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Evaluating Disaster Impacts and Alignment with Sustainable Development Goals (SDG): A Case Study of South West Khasi Hills District, Meghalaya (2014–2024)

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Abstract The South West Khasi Hills District of Meghalaya has been significantly impacted by various natural disasters over the last decade. This study examines the impact of these disasters on local communities, infrastructure, and livelihoods. The research aligns with Sustainable Development Goals (SDGs) and proposes intervention strategies to mitigate the effects of floods, landslides, cyclones, hailstorms, and other calamities. The findings emphasize the need for resilient infrastructure, improved disaster preparedness, and sustainable community-based risk reduction strategies.

Keywords: Disaster Impact, South West Khasi Hills, Meghalaya, Climate Resilience, Sustainable Development Goals (SDGs), Risk Reduction, Community Resilience

Introduction

South West Khasi Hills District, Mawkyrwat, Meghalaya, is highly susceptible to natural calamities, including floods, landslides, hailstorms, cyclones, and pest attacks. Over the last ten years, these disasters have caused substantial economic losses, infrastructural damage, and human casualties. Understanding the scale and impact of these disasters is crucial for formulating effective disaster risk reduction (DRR) strategies aligned with national and international resilience frameworks.

Several studies emphasize the vulnerability of Meghalaya to climate-induced disasters due to its topography, high rainfall, and fragile ecosystems (**Tiwari & Joshi, 2019**). The **National Disaster Management Authority (NDMA, 2020)** has highlighted the urgent need for state-level interventions to enhance preparedness and mitigation efforts in high-risk districts. Additionally, research by **Dasgupta et al. (2021)** underscores the role of community-based approaches in mitigating disaster risks in the Northeast region of India. Scholars such as **Sharma et al. (2018)** have pointed out the socio-economic implications of repeated disasters on rural communities, particularly in mountainous terrains. Studies by **Mishra & Gupta (2022)** indicate that climate variability has intensified disaster occurrences, requiring localized resilience-building strategies. Furthermore, **Alam & Chakraborty (2023)** stress the significance of integrating indigenous knowledge with modern disaster management practices to enhance adaptive capacities.

Langshiang, E. S., & Langshiang, A. S. (2022) provide an in-depth analysis of landslides in South West Khasi Hills District, focusing on case studies from the 2022 events. Their research highlights the primary causes of landslides, including heavy rainfall, deforestation, and unstable slopes. The study also outlines key lessons learned, emphasizing the need for improved slope stabilization, early warning systems, and community-based mitigation strategies. Their findings align with broader disaster risk reduction frameworks, advocating for the integration of scientific assessments with local adaptation measures to reduce landslide risks effectively.

Other studies further reinforce the necessity of a holistic approach to DRR in Meghalaya. **Patel & Singh (2020)** discuss the impact of extreme weather events on agricultural productivity, highlighting economic vulnerabilities in farming communities. **Chakrabarti et al. (2021)** examine infrastructure resilience, noting that weak road networks and inadequate early warning systems exacerbate disaster impacts. **Goswami & Dutta (2019)** explore the interplay between heavy rainfall, deforestation, and flood risks, stressing the importance of watershed management. **Rai & Verma (2022)** assess gaps in disaster preparedness at the state level, calling for improved early warning dissemination and response coordination.

Additionally, **Baruah & Sarma (2020)** analysed the psychological and social impacts of recurring disasters on indigenous communities, advocating for trauma-informed disaster management approaches. **Sen et al. (2021)** emphasize the role of traditional ecological knowledge in disaster adaptation, demonstrating the effectiveness of practices such as terrace farming and bamboo-based flood control. **Kumar & Das (2023)** identify policy gaps in disaster governance, arguing for better integration of local government bodies into national DRR frameworks. **Sharma et al. (2023)** highlight the increasing frequency of cyclones and hailstorms, recommending improved forecasting models and land-use planning. **Roy & Banerjee (2022)** explore gender-specific vulnerabilities, emphasizing the disproportionate impact of disasters on women and children. Finally, **Das & Bhattacharya (2023)** examine post-disaster recovery patterns, stressing the need for better healthcare access and livelihood restoration programs.

