

Measuring Micro-Economic Resilience Post Cyclone Disaster in Case of Bhubaneswar

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Abstract

Tropical cyclones continue to threaten urban areas across the world, and more so in prone coastal states such as Odisha, India. Bhubaneswar, being a fast-growing urban centre, is still under threat from the physical as well as economic impacts of such climatic events. This research examines the microeconomic resilience of families against cyclonic activity, with an emphasis on the ability of different income groups to absorb and cope with welfare and consumption shocks. The main aim was to evaluate the extent to which households are able to sustain economic stability in the event of disaster-induced shocks. Employing the World Bank's microeconomic resilience framework, a household survey was undertaken using cluster sampling over various income groups in Bhubaneswar. The approach compared welfare losses prior to and subsequent to the cyclone, immediate economic effects, and the capacity of households to smooth consumption over time. Results show that poor households suffer disproportionately greater welfare losses and have more trouble in economic recovery because of scarce savings, informal livelihoods, and limited access to financial instruments. Wealthier households, on the other hand, showed better coping capacity. The research concludes that while state-level disaster preparedness is on the rise, important gaps still exist at the household level. Improving financial resilience, encouraging inclusive risk-reduction, and integrating micro-level data into urban disaster planning are necessary for constructing long-term economic resilience.

Keywords: Microeconomic resilience, disaster risk reduction, tropical cyclones, household welfare and urban vulnerability, Bhubaneswar.

1. Introduction

Natural disasters are usually referred to as "natural" phenomena, but the term simplifies their real nature. Disasters actually occur as a result of the convergence of natural hazards—like earthquakes, cyclones, floods, landslides, droughts, heatwaves, and storms—on vulnerable human systems. A hazard turns into a disaster only when it produces a significant negative effect on human life, infrastructure, and socio-economic activities. As stressed by the World Bank (2010), natural disasters are basically social events since their impacts are defined in terms of the exposure and vulnerability of human systems (Ernawati, 2025). Thus, the consequences of natural hazards are influenced not only by environmental determinants but also by socio-economic conditions, infrastructure, institutional capacity, and levels of preparedness.

Tropical cyclones, also known as hurricanes over the North Atlantic and Northeast Pacific, and typhoons in the Northwest Pacific, are one of the most destructive

hydro-meteorological hazards. They form over warm tropical oceans and are characterized by persistent high-speed winds, storm surges, rainfall, and flooding (Poulos, 2010; Gallina et al., 2016). Their destructive potential is enhanced enormously when they make landfall, impacting coastal populations that tend to be densely populated and economically valuable (Saxena et al., 2013; Hoque et al., 2017b). The number and intensity of tropical cyclones globally are projected to increase with anthropogenic climate change, which enhances the risks posed to exposed areas (Mendelsohn et al., 2012; Yin et al., 2013; Krishnamohan et al., 2014; Deo & Ganer, 2014; Rözer et al., 2025).

Historically, tropical cyclones have produced tremendous human and economic loss. During the last two centuries, they have been responsible for around 1.9 million deaths globally and have resulted in large-scale devastation of property and ecosystems (Shultz et al., 2005; Hoque et al., 2017a). Their economic impact is staggering. Within the United States alone, cyclones

cause approximately USD \$5 billion in damage per year, primarily along the East and Gulf Coasts (Burroughs, 2007). Globally, Mendelsohn et al. (2012) estimate that losses due to annual cyclone impacts are around USD \$26 billion. These numbers highlight the substantial cost tropical cyclones impose upon both developed and developing countries alike, in both direct economic damages and long-term development losses (Ernawati, 2025; Hong et al., 2025).

The scenario is especially alarming in Asia, where there is high population density, fast urbanization, and mixed levels of socio-economic development. Most Asian nations are situated in cyclone-exposed areas and are exposed further by environmental degradation, expansion of coastal settlements, and lack of disaster preparedness. The confluence of all these factors has rendered Asia the most disaster-exposed region on the planet (Abdillah et al., 2025). For sustainable development under such circumstances, economic as well as physical systems need to be made resilient to weather shocks. This calls for emphasis on a system that can be resilient enough to absorb the impact of disasters, reduce welfare losses, and enable quick recovery.

