Assessing the Disproportionate Effects of Disasters on Vulnerable in India: Implications for Achieving Sustainable Development Goals

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Abstract

Disasters- both natural and man-made, have a profound impact on countries worldwide. However, the effects are not uniform, as they disproportionately affect vulnerable regions and communities. This study conducts a comprehensive analysis of India's disaster landscape scrutinizing the frequency of catastrophes and their impact on the economic and social development of the country highlighting disaster-prone regions. By using regression and correlation tools we examine the frequency and impact of the disasters on GDP, inequality, Poverty, Unemployment, and Climate change from the lens of annual temperature and rainfall to gain insights into disaster vulnerability in India. Additionally, we analyze the flash flood scenario in India over six decades by focusing on the Kerala floods-2018 Vs. Uttarakhand Floods 2013 and the recent Joshimath Disaster. Through an in-depth exploration of India's disaster vulnerability, the study contributes to a broader discourse on building resilience through the effective implementation of sustainable development. Thus, we emphasize, the imperative to align government efforts, with sustainable development goals acknowledging the intersectionality of disasters with inequality, poverty, and climate change.

Keywords: *Disaster, SDGs, Vulnerability, Inequality, Climate Change, Resilience*

Introduction

India has been susceptive to natural calamities such as floods, cyclones, earthquakes, landslides, tsunamis, etc. due to its geo-climatic characteristics. Approximately 68% of the area is sensitive to droughts, 60% of the landmass to earthquakes of varying magnitude, over 40 million hectares to floods, and 8% of the total area to cyclones. Every year between 1990 and 2000, there were approximately 4344 fatalities and 30 million people who were affected by disasters. A report titled *India 2022: An Assessment of Extreme Weather Events* revealed that most people were killed as a result of these incidents in Himachal Pradesh (359), followed by Assam and Madhya Pradesh (301). According to the data, Assam reported the most destroyed homes and animal deaths. Over 50% of the cropland in the nation was impacted by an extreme weather event that lasted 82 days in Karnataka. Geographically, India's central and north-western regions reported the most days with extreme weather events (198 and 195, respectively). The East and North East of India came in second (783 deaths), and central India came in first (887 deaths).

The amount of individual, communal, and public assets lost has been enormous and it is disproportionate. A peculiar feature observed across the globe regarding the incidence and impacts of disasters is that there are certain regions and communities where the vulnerability to catastrophic phenomena is higher than others. Understanding vulnerability can be difficult since it frequently refers to several concepts such as fragility,

lack of capacity, heightened sensitivity, weakness, etc. Numerous factors, including the state of the economy, the environment, and the availability of resources and information, have an impact on vulnerability in the context of catastrophes. By incorporating vulnerability into our understanding of disaster risk, we acknowledge the fact that disaster risk is a reflection of both the susceptibility of people and economic assets to suffer loss and damage in addition to the severity of the hazard or the number of people or assets exposed. Since the disaster risk is higher among the marginalized, mitigation efforts and attempts to increase resilience, risk governance, and policy formulation should be oriented towards vulnerable communities more than the population who is not as susceptible to the calamities.

In the backdrop of this, the chapter delves deeper into disaster vulnerability while comparing with macroeconomic parameters of India such as GDP, SDG Index, Poverty Rate, Inequality (Gini Coefficients), Economic loss due to disasters, government expenditure on relief, loss of lives, Population index, and Demographic Composition, etc. Additionally, an attempt is made to explore certain case studies with special referece to flash floods through a comparative analysis of Kerala floods-2018 Vs. Uttarakhand Floods 2013 and Joshimath disaster from the lens of vulnerability and how certain natural disasters are driven by development-oriented projects.

Review of Literature

Several studies have been investigating the disproportionate impacts of disasters on vulnerable regions and communities. Following are some of the studies examining the same in India and across the globe.

Ariyabandu, M. M. (2005). Stated, that for all facets of growth, disasters are a severe threat. In developing nations, 90% of all-natural disasters and 95% of deaths resulting from them happen. By 2025, it is predicted that 80% of the world's population will reside in developing countries and be at risk from natural disasters.

Kimuli et al. (2021) performed a multisource trend analysis of floods in the Asia Pacific from 1990 to 2018, assessing their implications for SDG 13 (Climate Action). They found that these disasters have been detrimental to prior progress, underscoring the urgency for concerted climate action by all stakeholders. The study highlights the importance of further research to fully grasp the disaster's impact on vulnerability and to formulate effective action plans.

