Assessing the Impact of Cyclone Tauktae on Compensation Distribution and Mitigation Efforts: A Case Study of Goa

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DECLARATION BY STUDENT

I hereby declare that the data presented in this Dissertation report entitled, "Assessing the Impact of Cyclone Tauktae on Compensation Distribution and Mitigation Efforts: A Case Study of Goa" is based on the results of investigation carried out by me in Economics at the Goa Business School, Goa University under the Supervision of Dr. Pranab Mukhopadhyay and the same has not been submitted elsewhere for the ward of degree by me. Further, I understand that Goa University or its authorities will be not be responsible for the correctness of observations / experimental or other findings given the dissertation.

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COMPLETION CERTIFICATE

This is to certify that the dissertation report "Assessing the Impact of Cyclone Tauktae on Compensation Distribution and Mitigation Efforts: A Case Study of Goa" is a bonafide work carried out by Ms. Huzaifa Yakub Shaikh under my supervision in partial fulfilment of the requirements for the award of the degree of Masters of Arts in the Discipline Economics at the Goa Business School, Goa University.

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PREFACE

The completion of this dissertation signifies the culmination of an enriching academic journey embarked upon during my pursuit of a Master's degree in Economics. At the heart of this journey lies an exploration into the economic ramifications of natural disasters, with a particular focus on the impact of Cyclone Tauktae on the state of Goa in May 2021.

This dissertation represents an endeavour to analyze and comprehend the intricate interplay between government compensation policies and cyclone-induced losses within the context of Goa. Through meticulous research, data analysis, and economic modelling, I have endeavoured to shed light on the effectiveness of government interventions in mitigating the socioeconomic repercussions of natural calamities.

Undertaking this research venture has provided me with a profound understanding of the complexities inherent in disaster management and the pivotal role that economic analysis plays in informing policy decisions aimed at disaster resilience and recovery.

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ABSTRACT

Cyclone Tauktae, a significant tropical storm, struck India's western coast in May 2021, impacting various states, including Goa. Originating from the Arabian Sea, it marked the third consecutive year of cyclonic activity in the region. The cyclone caused widespread devastation, particularly in Gujarat, Maharashtra, and Goa, leading to loss of life, displacement, and infrastructure damage. Goa, with its coastal geography and reliance on tourism and agriculture, faced significant challenges. The Government of Goa initiated compensation measures to aid recovery across sectors. This study aims to analyze the impact of Cyclone Tauktae on Goa's population, focusing on damage assessment, compensation allocation, and post-cyclone recovery efforts. Utilizing mixed-method research design, data was collected from Disaster Management Cells in North and South Goa. The study employs statistical tests and regression analysis to explore disparities in compensation, factors influencing compensation allocation, and the impact of cyclone severity and distance from the sea on compensation sought. Findings reveal significant variations in damage distribution, compensation allocation, and impact across different regions and property types. The study contributes to understanding cyclone-induced damages and enhancing disaster management strategies for future events.

KEYWORDS

Cyclone Tauktae Impact	Goa
Compensation	Public and Private Properties
Talukas	Disparities
Total Compensation	Agricultural Crops
Damage Assessment	Infrastructure
Housing	Recovery Measures
Goa Disaster Management Cells	Urban/Rural Classification
Severity	Distance from the Sea

CHAPTER 1: NATURAL DISASTER MANAGEMENT OF INDIA

1.1 Overview

India has a historical susceptibility to a range of natural and human-induced calamities, spanning from earthquakes and floods to industrial mishaps. However, it was the tragic Bhopal gas incident in 1984 that prompted acknowledgment of the inadequacies in the prevailing disaster management framework. The catastrophic leakage of gas from a pesticide factory in Bhopal resulted in the loss of thousands of lives and underscored the urgent necessity for a more robust and coordinated disaster management approach.

Subsequent decades witnessed a notable shift in global strategies for disaster management. Recognizing the escalating frequency and severity of disasters, the international community began advocating for proactive planning, risk mitigation, and community engagement. The adoption of the Hyogo Framework for Action in 2005 urged states to prioritize measures for disaster risk reduction and resilience-building. This global context significantly influenced India's approach to disaster management and laid the foundation for the development of a comprehensive legal framework.

In response to the evolving global outlook and the lessons gleaned from past disasters, the Government of India took proactive measures to establish a legal framework for disaster management. The Disasters (Management and Handling) Bill of 2005 was introduced to establish a structured and coordinated system for disaster management. This bill underwent scrutiny and debate in Parliament before being enacted as the Disaster Management Act of 2005.

1.2 The Disaster Management Act, 2005

The Disaster Management Act, enacted on December 23, 2005, marked a significant milestone in India's disaster management endeavors. It established a multi-tiered institutional framework

to bolster disaster management capabilities across various administrative levels. This framework included the establishment of the National Disaster Management Authority (NDMA) at the national level, led by the Prime Minister, the State Disaster Management Authority (SDMA) at the state level, headed by the Chief Minister, and the District Disaster Management Authority (DDMA) at the district level. These entities aimed to enhance coordination and decentralize disaster management initiatives.

Their roles and responsibilities are legally defined and influenced by the recommendations of the Finance Commission. The Act also acknowledged the pivotal role of local authorities and citizens in disaster preparedness and response, mandating the establishment of local authorities at the grassroots level to tailor disaster management plans to the specific needs of each locality.

a) The National Disaster Management Authority (NDMA)

The National Disaster Management Authority of India, entrusted with the crucial responsibility of formulating policies, plans, and guidelines for effective disaster management at the national level, serves as the premier authority in the country. Established under the Disaster Management Act of 2005, the NDMA plays a pivotal role in coordinating and overseeing disaster response efforts nationwide. As per the Disaster Management Act of 2005, the NDMA serves as a key coordinating body for disaster response efforts at the national level.

Established on December 23, 2005, under the Disaster Management Act, the NDMA is chaired by the Prime Minister of India, emphasizing the nation's commitment to disaster management. The NDMA comprises the Vice Chairman, who also holds the position of Union Home Minister, along with several specialists and professionals in the field of disaster management.

The formulation of a National Disaster Management Plan, which provides a comprehensive framework for disaster response, recovery, and risk reduction, stands as a primary objective of

the NDMA. Ensuring a coordinated, swift, and effective response to disasters occurring in different parts of the country remains the NDMA's primary objective.

A significant aspect of the NDMA's role involves coordinating disaster response efforts among various ministries, departments, and agencies at the national level. Collaborating with State Disaster Management Authorities (SDMAs) and District Disaster Management Authorities (DDMAs), the NDMA facilitates the seamless flow of information and resources during disasters. Such coordination is crucial to ensure well-organized response efforts and effective resource deployment.

b) State Disaster Management Authority (SDMA)

At the state level, the State Disaster Management Authority (SDMA), under the leadership of the Chief Minister, formulates policies and strategies for disaster management within the state. Its responsibilities include endorsing the State Plan in accordance with the directives set forth by the National Disaster Management Authority (NDMA). The SDMA oversees the implementation of the State Plan, recommends funding allocations for mitigation and preparedness measures, and evaluates the development plans of various state departments to ensure seamless integration of prevention, preparedness, and mitigation endeavors.

To aid in fulfilling its duties, the State Government establishes a State Executive Committee (SEC). This committee, led by the Chief Secretary to the State Government, coordinates and supervises the implementation of the National Policy, National Plan, and State Plan. Additionally, the SEC acts as a conduit for information, providing relevant details to the NDMA regarding various aspects of disaster management.

c) District Disaster Management Authority (DDMA):

The District Disaster Management Authority (DDMA), headed by the District Collector, Deputy Commissioner, or District Magistrate, as appropriate, with the elected representative

of the local authority serving as Co-Chairperson. The DDMA serves as the planning, coordination, and execution body for disaster management at the district level. It is tasked with implementing all necessary measures in alignment with guidelines provided by the NDMA and SDMA.

Among its functions, the DDMA formulates the District Disaster Management plan and oversees the implementation of the National Policy, State Policy, National Plan, State Plan, and District Plan. Additionally, it ensures strict adherence to guidelines for prevention, mitigation, preparedness, and response measures stipulated by both the NDMA and SDMA. This includes monitoring compliance with these guidelines by all State Government Departments operating at the district level and by the local authorities within the district.

d) Local Authorities

For the purposes of this policy, local authorities are defined as organizations responsible for overseeing and managing civic services, such as Panchayati Raj Institutions (PRI), Municipalities, District and Cantonment Boards, and Town Planning Authorities. These organizations will assist in disaster management, provide relief, rehabilitation, and reconstruction efforts in affected areas, and develop disaster management plans in accordance with NDMA, SDMA, and DDMA guidelines.

1.3 The 15th Finance Commission

The 15th Finance Commission has observed that the existing mechanisms for funding disaster risk appear inadequate considering the escalating frequency and economic impact of disasters. Consequently, the Commission has been tasked with providing two reports: one for the fiscal year 2021-2022 and a final report covering the period from 2021–2022 to 2025–2026.

Departing from traditional expenditure-based approaches, the 15th Finance Commission has introduced a novel methodology for determining state-wise allocations for disaster management in its 2020-21 Report. This innovative approach blends three key factors: capacity, risk exposure, and hazard and vulnerability.

Capacity is assessed based on past expenditure, offering insights into a state's historical commitment and competence in managing disasters effectively. ***Risk exposure*** takes into account both geographical area and population density, recognizing that states face varying degrees of risk based on their size and population concentration. The disaster risk index, incorporating hazard and vulnerability, adds a dynamic element to the methodology, reflecting the specific challenges each state faces regarding natural disasters.

This methodology is tailored for implementation during the current financial years from 2021-22 to 2025-26. Its multi-dimensional nature acknowledges that a uniform strategy is insufficient for addressing the diverse nature of disaster risks across different states in India.

1.4 NATIONAL AND STATE DISASTER RISK MANAGEMENT FUNDS:

In line with the recommendations, the 15th Finance Commission proposes the establishment of two funds: the National Disaster Risk Management Fund (NDRMF) and the State Disaster Risk Management Fund (SDRMF).

a) The National Disaster Risk Management Fund (NDRMF) functions as a centralized pool of resources at the national level, aimed at providing the necessary financial support for comprehensive disaster risk reduction, preparedness, and response measures on a broader scale.

b) The State Disaster Risk Management Fund (SDRMF) is set up at the state level, recognizing the significance of localized approaches to disaster management. This fund empowers states to tailor their disaster risk reduction strategies according to their specific needs, vulnerabilities, and risk profiles.

Both the NDRMF and SDRMF encompass Response Fund and Mitigation Fund components, ensuring a comprehensive approach to disaster risk management at both the national and state levels.

1.5 NATIONAL AND STATE RESPONSE FUNDS

a) The National Disaster Response Fund (NDRF): The National Disaster Response Fund (NDRF), established under the Disaster Management Act of 2005, serves as an official fund to address expenses related to emergency response, relief efforts, and rehabilitation following both natural and man-made disasters. Oversight of the NDRF's central operations is provided by the National Executive Committee (NEC) under the direction of the National Disaster Management Authority (NDMA). During times of disaster, the NDRF is primarily utilized for swift and effective response actions, including relief efforts, evacuation, medical aid, and reconstruction.

b) The State Disaster Respond Fund (SDRF): The State Disaster Response Fund (SDRF), governed by the Disaster Management Act, operates under the supervision of each state's Chief minister. This fund acts as a vital resource pool, ensuring that states have immediate access to funds for disaster response and recovery without solely relying on central assistance. Specifically tailored to finance response and relief expenses for disasters of moderate severity, the SDRF supports various state-level activities such as search and rescue operations, medical assistance, temporary shelter, and restoration of essential services. By enabling states to promptly address the immediate needs of affected populations, the SDRF facilitates efficient and localized disaster response efforts.

1.6 NATIONAL AND STATE MITIGATION FUNDS:

The Disaster Management Act defines "Mitigation" as measures taken to reduce the likelihood, severity, or consequences of disasters or situations that could lead to them. While large-scale

infrastructure projects like flood embankments or coastal barriers are considered mitigation measures, the 15th Finance Commission prioritizes community-based and local-level initiatives that reduce risks and promote environmentally sustainable settlements and livelihood patterns for funding through the Mitigation Fund. The Act mandates the National Disaster Management Authority (NDMA) and State Disaster Management Authorities (SDMAs) to oversee the National and State Disaster Mitigation Funds.

*The Central Government constituted **the National Disaster Mitigation Fund (NDMF)** on **05.02.2021** and also advised all the State Governments to set up **State Disaster Mitigation Funds (SDMFs).***

a) The National Disaster Mitigation Fund (NDMF): The National Disaster Mitigation Fund (NDMF) was established on 5th February 2021, for projects only for the purpose of mitigation, as required by the Act. The NDMA implements the NDMF, which follows the Finance Commission's periodic recommendations.

The proposed NDMF is primarily focused on providing funding for long-term planning, infrastructure development, and community resilience programs—all of which are intended to lessen the effects of disasters. The development of resilient infrastructure, the installation of early warning systems, and community training initiatives are just a few of the uses for NDMF funding.

b) The State Disaster Mitigation Fund (SDMF): Similarly, recognizing the importance of localized financial resources for long-term disaster mitigation plans, the concept of State Disaster Mitigation Fund (SDMF) mirrors that of the NDMF. Operating at the state level, the SDMF finances initiatives and programs aimed at reducing each state's vulnerability to disasters. It emphasizes the need for states to invest autonomously in programs that enhance resilience and mitigate future disaster impacts. SDMF-supported initiatives include resilient

infrastructure development, community-centered training programs, and tailored mitigation strategies, all aimed at proactively reducing disaster risks and enhancing community resilience.

1.7 FUNDS ALLOCATION FOR STATE DISASTER RISK MANAGEMENT FUND

The 15th Finance Commission has devised a structured framework for disaster management funding, encapsulated within the State Disaster Risk Management Fund (SDRMF), which underscores a holistic approach towards addressing various dimensions of disaster response and mitigation.

a) A significant sum of **Rs. 1,60,153 crores** is earmarked for the SDRMF, with a clear delineation between the State Disaster Response Fund (SDRF) and the State Disaster Mitigation Fund (SDMF).

b) The SDRF receives 80% of this total amount, totaling **Rs. 1,28,122 crores**, while the remaining 20%, amounting to Rs. 32,031 crores, is allocated to the SDMF. It's crucial to note that SDRF and SDMF serve distinct functions within the disaster management framework and are not interchangeable.

Further breakdown within the State Disaster Response Fund (SDRF) is established through three sub-windows, each with specific allocations aimed at addressing different phases of the disaster management cycle.

Fund (percentage distribution)	Amount (Rs. crore)
SDRF (80)	***1,28,122***
i. Response and Relief (40)	64,061
ii. Recovery and Reconstruction (30)	48,046
iii. Preparedness and Capacity Building (10)	16,015
SDMF (20)	***13,031***
Total (SDRF + SMF) (100)	

Source: XV FC Commission Report 2021-26

40% of the allocation, a significant sum of Rs. 64,061 crores, is designated for **Response and Relief efforts.** This allocation aims to swiftly address immediate response and relief needs, encompassing activities such as rescue operations, emergency aid distribution, and ensuring the safety and well-being of affected communities in the aftermath of a disaster.

30% of the allocation, amounting to Rs. 48,046 crores, is allocated to **Recovery and Reconstruction.** This portion recognizes the importance of long-term recovery and reconstruction endeavors following a disaster. These funds are intended to support the rebuilding of infrastructure, restoration of livelihoods, and overall rehabilitation of disaster-affected areas.

10% of the allocation, totaling Rs. 16,015 crores, is earmarked for **Preparedness & Capacity Building.** This allocation underscores the necessity for proactive measures and capacity-building initiatives. These funds are directed towards enhancing states' capabilities to respond effectively to disasters, including through training programs, infrastructure development for disaster preparedness, and community awareness initiatives.

1.8 FUNDS ALLOCATION FOR NATIONAL DISASTER RISK MANAGEMENT FUND

While the three sub-windows of the SDRF are distinct and not interchangeable with the funding windows of the SDMF, there may be some flexibility in how funds are allocated.

The allocation plan for the National Disaster Risk Management Fund (NDRMF) includes the establishment of the National Disaster Risk Management Fund (NDRMF) and the distribution of funds between the National Disaster Response Fund (NDRF) and the National Disaster Mitigation Fund (NDMF).

The total allocation amounts to Rs. 68,463 crores from 2021-22 to 2025-26, with the NDRF receiving the majority share of 80%, equivalent to Rs. 54,770 crore, and the remaining 20%, amounting to Rs. 13,693 crores, designated for the NDMF.

Further breakdown within the National Disaster Response Fund (NDRF) is established through three sub-windows, each with specific allocations addressing distinct phases of the disaster management cycle.

Fund (percentage distribution)	Amount (Rs. crore)
NDRF (80)	***54,770***
iv. Response and Relief (40)	27,385
v. Recovery and Reconstruction (30)	20,539
vi. Preparedness and Capacity Building (10)	6,846
NDMF (20)	***13,693***
Total (NDRF + NDMF) (100)	

Source: XV FC Commission Report 2021-2026

40% of the National Disaster Response Fund (NDRF), equivalent to Rs. 27,385 crores, is designated for **Response and Relief efforts**. This allocation is geared towards swiftly addressing the immediate response and relief needs during and after a disaster, catering to the urgent requirements of affected communities.

30% of the NDRF, totaling Rs. 20,539 crores, is allocated for **Recovery and Reconstruction.** This allocation acknowledges the crucial phase of recovery and reconstruction following a disaster, emphasizing the long-term rehabilitation and rebuilding efforts necessary to return affected areas to a state of normalcy.

10% of the NDRF, amounting to Rs. 6,846 crores, is earmarked for **Preparedness & Capacity Building.** The allocation plan incorporates flexibility by allowing for the reallocation of funds within the three sub-windows of the NDRF, permitting adjustments of up to 10% of the allocation of each sub-window.

1.9 THE FOUR INSURANCE INTERVENTIONS BY XV FC:

The XV Finance Commission has identified insurance instruments as highly effective, especially for providing coverage to individuals affected by infrequent yet potentially impactful disasters. While more common natural hazards occurring every five to ten years are typically managed using public funds like the State Disaster Response Fund (SDRF) and National Disaster Response Fund (NDRF), severe events happening every ten to hundred years are better suited for coverage through insurance policies or catastrophe bonds.

Aligned with these principles, the commission has proposed four insurance interventions with the goal of offering an added layer of protection to people residing in disaster-prone regions. It's important to note that these proposed interventions are not meant to replace existing public fund mechanisms but rather to complement and strengthen them.

a) National Insurance Scheme for Disaster-related Deaths: This initiative proposes establishing a national insurance scheme in collaboration with an insurance firm, leveraging state-wise disaster mortality data. State Governments would contribute by paying insurance premiums based on their respective annual mortality rates, potentially supplemented by the Union Government. These premiums are anticipated to be lower than the ex-gratia assistance typically provided. In the event of fatalities, insurance companies would disburse payouts in stages, including immediate, five-year, and ten-year installments, with an option for monthly payments.

b) Coordinating Relief Assistance with Crop Insurance: Recognizing the significant impact of crop failures on farmers' livelihoods during disasters, this scheme aims to integrate relief assistance with payouts from the Pradhan Mantri Fasal Bima Yojana (PMFBY), a crop insurance scheme. While farmers currently receive assistance from government sources like the SDRF and NDRF, it may not adequately address their needs. By synchronizing relief

assistance with PMFBY payouts, the total support provided to farmers can be substantially increased.

c) Risk Pool for Infrastructure Protection and Recovery: This initiative acknowledges the critical role of infrastructure in disaster response and recovery efforts. Infrastructure assets are vulnerable to various hazards, and their destruction can have significant economic and social implications. By establishing a risk pool, governments can pool resources to cover the costs of repairing or replacing damaged infrastructure, thereby reducing the financial burden on individual entities.

d) Access to International Reinsurance for Outlier Hazard Events: This initiative recognizes the limitations of domestic insurance markets in covering catastrophic risks. While domestic insurance schemes can offer valuable protection against common hazards, they may lack the capacity to handle large-scale disasters or rare events with high severity. By accessing international reinsurance markets, governments can obtain additional coverage for outlier hazard events, such as earthquakes or tsunamis, which may exceed the capacity of domestic insurers.

CHAPTER 2: GOA STATE DISASTER MANAGEMENT

The Goa State Disaster Management Rules, 2007

The Goa State Disaster Management Rules, 2007, were formally instituted on September 13, 2007. They were enacted to align with the National Disaster Management Act, 2005, which laid the foundation for a structured and coordinated approach to disaster management across the country.

2.1 GOA STATE DISASTER MANAGEMENT AUTHORITY

The institutional framework for disaster management in the state of Goa is governed by the Goa State Disaster Management Authority (GSDMA), comprising three essential components – the State Disaster Management Authority (SDMA), the State Executive Committee (SEC), and the District Disaster Management Authority (DDMA).

a) State Disaster Management Authority (SDMA):

The apex body within the Goa State Disaster Management Authority, the State Disaster Management Authority (SDMA), is chaired by the Chief Minister of Goa. It serves as the highest decision-making body for disaster management in the state.

Under the guidance of the SDMA, the Goa State Disaster Management Plan is formulated, outlining the strategies and mechanisms for disaster management in the state.

b) State Executive Committee (SEC):

The State Executive Committee (SEC) operates as the executive arm of the Goa State Disaster Management Authority. Headed by the Chief Secretary of the state, the SEC is responsible for implementing the policies and plans laid out by the SDMA.