These studies collectively highlight the pressing need for a multi-disciplinary, community-centered approach to disaster risk reduction in South West Khasi Hills District. By integrating scientific research, policy reforms, and local knowledge, stakeholders can develop sustainable strategies to mitigate disaster impacts and build long-term resilience.

Methodology

This case study employs a mixed-method approach, combining qualitative and quantitative data. The study focuses on South West Khasi Hills District, Mawkyrwat, Meghalaya, India, an area highly vulnerable to natural disasters such as floods, landslides, hailstorms, cyclones, and pest infestations.

The primary data sources include government records, field surveys, and interviews with affected communities and local authorities. Secondary data were collected from meteorological reports, disaster response agency reports, and previous research on disaster risk reduction in Meghalaya. The study analyses disaster trends, vulnerabilities, and mitigation efforts over the last decade to assess the effectiveness of existing disaster preparedness strategies and identify gaps in risk reduction measures.

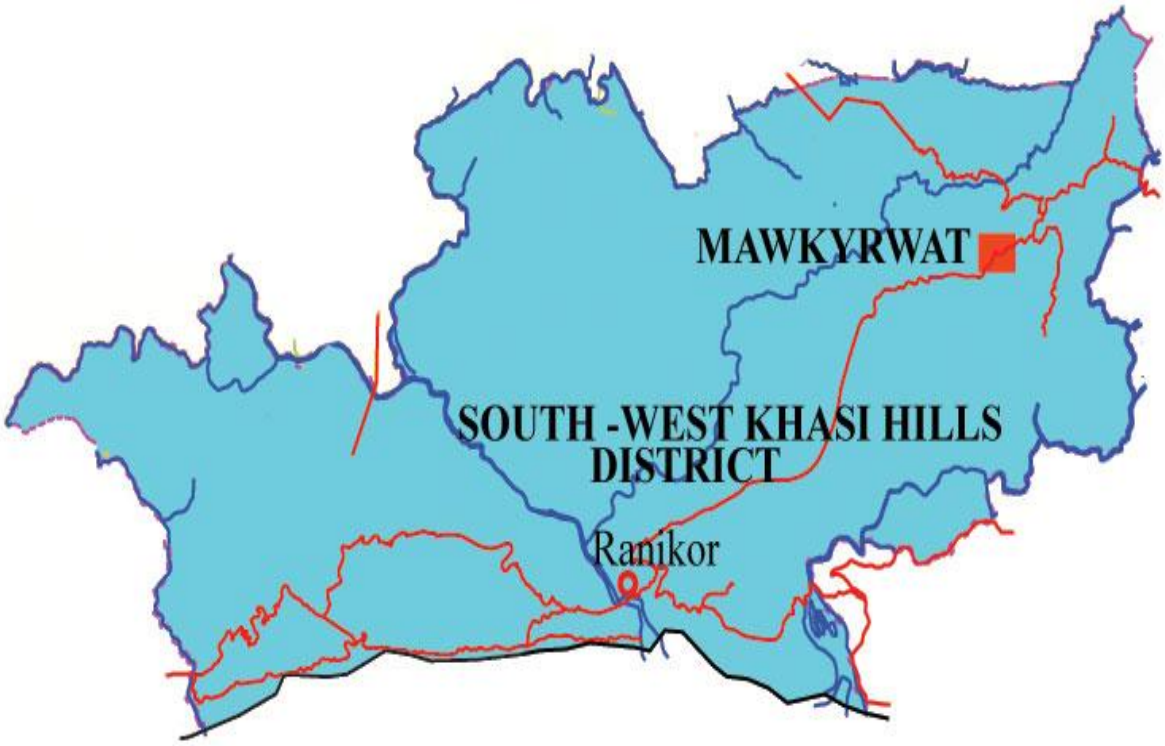

Figure 1. District map of South West Khasi Hills District

Results and Findings

The results of this study highlight the **widespread impacts of disasters** in South West Khasi Hills District, Mawkyrwat, Meghalaya, over the past decade. The study reveals significant damage to **infrastructure, agriculture, livelihoods, and human lives** caused by cyclones, floods, landslides, hailstorms, fire incidents, pest attacks, and lightning strikes.