Tasri, E. S., Karimi, K., & Muslim, I. (2022) explored the effects of unemployment and poverty on catastrophe losses, the causes of income disparity in Indonesia caused by disasters, and the causal connection between disaster losses and income inequality and showed empirical evidence for the same.

Sam. A. et al. (2021) investigated flood security in Eastern India and its implications on food security. India is an agrarian country with several flood-prone areas. Farming communities in these regions are highly vulnerable to the disaster risk. The interlinkages with agriculture pose grave challenges to the SDGs such as – No poverty, zero hunger, and climate action.

Pramanik, Malay, et al. (2021) conducted a study to analyze the impacts of COVID-19 and Amphan Cyclone on SDGs in the region of Sundarban, India- a multi-hazard region of the country at the Bangladesh border. In the wake of Cyclone Amphan and the context of the COVID-19 pandemic, this study examined the effects on local livelihoods and tracked the advancement of the Sustainable Development Goals. The study indicated a negative impact on the livelihood systems of the Sundarbans' most vulnerable populations.

Kushwaha et al. (2023) conducted a critical review of the localization of SDG 11 in South Asia, with a focus on implications for India. South Asian countries, housing one-fifth of the global population and experiencing rapid urbanization, are central to sustainability challenges. The study identified key drivers for success, including open institutional and financial systems, stakeholder engagement in resource allocation, robust data ecosystems promoting social innovation, and flexible policy reforms fostering innovative solutions. These factors can guide Indian cities in establishing a contextual framework for SDG 11 and driving informed policy decisions toward a transformative paradigm shift.

Singh. P, (2023) highlighted the gender dimension of disaster risk, emphasizing that impoverished rural women are particularly vulnerable to climate change impacts due to their subordinate status and limited access to resources. In India, women often engage in climate-dependent traditional occupations, many of which are disappearing. This trend negatively affects household income, social security, women's and girls' health, and education, leading to rural-urban migration driven by climate-induced challenges. Recognizing and addressing this gender-specific aspect of climate variability is crucial.

Objectives of the Study

1. To analyze the relationship between Inequality and Climate Change in India.
2. To gain insights into financial damage caused by Disasters on Gross Domestic Product.

3. To gain an understanding of the implication of disaster vulnerability on Sustainable development goals with a focus on SDG1- No poverty, SDG10- Reduced Inequality, and SDG13 – Climate action.
4. To investigate the trends of disasters in India between 1990-2023 through geographic and demographic perspectives.

Hypothesis

- H0: Inequality is influenced by the Climate Change
- H1: Inequality is **not** influenced by the Climate Change
- H0: The frequency of disasters and Poverty are inversely proportional to each other.
- H1: Frequency of disasters and Poverty are **not** inversely proportional to each other.
- H0: Gross Domestic Product and financial loss caused by disasters have a negative correlation.
- H1: Gross Domestic Product and financial loss caused by disasters **do not** have a negative correlation.

Research Methodology

The study is a blend of descriptive and exploratory research methods as it attempts to explore the correlation between disaster vulnerability with economic indicators such as GDP, Poverty, and inequality along with providing a qualitative explanation of the same. The data utilized for analysis is secondary. The considered data is collected from various government and non-government databases, reports, websites, and other forms of literature reviewed. The data sets considered were for a time frame of 32 years i.e., 1990 - 2022 as follows:

- Frequency of Disasters
- GDP of India (in USD)
- Damage caused by Disasters as a percentage of GDP
- Inequality index of India (Gini coefficient)
- Poverty Rate in India
- Mean Annual Temperature
- Annual rainfall
- Per Capita CO_2 emission

Discussion

Figure1- emphasizes that while poverty and inequality are growing in opposite direction to each other in India. Between 2000 and 2019, India's income per person increased by five times. This does not imply that everyone in society is now earning more money.