On this point, the notion of resilience—specifically microeconomic resilience—has become increasingly popular in scholarly and policy literature. Resilience generally means the ability of systems, communities, and people to withstand and absorb shocks and stresses, and bounce back from them. Economically, microeconomic resilience refers particularly to the potential of households and local economies to sustain welfare levels and prevent substantial drops in well-being after a disaster of a specified size (World Bank, 2010). It includes the ability to level consumption, reach risk-sharing programs, and modify through coping capabilities. Microeconomic resilience determinants are pre-disaster household incomes, wealth inequalities, access to insurance and credit, availability of social protection, and support networks at the community level.

Determining and recognizing microeconomic resilience is vital to disaster risk management, particularly for areas where insurance coverage is insufficient and social protection systems are nascent. It offers a framework to analyze not only the overall economic loss, but differentiated effects on communities and households. This is particularly important in the developing world, where recovery post-disaster might

take years, and reinforce previous vulnerabilities. Analysis findings can shape the design of focused interventions, effective resource reallocation, and inclusive recovery strategies.

The Odisha state in India provides a strong case study for considering the microeconomic implications of resilience. Situated geographically on the Bay of Bengal, Odisha is extremely susceptible to tropical cyclones, floods, and other climate-related hazards. Odisha has seen a number of intense cyclonic occurrences over the last few decades, such as the devastating 1999 Super Cyclone that claimed more than 10,000 lives and caused extensive destruction of infrastructure. These disasters have had severe consequences on the economy of the state, impacting agriculture, livelihood, health, education, and public services (Krantzberg et al., 2025).

To respond to the 1999 tragedy, the state government formed the Odisha State Disaster Mitigation Authority (OSDMA) to enhance disaster readiness and response. Although OSDMA has helped enormously in enhancing the disaster risk reduction institutional framework—via early warning systems, cyclone shelters, and community participation, however fundamental gaps exist. The majority of cyclone damage assessments are done at the macroeconomic level, with emphasis on aggregate GDP loss, infrastructure loss, and fiscal expenditure. Micro-level impacts, especially on household well-being, are not well explored and quantified. This hinders policymakers' capacity to comprehend how disasters impact various social classes, how recovery paths vary across income classes, and what coping mechanisms households use to deal with shocks.

If disaster response planning does not have a clear notion of microeconomic resilience, it may be inefficient or unfair. For example, poor families, who tend to have no savings, access to credit, or social contacts, are going to suffer larger welfare losses and slower rates of recovery. If these losses are not factored into plans and investment decisions, the recovery can widen current inequalities. In addition, household resilience is vital for overall economic recovery because shocks to consumption, labour markets, and informal economies can push long-term development objectives off course.

Considering the high frequency of natural disasters Odisha faces and its developmental issues,

microeconomic resilience analysis provides key insights into Odisha's ability to bear and bounce back from climate-related shocks. Such studies can inform the design of region-specific disaster management policies, social protection systems, and infrastructure investments that build adaptive capacity and inclusive growth. It is also consistent with international frameworks like the Sendai Framework for Disaster Risk Reduction and the Sustainable Development Goals, which prioritize resilient infrastructure and inclusive development.

At the end, as the frequency and intensity of natural calamities are likely to increase with accelerating climate change, the demand for robust systems at every level—individual, community, and institutional—is greater than ever before. For Odisha-type states, the capacity to mitigate household-level welfare loss during disasters will be a determining driver for sustainable and inclusive development. Exploring and strengthening microeconomic resilience, therefore, emerges as a research priority with significant policy relevance.

2. Objectives

The purpose of this study is to evaluate the microeconomic resilience of Bhubaneswar's local economy during cyclone-induced shocks. Bhubaneswar is a city in an area prone to cyclones on India's coast, and the area is plagued repeatedly by cyclones that deeply impact households, infrastructure, and livelihoods. Resilience here is the ability of households to resist economic shocks, reduce welfare losses, and bounce back after a disaster with minimal outside help.

The main aim is to assess the degree of economic shock caused by cyclonic events and examine how households cope with and recover from such shocks. This entails a comparative examination of economic indicators—like income, consumption behaviour, and loss of assets—prior to and subsequent to the cyclone. The research aims to identify changes in household welfare and economic behaviour and thus measure the depth of vulnerability and the resilience of coping mechanisms across various income groups.