To ensure a structured and evidence-based approach to disaster risk reduction (DRR), the results have been categorized into two main sections:

1. **Disaster Impact Analysis**
2. **Findings and SDG-Aligned Interventions**

Table.1: Disaster Impact Analysis.

Disaster Type	Impact	Key Observations
Cyclones and Storms	Over **2,300 houses** damaged, **69 schools** affected (2011-2024). Disruptions to power lines and communication.	Affected families faced **temporary displacement**, school closures impacted education, and recovery was slow.
Fire Incidents	**157 houses** destroyed, leading to loss of essential household goods, livestock, and community resources.	Fire hazards increased due to **closely packed housing structures**, lack of fire safety awareness, and delayed emergency response.
Floods & Flash Floods	**162.39 hectares** of crops lost, **134 houses** damaged, **severe road damage** impacting transport and connectivity.	Market disruptions led to **increased food prices**, affecting economic stability and agricultural productivity.
Hailstorms	**5,787 houses** and **1,049.55 hectares** of agricultural land damaged. **Crops like paddy, maize, and vegetables destroyed.**	Increased **risk of food insecurity** and **economic setbacks** for farmers, with many falling into debt.
Landslides	**501.19 hectares** of land affected, **97 houses** damaged, leading to **displacements and fatalities**.	Infrastructure collapse (roads and houses), **blocked highways**, and **inaccessibility of relief operations**.
Pest Attacks	**89.76 hectares** of crops destroyed, reducing **agricultural output** and leading to **food shortages**.	Farmers lacked **early pest control measures** and sustainable farming techniques to mitigate outbreaks.
Lightning Strikes	Multiple fatalities and injuries reported across the region. **Schools and public spaces lacked lightning protection.**	Need for **lightning arrestors** in vulnerable areas, especially **schools and hospitals**.

The **Disaster Impact Analysis** table provides a comprehensive overview of the **major disaster events** affecting the **South West Khasi Hills District**, highlighting their impact, key observations, and implications for disaster preparedness and response.

One of the key significances of this table is that it **quantifies the damage caused by various disasters** such as cyclones, fire incidents, floods, hailstorms, landslides, pest attacks, and lightning strikes. By presenting specific figures on the number of affected houses, schools, agricultural losses, and fatalities, the table helps in **assessing the severity of each disaster event** over the years.

The **observations section** identifies critical **vulnerabilities** and challenges that exacerbate disaster risks. For instance, in the case of **fire incidents**, the data indicates that **closely packed housing structures and lack of fire safety awareness** contribute to increased damage. Similarly, **floods and flash floods** not only damage

infrastructure but also disrupt markets, **leading to economic instability and food price hikes**. These insights are crucial for policymakers and disaster management authorities in designing targeted **risk reduction strategies**.

Another important aspect is the **identification of gaps in preparedness and mitigation measures**. For example, the table highlights the **absence of early pest control measures**, which led to extensive crop damage, as well as the **lack of lightning protection systems in schools and public areas**, resulting in multiple fatalities. These findings emphasize the need for **improving disaster resilience through proactive interventions**, such as installing **lightning arrestors**, promoting **sustainable farming techniques**, and enhancing **fire safety measures** in densely populated areas.

Furthermore, the table underscores the **long-term socio-economic consequences of disasters**. The impact of **hailstorms and landslides**, for example, extends beyond immediate damage, pushing many farmers into **financial distress** due to crop loss and increasing the risk of **food insecurity** in the region. Infrastructure damage from **landslides and floods** also disrupts connectivity, hampering **emergency response and relief operations**.

By providing a **detailed disaster impact analysis**, this table serves as a **crucial reference for disaster planning and mitigation efforts**. It highlights the **need for resilient infrastructure, improved early warning systems, community awareness programs, and sustainable agricultural practices**. The findings in this table can guide local governments, disaster response agencies, and policymakers in **developing risk-informed strategies** to minimize future disaster impacts and build a more **resilient community**.

