban floods susceptibility maps against different scenarios iii. Urban Floods magnitude and frequency analysis iv. Identification of hotspots	Return periods of 5, 10, 25, 100, 200 years i) Flood depth ii) Flood duration iii) Flood Velocity iv) Flood extents

Tsunami	Landslide	Heatwaves	Drought	Cyclone
i. The model was redesigned/ run on the globally developed model like GeoClaw. Outputs were generated of; ii. Storm surge hazard maps iii. Wave height iv. Velocity plots v. Inundation extents	i. Landslide hazard assessment of priority areas namely Chitral, Hunza, Muzaffarabad, Neelum, Upper Mansehra and Shangla along KKH. Outputs includes ii. Landslide Inventory iii. Susceptibility zone maps using Analytical Hierarchical Process (AHP)	i. Mapping and assessment of return periods of extreme weather events. Outputs are; ii. Heatwave Maps iii. Reports	i. Drought Hazard Maps ii. Indicators/ Indices data, iii. Drought sereneness (Classification) iv. Duration and Spatial Extent	i. Cyclone Tracks ii. Cyclone Hazard Maps on hazard events over return periods of 10,50, 100 & 100 years, and iii. Cyclone Storm Surge Intensity Maps.

Each probabilistic model in NatCat models hazard for different return periods (e.g. 5, 10, 25, 50, 100 years) through simulating thousands of potential events, high-resolution satellite-based remote sensing data, and long-time historical records. For each return period, it quantifies the hazard's exposure (i.e. assets at risks) and (social and physical) vulnerabilities for all national to tehsil levels. This provides the comprehensive picture of the hazard's risk profile in a WEBGIS-based interactive platform (i.e. the Risk Calculator, another component of the NatCat Model). The model than estimates monitory losses for each hazard's risk against each sector/item (e.g. crops, livestock, infrastructure) and against each administrative level. This evidence-based approach provides the scientific basses to DRR and DRF actions at any location, thereby making it an essential resource for strategic planning and resource allocation before, during and after disaster events.

Precision at Scale:

Hazard Mapping:
5m resolution ensures no detail missed

Risk Statistics:
Optimized for tehsil-level decision making

Continuous Improvement:
Enhanced granularity in development

NatCat Specialized Interface

NatCat Risk Calculator enables users to explore interactions between different hazards (e.g., how earthquakes can trigger landslides and subsequent floods). Multiple interfaces of the NatCat Risk Calculator support Pakistan's Federal Flood Commission (FFC) and the Ministry of Planning, Development & Special Initiatives (MoPD&SI), aid informed decision-making and strategic planning. It benefits officials, policymakers and professionals in disaster risk management and urban planning, enhancing resilience against natural hazards and assessing risks for proposed PSDP projects

1. Risk Calculator

Risk Calculator is a technology based tool to explore the Multi Hazard Risk associated to various national disasters in the country. It provides an opportunity to explore and build exposure, vulnerability and risk mapping of the geographic areas. It also provides you with a risk-sensitive decision-making tool for your disaster risk management and regular development projects. This interface will provide all users / public with basic access to NatCat (complete visualization and basic reporting). It includes the following information;

Risk Calculator (Public Access)

- Database and Web Application
- Interactive hazard exploration
- Basic risk assessment tools
- Educational resources
- Hydro-meteorological Hazard Assessment (Flood, Urban flood, Flash flood, Heatwave, Drought, Cyclone)
- Geo-physical Hazard Assessment (Seismic, Tsunami and Landslide)
- Exposure of Land cover, Crops and Infrastructure to Hydro-meteorological and Geo-physical Hazards
- Loss and Risk Assessment against Hydro-meteorological and Geophysical Hazards
- Integrated Risk Assessment

Federal Flood Commission

NatCat Interface for the Federal Flood Commission (FFC) for assessing several risks associated with Flooding. They can plan their interventions of Flood Protection and Mitigation based on the analysis of this model. Besides the above Risk Calculator Facilities of Modelling, the following information will be uploaded by FFC on this interface;

- **Daily discharge monitoring**
- **Vulnerable location tracking**
- **Historical flood analysis**
- **Mitigation planning tools**

Ministry of Planning, Development & Special Initiative (MoPD&SI)

NatCat interface for Ministry of Planning, Development & Special Initiatives (MoPD&SI) for integration of Risk Assessments in Development Projects. This will ensure all the development planning risk informed in the country.

- **Development project risk screening**
- **Investment prioritization**
- **Policy impact assessment**

Get Started with NatCat

Access Pakistan's Premier Risk Intelligence Platform

Web Portals:

- **Risk Calculator:** natcat.ndrmf.pk
- **FFC Interface:** natcat-ffc.ndrmf.pk
- **MoPD Interface:** natcat-mopd.ndrmf.pk

Who Should Use NatCat:

· Government agencies and policymakers · Development project planners · Insurance and financial institutions · Emergency management authorities · Urban planners and engineers · Research institutions · International development partners

Training & Capacity Building: NDRMF provides comprehensive training programs for:

- Risk assessment methodologies
- Platform navigation and analysis
- Integration with planning processes
- Policy application and decision-making

NDRMF

National Disaster Risk Management Fund (NDRMF)

Contact Information: National Disaster Risk Management Fund (NDRMF) 5th Floor, EOBI House, Mauve Area Sector G-10/4, Islamabad, Pakistan

Email: info@ndrmf.pk **Web:** www.ndrmf.pk **Technical Support:** support@natcat.ndrmf.pk

www.ndrmf.pk ndrmf-pk www.linkedin.com/company/ndrmf/

Building Resilient Pakistan Through Probabilistic Risk Assessment

Prepared by:
Reema HoD Media and Communications NDRMF
Date: January 2026