It is based on a systematic household survey carried out among 600 clusters selected via cluster sampling from 81 wards of Bhubaneswar. The cluster sampling helped achieve representative coverage throughout the city, accounting for necessary socioeconomic diversity for sound analysis. Through the survey, data was gathered

on pre- and post-disaster income, consumption expenditure, damage to assets, savings behaviour, and household preparedness. These variables make it possible to have a detailed grasp of the economic hardship incurred and how much households could recover or stay stable.

One of the main emphases of the study is on measuring microeconomic resilience through a framework guided by the World Bank's approach. This involves three main steps: identifying ex-ante welfare conditions, quantifying immediate post-cyclone economic effects, and assessing the level of resilience based on the capacity of households to recover or absorb the shock. This method offers a systematic measure for evaluating the actual economic effect of cyclones and the difference in resilience across income levels.

Patterns of consumption are used as a proxy for household well-being. A sharp decline in consumption signals a decline in well-being, whereas stability in expenditure implies the existence of good coping mechanisms, including savings, access to credit, or social support. The analysis also takes into account the level of preparedness among households, specifically the contribution of financial savings accumulated in expectation of the cyclone and how these savings affected recovery paths.

In addition, the study fills the gap in literature regarding household-level measures of resilience in urban Indian settings. Whereas macro-level disaster impacts are commonly examined, the localized, microeconomic effects are not as well understood. Through an emphasis on individual households, this research provides policy-relevant information regarding economic vulnerabilities and adaptive capacities in a rapidly urbanizing and hazard-exposed city.

Finally, this study aims to shed more light on urban resilience, informing disaster readiness, risk reduction measures, and post-disaster rehabilitation planning that takes into consideration the economic conditions of households in urban centres such as Bhubaneswar.

3. Literature Review

Knowledge of the economic impacts of natural disasters and the ability of communities to rebound has been an expanding research and policy topic. Economic resilience, particularly on the microeconomic level, is now widely used to analyze how households and regions deal with, absorb, and bounce back from the shocks triggered by disasters. As defined by the World

Bank (2010), resilience is the capacity of an economy or society to reduce welfare losses from a disaster of a certain size. It focuses not just on physical recovery but also on safeguarding human well-being and consumption stability.

In order to evaluate economic resilience in a holistic way, it is important to examine a variety of indicators—ranging from income and asset loss to protection, consumption smoothing, and capacity at the institutional level (World Bank, 2010). The current research draws from a varied literature that has provided methods and frameworks for examining these dimensions across developed and developing country contexts.

Empirical and Theoretical Contributions

A number of methodologies have been created to quantify disaster-caused economic effects. One of the most important contributions in this field is from research that applies the HAZUS methodology, which categorizes economic losses as either direct—like physical damage to infrastructure—or indirect, which encompass wider inter-sectoral impacts on the economy (Gallina et al., 2016). Structural Growth Models (SGMs) have been applied in this context to capture the indirect effects, enabling the examination of systemic interdependencies and long-term disruptions.

As an example, the economic crisis and Italian households' study employed a life-cycle framework to examine micro-level individual resilience based on socio-demographic and generational criteria and proposed a macro-level resilience measure based on elasticity to quantify regional strength (Gallina et al., 2016). Both the micro and macro views emphasize the way resilience differently occurs among different social groups and regions. Complementing these approaches, Medina et al. (2020) demonstrated the value of integrating index-based assessments with principal component analysis to capture socio-economic vulnerability patterns in post-disaster environments, offering more detailed insights into household-level disparities and resilience capacities.

For China, scientists employed a dynamic spatial Computable General Equilibrium (CGE) model

calibrated for 30 cities to estimate the impacts of a catastrophic earthquake on the Bohai Economic Rim. The model calculated pre-disaster investment in protection and post-disaster recovery expenditures, and provided analysis of the short- and long-run dynamics of disaster response (Yin et al., 2013). Notably, the CGE model permits quantification of trade flows, price responses, and commodity substitution between sectors, and it is thus a potent instrument for disaster modelling across regions.

One useful application at the household level of disaster economics is illustrated in a study carried out in Quang Nam, Vietnam, in which the Contingent Valuation (CV) approach was used to quantify welfare loss due to flooding. In this research, household willingness-to-contribute (WTC) labour to flood protection activities and calculated welfare loss using labour valuation terms converted from the opportunity cost (Shultz et al., 2005). This methodology has a distinct application in poor contexts where financial information is not abundant but valuation of labour presents a reliable alternative proxy for welfare.