Table 2: Findings and SDG-Aligned Interventions

Findings	Impact	SDG Alignment	Proposed Interventions
Widespread damage to houses (Total: **8,475** across disasters)	• Economic loss, displacement, and increased vulnerability of affected families	**SDG 1 (No Poverty)**	➢ **Climate-Resilient Housing:** Implement retrofitting & safe housing schemes for disaster-prone areas ➢ **Livelihood Support:** Post-disaster livelihood recovery programs (cash grants, skill-building) ➢ **Insurance & Compensation:** Strengthening access to crop, livestock, and housing insurance

Large-scale crop losses (Floods: 162.39 Ha, Hailstorms: 1,049.55 Ha, Pest Attacks: 89.76 Ha)	• Food insecurity, loss of agricultural income, and disruption in local markets	**SDG 2 (Zero Hunger)**	➢ **Climate-Resilient Agriculture:** Promote flood/drought-resistant crops ➢ **Crop Diversification:** Introduce multi-cropping systems to mitigate disaster losses ➢ **Pest Control:** Strengthen Integrated Pest Management (IPM) strategies
Fatalities from floods, landslides, and lightning (10 human deaths, 9 livestock deaths)	• Loss of lives, livestock, and long-term psychological distress	**SDG 3 (Good Health & Well-being)**	➢ **Strengthening Emergency Healthcare:** Deploy mobile health units & establish emergency medical teams ➢ **Mental Health Support:** Psychological counseling & trauma care services ➢ **Hospital Preparedness:** Ensure hospitals have contingency plans for disaster response
Damage to schools (Cyclone: 69, Hailstorm: 37, Landslides: 2)	• Interruption of education due to infrastructure damage, affecting students' learning continuity	**SDG 4 (Quality Education)**	➢ **Disaster-Resilient Schools:** Strengthen school buildings against disasters through retrofitting ➢ **Temporary Learning Centers:** Set up emergency classrooms post-disaster ➢ **School Safety Programs:** Conduct mock drills & integrate DRR into the school curriculum
Disruption of clean water supply (52 PHE main lines damaged)	• Limited access to safe drinking water, increased risk of waterborne diseases	**SDG 6 (Clean Water & Sanitation)**	➢ **Resilient Water Infrastructure:** Strengthen PHE pipelines & storage facilities ➢ **Alternate Water Sources:** Promote rainwater harvesting & community wells ➢ **Rapid Restoration Plans:** Deploy emergency

			response teams for water system restoration.
Roads damaged due to floods and landslides (Total: 61 roads affected)	Hindered mobility, disrupted access to essential services and trade routes	**SDG 9 (Industry, Innovation & Infrastructure)**	➢ - **Landslide-Resistant Roads:** Construct geosynthetic-reinforced roads ➢ **Flood-Resilient Bridges:** Elevated bridge designs in flood-prone areas ➢ **Early Warning Systems:** Use geospatial mapping for identifying high-risk roads
High housing damage across multiple disasters	Unsafe living conditions due to poor enforcement of building codes	**SDG 11 (Sustainable Cities & Communities)**	➢ **Disaster-Resilient Urban Planning:** Implement strict enforcement of safe building codes ➢ **Community-Based Disaster Risk Reduction (CBDRR):** Train communities on resilient construction ➢ **Resettlement Plans:** Identify and relocate high-risk settlements to safer areas
Increased frequency of floods, cyclones, and hailstorms	Climate variability intensifies disasters, increasing vulnerability	**SDG 13 (Climate Action)**	➢ **Climate Adaptation Programs:** Promote afforestation & watershed management ➢ **Nature-Based Solutions:** Implement floodplain zoning & wetland conservation ➢ **Strengthening Early Warning Systems:** Improve IMD/NESAC forecasting services
Landslides affecting 501.19 Ha & increased pest attacks	Land degradation, soil erosion, and biodiversity loss	**SDG 15 (Life on Land)**	➢ **Reforestation & Soil Conservation:** Implement plantation drives in landslide-prone areas ➢ **Agroforestry Promotion:** Encourage tree-based farming to stabilize slopes ➢ **Pest Control Measures:** Strengthen surveillance &

			biological pest control methods

The table provides a structured analysis of disaster impacts in **South West Khasi Hills District** and aligns them with relevant **Sustainable Development Goals (SDGs)** to ensure a targeted and sustainable approach to disaster risk reduction. It highlights key disaster-induced vulnerabilities across multiple sectors, including housing, agriculture, infrastructure, water supply, and public health, while proposing appropriate interventions to mitigate these challenges.