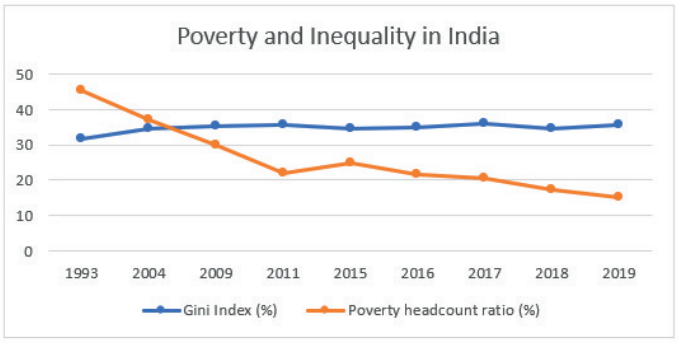

Fig 1 Poverty and Inequality in India *(Authors' visualization based on NSSO data on Poverty and Inequality)*

In 2019, 21% of India's income went to the wealthiest one percent of citizens. For 1990, this was 11%. In 2019, the country's richest 10% earned 56% of the total income, while the bottom 10% took home just 3.5%. The Gini coefficient, which measures income distributional disparity, indicates rising inequality in India. In 2014, the coefficient was 34.4% In 1993 and 2019, the coefficient rose to 31.7% and 35.7%, respectively. Disasters aggravate the already existing phenomenon of unequal distribution of wealth and inequality.

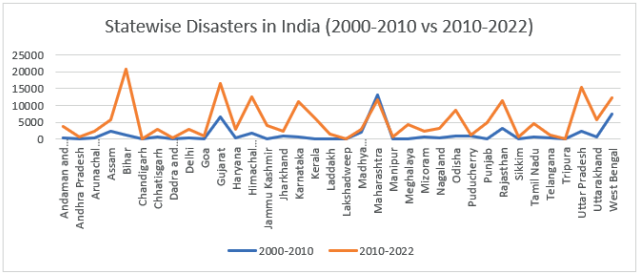

Fig 2 State-wise Disasters in India 2000-2010 vs. 2010-2022 *(Compiled and Visualized by Authors based on data from nidm.gov)*

Fig:2 shows the disasters in India from 2000-2010 and 2010-2022. It can be interpreted that the frequency of disasters has increased significantly in the latter decade. States with a higher number of natural calamities are Assam, Bihar, Gujarat, Maharashtra, Odisha, Tripura, Himachal Pradesh, Uttarakhand and Uttara Pradesh. These states belong to the humid Subtropical Climatic region. Thus, it is strong evidence of geographical and climatic inequality of disasters.

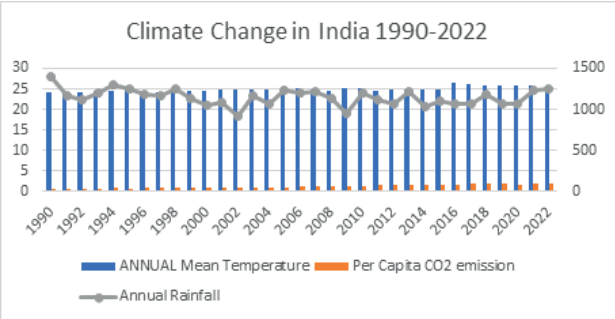

Fig 3 Climate Change in India 1990-2022 *(Compiled and Visualized by authors based on various databases referred)*

Fig 3 demonstrates the trends in climate change parameters considered – Mean temperature, Rainfall, and Per Capita CO_2 emission in India. In 1990 per capita CO_2 emission was 0.62 which increased to 1.95 reflecting a massive increment. Annual mean temperature has increased from 24.21 to 26 between 1990 and 2022 respectively. It can be noted that it is in tune with the rate of global warming i.e., 2^0 as noted by IPCC. Rainfall does not have a constant pattern and it lies between 1100 mm to 1400 mm in the past 32 years.

Hypothesis Testing

Regression Analysis- Inequality and Climate Change

- H0: Inequality is influenced by Climate Change.
- H1: Inequality is not influenced by Climate Change.

Econometric Model

$$Y = 0i + 0.008588 * X1 + 0.571934 * X2 + 0.843882 * X3 + e \quad \text{----------(1)}$$

Equation (1) shows the linear relationship between inequality and climate change derived from regression analysis, where Y= Inequality, X1= Annual mean temperature, X2= Per Capita CO_2 Emission, X3= Annual rainfall, e= error term, i= intercept and associated are the coefficient values.

The following table is the result of the Regression of Inequality with Climate Change Variables – (Mean temperature, per capita CO_2 Emission, and Annual rainfall.