Another research created a multi-dimensional index of resilience, combining macroeconomic conditions, social stability, quality of governance, and microeconomic productivity (Li & Li, 2013). The index showed that economic resilience is closely related to GDP per capita, but vulnerability tends to be less sensitive to income changes than resilience. This adds further emphasis on policy structures favouring not only economic growth but also institutional strength and social protection mechanisms.

In Odisha, India—a state often hit by cyclones—the progressive enhancement of disaster preparedness since the 1999 Super Cyclone has been extensively documented (Hoque et al., 2017a). More effective evacuation policies and timely warning systems decreased deaths from Cyclones Phailin, Hudhud, and Fani. Yet micro-level research examining household economic resilience is scarce, which reflects a substantial research gap. The reviewed studies are tabulated in Table 1 below under methodologies, focus areas, and primary contributions.

Table 1: Summary of Key Studies on Economic and Microeconomic Resilience; Sources: Gallina et al. (2016); Yin et al. (2013); Shultz et al. (2005); Li & Li (2013); World Bank (2010); Hoque et al. (2017a)

Study Location	Methodology	Focus Area	Key Contribution
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Italy	Life-cycle structural model	Generational & regional resilience	Socio-demographic influence on resilience
China (Bohai Rim)	Dynamic spatial CGE model	Earthquake simulation across 30 cities	Economic interdependencies and recovery modelling
Vietnam (Quang Nam)	Contingent Valuation (CV)	Flood-induced welfare loss	Labour-based measure of household resilience
Europe	Cross-regional GDP analysis	Cyclone impact on GDP and employment	Multi-region monitoring of disaster effects
Global	Microeconomic resilience framework	Welfare loss minimization & smoothing	Policy tool for assessing household vulnerability

The existing literature substantiates the demand for contextual, evidence-based resilience assessment. For India and, in particular, for Odisha, there is little empirical work that measures household economic resilience in response to natural disasters. Drawing upon rigorous existing methods and deploying these within Bhubaneswar, known as the "Cyclone City" due to the numerous cyclones hitting it every year, this work endeavours to both contribute academically and policy-wise in disaster readiness and recuperation.

The literature unequivocally demonstrates the need to measure community and household resilience to natural disasters. Although macroeconomic models provide useful information, they tend to mask the differential effects on poor households. For example, poor households can lose fewer physical assets but experience higher welfare losses, which are not always apparent in national data (World Bank, 2010). There is an evident gap in the empirical research on household-level economic resilience in urban India, and specifically in cyclone-exposed regions like Odisha. Although internationally applicable modelling frameworks such as CGE and CV have been found to be useful, scant few have been applied locally to Indian settings. The World Bank's microeconomic resilience framework focusing on pre-disaster vulnerability, consumption smoothing, and post-disaster recovery provides a robust model for application in this study.

4. Methods

Study Location: This study was conducted in Bhubaneswar, the capital city of Odisha, which is highly prone to cyclonic activity. Odisha, between 1891 and 2019, experienced 98 cyclonic events, making it the most affected state on India's east coast. Bhubaneswar, despite being a smart city, faced significant damage, including displacement of over 60% of its population during major cyclones.

Research Design: A quantitative research design was employed to assess microeconomic resilience. The study utilized a framework developed by the World Bank to evaluate household-level economic responses before, during, and after cyclonic events.

Study Population: The population comprised households in Bhubaneswar, especially those in cyclone-affected coastal regions. The study particularly focused on vulnerable groups, including low-income families, the elderly, children, and people with disabilities.

Data Source / Sampling Technique: Primary data were collected through a structured questionnaire administered to 600 households, selected using a cluster sampling technique. The city's population of 8.3 lakh was divided into smaller geographic clusters, from which a representative sample of households was drawn to reflect the city's diverse socioeconomic groups. This method ensured time- and cost-effective data collection across a large urban area. The survey gathered information on pre- and post-cyclone economic conditions, including income, expenditure, asset loss, and coping mechanisms, as well as respondents' access to basic needs, credit facilities, and insurance coverage. In addition, secondary data were obtained from government cyclone vulnerability reports and World Bank methodologies to complement and contextualize the primary survey findings.

Inclusion/Exclusion Criteria: Included were households residing in Bhubaneswar for over one year, especially those affected by cyclones in the past decade. Excluded were transient or non-resident households and those unwilling to participate.

