

## MOUNTAIN URBANISM IN DARJEELING HIMALAYANS: INTEGRATING SUSTAINABILITY AND DISASTER PREPAREDNESS

### URBANISM MONTAN ÎN HIMALAYA DIN DARJEELING: INTEGRAREA DURABILITĂȚII ȘI A PREGĂTIRII PENTRU DEZASTRE

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**Sumar.** Creșterea rapidă a urbanizării recente, determinată de creșterea populației, oportunitățile economice și industrializare, a devenit o preocupare la nivel global. Expansiunea necontrolată exercită presiune asupra resurselor, ceea ce duce la degradarea mediului, reducerea biodiversității și creșterea poluării. Regiunea Himalaya din Darjeeling a generat îngrijorări semnificative de ordin ecologic, precum urbanizarea accelerată, defrișările, degradarea solului, alunecările de teren și extracția apei naturale — factori care sporesc riscul de dezastre naturale în zonă. Această cercetare investighează natura dezvoltării urbane din aria de studiu și propune soluții pentru o dezvoltare urbană durabilă. În urma unui studiu de teren detaliat, realizat prin observație directă și interviuri cu părțile interesate, precum și prin revizuirea literaturii de specialitate existente, autorul oferă soluții pe termen lung, precum: stabilizarea versanților, menținerea zonelor verzi, aplicarea unor tehnici de construcție controlate și gestionarea eficientă a sistemelor de drenaj. Implementarea riguroasă a acestor tehnici în zona analizată va reduce probabilitatea producerii unor dezastre precum cutremurele, alunecările de teren și viiturile, contribuind în același timp la conservarea mediului și la dezvoltarea durabilă a regiunii. Concluziile cercetării oferă fundația pentru ghiduri de planificare urbană și inițiative politice menite să reducă riscurile dezastrului și degradarea mediului.

**Cuvinte-cheie:** Dealurile Darjeeling, Managementul dezastrelor, Conservarea mediului, Atenuarea/alungarea riscului de alunecări de teren, Planificare urbană durabilă

## INTRODUCTION

In India, mountain urbanization is a complicated blend of development and ecological constraints, particularly in the Eastern Himalayas, where Darjeeling is a noteworthy example. Once a British hill station, Darjeeling has seen a major urban transition due to population increase, tourism, and infrastructure development [1, 2]. But this evolution occurred in a fragile environmental region characterized by steep slope, high precipitation intensity, earthquake weakness, and sensitive biodiversity [3-5]. Located in a high earthquake risk region and prone to landslides and soil decay, Darjeeling is an example of complex challenges raised by mountain urbanism in the Indian context [6-8]. The city's

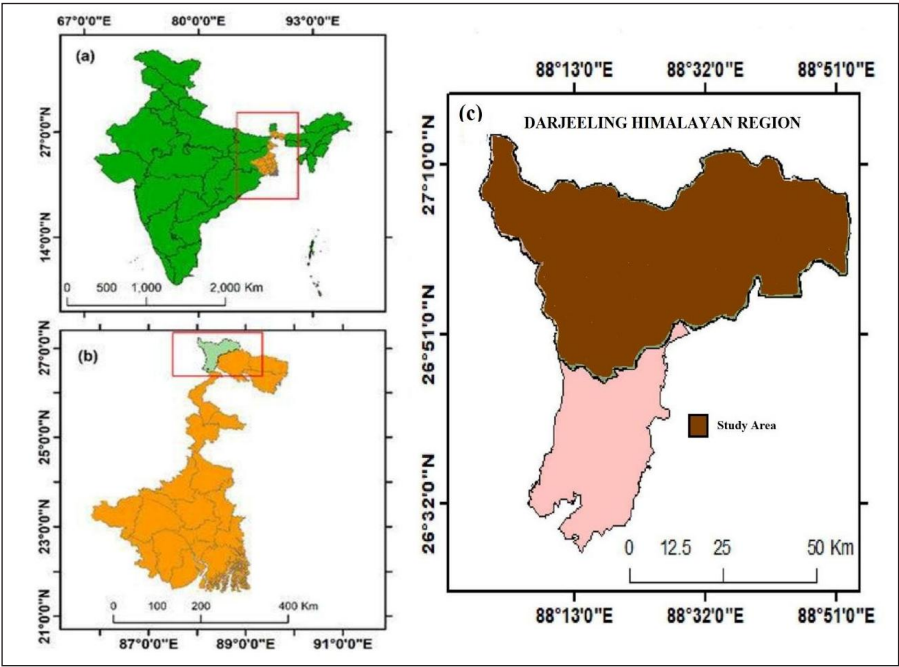
orographic precipitation, which often exceeds 3000 mm annually, destabilizes the terrain, making shield management and flow control important for sustainable development [8,9]. Uncontrolled urban growth in Darjeeling led to land-use changes that ignore topographic thresholds, resulting in landslide-prone slopes and the degradation of forest cover and ecosystems [10,11]. Fast vertical expansion and density have increased the burden of old infrastructure, resulting in additional drainage systems, solid waste deposits in water, and mountain carrying capacity [12-14]. In addition, traditional settlement planning strategies have been replaced by concrete expansion without adherence to proper geological evaluation or building codes [15,16]. This unplanned development undermines socio-economic-environmental balance and increases community weaknesses towards disaster. Many urban settlements in Darjeeling are characterized by poor road connections, insufficient water supply, lack of sanitation network, and lack of waste management, which often leads to environmental pollution and health risks.[17]. In the rainy season, these infrastructure weaknesses became catalysts for local floods and landslides, especially in informal settlements built on unstable slopes [19,20]. Urban expansion has intensified the division of forest corridors and wildlife habitat, contributing to reducing environmental pressure and ecosystem services [21,22]. Climate change adds another level of complexity to mountain urbanism, changes in precipitation type, an increase in temperature trend, and extreme weather events already pose more risk for weak urban systems [23-24]. Despite numerous policy structures and institutional processes, such as the National City Policy Structure (2018), state action plans on climate change, and the Smart City Mission-Hill Region implementation remain insufficient due to limited capacity, fragmented regime, and lack of mountain-specific urban design techniques [25,26]. The need to integrate durability in Darjeeling's hill urban planning is derived not only from environmental sensitivity but also from the need to increase the elasticity of its socioeconomic system. Concepts such as shield-sensitive architecture, blue-green infrastructure, decentralized waste treatment, and participatory planning need to be flowed in mainstreamed within the urban policy framework [27,28]. In addition, the Sendai Framework (2015-2030) emphasizes the critical need for disaster resilience in urban administration, given geographically limited and disaster-prone settings, particularly in Darjeeling [29,30]. Therefore, integration of sustainability and disaster preparation in Darjeeling's urban plan is essential to ensure environmental integrity, reduce risk, and promote the right and elastic urban future of the Himalayas.