Table 1 Goodness of fit and F significance

Multiple R	0.9995
R^2	0.9990
Adjusted R^2	0.8320
F significance	0.0000

Since R^2 is 0.99 it denotes goodness of fit and very high correlation between dependent and independent variables. Thus, the model demonstrates that our dependent variable Inequality is highly influenced by the dependent variables of Mean annual Temperature, Per Capita CO_2 emission, and Annual rainfall. F significance of 0.000 in regression provides strong evidence that the model is statistically significant and that the independent variables collectively have a meaningful impact on the dependent variable.

Table 2 P- Test Based on Regression Analysis

Variables	P-value	Significance	Hypothesis testing
Annual Mean temperature	0.008588	0.008<0.05 (Significant)	H0 is rejected.
Per Capita CO_2 Emission	0.571934	0.57>0.05 (Insignificant)	H0 is accepted.
Annual Rainfall	0.843882	0.84>0.05 (Insignificant)	H0 is accepted.

Here, the Per Capita CO_2 Emission and rainfall influence the inequality to a large extent. While the annual mean temperature doesn't show a direct influence on inequality from the above analysis. However, we need to note that annual temperature impacts other climate variables and it is increasing every year at a gradual pace which can result in a larger change in the future when seen with an elongated time frame. Annual rainfall also influences inequality, as it is erratic.

Correlation Analysis

- H0: Frequency of disasters and Poverty are inversely proportional.

  H1: Frequency of disasters and Poverty are not inversely proportional.
- H0: Gross Domestic Product and financial loss caused by disasters have a negative correlation.

  H1: Gross Domestic Product and financial loss caused by disasters do not have a negative correlation.

Table 3 Correlation Analysis

	Correlation Coefficient	Remarks	
Inequality (Gini coefficients) and frequency of disasters	0.250533	Weak Positive Correlation	Inequality and frequency of disasters weakly inverse proportional.

Disaster frequency and Multidimensional poverty Index of selected states	0.619868	Positive-Correlation	Disaster and Poverty are directly proportional.
Poverty headcount ratio and disaster damage as % of GDP	0.313872	Weak Positive Correlation	Poverty headcount ratio and financial damage by disasters as a share of GDP have a weak direct relationship.
GDP of India and Financial Loss as a percentage of GDP	-0.28236	Negative correlation	GDP and Financial loss as a percentage of GDP are inversely proportional.

Thus, we accept the null hypothesis in both the cases as Frequency of disasters and Poverty are inversely proportional to each other and the Gross Domestic Product and financial loss caused by disasters have a negative correlation.

Case Study 1: Flash Floods in India

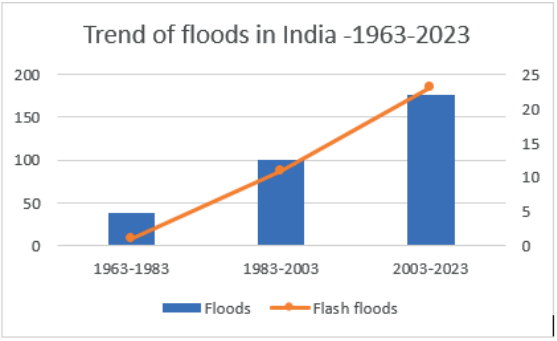

Fig 4 ***Trend of floods in India 1963-2023*** **(Authors' compilation and visualization based on CRED and EM-DAT)**

Fig 4 demonstrates the vicennial trends of floods and flash floods in India. Over six decades India has witnessed significant escalation in both floods and flash floods. From 1963-1983 there were instances of 38 floods and 1 flash flood, while the time frame between 2003-2023 experienced 176 floods and 23 flash floods. This is a massive 363.16% surge in case of the frequency of the floods in the country.

Against this backdrop, we analyse the Uttarakhand Flash flood-2013 and the Kerala Flash flood-2018.

Table 4 ***Snapshot of Uttarakhand Flash Floods-2013 and Kerala Flash Floods-2018 (Compiled by authors' from NIDM reports & literature reviewed)***

Year	GSDP	SDG rank	Population Density (As per Census 2011)	Reason for flash flood	Life loss	Economic damage	Sector with Highest Damage
2013	149074	5	189	Heavy Rainfall, Eruption of rivers-Mandakini, Lake, Glacial Melting-Chorabari	4190	Rs.50000-Cr	Tourism and agriculture
2018	772894	1	860	High Rainfall, Inefficient management of Dams, Overflow of rivers, Blockage in water bodies, etc.	339	Rs.31000-Cr.	Agriculture and Allied Activities