Research Method: The World Bank's microeconomic resilience framework was used to evaluate household consumption, income losses, and welfare changes. The study focused on ex-ante welfare analysis to

understand impacts on underprivileged and privileged households. Economic resilience was assessed through three key components: direct welfare losses, ability to smooth consumption over time, and long-term recovery capability.

Data Analysis Methods: Collected data were analyzed using statistical tools to compute averages, generate tables, and visualize trends. Household welfare losses were measured and disaggregated by income group. The microeconomic resilience index was calculated by comparing welfare losses and changes in aggregate consumption. Distributional effects and heterogeneity across households were taken into account to provide a nuanced understanding of resilience.

5. Discussion and Results

Ex-Ante Welfare Impact

In order to analyze the microeconomic resilience of Bhubaneswar households, the research initiated with the computation of the ex-ante welfare effect—a relative indicator of household well-being before the cyclone. This module constitutes the resilience building block that estimates initial welfare levels using income categories and consumption patterns of households. The estimate is based on the World Bank's (2010) method for measuring welfare impacts and can be expressed with the following formula:

$$W^- = n_p^a u(\tilde{C}_p) + n_r^a u(\tilde{C}_r)$$

Where:

- W^- represents the ex-ante welfare;
- n_p^a and n_r^a are the proportions of underprivileged and privileged households, respectively;
- $u(\tilde{C}_p)$ and $u(\tilde{C}_r)$ denote the utility derived from the average consumption of underprivileged and privileged households before the shock.

Survey results indicated that 61.7% of the households were poor and 38.3% were non-poor. The consumption levels prior to the cyclone were estimated as 24.8% for poor households and 30% for non-poor households. These estimates were used in the equation to estimate the total pre-disaster welfare:

$$\begin{aligned} W^- &= (0.617 \cdot 0.248) + (0.383 \cdot 0.30) \\ &= 0.153 + 0.115 \\ &= 0.2679 \text{ or } 26.79\% \end{aligned}$$

This implies that, in the pre-cyclone situation, the collective level of well-being among the poor and the non-poor household was 26.79%, which became the baseline on which post-cyclone well-being can be contrasted (see figure 1). Evidence was also elicited that during this baseline duration, 28.27% of the sample indicated unhealthy or unsustainable consumption trends and high expenditures pre-disaster as a fraction of income. In particular, the share of excessive expenditure was greatest among richer households, whose spending was above 30% even prior to the cyclone's occurrence. This illustrates inequalities in spending power and reveals the susceptibility of poorer households, whose consumption levels were already at or near subsistence.

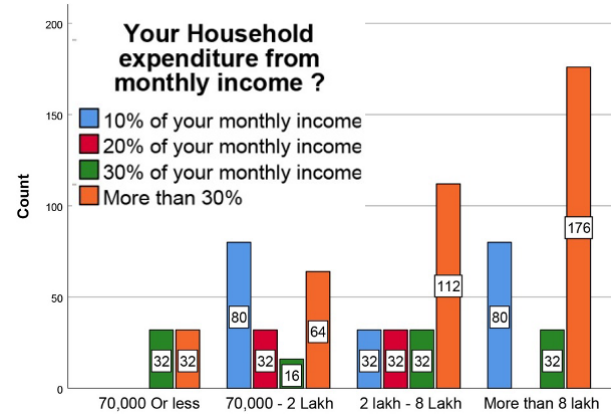


Figure 1: The household expenditure before cyclone impact on basis of income levels (Survey, 2025)

Such numbers imply that economic exposure was highly stratified by income, even prior to the cyclone event. Lower-consuming households had scarce ability to absorb external shocks, whereas better-off households had greater—but generally inefficient—rates of spending. Pre-disaster consumption inequality of considerable magnitude underlies the justification for applying differentiated weights in resilience analysis.

To further enhance the model, distributional weights ω_a and marginal differences in utility $\Delta u'$ were computed. These assist in measuring the relative significance of changes in consumption by income classes. According to survey-based data:

- The share of total consumption attributed to poor households was $C_p^a = 7.15\%$
- The total consumption was normalized at $C^a = 100\%$,
- Asset-loss-based distributional weights were calculated as $\omega_a = 0.71$,

- The difference in marginal utility income between underprivileged and privileged was estimated as $\Delta u' = -12.8\%$,
- The resulting adjusted utility for poor households was calculated at 55.82% of pre-disaster levels.