It oversees the allocation of resources, both human and material, to the District Disaster Management Authorities (DDMAs) and ensures that they are adequately equipped to respond

to disasters. Additionally, the SEC is actively involved in organizing training programs and capacity-building initiatives for officials and personnel involved in disaster management at different levels.

c) District Disaster Management Authority (DDMA):

At the district level, the District Disaster Management Authority (DDMA) forms the grassroots unit of the disaster management structure in Goa. Chaired by the District Magistrate or the Collector, the DDMA coordinates and implements disaster management plans at the local level. Each district in Goa has its own DDMA, which serves as the focal point for disaster preparedness, response, recovery, and mitigation within its jurisdiction. Each district in Goa has its own DDMA. And typically, there are two DDMA in Goa; South-Goa District Disaster Management Authority and North-Goa District Disaster Management Authority

I. The South-Goa Disaster Management Authority is situated in the District Collectorate, Margao, and coordinates disaster management efforts across seven talukas within its jurisdiction: Mormugao, Salcete, Quepem, Sanguem, Canacona, Dharbandora, and Ponda.

II. The North-Goa Disaster Management Authority is situated in the District Collectorate, Panjim, and coordinates disaster management efforts across five talukas within its jurisdiction: Bardez, Tiswadi, Bicholim, Pernen, and Sattari.

Funds allocation to District Disaster Management Authorities (DDMAs) in the State is primarily facilitated through the state's budgetary provisions, i.e. **The Annual Financial Statement** of the State (Goa).

Within this statement, specific provisions are made for disaster management and relief efforts, including allocations designated for DDMAs to support their operational activities, such as preparedness, response, and recovery initiatives in the face of natural disasters or emergencies.

2.2 The Annual Financial Statement

Article 202 of the Indian Constitution states that the Governor must lay down before the Legislative assembly lay down the estimated receipts and expenditures of the State for a financial year. This statement is referred to as the ***'Annual Financial Statement'*** in the Constitution, is the main fiscal or budgetary document of the Government of Goa, prepared by the Finance Department and the Administrative Departments.

Financial Year for Government of Goa is from April to March in line with that for Government of India. The constitutional provisions governing the budgetary process in the State of Goa outline the financial proceedings in the Assembly, which include several components. These components encompass the General Budget (AFS), Demands for Grants, Vote on Account, Supplementary Demands for Grants, Appropriation Bill, and the Finance Bill.

The budget documents, in general, show data about receipts and expenditures for the three consecutive years, i.e.

i. Previous year's actuals
ii. This year's revised estimates for the current fiscal year
iii. Budget estimates for the following fiscal year

The Annual Financial Statement categorizes government receipts and expenditures into 3 sections,

(i) State Consolidated Fund;
(ii) State Contingency Fund; and
(iii) Public Account.

The portion of the expenditure estimates not covered by the Consolidated Fund of the State, is presented in the form of **Demands for Grants** to the Assembly. These estimates can be

deliberated upon by the Assembly, which has the authority to approve, reject, or amend any demand.

The Finance Department is responsible for preparing these budget estimates and grant proposals under the Business of the Government of Goa (Allocation) Rules, 1987, which were framed under Article 166 of the Constitution.

a) Fund Allocations for Natural Calamity Relief: Annual Financial Statements of Goa

The Annual Financial Statement of Goa encompasses various expenditures, among which is the allocation for relief in response to natural calamities. Over six years, the Relief on Account of Natural Calamities has shown notable fluctuations**.**

YEAR	RELIEF ON ACCOUNT OF NATURAL CALAMITIES (IN LAKHS)
2017 -18	**586.00**
2018 - 19	**287.50**
2019 - 20	**991.60**
2020 - 21	**287.50**
2021 - 22	**3428.58**
2022 - 23	**3852.30**

Source: Annual Financial Statements, Goa

In 2017-18, it was 586.00 lakhs, reflecting the financial commitment towards addressing the impact of disasters. The subsequent year witnessed a decrease to 287.50 lakhs. However, in 2019-20, the relief increased significantly to 991.60 lakhs, possibly indicating a surge in the occurrence or severity of natural disasters. The figure reverted to 287.50 lakhs in 2020-21, before experiencing a substantial spike in 2021-22, reaching 3428.58 lakhs, emphasizing the heightened need for assistance during that period. In 2022-23, with relief amount reached 3852.30 lakhs, to address the challenges posed by natural calamities in Goa.

b) Fund Allocations for Natural Calamity: Demand for Grants of Goa

Just as states annually release their financial statements to provide a comprehensive overview of their fiscal health and expenditure, they also issue Demand for Grants (DFGs).

Demand for Grants documents serves as formal requests from government ministries and departments for funds to execute planned activities and programs in the upcoming fiscal year. These documents detail the estimated expenditures for various sectors, projects, and initiatives.

Demand For Grants	In Lakhs (Actuals) Year 2017 - 18	In Lakhs (Actuals) Year 2018 -19	In Lakhs (Actuals) Year 2019 - 20	In Lakhs (Actuals) Year 2020 - 21	In Lakhs (Actuals) Year 2021 - 22
COLLECTORATE, NORTH GOA					
Relief on Account of Natural Calamities	4.25	44.56	350.00	387.79	1131.50
Flood. Cyclones, etc.	4.25	44.56	350.00	387.79	1131.50
Gratuitous Relief	4.25	44.56	350.00	387.79	1131.50
Gratuitous Relief for Affected Victims	4.25	44.56	350.00	387.79	1131.50
COLLECTORATE, SOUTH GOA					
Relief on Account of Natural Calamities	8.86	10.80	21.25	1505.27	1073.21

Flood. Cyclones, etc.	8.36	10.80	21.25	1505.27	1073.21
Gratuitous Relief	8.36	10.80	21.25	1505.27	1073.21
Gratuitous Relief for Affected Victims	8.36	10.57	21.66	14.80	183.66
Relief on account of natural Calamity	573.39	232.14	620.35	1959.24	1223.87
State disaster relief fund (SDRF)	408.90	180.93	553.41	1420.00	1211.83

Source: Demand For Grants (DFGs), Goa Budget

In the financial years from 2017-18 to 2021-22, funds were allocated for various categories of relief in both the North Goa and South Goa Collectorates. For Relief on Account of Natural Calamities, the State Disaster Relief Fund (SDRF) received allocations of 4.25 lakhs consistently across the specified years. Additionally, funds for Floods, Cyclones, etc., were allocated in the amounts of 8.86 lakhs and 8.36 lakhs for 2017-18 and 2018-19 respectively, with a subsequent decrease to 573.39 lakhs in 2019-20, and remaining consistent at 44.56 lakhs from 2020-21 to 2021-22.

Gratuitous relief and Relief for Affected Victims received varying allocations, with amounts fluctuating across the years. Specifically, in North Goa, gratuitous relief fluctuated between 10.80 and 387.79 lakhs, while in South Goa, it remained constant at 1073.21 lakhs from 2017-18 to 2021-22. The Relief for Affected Victims also showed variations, ranging from 14.80 to 1505.27 lakhs in North Goa and from 183.66 to 1211.83 lakhs in South Goa over the specified period. These allocations reflect the changing needs and priorities in response to natural calamities and their impact on affected regions.

CHAPTER 3: INTRODUCTION

Natural disasters, such as cyclones, pose significant challenges to both human lives and economies, often leading to widespread devastation and loss. Governments worldwide grapple with the aftermath of such calamities, aiming to mitigate the impact on affected populations and regions.

In the Indian state of Goa, the occurrence of Cyclone Tauktae in 2021 brought about considerable destruction, prompting a critical examination of the government's compensation mechanisms. This dissertation undertakes an economic analysis of the compensation provided by the Goan government for cyclone-induced losses, focusing on Cyclone Tauktae's impact in 2021. By delving into the intricacies of disaster response and recovery efforts, this study aims to contribute to the existing literature on disaster management and policy formulation, offering insights that can inform more resilient and equitable strategies for addressing the aftermath of natural disasters in Goa and beyond.

3.1 Overview of Natural Disasters and Cyclones in India

India, with its diverse geographical features and climatic conditions, is highly prone to a wide range of natural disasters. These natural disasters encompass a wide range of destructive events triggered by natural forces, including earthquakes, floods, tsunamis, and cyclones. Among these, cyclones stand out as formidable atmospheric disturbances characterized by intense winds, heavy rainfall, and storm surges.

Cyclones, also known as hurricanes or typhoons depending on their location, vary in intensity and impact, ranging from mild disturbances to catastrophic events with far-reaching consequences. Besides, being situated in the tropical region, India's extensive coastline along the Bay of Bengal and the Arabian Sea makes it particularly susceptible to cyclonic disturbances originating from the Indian Ocean. The frequency and intensity of cyclones vary

across different regions and seasons, with the coastal states of Andhra Pradesh, Odisha, West Bengal, Tamil Nadu, and Gujarat being the most vulnerable.

Cyclones in India typically occur during the pre-monsoon (April-June) and post-monsoon (October-December) seasons, bringing heavy rainfall, strong winds, and storm surges that often result in widespread devastation. These events not only cause loss of lives and displacement of populations but also inflict significant damage to infrastructure, agriculture, and ecosystems. The socio-economic impacts of cyclones are particularly severe in coastal communities, where livelihoods are closely tied to marine resources and agriculture.

3.2 Background

Goa, renowned for its coastal beauty and vibrant communities, faced a daunting challenge in May 2021 with the advent of Cyclone Tauktae. With a long coastline, spanning approximately 7,516 km, and a shallow continental shelf, the vulnerability of Goa to natural disasters is pronounced. The region's high population density, geographical location, and unique physiological features make it particularly susceptible to the destructive forces of cyclones.

Approximately 8% of the geographical area, comprising 84 coastal districts in 13 coastal states and union territories, bears the recurrent brunt of severe tropical cyclones.

Historically, Goa has experienced several cyclonic events, each leaving a profound impact on its communities and economy. In response to these challenges, the Government of Goa has made concerted efforts to enhance its disaster preparedness and response capabilities. Initiatives such as early warning systems, disaster risk reduction programs, and community resilience-building activities aim to mitigate the adverse effects of cyclones on vulnerable populations.

Despite these efforts, the occurrence of Cyclone Tauktae in 2021 underscored the persistent threat posed by cyclones to Goa's socio-economic fabric.

3.3 Cyclone Tauktae: Significance and Impact

Cyclone Tauktae, a formidable tropical storm that made landfall on India's western coast in May 2021, left an indelible mark on both the nation and the state of Goa. Originating from the Arabian Sea, Tauktae marked the third consecutive year in which a cyclone closely approached the west coast of India, following in the wake of Cyclones Vayu in 2019 and Nisarga in 2020. Coastal regions spanning Kerala, Karnataka, Tamil Nadu, Maharashtra, Gujarat, and Goa, were some states among others, that bore the impact of Cyclone Tauktae.

In India, Tauktae's onslaught resulted in widespread devastation, particularly along the coastal states of Gujarat, Maharashtra, and Goa. The cyclone unleashed powerful winds, heavy rainfall, and storm surges, leading to loss of life, displacement of communities, and extensive damage to infrastructure. Its impact was felt across sectors, disrupting transportation networks, damaging power lines, and causing significant economic losses, particularly in agriculture and fisheries.

For Goa, Tauktae posed significant challenges due to its coastal geography and reliance on tourism, agriculture and infrastructure. Agricultural lands bore the impact of Tauktae's fury, with crops destroyed and livelihoods jeopardized. The tourism sector, a lifeline of Goa's economy, suffered disruptions due to infrastructure damage and safety concerns, exacerbating the financial strain inflicted by the COVID-19 pandemic.

The Government of Goa initiated various compensation measures to alleviate the suffering of affected populations and facilitate the recovery process. These measures aimed to address the diverse impacts of the cyclone across different sectors, ranging from agriculture and fisheries to infrastructure and housing.

Given the substantial damage inflicted on agricultural lands and crops, financial assistance to farmers who suffered losses due to Cyclone Tauktae. The government also extended support to

fishermen who incurred losses due to damaged boats, gear, and infrastructure. Financial assistance, along with measures to repair and replace fishing equipment, helped mitigate the impact of Cyclone Tauktae on the fishing industry. Furthermore, efforts were made to restore coastal ecosystems and enhance resilience against future cyclonic events.

Infrastructure damage, including roads, bridges, and power lines, posed significant challenges to post-cyclone recovery efforts. Funds were allocated for repairing and reconstructing damaged infrastructure to restore essential services and facilitate transportation and communication networks. Timely rehabilitation of critical infrastructure was crucial for ensuring the continuity of economic activities and restoring normalcy in affected areas.

Housing was another critical area requiring attention, as many residential buildings suffered structural damage during Cyclone Tauktae. The financial assistance and technical support for repairing and rebuilding damaged houses, ensuring that affected families could return to safe and habitable living conditions.

Additionally, measures were taken to enhance the resilience of housing infrastructure against future cyclonic events through improved building codes and construction practices. Besides there, the forested areas of both North and South Goa also suffered extensive damage due to the cyclone. Trees were uprooted, and vegetation was decimated, posing ecological challenges. The Forest Department's properties in both districts were affected, necessitating immediate measures for restoration and conservation.

3.4 Aim:

The aim of this study is to comprehensively evaluate the impact of Cyclone Tauktae on properties and agricultural crops in Goa, with a specific focus on damages incurred, compensation allocation across different administrative regions.

3.4 Research Objectives:

1. To compare the damages sustained by Government and Private properties during Cyclone Tauktae.
2. To assess the extent of compensation provided for Government and Private properties affected by Cyclone Tauktae.
3. To examine potential disparities in compensation amounts for similar damage types across various talukas within South Goa.
4. To investigate the factors that influence the total compensation disbursed for the restoration of damage caused by Cyclone Tauktae.
5. To determine if there are variations in the impact of Cyclone Tauktae on crops across districts.

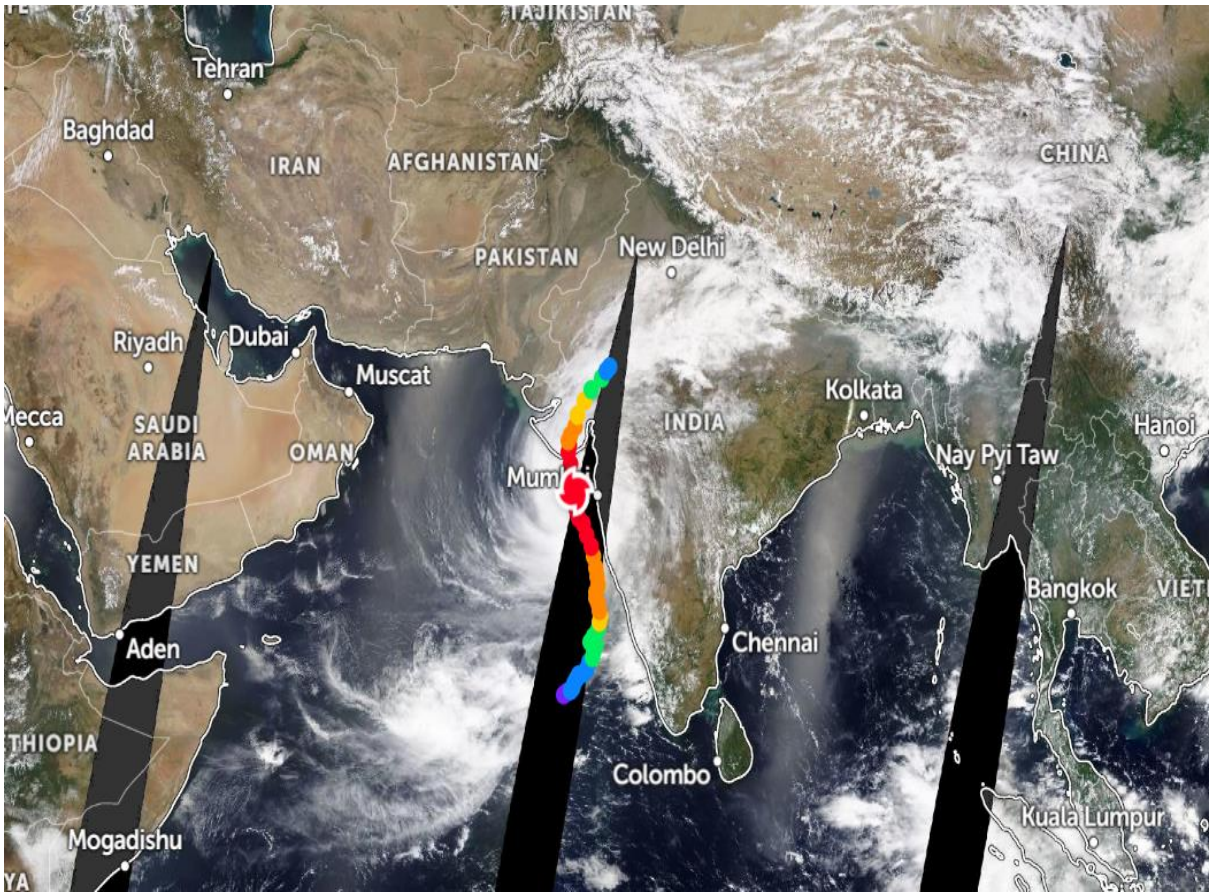
3.5 Research Questions:

1. How do the damages incurred by Public and Private properties compare during the Cyclone Tauktae?
2. What is the extent of compensation allocated for both Public and Private Properties affected by Cyclone Tauktae?
3. Are there significant disparities in compensation amounts for similar types of damage across different talukas post-Cyclone Tauktae?
4. Did the impact of Cyclone Tauktae vary significantly on crops across districts?
5. What factors contribute to the total compensation disbursed for the restoration of Tauktae-induced damage?

3.6 Scope:

The scope of this study is restricted only to the population of Goa who were affected by Cyclone Tauktae, May 2021. It encompasses an examination of the impact of Cyclone Tauktae on the

state of Goa, considering its coastal geography, and socio-economic fabric. It aims to analyze the significance and repercussions of Cyclone Tauktae on various sectors, including agriculture, infrastructure, and housing. Additionally, the study delves into the effectiveness of the Government of Goa's response and recovery measures, particularly in terms of compensation allocation and infrastructure restoration.



Source: Satellite Image - Zoom Earth Source:

CHAPTER 4: LITERATURE REVIEW

Initially, disaster mitigation funds were traditionally allocated based on expenditure considerations, with limited emphasis on the specific needs and vulnerabilities of different regions. However, **(Sharma)** examination of the recommendations by the 15th Finance Commission marks a significant departure from this traditional approach. The Commission advocates for a more sophisticated formula-based allocation system, which takes into account not only the financial aspect but also physical and socio-economic factors. This marks a pivotal evolution in the understanding of disaster funding, reflecting a recognition of the multifaceted nature of disaster risk and the need for tailored mitigation strategies at different administrative levels. Concurrently, the reliance on direct donations for post-disaster reconstruction, as critiqued by **(Hakim),** reveals early efforts to empower disaster victims. However, shortcomings such as systemic weaknesses and a lack of community involvement underscore the limitations of this approach. This critique signifies a growing awareness of the importance of sustainable, community-driven reconstruction efforts that address not only immediate needs but also long-term resilience. **(Saon Ray et al.)**, exploration of governmental roles in compensating disaster victims further illustrates the evolving landscape of disaster management. The shift towards recognizing the diverse needs of affected individuals and communities reflects an increasing understanding of the complexities involved in post-disaster recovery. This evolution underscores a growing emphasis on the development of flexible, adaptive compensation mechanisms that can effectively address the varied needs of disaster survivors. **(Sugarman)'s** presentation of multiple solutions for disaster compensation contributes to this evolution by highlighting the need for comprehensive, nuanced approaches to compensation. By advocating for the restructuring of aid providers and the redefinition of compensation criteria, Sugarman underscores the importance of considering the diverse range of losses incurred during disasters. This reflects a broader recognition of the multifaceted nature

of disaster impacts and the need for compensation mechanisms that can adequately address these complexities.

In parallel**, (Mohapatra et al.)** analysis of disaster vulnerability in coastal regions reveals an evolving understanding of hazard proneness. By identifying specific regions vulnerable to cyclones, the study underscores the importance of tailored mitigation strategies that account for regional variations in risk. This evolution reflects a growing acknowledgment of the need for localized, context-specific approaches to disaster risk management. **(Patil)** emphasis on integrating disaster mitigation into broader development frameworks signifies a holistic approach to disaster management. This evolution reflects a recognition of the interconnectedness between disaster risk and broader development goals, highlighting the importance of mainstreaming disaster risk reduction efforts into development planning processes. Overall, the literature review portrays a dynamic evolution in disaster mitigation and management strategies, characterized by a shift towards more holistic, context-specific approaches that recognize the multifaceted nature of disaster risk and vulnerability.

(Faure) emphasizes the critical role of post-disaster compensation procedures in shaping behaviors towards disaster risk reduction. By examining mechanisms such as first-party insurance and liability regulations, the study aims to incentivize operators to prioritize risk reduction measures. This approach acknowledges the importance of aligning financial incentives with proactive risk mitigation strategies, ultimately contributing to enhanced disaster resilience at both individual and community levels. **(Basyah et al.)** delve deeply into the ethical dimensions of disaster management, particularly in the context of allocating relief resources during public health disasters. The paper engages with complex ethical dilemmas inherent in disaster response, advocating for principles of justice and fairness to guide decision-making processes. Moreover, it underscores the necessity of community participation throughout all phases of disaster management, recognizing the diverse perspectives and needs

of affected populations. By fostering ethical discourse and promoting inclusive approaches, the study seeks to strengthen the ethical foundation of disaster management practices while calling for continued research to advance ethical considerations in the field.