One of the primary significances of this table is that it offers a **comprehensive disaster impact assessment**, quantifying the extent of damage caused by disasters such as floods, landslides, cyclones, hailstorms, and pest attacks. This assessment helps in understanding the economic and social costs of disasters, particularly the loss of livelihoods, displacement of families, and disruptions in essential services.

The alignment of disaster impacts with **specific SDGs** ensures that resilience-building efforts contribute to global development priorities. For example, widespread damage to houses is linked to **SDG 1 (No Poverty)**, while large-scale crop losses align with **SDG 2 (Zero Hunger)**, and disruptions to education due to school damage are associated with **SDG 4 (Quality Education)**. By structuring the response through SDG-aligned strategies, the table emphasizes sustainable and long-term solutions.

Additionally, the proposed interventions focus on **targeted resilience measures** such as **climate-resilient housing, disaster-resistant schools, emergency healthcare improvements, sustainable agricultural practices, and strengthened early warning systems**. These measures aim to reduce vulnerabilities, enhance community preparedness, and minimize future risks.

Another significant aspect of the table is its emphasis on **climate adaptation and mitigation strategies**. Given the increasing frequency of extreme weather events, the interventions prioritize nature-based solutions, floodplain zoning, afforestation, and improved early warning mechanisms to address climate-induced disasters under **SDG 13 (Climate Action)**.

Furthermore, the interventions highlight the importance of **community empowerment and policy strengthening** through initiatives such as **Community-Based Disaster Risk Reduction (CBDRR)**, stricter enforcement of building codes, and relocation of high-risk settlements. These strategies ensure that disaster preparedness becomes an integral part of local governance and community planning.

Overall, this table serves as a **blueprint for policymakers, disaster management authorities, and development agencies** to implement **risk-informed planning and resilience-building strategies**. By integrating disaster risk reduction with sustainable development, it provides a roadmap for creating safer, more resilient communities in South West Khasi Hills District.

Conclusion and Way Forward

The study highlights the severe impact of natural disasters in South West Khasi Hills District, Mawkyrwat, Meghalaya, over the last decade, affecting infrastructure, agriculture, livelihoods, and human lives. Key findings indicate significant damage from floods, landslides, cyclones, hailstorms, fire incidents, and pest attacks, exacerbated by climate variability, weak infrastructure, and limited preparedness. The research underscores the urgent need for climate-resilient infrastructure, improved early warning systems, sustainable agriculture, and community-based disaster risk reduction (CBDRR).

Moving forward, strengthening policy enforcement on building codes, enhancing disaster education, and integrating modern technology with indigenous knowledge will be crucial. Investments in resilient housing, road networks, and water management, alongside targeted livelihood recovery programs, will help reduce vulnerabilities. Multi-stakeholder collaboration between government agencies, communities, and research institutions will ensure a holistic, sustainable, and adaptive disaster risk reduction framework.

Additionally, enhancing institutional capacity through regular training programs, conducting vulnerability assessments, and integrating disaster risk reduction (DRR) into local governance and development planning will further strengthen preparedness. Expanding financial mechanisms such as risk insurance, contingency funds, and resilient livelihood programs will also help communities recover faster from disasters.

Public awareness campaigns, school safety programs, and community-led disaster response mechanisms should be prioritized to build a culture of preparedness. Strengthening partnerships with academic institutions and leveraging satellite-based disaster monitoring tools can improve data-driven decision-making. Moreover, mainstreaming gender-sensitive approaches in disaster management will ensure inclusivity and equitable resilience-building efforts.

By aligning interventions with Sustainable Development Goals (SDGs) and national disaster risk reduction frameworks, the district can enhance resilience and safeguard its communities against future disasters. A proactive, inclusive, and well-coordinated approach will be key to minimizing losses and ensuring sustainable development in the region.

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Conflicts of Interest

The authors declare that they have no competing interests.

Data collected

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