These values establish that poor households bear the disproportionate welfare burden, who had lower initial consumption and suffered higher relative utility loss (see figure 2). While their absolute consumption might not have altered as significantly, its effect on their overall well-being was much higher. This establishes the significance of considering distributional effects in determining the economic consequences of disasters.

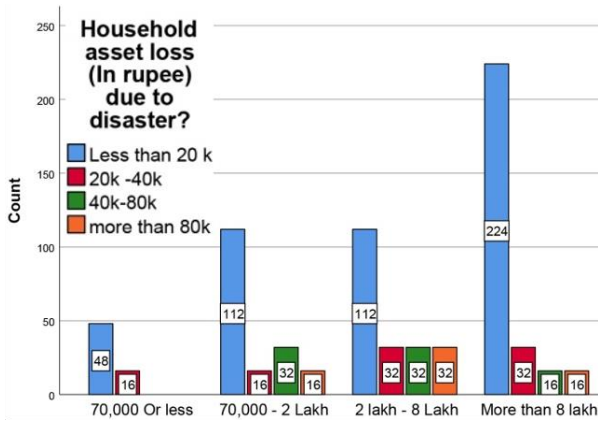


Figure 2: The household expenditure after cyclone impact on basis of income levels (Survey, 2025)

The outcomes of the ex-ante welfare analysis therefore contain a key insight: existing inequality and economic vulnerability weigh significantly in post-disaster results. Already on the margins of consumption, poorer households suffered substantial utility loss regardless of comparatively less absolute change. This conclusion conforms to the more general literature in calling for shifts away from GDP-centered disaster assessment (Gallina et al., 2016; Li & Li, 2013) and endorsing the activation of targeted resilience measures.

Instantaneous Impacts, Basic Needs, and Smoothing

Instantaneous impacts in disaster resilience studies pertain to the immediate effects of a natural disaster on living conditions and household wealth. These effects, usually harsh and heterogeneously distributed, are directly experienced by both the underprivileged and privileged households following the catastrophe. In this research, such effects were measured to estimate the reduction in well-being and economic security that was experienced soon after the cyclone hit the shores of Bhubaneswar.

While government relief and disaster assistance programs are involved in post-disaster survival, this model deals exclusively with economic behavior and does not account for transfers like humanitarian aid or public welfare payments. This framework is consistent with a number of international studies isolating market-level and household-level responses to disaster shocks (World Bank, 2010).

To quantify the instantaneous welfare loss, the following approximation was used:

$$\Delta W \approx \theta + n^a \Delta w_{max}$$

Where:

- ΔW is the estimated reduction in household welfare,
- θ is the fixed minimum welfare loss threshold,
- n^a is the number of affected households, and
- Δw_{max} represents the maximum loss in welfare due to asset and consumption shocks..

This equation expands the earlier formulation to capture the welfare effects more comprehensively by incorporating both demographic characteristics and statistical valuation of life. The expanded expression is presented as:

$$\Delta W \approx [\omega_a \Delta u' + u'(\tilde{C}_r)] \Delta \tilde{C}$$

And more explicitly:

$$\Delta W \approx \frac{C_p^a}{C^a} x u'(\tilde{C}_p) - u'(\tilde{C}_r) + u'(\tilde{C}_r) + n^a x n^h x VSL$$

Where:

- $n^a x n^h x VSL$ accounts for the demographic composition and value of statistical life, reflecting the implicit cost of life and security loss in disaster zones.

Based on the survey, substituting values according to primary data:

$$\Delta W \approx 55.82\%$$

This implies that, shortly after the cyclone, household aggregate welfare fell by about 55.82%, but with poor households disproportionately hit because of their lower resilience, limited savings, and absence of formal risk-smoothing mechanisms like insurance or credit.

In addition, it was seen that home readiness in the guise of disaster savings was an important factor in smoothing consumption. Amongst the 600 sampled homes, a small but significant percentage had actually saved money in anticipation of disaster situations. Nonetheless, amongst these households too, the resilience to return consumption expenditure to pre-disaster levels was low, which points towards the inadequacy of existing financial cushions (see figure 3).