(Singh) provides a comprehensive exploration of disaster implications, mitigation strategies, and preparedness measures, highlighting the multifaceted challenges faced by vulnerable populations. The paper underscores the disproportionate impact of disasters on marginalized groups, emphasizing the urgency of tailored interventions to address their specific vulnerabilities. Mitigation efforts are outlined across various disaster scenarios, encompassing both structural and non-structural measures aimed at reducing risks and enhancing resilience. Additionally, the study emphasizes the importance of international cooperation and coordinated response mechanisms to effectively address the escalating threats posed by natural and anthropogenic disasters. **(De Mot and Faure)** critically examine the limitations of public authority liability in correcting perverse incentives among disaster victims. Despite theoretical arguments supporting its efficacy, the authors highlight practical challenges in its implementation, including judicial discretion and the limited effectiveness of legal remedies. In response, the study advocates for a more holistic approach to disaster compensation, incorporating comprehensive insurance coverage and government reinsurance to ensure adequate and timely support for affected individuals and communities. This approach seeks to strike a balance between preserving incentives for risk reduction and providing equitable compensation for disaster victims.

(He and Faure) propose a dynamic partnership model for disaster compensation, emphasizing the need for collaboration between different stakeholders to optimize outcomes. By highlighting examples from various legal systems, the paper underscores the potential of public-private partnerships (PPPs) in enhancing compensation mechanisms while advancing broader disaster risk reduction goals. This collaborative approach seeks to leverage the

strengths of both public and private sectors, promoting innovation and efficiency in disaster response and recovery efforts. **(Deshpande)** sheds light on the vulnerability of specific regions and social groups to disasters in India, emphasizing the critical need for identification of vulnerable areas and enhanced coordination among institutions. The paper underscores the importance of multi-sectoral and inter-departmental collaboration, public awareness, community capacity building, and transparency in disaster management plans and actions. Furthermore, it advocates for the integration of state and national disaster management plans, establishment of quick shelter facilities, improvement of transportation networks, and household-level preparedness to effectively cope with disasters across the country.

(Sen et al.) reveal the significant impact of chronic poverty on household vulnerability to cyclones in coastal regions of India. The study highlights how long-term economic deprivation exacerbates the impact of natural disasters, while transient poverty, caused by income fluctuations, also contributes to increased vulnerability. Risk attitudes and community characteristics play pivotal roles in determining the level of vulnerability and adaptive capacity of households in cyclone-prone areas, emphasizing the importance of targeted programs such as consumption insurance, social safety nets, and livelihood diversification to protect affected households from chronic and transient poverty induced by tropical cyclones. **(Boragapu et al.)** underscore the high vulnerability of the Indian subcontinent to tropical cyclones, which impact millions of lives and cause significant economic losses. The paper provides valuable insights into the vulnerability of different regions in India to these natural disasters and emphasizes the importance of enhancing preparedness and resilience to mitigate their impact effectively. The study calls for comprehensive measures to strengthen infrastructure, improve early warning systems, and enhance community resilience to mitigate the devastating effects of tropical cyclones. **(Pande and Pande)** highlight the vulnerability of Uttarakhand to natural disasters, particularly landslides, emphasizing the urgent need for a sound Resettlement and Rehabilitation Policy to address both immediate and long-term effects. The paper recommends

the relocation of highly hazard-prone villages to safer locations and stresses the importance of implementing state-wide resettlement and rehabilitation policies to mitigate the impact of disasters effectively. This underscores the necessity of proactive measures to safeguard vulnerable communities and minimize the loss of life and property.

(Faisel T Illiyas, Keshav Mohan, Shibu K Mani, and A P Pradeepkumar) draw attention to the underreporting of lightning incidents in India and the inadequate media coverage of lightning-related disasters. The paper calls for a reorientation of perceptions on disaster insurance and government funding to provide adequate attention and relief to lightning victims. By highlighting this overlooked aspect of disaster management, the study underscores the need for increased awareness and preparedness measures to mitigate the risks posed by lightning strikes. **(Subhradipta Sarkar and Archana Sarma)** critically examine the Disaster Management Act, 2005, identifying various shortcomings and areas of concern. The paper discusses the lack of focus on the rights of affected communities, the need for better coordination among authorities, and the potential for political influence in key appointments. The authors suggest several recommendations for improving the act, including the declaration of disaster-prone zones, specification of qualifications for authority members, transparency in budgeting, and the involvement of local authorities and voluntary organizations in disaster management efforts. This highlights the imperative for legislative reforms and institutional strengthening to enhance the effectiveness of disaster management practices.

(Fischel and Shapiro) introduced Michelman's utilitarian standard as a method for evaluating compensation questions within the framework of economic efficiency principles. This standard offers a normative guide for choosing between the Pareto superiority criterion and the Kaldor-Hicks's criterion, providing a nuanced approach to assessing the costs and benefits of compensation. The authors argue that traditional insurance rationales for compensation may be inadequate, as they fail to address demoralization costs, which are a key consideration in

Michelman's standard. By incorporating these insights, the paper contributes to a deeper understanding of the economic dimensions of disaster compensation and the complexities involved in assessing its effectiveness. **(Sen et al.)** reveal the heightened vulnerability of households below the poverty line to cyclones, highlighting the significant impact of consumption volatility on their resilience. Fishing households, in particular, are identified as being at high risk due to chronic poverty and susceptibility to poverty traps resulting from erratic earnings and risk-taking behavior. The study emphasizes the importance of implementing targeted programs such as consumption insurance, social safety nets, and livelihood diversification to protect affected households from both chronic and transient poverty induced by tropical cyclones. This research underscores the urgent need for poverty-sensitive disaster risk reduction strategies that address the unique vulnerabilities of marginalized communities.

Deepika Shukla, Hiteshwar Kumar Azad, Kumar Abhishek, and S. Shitharth) present the Disaster Management Ontology (DMO) as a framework for enhancing decision-making in disaster management. This knowledge-driven decision support system provides a structured approach to task distribution among relevant authorities during various stages of disaster management. By removing ambiguity in the responsibility framework and integrating with the National Disaster Management Plan (NDMP), the DMO facilitates the implementation of guidelines for providing assistance to disaster-affected individuals. The proposed Ontology-based Decision Support System aims to enhance decision-making across different levels of authority, offering valuable assistance to the national disaster response fund team and other decision-making authorities involved in disaster management. This innovative approach holds promise for improving the efficiency and effectiveness of disaster response efforts. **(Garima Jain, Chandni Singh, Teja Malladi)** address issues with current post-disaster relocation practices in urban India, highlighting their potential to exacerbate inequalities and increase flood vulnerability. The paper emphasizes the need for participatory and risk-reducing plans

for relocation, stressing the importance of addressing underlying community needs and conducting vulnerability and impact assessments before crises occur. By advocating for a more inclusive and proactive approach to post-disaster relocation, the study contributes to ongoing discussions on sustainable urban development and disaster risk reduction.

(Iqbal and Ahmed) Employing Generalized Least Squares (GLS), Negative Binomial (NB), and Zero Inflated Negative Binomial (ZINB) models, this study probes the influence of political and fiscal decentralization on disaster outcomes. Notably, political decentralization emerges as a significant determinant affecting disaster outcomes, while fiscal decentralization alone doesn't exhibit a robust impact on mitigating death tolls. **(Skidmore and Toya)** This study integrates fiscal, economic, demographic, and geographic datasets alongside records of total fatalities resulting from natural disasters across multiple nations spanning from 1970 to 2005. Tobit random effects regression serves as the analytical tool to explore the correlation between fiscal decentralization and fatalities triggered by natural disasters. The findings indicate that countries with decentralized governance structures might encounter reduced instances of disaster-induced fatalities. Additionally, factors such as governmental effectiveness, income disparity, and urban population density are identified as influential elements shaping the repercussions of natural disasters.

(Kellenberg and Mobarak) This study delves into the economic ramifications of natural disasters, advocating for tailored disaster management strategies that account for the diverse socio-economic landscapes of different countries. It underscores the imperative of research into predisaster mitigation efforts and the development of sophisticated disaster insurance markets to bolster effective risk management practices. **(Anasua Mukherjee Das)** Focusing on the National Disaster Management Plan (NDMP) 2016 in India, this paper delineates its objectives and implications for enhancing disaster resilience and management. The NDMP emphasizes a comprehensive approach across prevention, mitigation, response, and recovery phases,

highlighting the necessity of coordinated efforts at all levels of governance. **(C. N. Ray)** The paper delves into the Disaster Management Bill of 2005, centering on its stipulations, consequences, and potential influence on disaster mitigation endeavors within India. It dissects the pivotal elements of the legislation and assesses its efficacy in tackling the challenges of disaster management. The primary objective of the Disaster Management Bill, 2005 is to establish a legal framework aimed at expediting disaster mitigation initiatives by public entities. However, apprehensions arise regarding the bill's potential inclination towards prioritizing relief and rehabilitation over risk reduction and mitigation efforts. There is a recognized need for targeted considerations toward vulnerable demographics such as women, tribal populations, and isolated communities in the planning of disaster management strategies. **(Khan)** The research employed econometric software to assess the influence of political and fiscal decentralization on disaster outcomes, incorporating instruments and controlling for variables such as income inequality. Findings revealed that the impact of decentralization on disaster outcomes fluctuates depending on the types and levels of decentralized governance. Particularly noteworthy were the significant and resilient results observed at the lowest tier of governance, notably the Municipality level. Elected governments at this level were linked to a rise in both the number of fatalities and affected individuals, whereas the effect was deemed insignificant at the state level.

(MIHIR R BHATT) A comparative analysis of disaster response preparedness in India and China reveals divergent approaches to post-disaster rebuilding and economic development. While India focuses primarily on reconstruction efforts following disasters, China leverages disaster response as an avenue for economic growth. This highlights the pressing need for India to adopt proactive disaster risk reduction measures and bolster institutional capacity for more effective disaster response mechanisms. **(Anu Kapur)** Investigating the treatment of disasters by the government, media, and academia in India, this study exposes deficiencies in disaster management laws and research funding. It underscores the necessity for comprehensive

disaster prevention and management strategies, given the prevailing insensitivity towards disaster mitigation efforts and the predominant focus on natural disasters over human-made ones in both policy and academic discourse. **(Khan et al.)** The research examines the repercussions and reactions stemming from cyclones Sidr, Aila, and Mahasen in the south-western region of Bangladesh. It specifically scrutinizes the losses and damages experienced at the household level, the coping mechanisms employed, and the effects of engagement in the PRIME support initiative for ultra-poor households. Findings from the study illustrate the diverse adaptive strategies households employ, contingent upon their income brackets and the assistance they receive. Notably, it underscores the significance of social networks in navigating climate-induced disasters and emphasizes the pivotal role of microfinance in bolstering resilience among vulnerable communities confronting the challenges of climate change. **(Shukla et al.)** The paper presents the development of a Disaster Management Ontology (DMO) grounded in the National Disaster Management Authority (NDMA) of India's responsibility matrix. Methodologically, it employs OWL in Phase 1 to create a static knowledge base and SWRL in Phase 2 to establish a dynamic query environment. Utilizing OntoGraph, the authors enhance user interaction by constructing a class view of the taxonomy. The DMO framework facilitates task allocation among relevant authorities across different stages of disaster management, serving as a knowledge-driven decision support system for providing financial assistance to disaster victims. By clarifying roles throughout disaster comprehension and management stages, the ontology reduces ambiguity within the responsibility framework. Aligned with the National Disaster Management Plan (NDMP), the DMO integrates Semantic Web Rule Language (SWRL) rules to implement NDMP guidelines, fostering assistance provision to disaster-affected individuals. Evaluation across diverse disaster scenarios ensures the ontology's effectiveness, identifying areas for refinement to enhance its utility in real-world disaster management contexts.

CHAPTER 5: METHODOLOGY

The primary sources of secondary data for this study are the Disaster Management Cells situated at the South and North Goa Collectorates. These cells provided detailed household-level data pertaining to the impact of Cyclone Tauktae in Goa. The dataset includes information such as the names of individuals claiming assistance, their addresses, the nature of damages incurred (e.g., roof damage, structural damage, window/shutter damage, uprooted/fallen trees, injuries sustained), and the corresponding compensation disbursed by the State Disaster Management Authority.

The study focuses on the interdisciplinary nexus of Environment Economics within the geographical context of Goa, specifically during the occurrence of Cyclone Tauktae in 2021. Utilizing a mixed-method research design, the study integrates both quantitative and qualitative approaches to comprehensively analyze the impact of the cyclone on households and the subsequent allocation of funds by the State Disaster Management Authority.

The primary method of data collection is secondary, involving the extraction and compilation of information from the aforementioned sources. The data encompasses a mixed type, comprising both quantitative variables (e.g., compensation amounts, distances) and qualitative variables (e.g., nature of damage, villages).

The study encompasses the entire geographical expanse of Goa during Cyclone Tauktae, with a total of 540 observations. These observations are derived from the household-level data provided by the Disaster Management Cells. The South Goa Collector Office provided data for five out of 7 talukas (Mormugao, Salcete, Ponda, Canacona, and Sanguem) expect for (Dharbandora and Quepem), while the North Goa Collector Office provided data for all five talukas under its jurisdiction (Tiswadi, Bardez, Pernem, Bicholim, and Sattari). The analysis employs a multifaceted approach, utilizing graphical tools for visual representation and comprehension of attribute classification within the dataset.

For the classification of funds allocated in the talukas of the North District, where the nature of damage was unspecified, a classification scheme based on the extent of damage was devised. This involved categorizing households as partially, moderately, or severely damaged based on the compensation amount received. Additionally, observations were classified based on their proximity to the sea, creating a variable "Distance from the Sea" to analyze the relationship between distance from the sea and the impact of the cyclone

Before conducting the tests, the assumption of normality was assessed using the Shapiro-Wilk Test. The results of the Shapiro-Wilk Test indicated that the data for both the government and private household categories did not meet the assumption of normality, as evidenced by p-values less than 0.05. Given this violation of normality, it was deemed inappropriate to proceed with the parametric tests. Furthermore, inferential statistical such as Chi-Square, Regression Analysis are employed to address the research objectives. Non-parametric tests, such as the Mann Whitney U test, and Kruskal Wallis tests are utilized when assumptions of parametric tests were not met.

For the analysis pertaining to objective 2, which aimed to assess the extent of damage incurred, Mann-Whitney U test (also known as the Wilcoxon rank-sum test) is adopted to compare the extent of compensation between two independent group, government properties and private properties.

For Regression Models 1 and 2, the primary objective was to examine the relationship between the distance from the sea and the impact of Cyclone Tauktae on households. To achieve this, a new variable "Distance from the Sea" was created using Geo Spatial techniques, specifically utilizing Geographic Information System (GIS) software such as QGIS. It then classified observations based on their proximity to the sea into three categories: "Close_From_Sea," "Intermediate_From_Sea," and "Far_From_Sea."

Each observation was assigned a classification based on its distance from the sea. If an observation fell within 1 km from the sea, it was labelled as "Close_From_Sea." Observations with distances between 1 km and 10 km from the sea were labelled as "Intermediate_From_Sea," while those with distances greater than 10 km were labelled as "Far_From_Sea."

After classifying observations based on their proximity to the sea, regression models were constructed to analyze the relationship between this newly created variable and the impact of Cyclone Tauktae on households. The models included additional relevant variables such as the nature of damage incurred, compensation amounts, and socio-economic factors to capture potential confounding variables.

Upon analyzing the interaction regression models, autocorrelation, the presence of autocorrelation and heteroskedasticity was detected using Durbin Watson and Breusch Pagan Test. To address these issues, Cochrane Orcutt and Robust standard errors were implemented. After implementing the above remedial measures, the interaction regression models were transformed to address the issues of autocorrelation, and heteroskedasticity.

These transformed models were presented, highlighting the modifications made to address the identified issues. The revised model specifications, coefficient estimates, standard errors, and statistical significance of the variables were provided to demonstrate the effectiveness of the remedial measures in improving the robustness and reliability of the regression analyses.

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CHAPTER 6: ANALYSIS

6.1 Analysis of Secondary Data collected

6.1.1 Graphical Representation

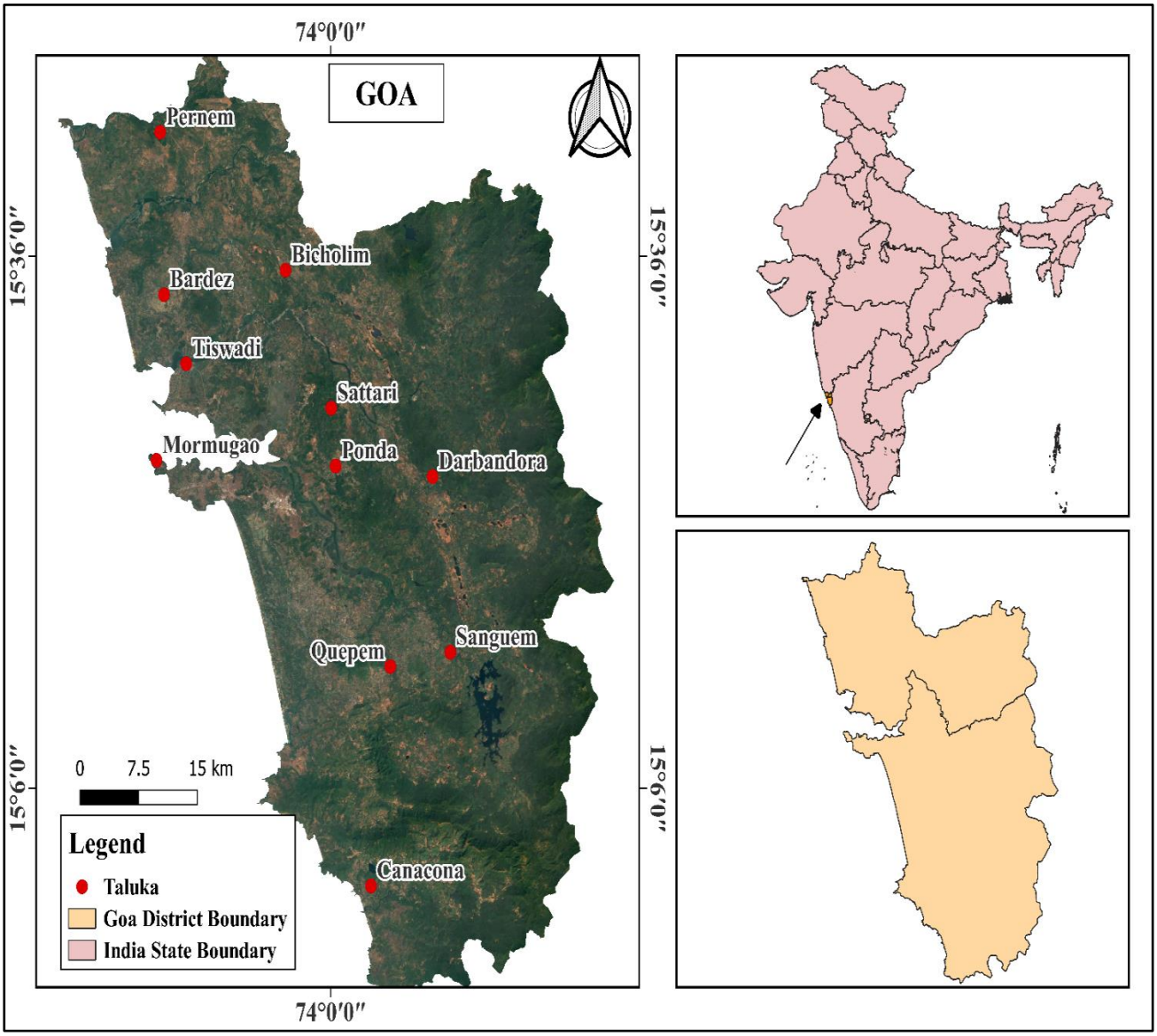
6.1.2 Geo Spatial Mapping

6.1.3 Analysis using Mann Whitney Test

6.1.4 Analysis using Chi-square

6.1.5 Interaction Regression Analysis

6.1.2.1: The Study Area - Goa



Source: The map is generated using QGIS

Interpretation:

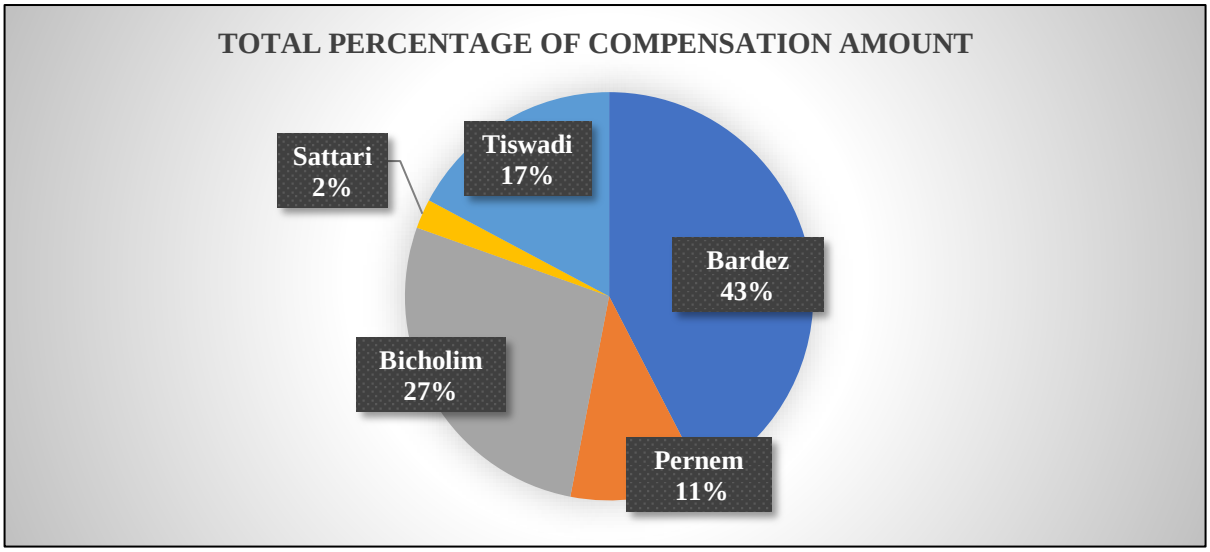
On the right side, the upper map illustrates India's political borders with Goa highlighted in light orange colour with an arrow pointing towards it, while the lower map offers a simplified outline of the State – Goa.