The 2013 Kedarnath floods caused extensive damage, including $195 million in lost tourism revenue and $285 million in bridge and road repairs, and believed deceased deaths are 4169. The 2018 Kerala floods caused enormous damage, resulting in 339 fatalities and a ₹31,000-crore overall economic loss. The primary areas of economic impact included substantial agricultural losses totaling ₹27,839.9-crore, damage to homes estimated to cost ₹7,357.104-crore, and substantial infrastructure losses, including damage to roads and bridges, totaling ₹9,538.45-crore. Including ₹7,434.0697-Crore in urgent aid for food and clothing, ₹23015.65 lakh for search and rescue, and other expenses for power, water supplies, and irrigation, the government spent ₹27100 lakh on relief activities. These figures demonstrate the scope of the losses and the enormous financial commitment made by the government to the rescue and recovery operations. Despite variations in their Sustainable Development Goal (SDG) rankings, both Kerala ranked first, and Uttarakhand ranked fifth, have encountered

notable difficulties in disaster relief and management. These challenges persist due to the unique geographical, ecological, and social vulnerabilities inherent to each state. This underscores the imperative for intensified efforts aimed at addressing and reconciling SDGs associated with climate change and inequality. The SDG rankings alone inadequately encapsulate the multifaceted complexities associated with disaster resilience and sustainable development.

Case Study 2 - Joshimath Disaster

In 2022, Joshimath, located in the Chamoli district of Uttarakhand, faced a significant crisis as cracks appeared in buildings and frequent landslides and flooding were reported. Uttarakhand government attributed the sinking of several areas in Joshimath to a combination of natural and human-induced factors. One significant factor contributing to the instability in Joshimath is its location on an ancient landslide deposit, not on solid rock. The undermining of the land by the Alaknanda and Dhauliganga rivers further exacerbates the problem. Additionally, the region's geology comprises scattered rocks covered in old landslide debris with a low bearing capacity, especially when saturated during monsoons. The proliferation of construction activities, hydroelectric projects, and the expansion of the national highway have made the slopes increasingly unstable. Land erosion from streams and natural waterways has also played a role in the deteriorating condition.

The impact of these factors has forced 66 families to evacuate, with 561 houses reporting cracks, affecting over 3,000 people. Many residents in Joshimath have been employed in the tourism sector, working as tour guides, hotel staff, or in small businesses catering to tourists. With the destruction of infrastructure and the decline in tourism, these individuals lose their primary sources of income. Poorer residents have been living in vulnerable areas with inadequate housing, making them more susceptible to the effects of landslides and flooding. The destruction of their homes exacerbates their vulnerability. Loss of income leads to food insecurity and non-accessibility of healthcare and education services.

Uttarakhand's 5th position in the SDG rankings reflects commendable progress in various aspects of sustainable development. However, the state's unique vulnerabilities, particularly in the realms of disaster resilience and climate change adaptation, demand a more targeted and all-encompassing strategy. Moreover, Uttarakhand's district-level SDG computation does not include SDG 10- Reduced Inequalities and SDG-12 Climate Change due to unavailability of data. This indicates the loopholes and shortcomings in SDG index Calculation. The sinking of Joshimath is a complex issue influenced by geological, environmental, and human factors. To save the town, immediate measures like halting development and relocating residents are necessary, along with long-term efforts such as improved drainage planning and reforestation. Collaboration between various stakeholders and a focus on scientific studies are crucial for sustainable solutions.

Implication to SDGs and Policy Suggestions

The analysis offers several crucial policy recommendations and consequences for tackling the difficulties faced by catastrophes, inequality, and their effects on India's Sustainable Development Goals (SDGs):

- The increasing income inequality trends highlight the need for policies aimed at reducing wealth disparities. Measures such as progressive taxation, social safety nets, and targeted welfare programs can help redistribute income and bridge the gap between the rich and the poor. This reduction in inequality is essential for achieving SDG goals related to poverty reduction and reduced inequalities.
- The geographical distribution of disasters, as seen in Fig-2, suggests the need for region-specific disaster management plans. Tailoring disaster response strategies to the unique characteristics of each region can help reduce the disproportionate impact of disasters on vulnerable populations and promote regional equality (SDG 10).
- To tackle the alarming rate of climate change Policymakers should prioritize climate change mitigation efforts, including transitioning to renewable energy sources, enhancing energy efficiency, and reforestation programs. These actions are crucial for achieving SDG 13-Climate Action.
- Since there is a strong link between disasters and poverty, it is important to integrate climate-resilient development strategies into poverty reduction efforts (SDG 1) to ensure that vulnerable populations are better prepared to cope with the impact of disasters.