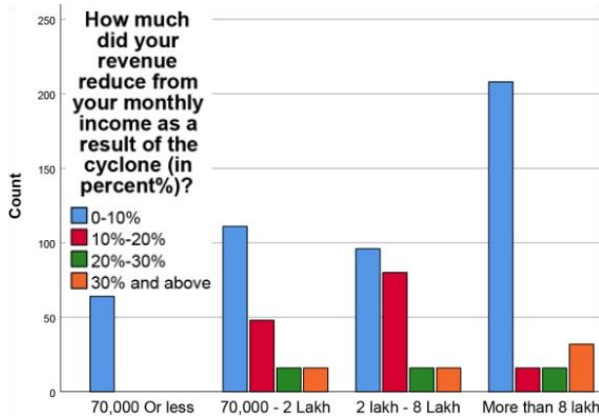


Figure 3: Income reduction of households (Survey, 2025)

With a cluster sampling design, the research controlled for variation in income groups in 81 wards in Bhubaneswar. The sample-derived household-to-population ratio (600 households to roughly 80,000 individuals) permitted an in-depth yet replicable portrayal of community-level effects. This high-resolution data series confirmed the finding that economic resilience continues to be highly stratified, with more affluent households having a lower proportional reduction in well-being because they can smooth the shock through current wealth.

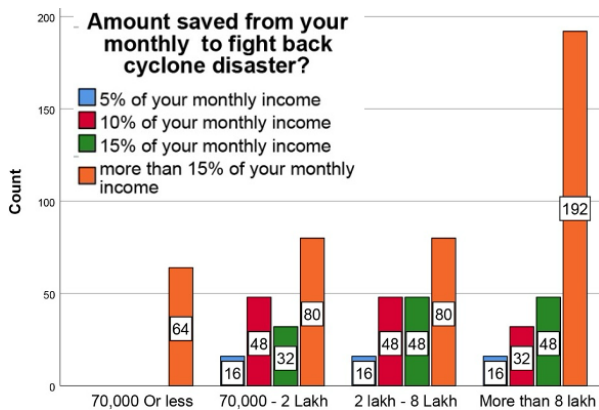


Figure 4: Chart showing the value of statistical life

These results are in line with international literature on disaster economics, where it has been shown that more

affluent households will recover better from shocks, and poor households have longer recovery times and greater welfare losses (Yin et al., 2013; Shultz et al., 2005). This asymmetry again supports the use of targeted policy instruments that improve the financial resilience of poor households through savings instruments, access to low-cost insurance, and inclusive credit systems.

Microeconomics

In microeconomic theory, the term resilience describes the ability of an economy or a society to reduce welfare losses caused by external shocks, e.g., natural disasters. Microeconomic resilience particularly addresses the extent to which individual households can sustain their level of living—expressed in terms of utility or consumption—despite being subjected to disturbances such as loss of assets, income decrease, or displacement.

This resilience is determined by dividing the aggregate loss in household consumption against the aggregate loss in welfare of the impacted population. Essentially, it captures how well a population can digest economic shock without much decline in well-being. The mathematical formula that is officially employed to calculate microeconomic resilience is as follows:

$$R^{\text{micro}} = \frac{\Delta \tilde{C}}{\Delta W}$$

Where:

- R^{micro} denotes microeconomic resilience,
- $\Delta \tilde{C}$ represents the proportion of aggregate consumption lost,
- ΔW represents the proportionate decline in aggregate household welfare,

Using the values derived from the earlier analysis and substituting into the equation:

$$R^{\text{micro}} = \frac{24.49\%}{55.82\%} \approx 0.44$$

This 0.44 value reflects that the population only absorbed 44% of the possible welfare loss from consumption shocks, or that the remaining 56% was realized as actual welfare loss. In other words, out of each lost unit of consumption, more than half of it was experienced as a real decrease in well-being.

A resilience index of less than 0.5 generally corresponds to low to moderate resilience and suggests that households have limited ability to protect themselves from the economic impacts of the disaster. This finding

is consistent with previous research in this study, which proved that:

- Poor households had limited financial buffers,
- Consumption smoothing through savings or insurance was minimal,
- The distributional burden of the cyclone disproportionately affected vulnerable groups.

The comparatively low resilience score highlights the imperative for policy action to enhance household financial readiness, especially in economically disadvantaged populations. Instruments like microinsurance, low-interest emergency credit, and targeted cash transfers can enhance resilience by lessening the extent to which consumption shocks are converted into welfare losses.