The primary map on the left displays the geography of Goa, India, through a satellite view with marked red dots indicating specific landmarks. These landmarks represent Talukas of Goa. Geographical coordinates border the map while a scale at the bottom left provides distance measurements in kilometers.

6.1 Analysis of Secondary Data collected from North and South Goa Collectorate Office.

6.1.1 Graphical Representation

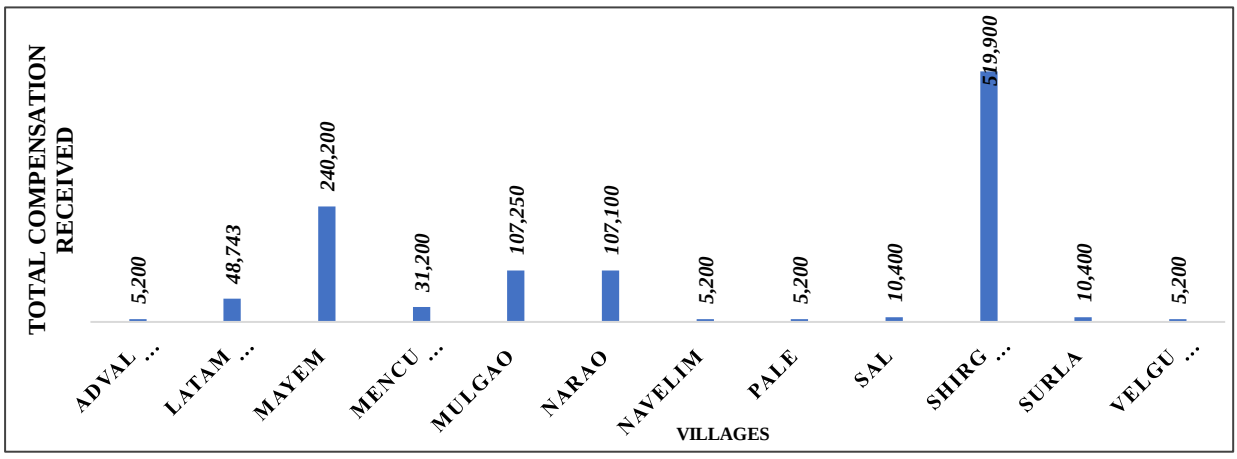
6.1.1.1: Classification of Compensation Received Based on Talukas in North Goa



Source: The graph is generated using Secondary Data

The above Pie Chart depicts total percentage of compensation received by various Talukas in the District of North Goa. From out of 5 Talukas, Bardez accounts the largest share of 43% followed by Bicholim with 27%, Tiswadi with 15%, Pernem and Sattari holds 11% and 1% as the smallest share out of the total compensation amount of Rs. 1,704,200.

6.1.1.2: Classification Based on The Funds Claimed by Villages in Bicholim Taluka

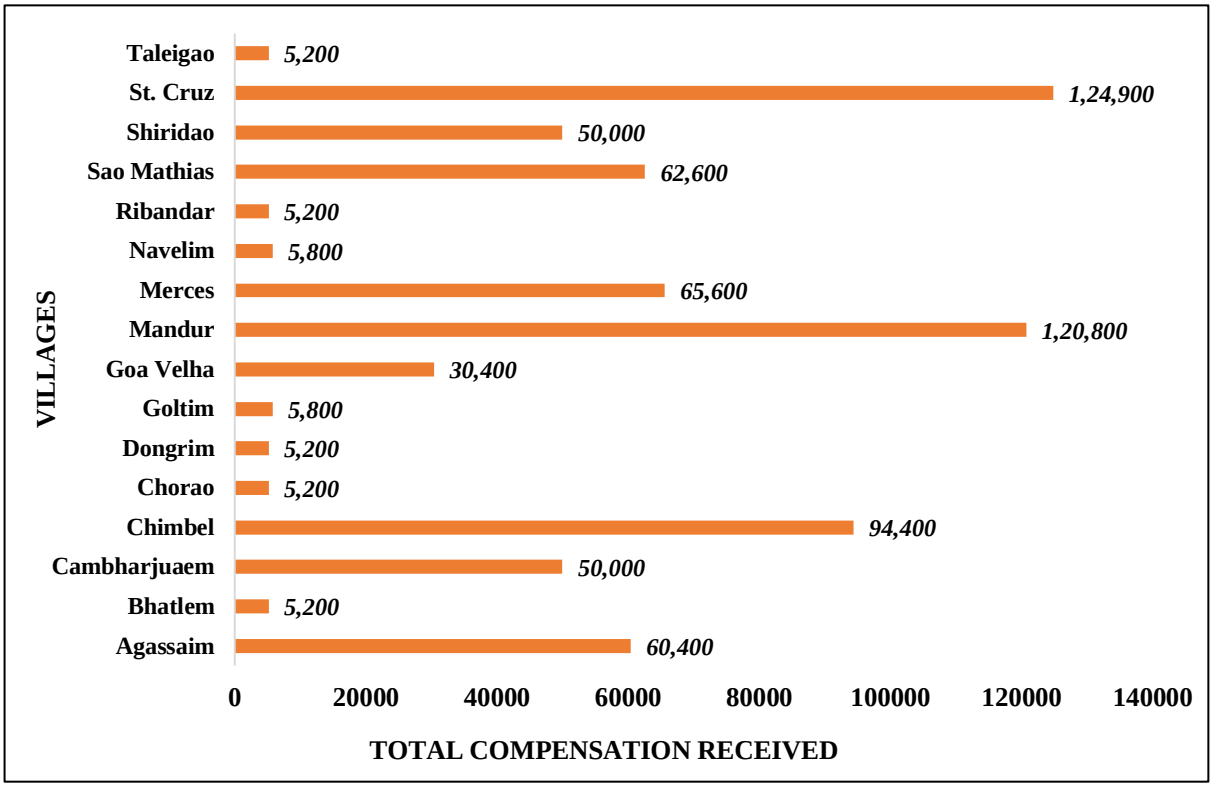


Source: This graph is generated with Secondary Data

The above Bar Graph depicts the total compensation received by various villages in Bicholim Taluka Shirgao emerges as the village with the highest compensation, receiving a substantial

amount of Rs. 5,19,900. Mayem, Narao and Latambarcem received Rs. 2,40,200 and Rs. 1,07,100, and Rs. 48,743 respectively. Conversely, villages like Advalpal, Devgni, Navelim, Pale, and Velguem received the lowest compensation amounts, all at Rs. 5,200 each. Sal and Surla received similar compensation of Rs. 10,400. And Mulgao and Mencurem also received notable compensation of Rs. 1,07,250 and Rs. 31,200, respectively.

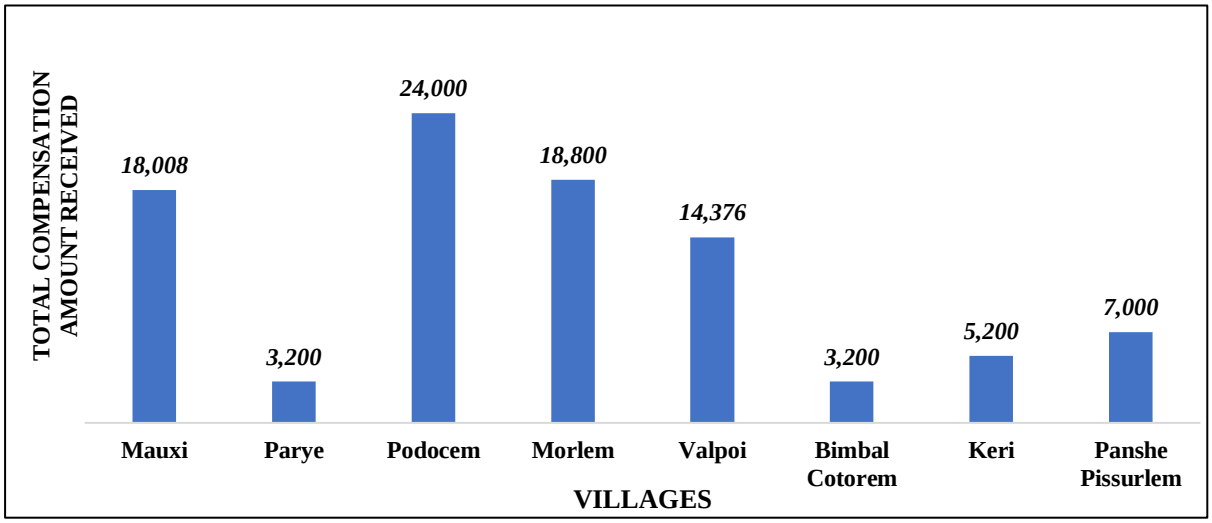
6.1.1.3: Classification Based on The Funds Claimed by Villages in Tiswadi Taluka



Source: The graph is generated using Secondary Data

The above bar graph depicts the total compensation received by various villages in Tiswadi Taluka. St. Cruz received the highest compensation, totaling Rs. 119,700. Mandur and Chimbel follow closely, with compensation amounts of Rs. 115,600 and Rs. 94,400, respectively. Merces and Aggasaim received Rs. 65,699 and 60,400, respectively. Sao Mathas received a total compensation of 57,400 Palem Shiridao with 50000, Cambharjuam with Rs. 50,000, Goa Velha with Rs. 30,400, Goltim with Rs. 11,600, and Dongrim with Rs. 10,400. Conversely, several villages, such as Bhatlem, Chorao, Ribandar, Taleigao, and Vanzuem, received a smaller compensation amount of Rs. 5,200 each.

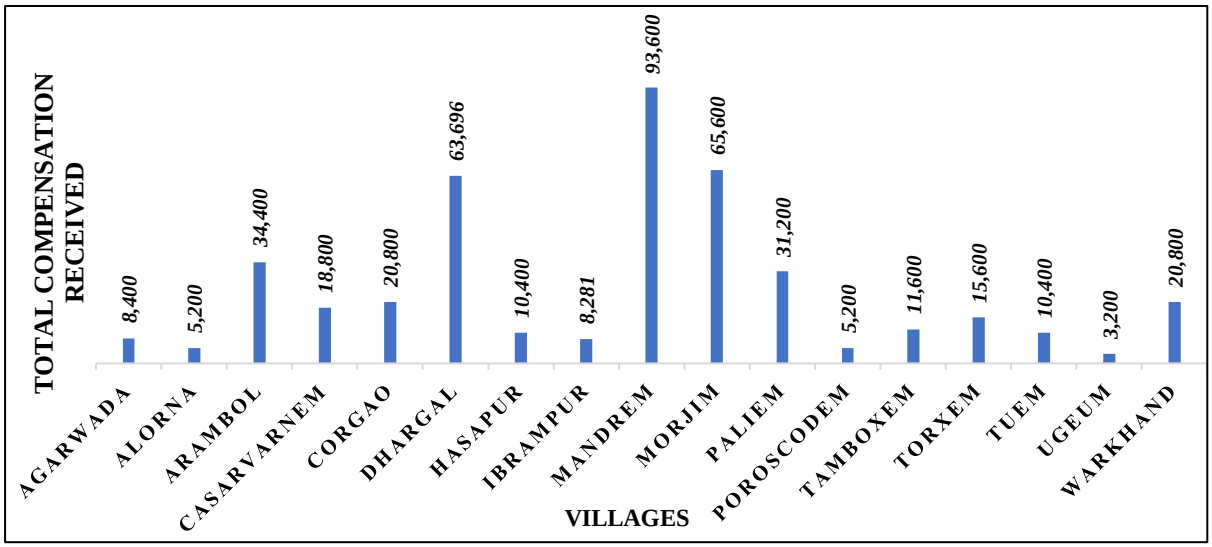
6.1.1.4: Classification Based on The Funds Claimed by Villages in Sattari Taluka



Source: This graph is generated using Secondary Data

The above Bar Graph depicts the total compensation received by various villages in Sattari Taluka. Podocem received the highest compensation of Rs. 24,000, followed by Morlem with Rs. 18,800 and Mauxi with Rs. 18,008. Valpoi and Panshe Pissurlem also received considerable compensation, of Rs. 14,376 and Rs. 7,000 respectively. Keri and Bimbal Cotorem received rs. 5,200 and 3,200. And Parye received a smaller compensation of Rs. 3,200 units.

6.1.1.5: Classification Based on The Funds Claimed by Villages in Pernem Taluka

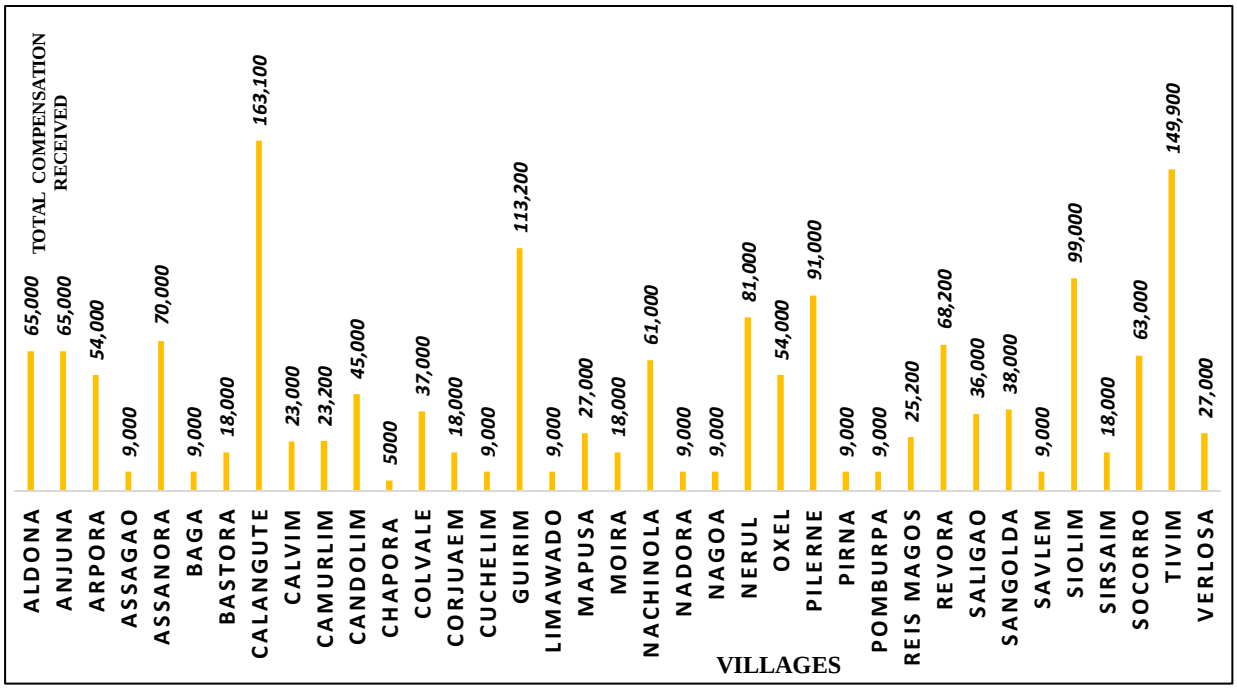


Source: This graph is generated using Secondary Data

The above Bar Graph depicts the total compensation received by various villages in Pernem Taluka. Mandrem and Morjim emerge as the top recipients, receiving Rs. 93,600 and Rs.

65,500 respectively. Arambol, Paliem and Dhargal follow closely with compensation amounts of Rs. 34,400, Rs. 31,200 and Rs. 63,696. Warkhand and Corgao receive similar amount of compensation worth Rs. 20,800 each. Casarvarem, Torxem, Tamboxem, Ibrampur and Agarwada receive Rs. 18,800, Rs. 15,600, Rs. 11,600, Rs. 8,282 and Rs. 8,400 respectively. Hasapur and Tuem received similar compensation amount of Rs. 10,400. Alorna and Poroscadem also received similar compensation of Rs. 5,200 each. Conversely, Ugeum received the least compensation, of Rs. 3,200.

6.1.1.6: Classification of Funds Allocation Based on The Funds Claimed by Villages in Bardez Taluka

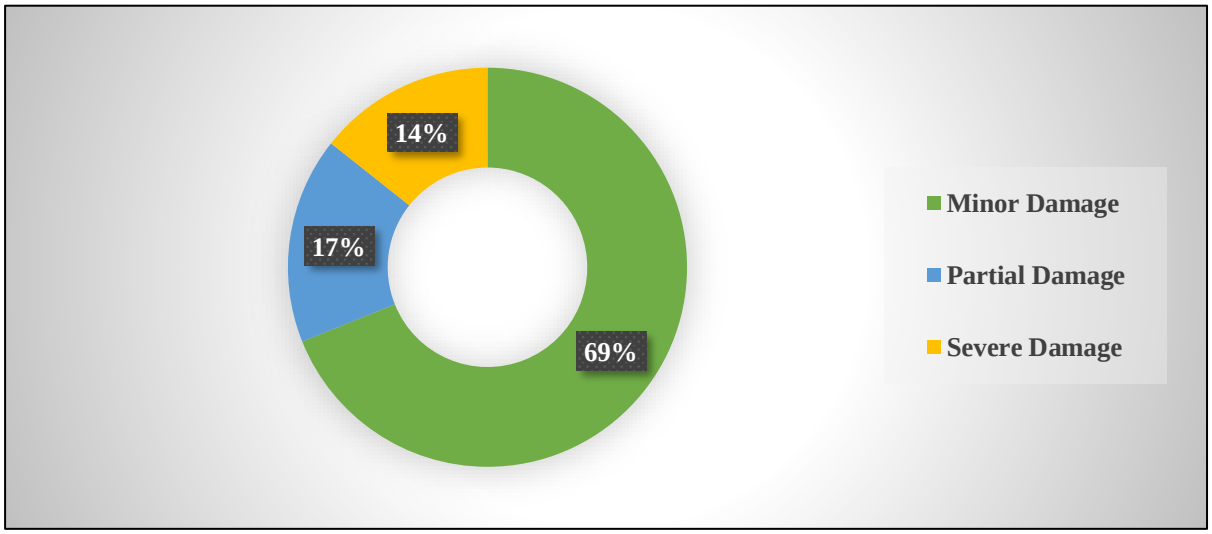


Source: The graph is generated using Secondary Data

In terms of compensation for villages in Bardez taluka, Aldona and Anjuna each received 65,000, while Arpora obtained 54,000. Assagao, Baga, Bastora, Cuchelim, Limawado, Nadora, Nagoa, Pirna, Pomburpa, and Savlem all received 9,000. Assanora secured 70,000, while Calangute received a significant 1,63,100. Calvim and Camurlim both received 23,000 and 23,200 respectively, while Candolim received 45,000. Chapora got 5,000, and Colvale obtained 37,000. Corjuaem, Moira, and Sirsaim each received 18,000. Guirim secured

1,13,200, while Mapusa received 27,000. Nachinola got 61,000, Nerul obtained 81,000, and Oxel secured 54,000. Pilerne received 91,000, Reis Magos secured 25,200, and Revora got 68,200. Saligao and Sangolda each received 36,000 and 38,000 respectively. Siolim received 99,000, Socorro obtained 63,000, and finally, Tivim got 1,49,900, with Verlosa receiving 27,000.