## **MATERIAL AND METHOD**

The current study employs a mixed-methods approach that synthesizes spatial analysis, statistical techniques, and participatory research tools to generate comprehensive insights into urban-environmental challenges and opportunities in this region. The field of study, the Darjeeling Municipality and its Peri-Town Environment, is located in the East Himalayas region of West Bengal, India, characterized by steep slope, complex landforms, and high environmental sensitivity. Initial information was collected through comprehensive field inspection, including the systematic monitoring of urban infrastructure, housing

patterns, and environmental degradation. Semi-structured interviews and focus groups were conducted with local partners to collect insights about urban administration, infrastructure shortages, disaster preparations, and traditional adaptation practices, including residents, municipal officials, NGOs, and planners. Secondary data have been collected through different governmental sources like the Census of India, the Geological Survey of India, different policy papers, books, and journals. The quantitative data have been analysed through the statistical techniques and used the GIS method for the preparation of a location map.

**About the Study area:** The study area Darjeeling Himalayas geographically located in the northern part of West Bengal, 26°31' north latitude and 87°59' east to 88°53' east to 88°53' east. Part of the East Himalayas, this mountain area is composed of steep slopes, fragile geology, and is earthquake-sensitive. Urban centres like Darjeeling, Kalimpong, Kurseong, and Mirik have witnessed rapid, unplanned urban development driven by immigration. These cities are characterized by dense population, insufficient infrastructure, and increasing environmental pressure. The environment-sensitive landscape of this region frequently encounters landslides, water shortages, and waste management, which makes it an important field for studying sustainable urban development and disaster preparation. Geographical constraints in Darjeeling, the unique combination of socioeconomic diversity and environmental risk, present an interesting context to explore hill urbanism strategies. This study field provides valuable insights to maintain the balance of environmental integrity with urban elasticity in the fragile environment of the Himalayas.



Map 1: Location of the study area

## RESULTS AND DISCUSSIONS

### Urban Growth and Spatial Dynamics:

The four major hill towns and cities in the Darjeeling Himalaya are Darjeeling, Kalimpong, Kurseong, and Mirik. In 2011, 25.37% of the region's total population lived there. Urbanization is a sluggish process, but given the overall impacts it has already caused to the local ecosystem, its unchecked growth cannot be disregarded.

**Table 1:** Spatio-temporal Urban Growth (1981-2011)

| Year | Name of the Municipal Town |           |          |       | Total Urban Population<br>(Persons in Number) |
|------|----------------------------|-----------|----------|-------|-----------------------------------------------|
|      | Darjeeling                 | Kalimpong | Kurseong | Mirik |                                               |
| 1981 | 57603                      | 28885     | 18008    | -     | 104496                                        |
| 1991 | 73062                      | 38832     | 26758    | 7022  | 145674                                        |
| 2001 | 107197                     | 42998     | 40019    | 9141  | 199355                                        |
| 2011 | 118805                     | 49403     | 42446    | 11513 | 222167                                        |

Source: Census of India

Table 1, shows that in 1981, Darjeeling town accounted for almost 55% of the urban population in the Darjeeling Himalayan region. Kalimpong and Kurseong had correspondingly lower urban population proportions of 28% and 17%, respectively. In 1991, Darjeeling Town accounted for half of the urban population, followed by Kalimpong (27%), Kurseong (18%), and Mirik Town (5%). According to the data, Darjeeling had the largest percentage of urban residents in 2001, roughly 54% followed by Kalimpong (21.5%), Kurseong (20%), and Mirik (4.5%). Although the spread of urbanization has never been a significant or unique phenomenon of colonization of the hill areas, it is surprising to learn that the four towns, which are widely separated from one another, have remained relatively small in size with a slow and indecisive rate of growth. In the 2011 census, Darjeeling town had a 53.5% urban population, followed by Kurseong (19.1%) and Kalimpong (22.2%). The region's smallest town, Mirik Town, recorded a meagre 5.1% during the same census period.