By and large, the microeconomic resilience index offers a numerical estimate of household vulnerability and potential for recovery. It functions as a crucial diagnostic tool for local governments and planners of disaster risk reduction so that evidence-based policy design in the socio-economic context of cities such as Bhubaneswar can be accomplished.

6. Conclusion and Policy Implications

This research used the World Bank framework for measuring microeconomic resilience to analyze the economic effects of cyclonic shocks on urban households in Odisha, Bhubaneswar. The framework that focuses on welfare losses and consumption smoothing facilitated a thorough analysis of how income groups cope with and recover from disasters. The research indicated severe differences between underprivileged and privileged households regarding vulnerability, coping ability, and recovery after disasters.

Key Findings

The analysis reiterated that poor families made up most of the population in the sample (61.7%), evidencing a structurally weak socio-economic base of the city. The families were disproportionately hit by the cyclone, not just due to limited savings and coping strategies, but also because of their reliance on precarious, informal income streams. The pre-marginal usefulness of income was considerably lower in the poor (7.2%) than that in richer households (20%), suggesting a strong imbalance in budgetary flexibility and adjustability.

While richer households experienced greater absolute losses, percentage welfare loss for poorer households was much higher. The instantaneous welfare loss, as realized in the core impact period, was at its peak at 55.82%, as opposed to a more moderate 29.09% welfare loss upon measurement prior to and subsequent to the cyclone. This difference indicates the intensity of the immediate post-disaster period, where poor households were under greater financial constraint and consumption shocks.

Additionally, other expenditure covered 24.8% of poor household pre-disaster consumption, but just 10% for rich households. Such disparity highlights more relative burden in low-income households who do not usually have any insurance, credit, or access to formal protection systems. Reduced marginal utility for income, due to the absence of financial shocks cushions, leaves poor households obliged to spend scant resources during rebound periods, perpetuating their enduring exposure.

The calculated microeconomic resilience index was 0.44, indicating that only 44% of the potential welfare loss was avoided, and the rest 56% resulted in actual reductions in well-being. This low resilience value indicates a strong need for strategic interventions to improve financial stability and disaster preparedness, particularly for economically vulnerable groups.

Policy Implications

The findings from Bhubaneswar are indicative of wider trends observed in cyclone-vulnerable coastal areas of Odisha, which, based on historical records as well as IPCC estimates, are witnessing more frequent and intense storm occurrences. Although there have been remarkable achievements in disaster preparedness at the macro level, including early warning systems, evacuation procedures, and relief operations, the microeconomic aspect of disaster resilience is still underdeveloped.

In order to bridge these gaps, the following policy suggestions are made:

- Targeted Financial Instruments for the Poor: Increase in microinsurance, disaster-related savings schemes, and low-cost low-interest credit may enable poor households to withstand and recover from shocks without incurring permanent welfare losses.
- Community-Based Risk Reduction: Drawing strength from Odisha's experience with

decentralized disaster management, the local self-help groups, cooperatives, and urban poor federations must be further strengthened to operationalize risk-reducing measures at the neighbourhood level.

- **Inclusive Infrastructure Investments:** Upgrading housing and basic services in informal settlements—where the urban poor live—can increase physical resilience and long-term financial protection from disasters.
- **Urban Poverty and Resilience Mapping:** Conducting real-time poverty and risk mapping at the ward level may assist policymakers in more efficiently allocating resources and reacting to disaster effects dynamically.
- **National Framework Interlinking:** Bhubaneswar's microeconomic resilience plan needs to be linked to national and global frameworks, such as the Sendai Framework for Disaster Risk Reduction, to facilitate consistency in data gathering, response planning, and access to international aid.

Concluding Reflections

Though Bhubaneswar and the larger Odisha area have come a long way in disaster preparedness, this research illustrates that microeconomic resilience at the household level is still unequal, with low-income families shouldering the most of post-disaster suffering. As climate change keeps increasing the frequency and magnitude of weather-related risks, microeconomic resilience has to be considered as a foundation of sustainable urban development.

Investments in financial security at the household level, inclusive city planning, and community-focused governance will be vital to bridging the resilience gap. By complementing current macro-level infrastructure with micro-targeted economic interventions, Bhubaneswar—and other at-risk cities—can not only survive shocks in the future but come out stronger and fairer in adversity.

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