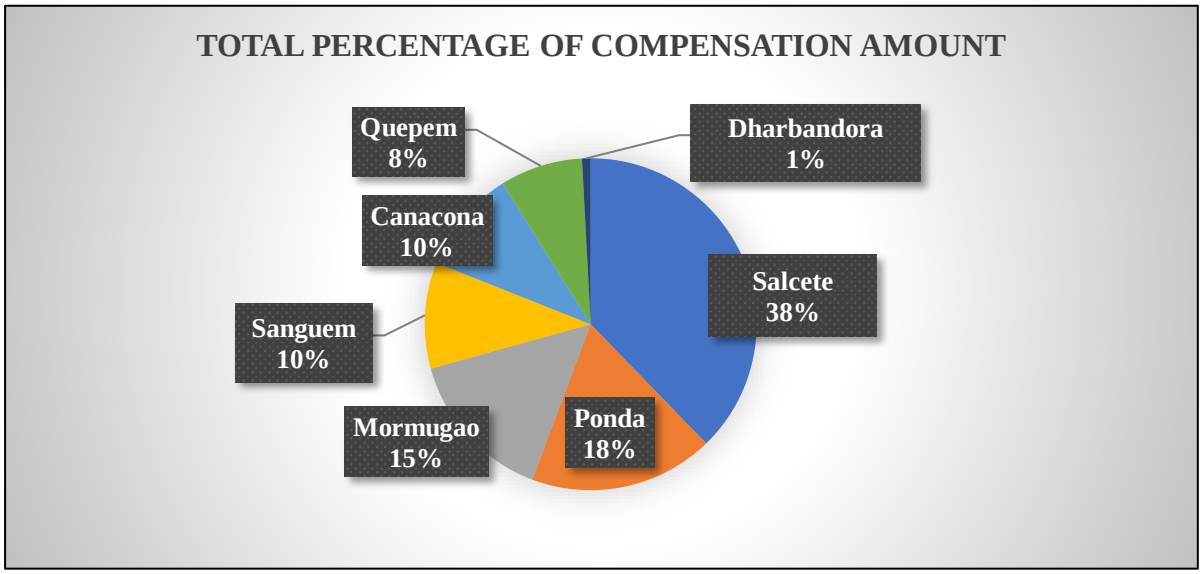
6.1.1.7: Classification of Funds Allocation Based on the Nature of Damage in North Goa



Source: The graph is generated using Secondary Data

The above stacked bar graph illustrates the distribution of damage severity, categorized as Minor, Partial, and Severe. Most claims—65%—reported minor property damage, 17% of the claims experienced their property as partially damage and only around 14% of them claimed for their severely damaged property. This distribution highlights a predominance of relatively minor damage, suggesting that the majority of incidents experienced only minor impacts, while severe damage occurrences are relatively rare but still significant in their impact.

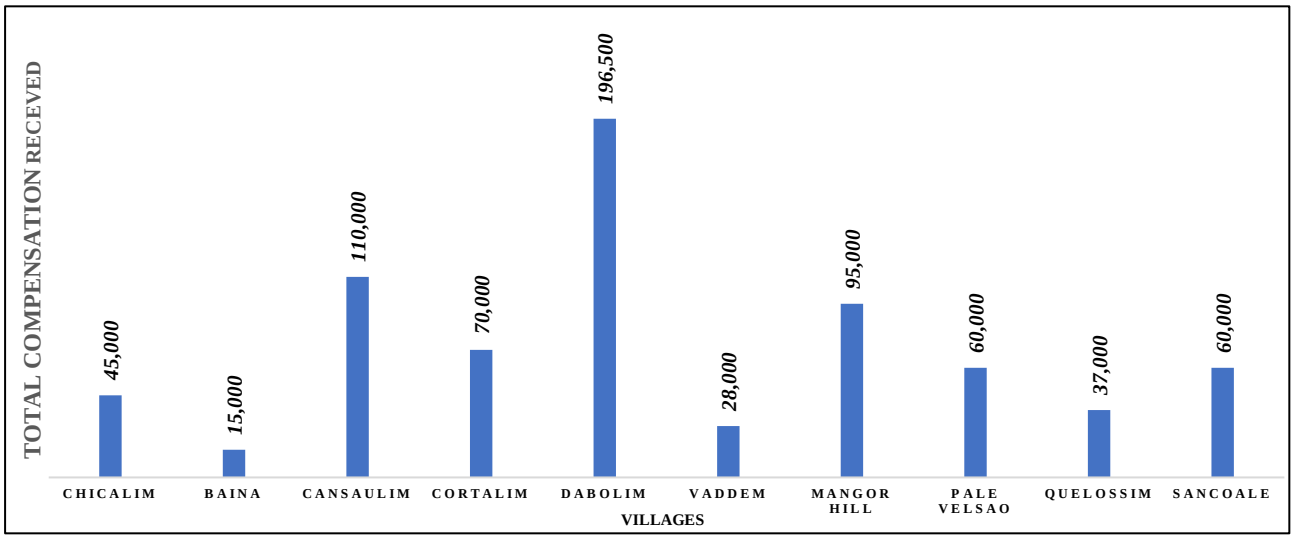
6.1.1.8: Classification Based on The Funds Claimed by Talukas in South Goa



Source: The graph is generated using Secondary Data

The above Pie Chart depicts total percentage of compensation received by various Talukas in the District of South Goa. From out of 7 Talukas, Salcete accounts the largest share of 38% followed by Ponda with 18%, Mormugao with 15%, Sanguem and Canacona holds 10%, Quepem with 8% and Dharbandora with the smallest share of 1% out of the total compensation amount of Rs. 47,87,890.

6.1.1.9: Classification Based on The Funds Claimed by Villages in Mormugao Taluka

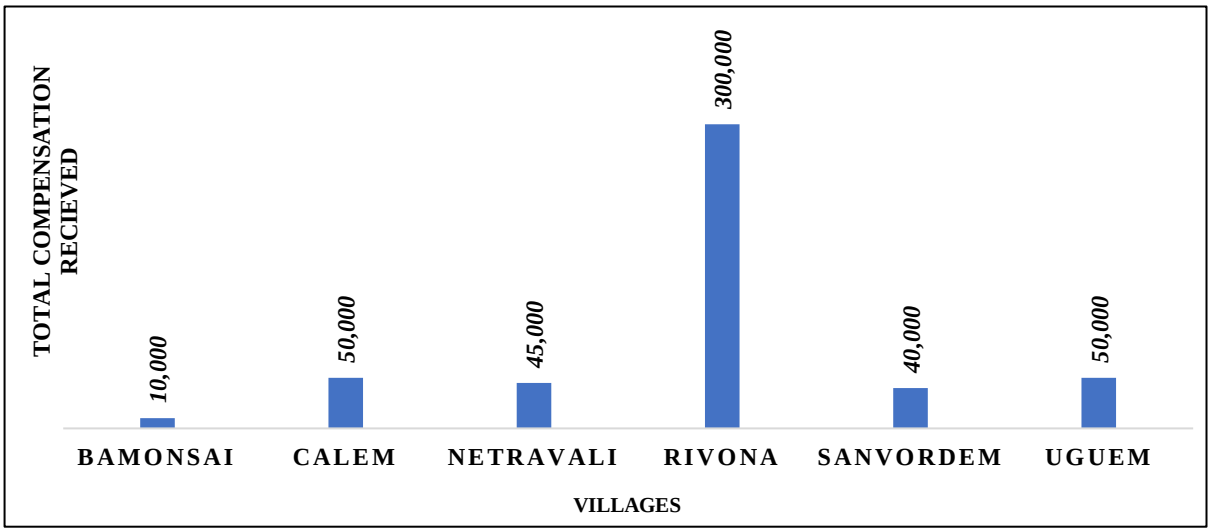


Source: The graph is generated using Secondary Data

The above Bar Graph depicts the total amount of compensation received by various villages in Mormugao Taluka. Out of 10 villages, Dabolim received the highest compensation of Rs. 1, 96, 500 followed by Cansaulim with Rs. 1,10,00. Mangor Hill received Rs. 95,000, Cortalim

with Rs. 70,000, Pale Velsao and Sancoale received a similar amount of Rs. 60,000 each. Chicalim received Rs. 45,000, Quelossim received Rs. 37,000, Vaddem with RS. 28,000 and Baina received the smallest amount of compensation of Rs. 15,000.

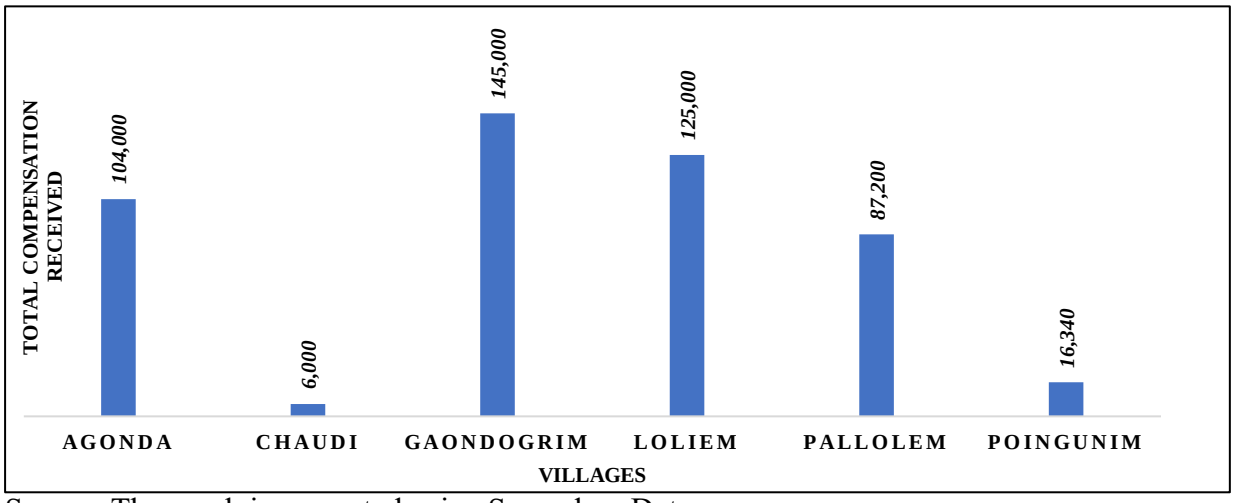
6.1.1.10: Classification Based on The Funds Claimed by Villages in Sanguem Taluka



Source: The graph is generated using Secondary Data

The above Bar Graph depicts the total amount of compensation received by various villages in Sanguem Taluka. Rivona received the highest compensation amount of Rs. 3,00,000. Followed by Uguem and Calem, both receiving Rs. 50,000 each. Netravali and Sanvordem received Rs. 45,000 and Rs. 40,000 respectively. Bamonsai received the lowest compensation among the above listed villages at Rs. 10,000

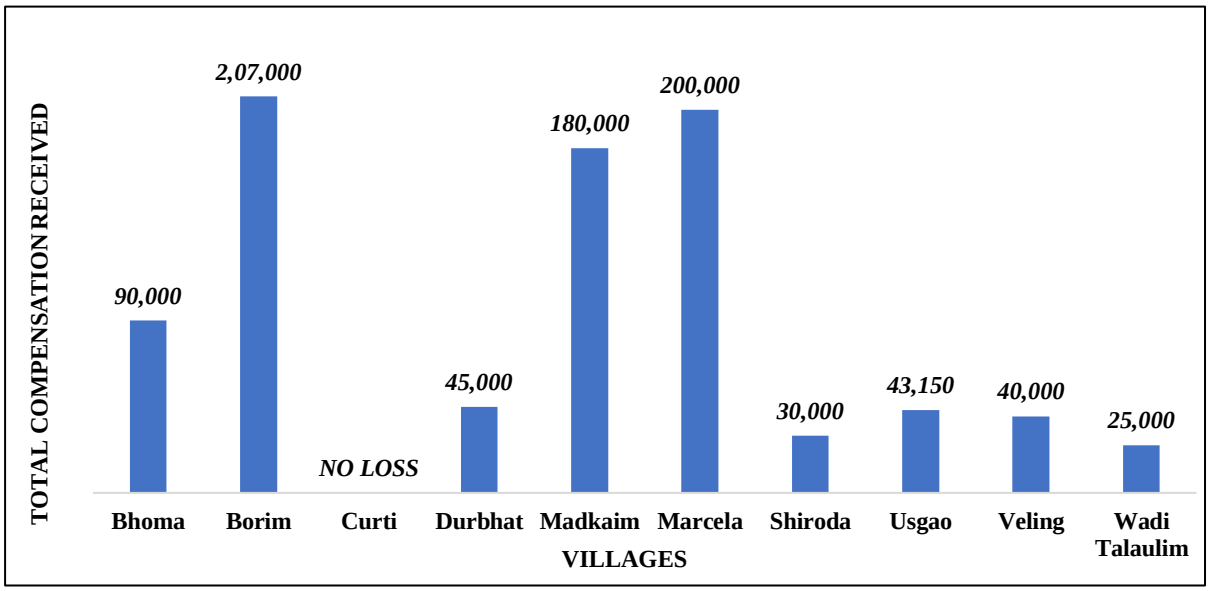
6.1.1.11: Classification Based on The Funds Claimed by Villages in Canacona Taluka



Source: The graph is generated using Secondary Data

The above Bar Graph depicts the total compensation received by various villages in Canacona Taluka. Gaondogrim received the highest compensation of Rs. 1,45,000, followed closely by Loliem with Rs. 1,25,000 units and Agonda with Rs. 1,04,000. Pallolem and Poingunim received lower compensations, with Rs. 87,200 and Rs. 16,340 respectively. And Chaudi received the least compensation among the villages, standing at 6,000 units. This graph indicates considerable discrepancies in compensation amounts across the villages.

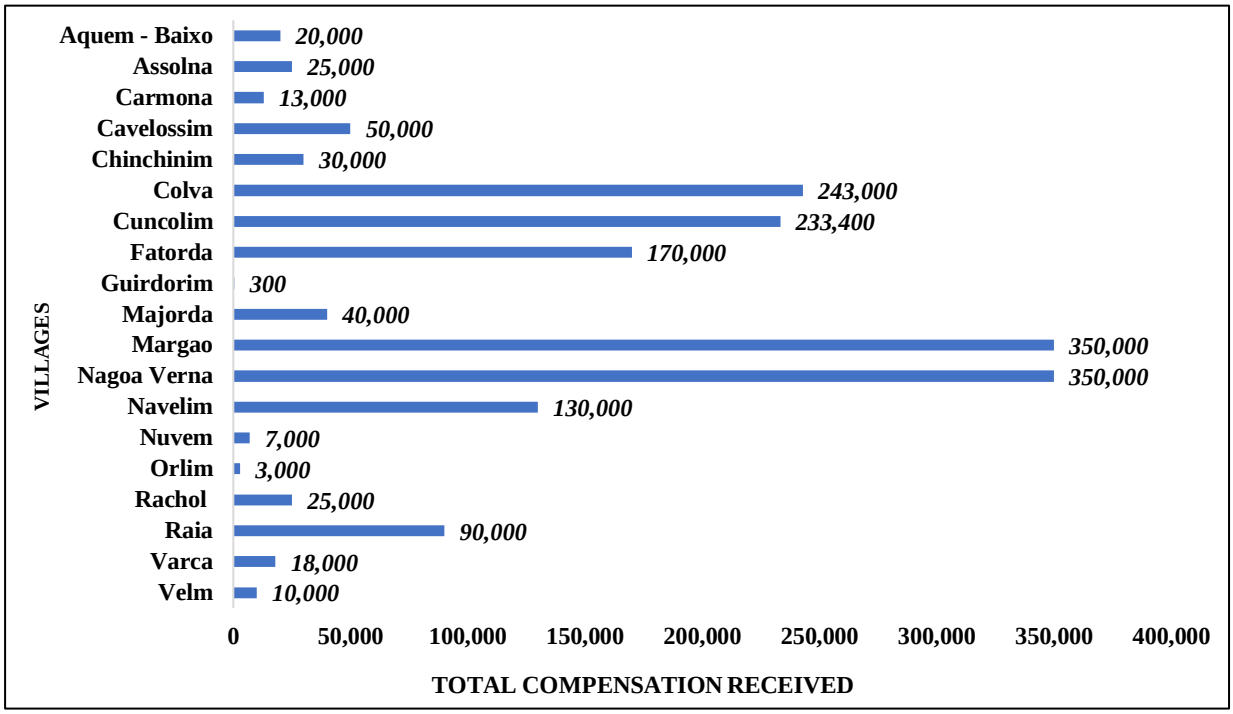
6.1.1.12: Classification Based on The Funds Claimed by Villages in Ponda Taluka



Source: The graph is generated using Secondary Data

The above Bar Graph depicts the total compensation received by various villages in Ponda Taluka. Out of 10 villages, Marcela and Borim received the highest compensations of Rs. 2,00,000 and Rs. 2,07,000 respectively. Madkaim received around Rs. 1,80,000. Notably, Curti faced no losses and thus received no compensation. Villages like Usgao, Durbhat, and Shiroda received compensations of Rs. 43,150, Rs. 45,000 and Rs. 30,00. While others like Veling and Wadi Talaulim received slightly lower amounts of Rs. 40,000 and Rs. 25,000 respectively.

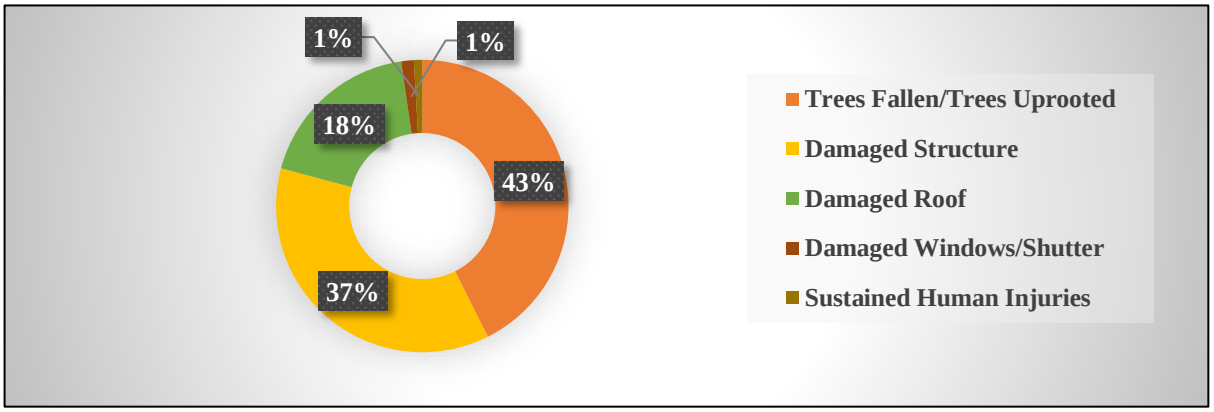
6.1.1.13: Classification Based on The Funds Claimed by Villages in Salcete Taluka



Source: The graph is generated using Secondary Data

The above Bar Graph depicts the total compensation received by various villages in Salcete Taluka. Margao and Nagao Verna stand out as the highest recipients, receiving Rs. 3,50,000 each. Followed by Colva and Cuncolim with Rs 2,43,000 and Rs. 2,33,400. Fatorda received Rs. 1,70,000, and Navelim with Rs. 1,30,000. Raia received 90,000, Cavelossim with 50,000 Majorda 40,000 Chinchinim 30,000 Assolna and Rachol received Rs. 25,000 each. Aquem-Baixo received 20,000 while Varca and Carmona received Rs. Rs. 18,000 and Rs. 13,000. Velm, Nuvem, and Orlim received an amount of Rs. 10,000 7,000, and 3,000 each. Conversely, Guirdorim received the lowest compensation of Rs. 300.

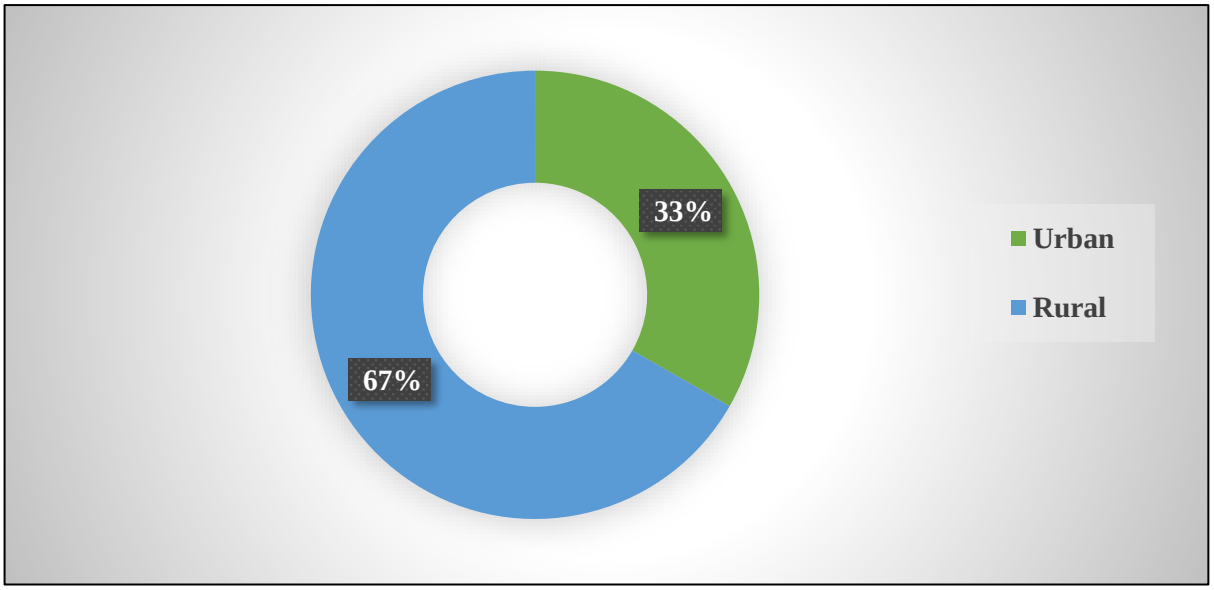
6.1.1.14: Classification of Funds Allocation Based on the Nature of Damage in South Goa



Source: The graph is generated using Secondary Data

A significant portion of the damage caused by Cyclone Tauktae in South Goa was related to trees being uprooted or fallen. The percentage of funds claimed for damaged structures is 37%. This indicates a substantial amount of damage to buildings and other structures in the area. The percentage of funds claimed for damaged roofs was 18%, indicating that roofs were highly affected during the cyclone. About 1% of funds were claimed for damaged windows or shutters, and for sustained human injuries. While any injuries are concerning, but this data suggests that the physical harm caused by the cyclone was relatively minimal compared to the damage to property and infrastructure.