Conclusion

In the context of India's pursuit of the Sustainable Development Goals (SDGs), this study has shed light on the complex interactions between catastrophes, climate change, and inequality. The findings showcase the alarming rise in income inequality over the years, emphasizing the imperative of redistributive policies to bridge the wealth gap. The escalating frequency of disasters, especially in the latter decade, underscores the critical need for proactive disaster risk reduction measures and climate change mitigation strategies. These challenges have a significant bearing on India's progress

toward SDGs, especially those related to poverty reduction, climate action, and reduced inequalities. Furthermore, the study underscores the need for region-specific disaster management plans and improved data infrastructure to enhance disaster risk assessment and SDG monitoring.

As India navigates its complex path toward sustainable development, policymakers must recognize the indivisibility of these challenges. An integrated approach that addresses inequality, invests in disaster preparedness, promotes climate-resilient development, and acknowledges regional disparities is paramount. In doing so, India can not only achieve its SDG targets but also foster a more equitable, sustainable, and resilient future for all its citizens. Ultimately, the success of India's development journey hinges on its ability to confront these multifaceted challenges head-on and implement evidence-based policies that leave no one behind in the pursuit of sustainable development.

Limitations and Scopes

The study faced data limitations regarding Gini coefficients and economic damage in Uttarakhand, necessitating reliance on data availability for particular years and resorting to estimations in such instances. Promising avenues for future research involve conducting nuanced state and district-level studies, enabling cross-state and cross-region analyses, with a particular focus on climate variables, to derive a holistic understanding of SDG implications for India.

References

1. Ariyabandu, M. M. (2005). Gender dimensions in disaster management: A guide for South Asia, Zubaan.
2. Champati Ray, P.K., Chattoraj, S.L., Bisht, M.P.S. et al. Kedarnath disaster 2013: Causes and consequences using remote sensing inputs. Nat Hazards **81**, 227–243 (2016).
3. IIT Bombay. (n.d.). Slipping Away: Surface Impact of Kerala 2018 Floods and Soil Erosion.
4. Kimuli, J. B., Di, B., Zhang, R., Wu, S., Li, J., & Yin, W. (2021). A multisource trend analysis of floods in Asia-Pacific 1990–2018: implications for climate change in sustainable development goals. *International Journal of Disaster Risk Reduction*, 59, 102237.
5. Kushwaha, N., Nangia, C., & Adhvaryu, B. (2023). Achieving Localization of SDG11: A critical review of South Asian region and learnings for India. International Review for Spatial Planning and Sustainable Development, 11(3),102-115.
6. Ministry of Home Affairs. (2004). Disaster Management of India- A Status Report, National Disaster Management Division, Government of India, New Delhi.
7. NIDM- Ministry of Home Affairs, GOI (2014), Uttarakhand Disaster
8. NIDM-Ministry of Home Affairs, GOI. (2018). Kerala Floods
9. Pant, M. K., Kumar, S., & Kapoor, P. (2022). SDG District Report-Chamoli.
10. Pramanik, M., et al (2021). Twin disasters: tracking COVID-19 and cyclone Amphan's impacts on SDGs in the Indian Sundarbans. Environment, Science and Policy for Sustainable Development, 63(4), 20-30.
11. Preetha, B. (2022). India saw natural disasters almost every day in the first 9 months of 2022, Down to Earth.
12. Sam, A. S., et al. (2021). Flood vulnerability and food security in eastern India: A threat to the achievement of the Sustainable Development Goals. *International Journal of Disaster Risk Reduction*, 66, 102589.
13. Singh, P. (2023). Climate Change, Gender, and Traditional Livelihoods: Some Reflections from India. In Global Climate Change and Environmental Refugees: Nature, Framework, and Legality. 77-90. Cham: Springer International Publishing.
14 Tasri, E. S., Karimi, K., & Muslim, I. (2022). The effect of economic variables on natural disasters and the impact of disasters on economic variables. Heliyon, 8(1).
15. Tripathi, S. (2019). Effect of disasters and climate change on poverty and inequality in India.