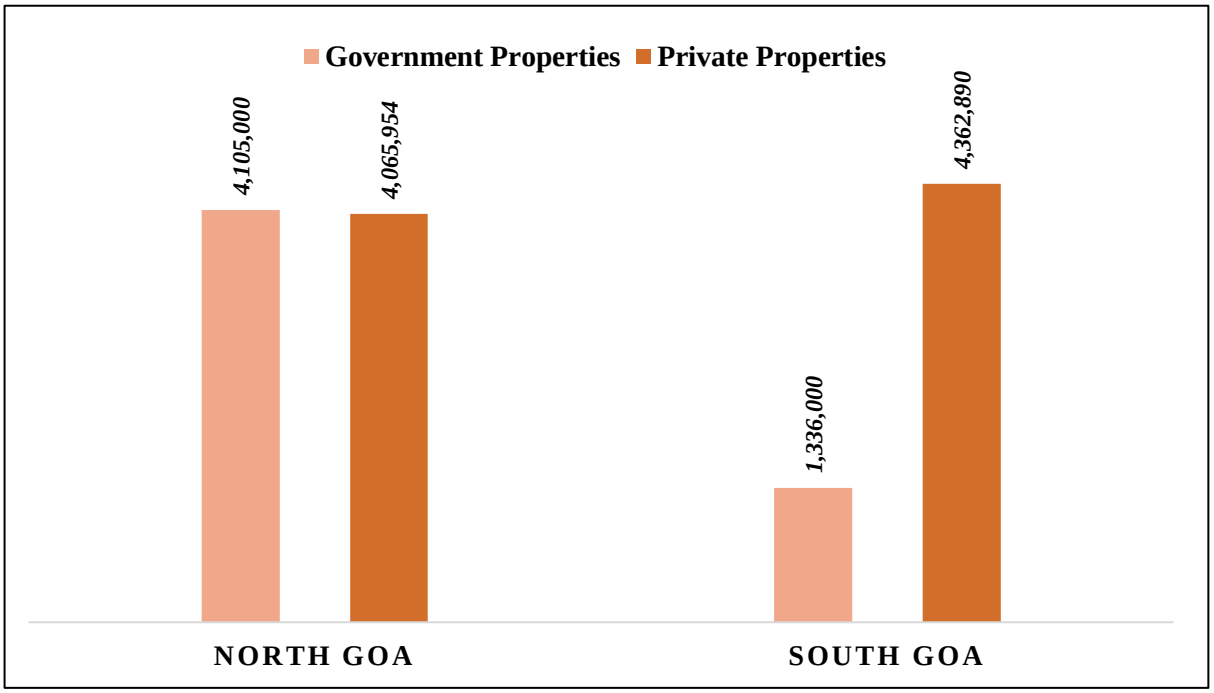
6.1.1.15: Classification of Funds Allocation Based on Regions (Urban- Rural)



Source: The chart is generated using Secondary Data:

The above Pie chart depicts that around 33% of funds claimed for the damaged properties were from Urban regions of Goa, while 67% of assistance claimed for the damaged properties were from the Rural regions of Goa, during Cyclone Taukate.

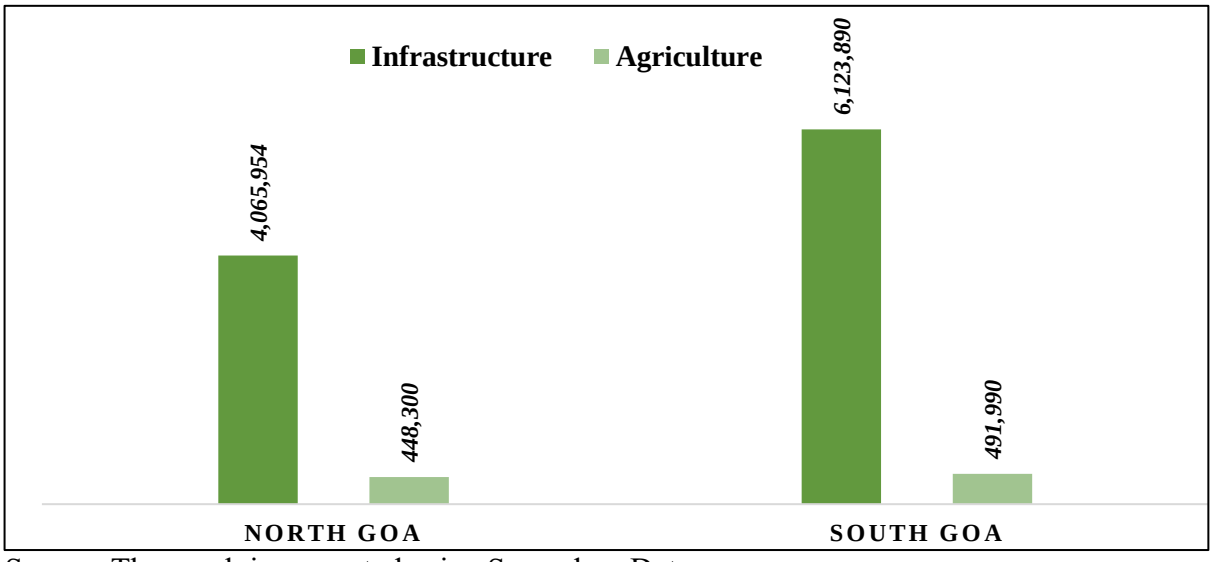
6.1.1.16: Classification of Funds Allocation Based on the Extent of Damage to Government and Private Properties in North and South Districts of Goa



Source: The graph is generated using Secondary Data

The stacked bar graph illustrates the total cost of damages to government and private properties in North and South Goa during Cyclone Tauktae 2021. The total assistance provided for losses incurred to private properties in North and South Goa was. Rs. 40,65,954 and 43,62,890. While that provided for government properties was, Rs. 41,05,000 and 13,36,000 respectively.

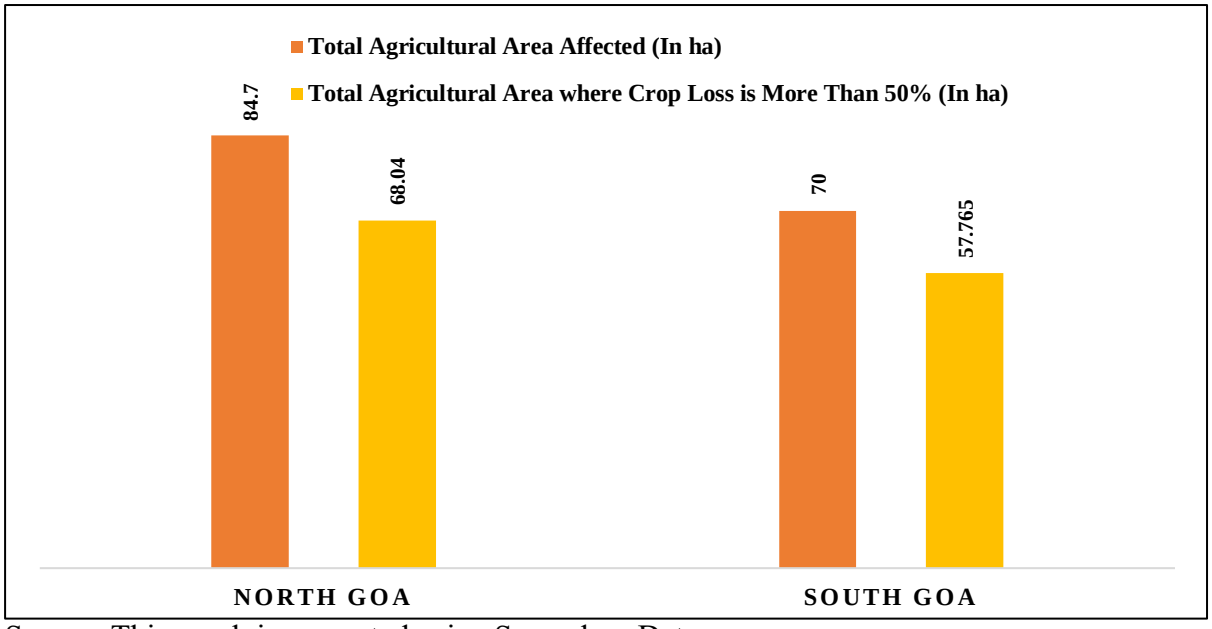
6.1.1.17: Classification Based on Total Assistance Sought for Agricultural and Infrastructural Losses in North and South Goa



Source: The graph is generated using Secondary Data

The stacked bar graph illustrates the total assistance provided for agricultural and infrastructural losses incurred during Cyclone Tauktae in both North Goa and South Goa. South Goa received significantly higher assistance for infrastructure losses compared to North Goa, with Rs. 61,23,890 as opposed to Rs. 40,65,954, indicating a greater impact on infrastructure in South Goa. However, in terms of agricultural losses, the disparity between the two regions is less pronounced, with South Goa receiving slightly higher assistance at Rs. 4,91,990 compared to Rs. 4,48,300 in North Goa. This suggests a relatively similar impact on agriculture in both regions.

6.1.1.18: Classification of Agriculture Damage Based on the Total Area affected and Total Crop Loss

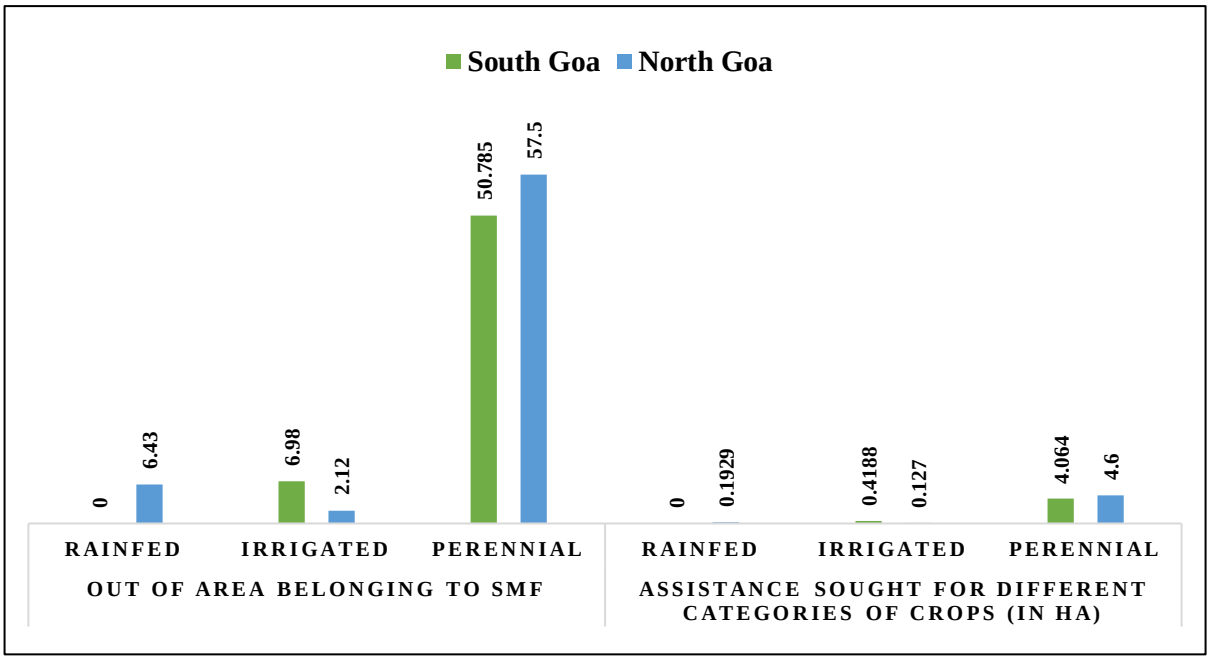


Source: This graph is generated using Secondary Data

The above stacked bar graph illustrates the extent of agricultural impact in South and North Goa districts, during Cyclone. Thereby, indicating the total agricultural area affected and the portion experiencing severe crop loss exceeding 50%. North Goa shows a larger total agricultural area affected compared to South Goa. However, when considering severe crop loss, South Goa has a higher proportion, with approximately 82% of its affected agricultural area experiencing losses exceeding 50%, whereas North Goa has around 80% of its affected area experiencing similar levels of loss. This suggests a significant agricultural challenge in both

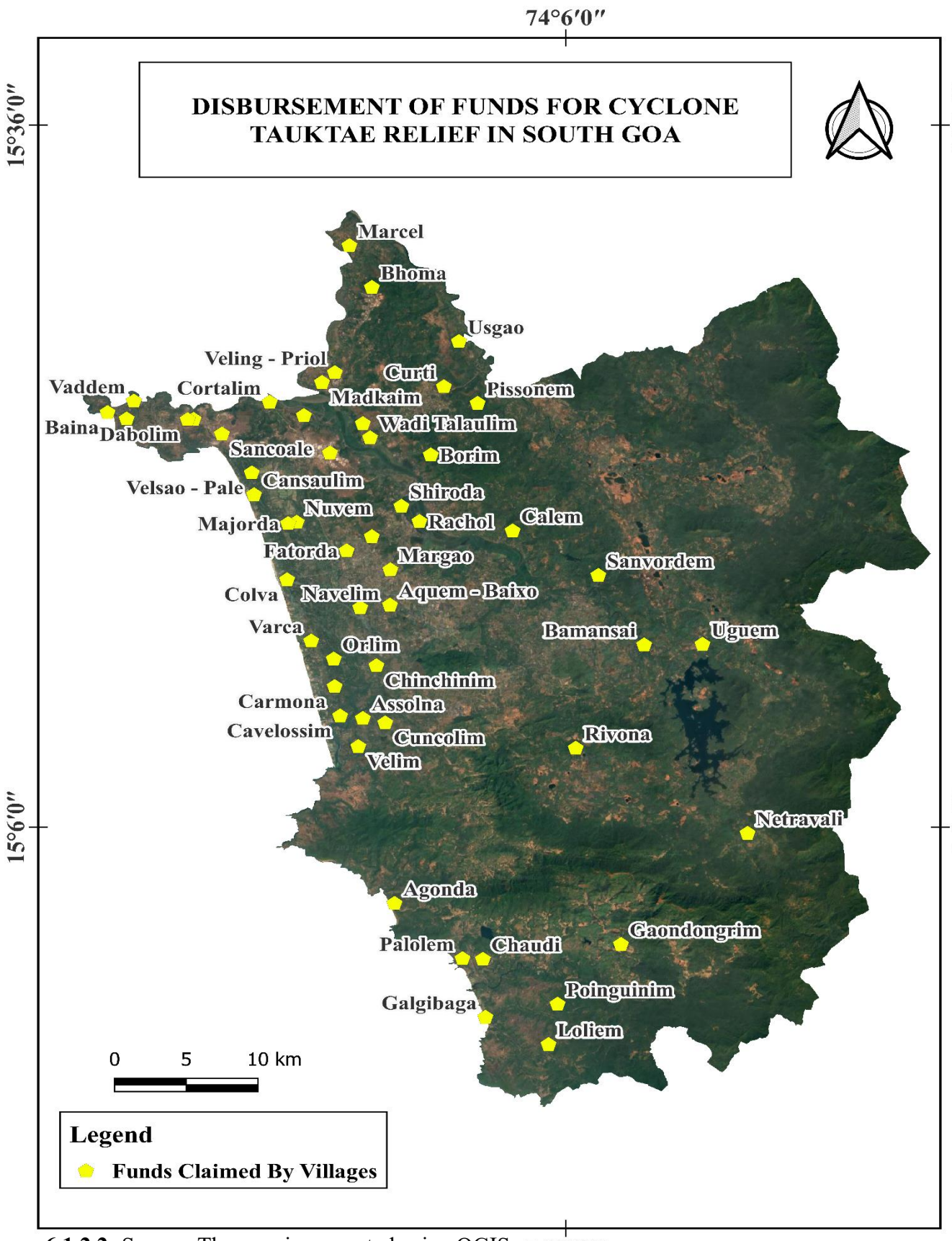
districts, with South Goa facing slightly more severe losses in proportion to its total affected area.

6.1.1.19: Classification of Assistance Sought Based on the Different Categories of Crop Loss



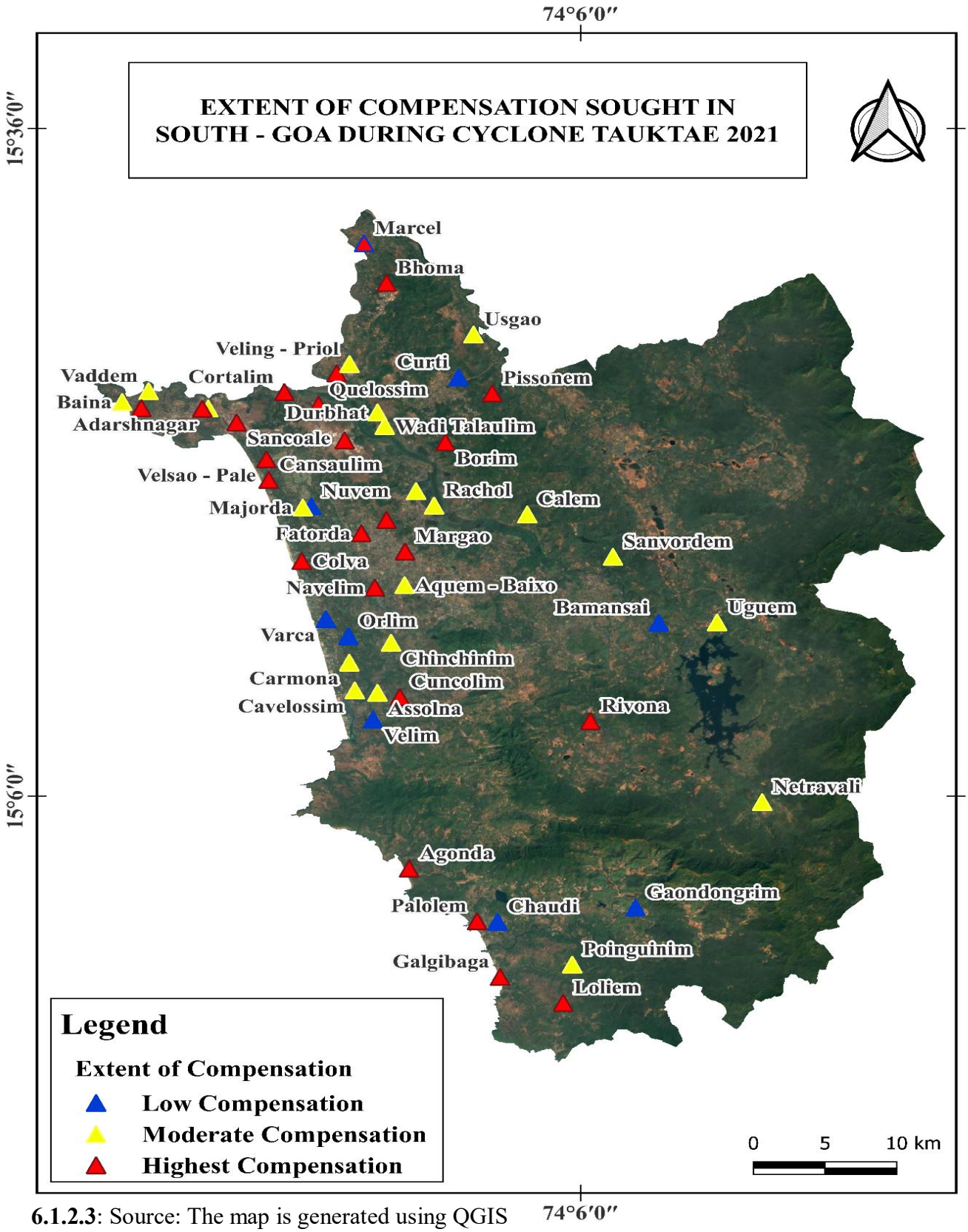
Source: The graph is generated using Secondary Data

The above stacked bar graph illustrates the assistance sought for different categories of crops in hectares across South and North Goa, categorized into rainfed, irrigated, and perennial crops. In South Goa, the majority of assistance is sought for perennial crops, followed by irrigated crops, with negligible assistance sought for rainfed crops. Conversely, North Goa seeks assistance predominantly for perennial crops, followed by rainfed crops, while assistance for irrigated crops is comparatively lower. Overall, South Goa appears to rely more heavily on assistance for perennial crops, whereas North Goa shows a more balanced distribution across crop categories, with a slightly higher emphasis on perennial and rainfed crops.



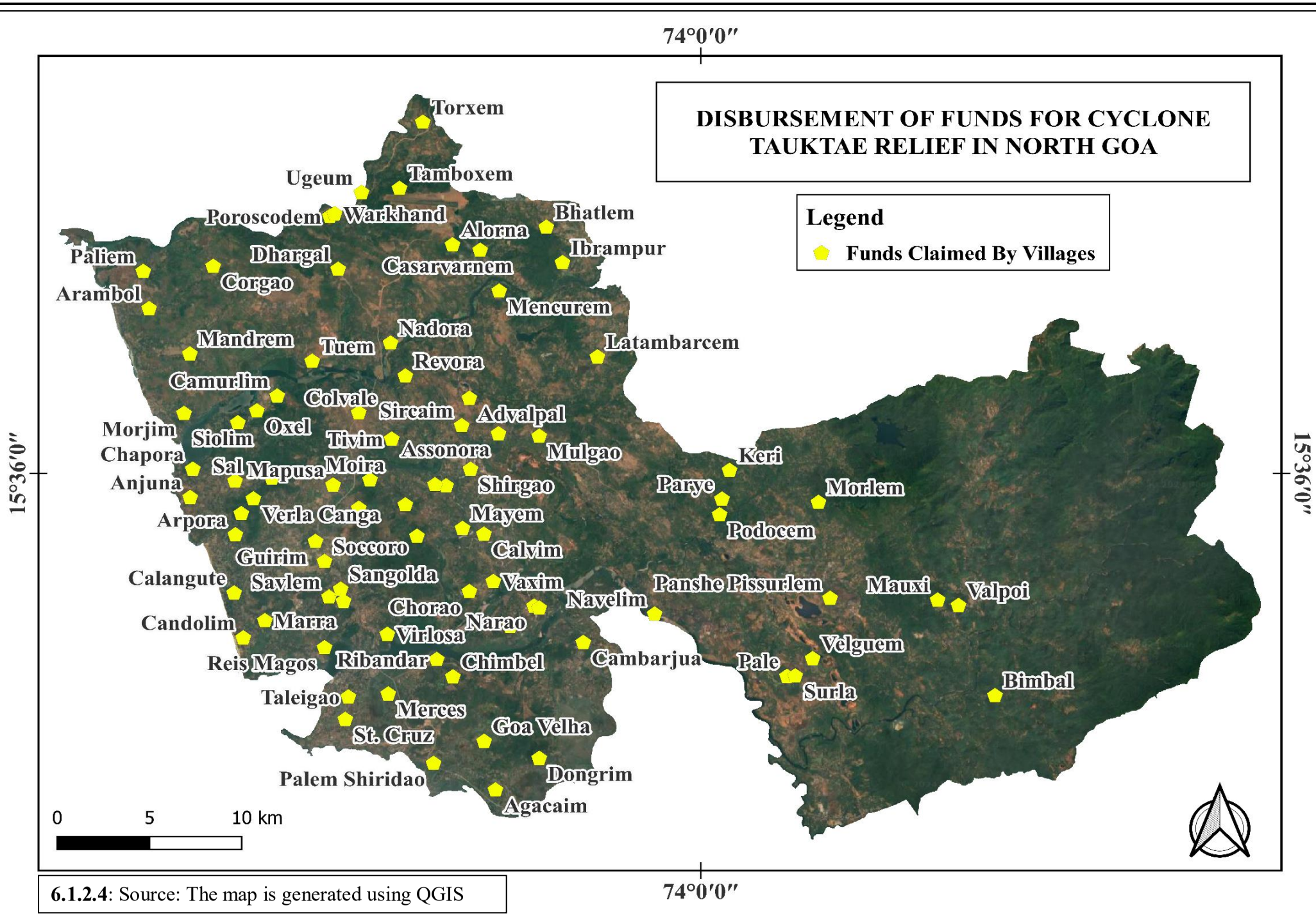
6.1.2.2: Source: The map is generated using QGIS

Interpretation: The above satellite image represents a map of Goa. It indicates the relief efforts in South Goa during Cyclone Tauktae in May 2021. It delineates the regions with labelled villages. The yellow markers highlight the villages that have received financial assistance.

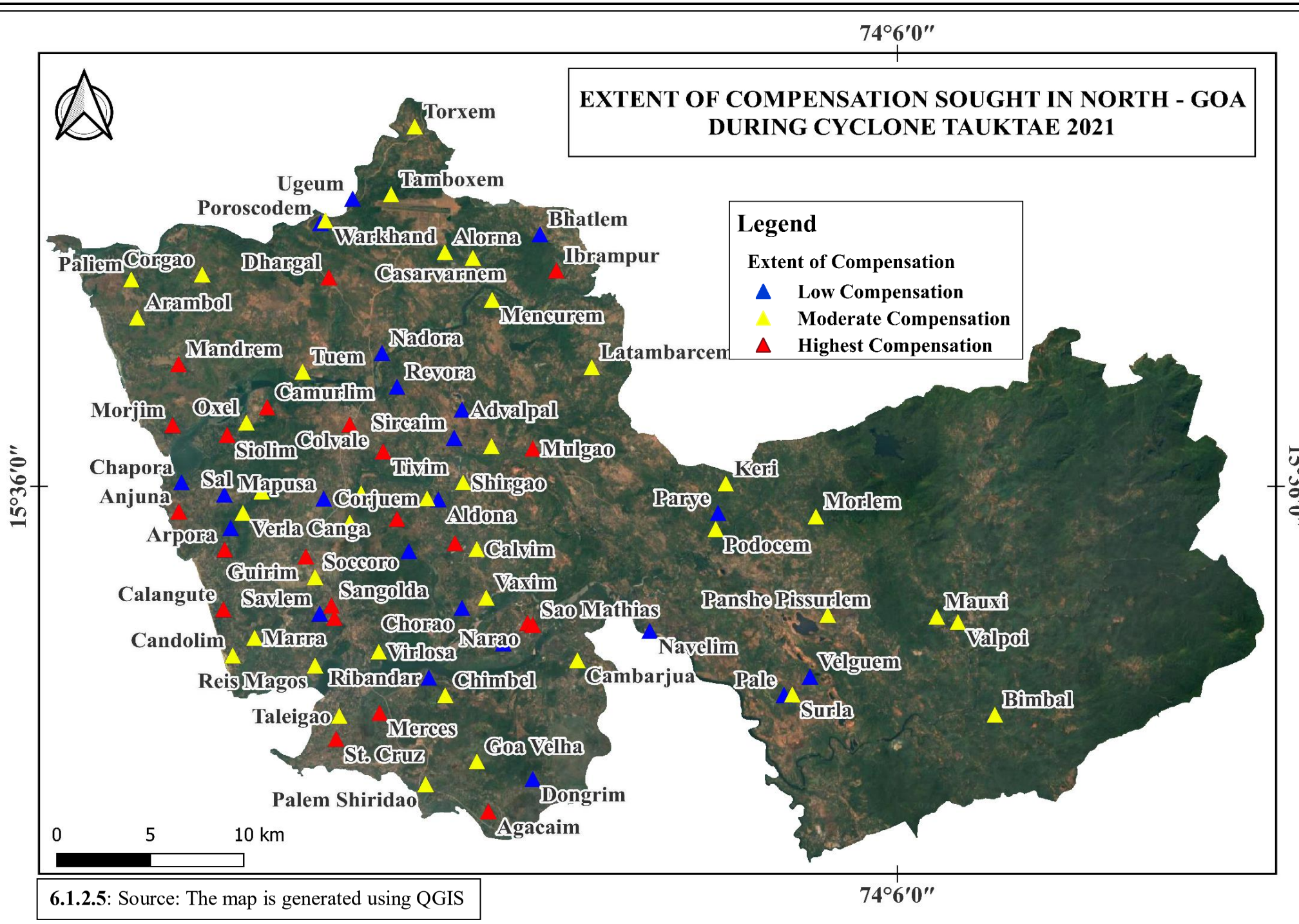


6.1.2.3: Source: The map is generated using QGIS

Interpretation: The above satellite image represents a map of Goa, specifically focusing on South Goa and the compensation sought during Cyclone Tauktae in May 2021. It delineates the region with labelled villages. Marked by yellow, blue, and red triangles. These triangles indicate areas seeking Low (0-10,000 Rs), Moderate (10,000-50,000), and High Compensation (above 50,000), respectively.



6.1.2.4: Source: The map is generated using QGIS



6.1.2.5: Source: The map is generated using QGIS

Fig 6.1.2.4 Interpretation: The above satellite map presents a map of Goa. It indicates the relief efforts in North Goa during Cyclone Tauktae in May 2021.
The Map delineates the regions with labelled villages. The yellow markers highlight the villages that have received financial assistance for the damages/losses incurred by the cyclone.

Fig 6.1.2.5 Interpretation: The above satellite mage presents a map of Goa, specifically focusing on North Goa and the compensation sought during Cyclone Tauktae in May 2021.
It delineates the region with labelled villages. Marked by yellow, blue, and red triangles.
These triangles indicate areas seeking Low (0 - 10,000 Rs), Moderate (10,000 - 50,000 Rs), and High Compensation (above 50,000), respectively.

To test the Normality of the Data:

Hypothesis:

H0: The data are normally distributed. Alternative Hypothesis

H1: The data are not normally distributed.

Shapiro-Wilk normality test

data: CyclTauk
W = 0.3442, p-value < 2.2e-16

Source: The output is generated using R

Interpretation:

The test statistic (W) is 0.3442, and the p-value is less than 2.2e-16. The p-value is less than the typical significance level of 0.05. Therefore, based on the Shapiro-Wilk test, there is strong evidence to suggest that the distribution of the data significantly deviates from a normal distribution.

Objective 1: Hypothesis:

H0: There is no difference between the distributions of damages incurred by government and private properties during Cyclone Tauktae.

H1: There is a difference between the distributions of damages incurred by government and private properties during Cyclone Tauktae.

Results:

```
        Wilcoxon rank sum test with continuity correction

              data:  Govt_damage and Private_damage
                     W = 119561, p-value = 1
  alternative hypothesis: true location shift is not equal to 0
```

Source: The output is generated using R

Interpretation:

The test statistic is 119561. This value represents the Wilcoxon rank sum, which summarizes the ranks of the observations in the two groups. It determines if there is a significant difference between the distributions of damages incurred by government and private properties.

The p-value obtained from the test is 1, which is greater than the typical level of significance of 0.05. Therefore, we do not have sufficient evidence to conclude that there are significant differenc es in the extent of damage between government and private properties.

Objective 2: Hypothesis:

H0: There is no significant difference in the extent of compensation allocated between public and private properties.

H1: There is a significant difference in the extent of compensation allocated between public and private properties.

Results:

```
        Wilcoxon rank sum test with continuity correction

        data:  Govt_Compensation and Private_Compensation
                    W = 0, p-value < 2.2e-16
  alternative hypothesis: true location shift is not equal to 0
```

Source: The output is generated using R

Interpretation:

The results of the Wilcoxon rank sum test (also known as the Mann-Whitney U test) with continuity correction comparing compensation allocated to Government and Private properties.

The test statistic W is 0. The p-value is less than 2.2×10^{16}, which is extremely small. Since the p-value is much smaller than the significance level (typically 0.05), we reject the null hypothesis. This indicates that there is a significant difference in the extent of compensation a llocated between Government and Private properties. Therefore, we have evidence to support the alternative hypothesis that there is a significant difference in compensation between Government and Private properties. Specifically, the median compensation for one group is significantly different from the median compensation for the other group.

Objective 3: Hypothesis:

H0: There are no significant differences in compensation amounts for similar types of damage across talukas in South Goa

H1: There are significant differences in compensation amounts for similar types of damage across talukas in Soth Goa

Results:

```
        Kruskal-Wallis rank sum test

data:  compensation by talukas
Kruskal-Wallis chi-squared = 4.1911, df = 4, p-value = 0.3808
```

Source: The output is generated using R

Interpretation:

The Kruskal-Wallis chi-squared value of 4.1911 indicates the extent of variability in compensation amounts across the talukas. The degrees of freedom are 4 and the p-value of 0.3808 is greater than the typical significance level of 0.05. Since the p-value (0.3808) is greater than the significance level, we fail to reject the null hypothesis.

Hence, there is no sufficient evidence to conclude that there are significant differences in compensation amounts for similar types of damage across talukas in South Goa.

Objective 4: Hypothesis:

H0: There is no association between the districts and the level of crop loss; the distribution of crop loss levels is the same across both the districts (North and South) of Goa during cyclone Tauktae.

H1: There is an association between the districts and the level of crop loss; the distribution of crop loss levels varies across both the districts (North and South) of Goa during cyclone Tauktae.

Result:

```
        Chi-squared test for given probabilities

                data:  contingency_table
X-squared = 32.081, df = 2, p-value = 1.081e-07
```

Source: The output is generated using R

Interpretation:

The result of the chi-squared test indicates a statistically significant association between the di stricts (North and South) of Goa and the level of crop loss during cyclone Tauktae. With a p-value of 1.081e-07, which is significantly lower than the typical significance level of 0.05, there is strong evidence to reject the null hypothesis (H0) that there is no association between the districts and the level of crop loss.

Therefore, we can conclude that there is indeed an association between the districts and the le vel of crop loss, suggesting that the distribution of crop loss levels differs significantly betwee n the North and South districts of Goa during cyclone Tauktae.

REGRESSION ANALYSIS

Summary Statistics:

Variable	Mean	Std. Dev	Minimum	Maximum
Roof_Damage	0.110294118	0.313544323	0.000000	1.000000
Structural_Damage	0.860294118	0.347000706	0.000000	1.000000
TreesUprooting_FallenTrees	0.180147059	0.38466361	0.000000	1.000000
Injuries_Sustained	0.003676471	0.060578048	0.000000	1.000000
Window_Shutter_Damage	0.007352941	0.085512088	0.000000	1.000000
Taluka	0.098713235	0.298304023	0.000000	1.000000
Ownership	1.0000000	0.500229938	0.000000	1.000000
District	0.5	0.500229938	0.000000	1.000000
Extent of Compensation	0.333333333	0.471549013	0.000000	1.000000
Distance_from_the_Sea	6.824	3.131424	0.000000	1.000000
D_Urban	0.332720588	0.471621109	0.000000	1.000000
D_Rural	0.66911765	0.47096386	0.000000	1.000000

Table 6.1: Source: The table is generated using Excel

Interpretation:

The mean of 'ROOF_DAMAGE' is approximately 0.1102. The standard deviation of 0.3135. The minimum and maximum values are 0.000 and 1.000, respectively, indicating the range of possible values for this variable.

The mean of 'STRUCTURAL_DAMAGE' is approximately 0.8602. The standard deviation of 0.3470. The minimum and maximum values are 0.000 and 1.000, respectively, indicating the range of possible values for this variable.

The mean of 'TREESUPROOTING_FALLENTREES' is approximately 0.1801. The standard deviation of 0.3846. The minimum and maximum values are 0.000 and 1.000, respectively, indicating the range of possible values for this variable.

The mean of 'INJURIES_SUSTAINED' is approximately 0.0036. The standard deviation of 0.0605. The minimum and maximum values are 0.000 and 1.000, respectively, indicating the range of possible values for this variable.

The mean of 'WINDOW_SHUTTER_DAMAGE' is approximately 0.321. The standard deviation of 0.467. The minimum and maximum values are 0.000 and 1.000, respectively, indicating the range of possible values for this variable.

The mean of 'TALUKA', value is around 0.099. However, the standard deviation of 0.298 highlights considerable variability in the distribution of taluka values. The minimum and maximum values are 0.000 and 1.000, respectively, representing the range of taluka categories.

With a mean value of 1.000, the 'OWNERSHIP' variable indicates a dominant presence of a particular ownership type within the dataset. The standard deviation of is 0.50. The minimum and maximum values of 0.000 and 1.000 indicate the binary nature of this variable, representing different ownership statuses.

The 'DISTRICT' variable has a mean value of 0.500. The standard deviation of 0.500. The minimum and maximum values of 0.000 and 1.000, respectively, represent the range of district categories within the dataset.

'EXTENT OF COMPENSATION', the mean value is 0.333. The standard deviation of 0.472 indicates some variability around this mean. The minimum and maximum values of 0.000 and 1.000 represent the range of compensation extents captured in the dataset.

For the variable 'DISTANCE FROM THE SEA', the mean value is 6.824. The standard deviation of 3.131 indicates variability in the distances recorded. The minimum and maximum values of 0.000 and 1.000 suggest that distances range from proximity to the sea to farther distances.

The mean values for D_URBAN and D_RURAL are approximately 0.333 and 0.669, respectively. The standard deviations of 0.472 and 0.471. The minimum and maximum values of 0.000 and 1.000 represent the binary classification of urban and rural households.

Objective 5:

Model 1:

$$Extent\_of\_Comp = \beta_0 + \beta_1 Seve\_rity + \beta_2 Distance\_from\_the\_Sea + \beta_3 Ownership + \beta_4 District + \beta_5 Urban\_Rural + \beta_6 \ Seve\_rity: Distance\_from\_the\_Sea + \mu$$

Hypothesis:

H0: There is no significant relationship between the independent variables (Seve_rity, Distance_from_the_Sea, Ownership, District, Urban_Rural, Seve_rity: Distance_from_the_ Sea) and the extent of compensation sought during Cyclone Taukate in Goa.

H1: there is a significant relationship between at least one of the independent variables (Seve_rity, Distance_from_the_Sea, Ownership, District, Urban_Rural, Seve_rity: Distance_ from_the_Sea) and the extent of compensation sought during Cyclone Taukate in Goa.

Results:

	Dependent variable:		
	Extent_of_Comp OLS	coefficient test	Extent_of_Comp OLS (coc)
	(1)	(2)	(3)
Seve_rity	-0.193*	-0.193	-0.170
	(0.116)	(0.143)	(0.124)
Distance_from_the_Sea	-0.086**	-0.086**	-0.059
	(0.037)	(0.043)	(0.040)
OwnershipPrivate	-0.912***	-0.912***	-0.911***
	(0.085)	(0.115)	(0.112)
DistrictSouth Goa	0.673***	0.673***	0.721***
	(0.094)	(0.118)	(0.111)
Urban_RuralUrban	0.116*	0.116*	0.087
	(0.062)	0.067)	(0.066)
Seve_rity:Distance_from_the_Sea	0.035**	-0.035*	0.022
	(0.016)	(0.020)	(0.018)
Constant	2.548***	2.548***	2.506***
	(0.244)	(0.279)	(0.271)
Observations	540		540
R2	0.419		
Adjusted R2	0.412		
Residual Std. Error	0.563 (df = 533)		
F Statistic	64.019*** (df = 6; 533)		
Note:			*p<0.1; **p<0.05; ***p<0.01

Source: The output is generated using R

Interpretation:

In the above model the Dependent Variable is ‘Extent of Compensation Sought’ and the Explanatory variables are Severity of Damage, Distance from the Sea, Nature of Ownership, District, Urban_Rural and the Interaction Term; Severity:Distance from the Sea.

The intercept represents the expected extent of compensation sought when all other predictor variables are zero. The coefficient for ‘Seve_rity’ is -0.170 with a standard error of 0.124. It indicates the change in the extent of compensation sought for a one-unit increase in Seve_rity, holding all other variables constant. However, this coefficient is not statistically significant a t the typical significance level of 0.05.

Distance_from_the_Sea has a coefficient of -0.059 with a standard error of 0.040. It is not statistically significant even at 10% level of significance. For every one-unit increase in ‘Distance_from_the_Sea’, the extent of compensation sought decreases by approximately 0.059 units, holding all other variables constant. Thus, it suggests that areas farther from the sea tend to seek less compensation, possibly due to reduced severity of cyclonic impacts or other factors. OwnershipPrivate has a coefficient of -0.911 with a standard error of 0.112 being statistically significant at 1% level. Hence, ‘Private’ ownership compared to (Government Properties) is associated with seeking less compensation. The coefficient indicates that privately owned properties tend to seek approximately 0.911 units less compensation compared to other ownership types, holding all other variables constant. This coefficient is highly statistically significant, suggesting that ownership type significantly influences the extent of compensation sought.

The variable ‘DistrictSouth Goa’ has a coefficient of 0.721 with a standard error of 0.111. It is statistically significant at the 1% level. Therefore, compared to other districts, properties in South Goa tend to seek approximately 0.721 units more compensation, holding all other variables constant. This coefficient is highly statistically significant at 1% level of significance, indicating that the district in which the property is located significantly affects th e extent of compensation sought. Variable ‘Urban_RuralUrban’ has a coefficient of 0.087 with a standard error of 0.066 not being statistically significant even at 10% level of significa nce. Here, ‘Urban’ areas compared to rural areas tend to seek approximately 0.087 units more compensation, holding all other variables constant.

The Interaction Term ‘(Seve_rity: Distance_from_the_Sea’ with the coefficient estimate of 0.022 and a standard error of 0.018 represents the change in the effect of Severity on compensation sought for a one-unit increase in Distance_from_the_Sea. While not being statistically significant even at the significance level of 1%. This positive coefficient for the interaction term "Severity:Distance_from _the_Sea" in the extent of compensation sought implies that the combined effect of severity and distance from the sea on compensation sought is greater than what would be expected from simply adding the individual effects of severity and distance from the sea.

Since at least one of the independent variables (Ownership, District) is statistically significant , we reject the null hypothesis. Therefore, we conclude that there is a significant relationship between at least one of the independent variables and the extent of compensation sought during Cyclone Taukate in Goa.

After accounting for Heteroskedasticity in the model, the Robust results convey that the coefficients and standard errors are similar to the OLS results, indicating robustness of the findings. While after accounting for Autocorrelation through Cochrane-Orcutt remedy, the coefficients slightly differed from the OLS and Robust models, suggesting potential autocorrelation correction effects. Here, the standard errors are slightly larger compared to the OLS and Robust models. But the significance levels remain consistent with the other two models. The R-squared value indicates that the models explain approximately 41.9% of the variance in the dependent variable. The F-statistic for the OLS model is significant, suggesting that the overall model is statistically significant.

Given significance levels and patterns across all models, the results of Cochrane-Orcutt model is supported after accounting the presence of Autocorrelation.

Model 2:

$$Extent\_of\_Comp = \beta_0 + \beta_1 Roof\_Damage + \beta_2 Structural\_Damage + \beta 3 Window\_Shutter\_Damage + \beta_4 TreesUprooting\_FallenTrees + \beta_5 Injuries\_Sustained + \beta_6 Severity + \beta_7 Distance\_from\_the\_Sea + \beta_8 Ownership + \beta_9 District + \beta_{10} Urban\_Rural + \beta_{11} Seve\_rity: Distance\_from\_the\_Sea + \mu$$

Hypothesis:

H0: There is no significant relationship between the independent variables (Roof_Damage, Structural_Damage, Window_Shutter_Damage, TreesUprooting_FallenTrees, Injuries_ Sustained, Severity, Distance_from_the_Sea, Ownership, District, Urban_Rural, Severity: Distance_from_the_Sea) and the extent of compensation sought post Cyclone Taukate in Goa.

H1: There is a significant relationship between at least one of the independent variables (Roof _Damage, Structural_Damage, Window_Shutter_Damage, TreesUprooting_FallenTrees, Injuries_Sustained, Severity, Distance_from_the_Sea, Ownership, District, Urban_Rural, Severity: Distance_from_the_Sea) and the extent of compensation sought post Cyclone Taukate in Goa.

Results:

	Dependent variable:		
	Extent_of_Comp OLS (1)	coefficient test (2)	Extent_of_Comp OLS (COC) (3)
Roof_Damage	0.227		0.188
	(0.161)		(0.159)
Structural_Damage	0.249**		0.161**
	(0.097)		(0.105)
Window_Shutter_Damage	0.391		0.251
	(0.361)		(0.335)
TreesUprooting_FallenTrees	0.085		0.130
	(0.104)		(0.126)
Injuries_Sustained	1.358***		1.118***
	(0.436)		(0.400)
Seve_rity	-0.076	-0.193	-0.070
	(0.158)	(0.227)	(0.159)

Distance_from_the_Sea	-0.101***	-0.086*	-0.067
	(0.039)	(0.047)	(0.042)
OwnershipPrivate	-0.980***	-0.912***	-0.955***
	(0.104)	(0.149)	(0.128)
DistrictSouth Goa	0.504***	0.673***	0.537***
	(0.161)	(0.213)	(0.173)
Urban_RuralUrban	0.107*	0.116*	0.073
	(0.062)	(0.068)	(0.066)
Seve_rity:Distance_from_the_Sea	0.043**	0.035*	0.027*
	(0.017)	(0.021)	(0.019)
Constant	2.125***	2.548***	2.171***
	(0.363)	(0.544)	(0.367)
Observations	540		540
R2	0.435		
Adjusted R2	0.423		
Residual Std. Error	0.558 (df = 528)		
F Statistic	36.884*** (df = 11; 528)		
Note:			*p<0.1; **p<0.05; ***p<0.01

Source: The output is generated using R

Interpretation:

In the above model the Dependent Variable is 'Extent of Compensation Sought' and the Explanatory variables are Roof Damage, Structural Damage, Window Shutter Damage, Injuries Sustained and Uprooted and Fallen Trees, Severity of Damage, Distance from the Sea , Nature of Ownership, District, Urban_Rural and the Interaction Term; Severity:Distance from the Sea.

The variable 'Roof_Damage' has a coefficient of 0.188 with a standard error of 0.159, indicating not being significant even at 10% level of significance. It indicates the change in the extent of compensation sought for a one-unit increase in roof damage. While Structural_Damage has a coefficient of 0.161, with a standard error of 0.105, being statistically significant 5% level of significance. For a one-unit increase in structural damage, the extent of compensation sought increases by approximately 0.161 units, implying that structural damage has a significant positive effect on the extent of compensation sought.

The coefficient for the variable 'Window_Shutter_Damage' is 0.251, with a standard error of 0.335. It indicates the change in the extent of compensation sought for a one-unit increase in window shutter damage. However, not being significant even at 10% level of significance.

The variable 'TreesUprooting_FallenTrees' has a coefficient of 0.130 and a standard error of 0.126. It represents the change in the extent of compensation sought for a one-unit increase in tree uprooting or fallen trees. However, this coefficient is not statistically significant even at 10% level of significance.

The coefficient of 1.118 with a standard error of 0.400 for 'Injuries_Sustained' indicates the change in the extent of compensation sought for a one-unit increase in injuries sustained. This coefficient is highly statistically significant at 1 % level of significance, suggesting that injuries sustained during the cyclone have a significant positive effect on the extent of compensation sought. The coefficient 0.070 and a standard error of 0.159 for Seve_rity suggests that for a one-unit increase in cyclone severity, the extent of compensation sought increases by approximately 0.070 units. Being non-significant.

The variable 'Distance_from_the_Sea' has a coefficient of -0.067 and a standard error of 0.159, indicates that as the distance from the sea increases by one unit, the extent of compensation sought decreases by approximately 0.067 units. This coefficient is not statistically significant even at the 10% level of significance, suggesting that distance from the sea significantly influences the extent of compensation sought.

The coefficient of -0.955 with a standard error of 0.128 for 'OwnershipPrivate' suggests that properties with private ownership tend to seek approximately 0.955 units less compensation compared to Government Ownership and also highly significant at 1% level of significance indicating that 'Ownership Type' does significantly affects the extent of compensation sought.

The coefficient of 0.537 with a standard error of 0.173 for ‘DistrictSouth Goa’ represents the change in the extent of compensation sought for properties located in South Goa compared to other districts. This coefficient is highly statistically significant at 1% level of significance indicating that district location significantly influences the extent of compensation sought. The coefficient of 0.073 and a standard error of 0.066 for ‘Urban_RuralUrban’ suggests that urban areas tend to seek approximately 0.073 units more compensation compared to rural areas. This coefficient is not statistically significant even at 10% level of significance.

For The Interaction Term ‘Seve_rity: Distance_from_the_Sea’, The coefficient of 0.027 with a standard error of 0.019. This coefficient is statistically significant at 10% level of significance, suggesting that the relationship between severity and compensation sought varies with distance from the sea. This positive and significant coefficient for the interaction term "Seve_rity: Distance_from_the_Sea" in the extent of compensation sought implies that the combined effect of severity and distance from the sea on compensation sought is greater than what would be expected from simply adding the individual effects of severity and distance from the sea.

Since at least one of the independent variables (Injuries_Sustained, Ownership, District, Urban_Rural, and the interaction term) has a p-value less than 0.05, we reject the null hypothesis. Therefore, we conclude that there is a significant relationship between at least one of the independent variables and the extent of compensation sought post Cyclone Taukate in Goa.

Since at least one of the independent variables (Injuries_Sustained, Ownership, District) is statistically significant, we reject the null hypothesis. Therefore, we conclude that there is a si gnificant relationship between at least one of the independent variables and the extent of compensation sought post Cyclone Taukate in Goa.

After accounting for Heteroskedasticity in the model, the Robust results indicates robustness of the findings. While after accounting for Autocorrelation through Cochrane-Orcutt remedy, the coefficients slightly differed from the OLS and Robust models, suggesting potential autocorrelation correction effects. Here, the standard errors are slightly larger compared to the OLS and Robust models. But the significance levels remain consistent with the other two models. The R-squared value indicates that the models explain approximately 43% of the variance in the dependent variable. The F-statistic for the OLS model is significant, suggesting that the overall model is statistically significant.

Given significance levels and patterns across all models, the results of Cochrane-Orcutt model are supported after accounting the presence of Autocorrelation.

CHAPTER 7: FINDINGS

7.1: Major Findings:

In this section, the major findings of the survey based on Secondary data are highlighted. The major findings of the study are as follows.

The findings of the secondary data are as follows:

- For the Total Compensation Distribution in North Goa District, Bardez receives the largest share of 43%, Bicholim follows with 27%, Tiswadi receives 15% of the compensation, while Pernem and Sattari hold 11% and 1% respectively,
- For household compensation distribution in Bicholim Taluka, the study shows that the Shirgao village emerges as the top recipient with receiving highest total amount of compensation. Other villages like Mayem, Narao, and Latambarcem receive varying compensation amounts, with the lowest amounts set at Rs. 5,200 for villages like Advalpal, Devgni, Navelim, Pale, and Velguem.
- For household compensation distribution in Tiswadi Taluka, the study indicates that St. Cruz received the highest compensation, Mandur and Chimbel follow closely, receiving substantial compensation amounts. However, several villages received relatively lower compensation amounts, such as Bhatlem, Chorao, Ribandar, Taleigao, and Vanzuem, all set at Rs. 5,200 each.
- For household compensation distribution in Sattari Taluka, the study indicate that Podocem emerges as the top recipient with Rs. 24,000, followed by Morlem and Mauxi. Keri, Bimbal Cotorem, and Parye, received low compensation set at Rs. 5,200 and Rs. 3,200 respectively.
- For household compensation distribution in Pernem Taluka, the study shows that Mandrem and Morjim receive the highest compensation amounts, followed closely by Arambol, Paliem, and Dhargal. While other villages like Alorna and Poroscadem receive similar

compensation amounts of Rs. 5,200 each, Ugeum stands as the village with the least compensation amounting to Rs. 3,200.

- For household compensation sought in Bardez Taluka exhibited notable disparities. Aldona and Anjuna received 65,000, while Calangute received a substantial 1,63,100. Tivim secured the highest compensation at 1,49,900, with Chapora receiving only 5,000. Other villages received varying amounts, ranging from 9,000 to 99,000, indicating a wide spectrum of compensation across the region. These findings underscore the uneven distribution of compensation within Bardez Taluka.
- The study shows that around 65% of the claims reported from North Goa District experienced minor property damage (received compensation less than 10,000), 17% of the claims experienced partial/moderate damage to property (received compensation of Rs 10,000 – 50,000), while only 14% of claims were for severely damaged property (received compensation above Rs 50,000)
- In Total Compensation Distribution in South Goa District, Salcete accounts for the largest share of compensation at 38%. Ponda follows with 18% of the compensation, Mormugao and Sanguem Talukas both held 15% of the compensation, indicating similar levels of impact or need. Canacona and Quepem Talukas received 10% and 8% of the compensation respectively, Lastly, Dharbandora received the smallest share of 1% out of the total compensation amount.
- For household compensation distribution in Mormugao Taluka, the study denotes that Dabolim receives the highest compensation of Rs. 1,96,500, Cansaulim follows closely with Rs. 1,10,000. Mangor Hill, Cortalim, Pale Velsao, and Sancoale receive similar amounts of compensation ranging from Rs. 60,000 to Rs. 95,000. Households in villages like Chicalim, Quelossim, Vaddem, and Baina receive lower compensation amounts, suggesting comparatively lesser impact or need within these areas.

- For household compensation distribution in Sanguem Taluka, the study indicates that Rivona emerges as the top recipient with the highest compensation amount of Rs. 3,00,000, Uguem and Calem follow with Rs. 50,000, Netravali and Sanvordem receive Rs. 45,000 and Rs. 40,000 respectively. Lastly, Bamonsai receives the lowest compensation among the listed villages at Rs. 10,000, suggesting comparatively lesser impact or need within this area.
- For the Canacona Taluka household compensation distribution, the study shows that, Gaondogrim village received the highest compensation of Rs. 1,45,000, followed by Loliem with Rs. 1,25,000 and Agonda with Rs. 1,04,000. Villages - Pallolem and Poingunim received comparatively lower compensations of Rs. 87,200 and Rs. 16,340 respectively. And Chaudi village received the least compensation among the villages, standing at Rs. 6,000 units.
- For household compensation distribution in Ponda Taluka, Marcela and Borim villages received the highest compensations of Rs. 2,00,000 and Rs. 2,07,000 respectively out of 10 villages. Madkaim received around Rs. 1,80,000, while Curti faced no losses and thus received no compensation. Villages like Usgao, Durbhat, and Shiroda received compensations of Rs. 43,150, Rs. 45,000, and Rs. 30,00 respectively. Others like Veling and Wadi Talaulim received slightly lower amounts of Rs. 40,000 and Rs. 25,000 respectively.
- For household compensation distribution in Salcete Taluka, the study shows that Margao and Nagao Verna stand out as the highest recipients, receiving Rs. 3,50,000 each. Followed by Colva and Cuncolim with Rs. 2,43,000 and Rs. 2,33,400 respectively. Fatorda received Rs. 1,70,000, and Navelim with Rs. 1,30,000. And Guirdorim receiving the lowest compensation of Rs. 300.
- The study shows that a significant portion of the damage in South Goa was attributed to uprooted or fallen trees, Damage to structures accounted for 37% of the claimed funds,

with 18% of claimed funds allocated for roof damage. And only 1%, were claimed for damaged windows, shutters, and human injuries, indicating relatively limited physical harm compared to property and infrastructure damage.

- The study indicates that a significantly higher number of properties were damaged in Rural areas compared to Urban areas.
- The study shows that the total assistance provided for private property losses in South Goa was higher compared to North Goa. This reveals a stark contrast between the regions: North Goa incurred significantly higher damages to government properties, whereas South Goa experienced greater losses in private properties.
- In contrast, the study indicates that North Goa incurred significantly higher damages to government properties compared to South Goa.
- The study shows South Goa received significantly higher assistance for infrastructure losses compared to North Goa, totaling Rs. 61,23,890 and Rs. 40,65,954 respectively.
- The study indicates, South Goa received slightly higher assistance at Rs. 4,91,990 compared to Rs. 4,48,300 in North Goa.
- The study shows North Goa shows a larger total agricultural area affected compared to South Goa. However, South Goa has a higher proportion of severe crop loss, with approximately 82% of its affected agricultural area experiencing losses exceeding 50%. In contrast, around 80% of North Goa's affected area experienced similar levels of severe crop loss.
- In South Goa, the study indicates that the majority of assistance is sought for perennial crops, followed by irrigated crops, with negligible assistance for rainfed crops. Conversely, North Goa seeks assistance predominantly for perennial crops, followed by rainfed crops, while assistance for irrigated crops is comparatively lower.

7.2: The finding of the Wilcoxon Rank Sum Test is:

- The Wilcoxon rank sum test was conducted to assess whether there is a significant difference between the distributions of damages incurred by government and private properties during Cyclone Tauktae in Goa.

  Based on the Wilcoxon rank sum test results, we infer that government and private properties experienced significantly different levels of damage post cyclone Tauktae in Goa.
- The Wilcoxon rank sum test was conducted to assess whether there is a significant difference in the extent of compensation sought to the government and private properties post Cyclone Tauktae in Goa. The findings of the Wilcoxon rank sum test, infer that government and private properties experienced significantly different levels of compensation amounts post cyclone Tauktae in Goa. Thereby implying that, the impact of Cyclone Tauktae, as measured by the compensation amounts, varies significantly depending on property ownership.

7.3: The finding of the Kruskal Wallis Test is:

- With a p-value of 0.3808, which is greater than the typical significance level of 0.05, we fail to reject the null hypothesis. Therefore, based on this test, there is insufficient evidence to conclude that there are significant differences in compensation amounts across talukas in South Goa for similar types of damage.

7.4: The finding of the Chi-Square Test is:

- The finding derived from the Chi-Square test indicate that there is a significant difference in the distribution of crop loss levels between the North and South districts of Goa during cyclone Tauktae. This suggests that factors specific to each district, such as geographical

location, infrastructure, agricultural practices, or intensity of the cyclone impact, may have influenced the extent of crop damage differently in the two regions.

7.5: The findings of the Interaction Regression Models are as follows:

Model 1:

While the coefficient for severity is statistically not significant is insignificant even at 10% level of significance. Its coefficient suggests a marginal effect on the extent of compensation sought. The variable Distance_from_the_Sea has a significant negative effect on the compensation sought. Properties farther from the sea tend to seek less compensation, possibly due to reduced severity of cyclonic impacts. The variable is not significant even at 10% level of significance. Besides this, Private ownership is associated with seeking significantly less compensation compared to the properties owned by the Government. And is also highly significant at 1% level of significance. The coefficient for 'South Goa' is positive and highly significant at 1% level of significance. Hence, this indicates that Properties in South Goa tend to seek significantly more compensation compared to North Goa district.

For the variable 'Urban_Rural', the coefficient for Urban areas is positive, but not significant even at 1% level of significance. This indicates that, Urban areas tend to seek more compensation compared to rural areas. And the interaction between 'Seve_rity' and 'Distance_from_the_Sea' has a negative coefficient indicating that areas farther from the sea show a weaker relationship between cyclone severity and compensation sought. Since at least one independent variable is statistically significant, the null hypothesis is rejected. Hence, there is a significant relationship between at least one independent variable and the extent of compensation sought during Cyclone Taukate in Goa.

The robustness of the findings is supported by similar coefficients and standard errors across OLS, Robust, and Cochrane-Orcutt models. However, the Cochrane-Orcutt model provides

better estimates by correcting autocorrelation in the data. The model explains approximately 41.9% of the variance in the dependent variable (Extent of Compensation Sought). The overall model is statistically significant, as indicated by the F-statistic.

Overall, the findings of the model 1 highlight the need for considering multiple factors in designing effective compensation mechanism post-disaster, with particular emphasis on severity of damage and geographical location.

Model 2:

The variable 'Roof_Damage' is positive but not statistically significant even at the 10% level, indicating a negligible effect on compensation sought. While the variable 'Structural_Damage' is statistically significant at the 5% level, with a positive effect on compensation sought. The variables Window_Shutter_Damage and Trees_Uprooting_FallenTrees, both variables are not statistically significant at any conventional level. while 'Injuries Sustained' is highly statistically significant at the 1% level of significance, with a strong positive effect on compensation sought. The variables 'Seve_rity' and 'Distance_from_the_Sea', have negative effects on compensation sought and are statistically significant. The variables Ownership and District, are statistically significant at 99% level of significance and influence the extent of compensation sought.

The variable Urban_Rural is positive but not significant even at 10% level of significance. Lastly, the interaction between 'Seve_rity' and 'Distance_from_the_Sea' is statistically significant at 10%, indicating a varying relationship between severity and compensation sought depending on the distance from the sea. At least one independent variable has a p-value less than 0.05, leading to the rejection of the null hypothesis. Hence, here is a significant relationship between at least one independent variable and the extent of compensation sought during Cyclone Taukate in Goa.

The robustness of the findings is supported by similar coefficients and standard errors across OLS, Robust, and Cochrane-Orcutt models. However, the Cochrane-Orcutt model provides better estimates by correcting autocorrelation in the data. The model explains approximately 43.5% of the variance in the dependent variable (Extent of Compensation Sought). The overall model is statistically significant, as indicated by the F-statistic.

Overall, the findings of Model 2 underscore the importance of addressing the diverse range of damages experienced by affected communities and tailoring compensation strategies accordingly.

CHAPTER 8: CONCLUSION

8.1 Conclusion:

The literature review presented a nuanced understanding of disaster mitigation, management, and compensation strategies, illustrating a dynamic evolution in approaches over time. Traditionally, disaster mitigation funds were allocated based on expenditure considerations, with limited attention to regional vulnerabilities. However, recent shifts towards formula-based allocation systems, as advocated by the 15th Finance Commission, signify a recognition of the multifaceted nature of disaster risk. Moreover, critiques of direct donation-based reconstruction efforts underscore the importance of sustainable, community-driven approaches that prioritize long-term resilience. Governmental roles in compensating disaster victims have also evolved, emphasizing the need for flexible, adaptive mechanisms that address diverse needs. Additionally, studies on disaster vulnerability, integration of mitigation into development frameworks, and ethical dimensions of disaster management underscore the complexity and interconnectedness of disaster risk and resilience.

Building upon the insights gleaned from the literature review, this empirical study investigated the impact of Cyclone Tauktae on compensation distribution and mitigation efforts in North and South districts of Goa. The analysis revealed significant variations in compensation distribution across talukas, indicating differential impacts of the cyclone. Moreover, significant differences were observed in the levels of damage and compensation sought between government and private properties, highlighting the need for tailored assistance measures. The study also identified distinct patterns of crop loss between the North and South districts, emphasizing the importance of region-specific mitigation strategies. Regression analysis further elucidated the factors influencing compensation outcomes, including severity, proximity to the sea, property ownership, and urban/rural classification.

The synthesis of literature and study findings underscores the dynamic and multifaceted nature of disaster management. While the literature review highlighted theoretical advancements and evolving practices, the empirical study provided empirical evidence of the challenges and opportunities in disaster compensation and mitigation efforts.

8.2. Contributions and Recommendations:

This research contributes to the broader discourse on disaster management by providing empirical insights into compensation distribution and mitigation efforts post-Cyclone Tauktae in Goa. The findings offer valuable implications for policymakers, practitioners, and researchers, highlighting the importance of tailored assistance measures, stakeholder collaboration, and ethical considerations in disaster management. Recommendations include the adoption of formula-based allocation systems, community-driven reconstruction efforts, and region-specific mitigation strategies. Moreover, there is a need for further research to explore the long-term impacts of disasters on vulnerable communities and the effectiveness of mitigation measures.

6.3. Limitations and Future Direction: Despite its contributions, this research has several limitations. The study focused on a specific cyclone event in Goa, limiting its generalizability to other disasters and regions. Moreover, the analysis relied on secondary data, which may have inherent limitations and biases. Future research could address these limitations by conducting longitudinal studies, incorporating primary data collection methods, and exploring the effectiveness of specific mitigation interventions. In conclusion, this research highlights the dynamic and complex nature of disaster management, emphasizing the importance of adaptive, context-specific approaches. By synthesizing insights from the literature review and empirical study, this research contributes to a deeper understanding of disaster resilience and mitigation efforts. Moving forward, collaborative efforts are needed to build more resilient and sustainable communities in the face of escalating disaster risks.

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