**Table 2:** Spatio-Temporal Variation of Urban Growth in the Study Area

| Name of Town | 1981-1991<br>(Value in Percentage) | 1991-2001<br>(Value in Percentage) | 2001-2011<br>(Value in Percentage) |
|--------------|------------------------------------|------------------------------------|------------------------------------|
| Darjeeling   | 26.84                              | 46.72                              | 10.82                              |
| Kalimpong    | 34.44                              | 10.73                              | 14.9                               |
| Kurseong     | 48.6                               | 49.6                               | 6.06                               |
| Mirik        | 0                                  | 30.18                              | 25.94                              |

Source: prepared by the author based on Indian Census data

Population growth in the study region, which is being evaluated for this study, has been occurring since 1981. From 1981 to 2011, the population growth rate fluctuated gradually in practically every town. Darjeeling, Kalimpong, Kurseong, and Mirik are the four major hill towns in the Darjeeling District and West Bengal. Though Darjeeling is the district headquarters, its growth is relatively slow and erratic; from 1981-91, the decadal growth rate was 26.84%, which increased somewhat to 46.72% in 1991-2011 but dropped dramatically to 10.82% in 2001-2011 (Table: 2). Kurseong town experienced the most decadal change, with 48.6% and 49.6% during 1981-1991 and 1991-2001, respectively, before dropping dramatically to 6.6% between 2001 and 2011. Kalimpong, on the other hand, recorded 34.44% from 1981 to 1991, with a subsequent fall in decadal change of 10.73% from 1991 to 2011, and 14.9% from 2001 to 2011. Mirik, which only became a town in 2001, experienced a decadal population change of 30.18% from 1991 to 2001 and 25.94% from 2001 to 2011.

**Table 3:** Comparative Analysis of Urban Growth

| Census Year                                          | 1981  | 1991  | 2001  | 2011  |
|------------------------------------------------------|-------|-------|-------|-------|
| Overall Urban Growth in West Bengal State (%)        | 26.47 | 27.48 | 28.03 | 31.89 |
| Urban Growth in Darjeeling Himalayan Hill Region (%) | 27.55 | 30.47 | 32.34 | 39.42 |

Source: Census of India

The above Table 3 shows that during the year 1981, the overall growth of urbanization in West Bengal (26.47%) concerning the total population in West Bengal and the Darjeeling Himalayan Hill Region (27.55%) for the total population in the Darjeeling Himalayan Hill Region were nearly equal. However, the disparity grows over time; during the 1991 census, the Darjeeling Himalayan region experienced about 3% more urban growth (30.47%) than the state of West Bengal as a whole (27.48%). The disparity increased by around 5% between Census 2001 and Census 2011, reaching about 8% of the Darjeeling Himalayan Hill Region (39.42%) vs the total State urbanization (31.89%). As a result, the aforementioned evidence of unplanned rapid urbanization contributes to sustainable urban growth in the studied area.

***Environmental Concerns Related to Unplanned Urbanization in the Darjeeling Himalayan Hill Region:***

Rapid urbanization in the Darjeeling Himalayan hills region has serious consequences for both ecological balance and catastrophe susceptibility. This growth, driven mostly by a rising population and tourists, has put tremendous strain on the area’s natural environment, resulting in a variety of ecological disruptions and increased susceptibility to natural disasters.

***Deforestation and Loss of Biodiversity:*** Large tracts of forest are frequently destroyed to make way for new buildings, roads, and infrastructure. These forests, which

are home to diverse flora and animals, serve an important role in preserving ecological balance by stabilizing soil, supporting biodiversity, and regulating local microclimates. The loss of vegetation not only causes habitat fragmentation and species extinction, but it also affects ecosystem balance, making them more vulnerable to invading species and lowering biodiversity.

**Water Resource Strain:** Urban expansion has increased demand for water, putting a strain on the region's scarce water resources. Natural springs and streams, which are already constrained by steep topography, are frequently depleted or polluted as a result of uncontrolled garbage dumping and runoff from construction sites. The loss of green cover also reduces groundwater recharge, exacerbating water scarcity concerns. Polluted water sources endanger aquatic life and residents' health, restricting access to safe drinking water.

**Soil Erosion and Degraded Soil Quality:** When natural vegetation is destroyed for urban development, exposed soil becomes more prone to erosion, particularly during the monsoon season. Erosion depletes soil fertility, affecting local agriculture and further undermining slopes. Urban development also compacts soil, reducing its ability to absorb water, interfering with natural drainage, and limiting the regeneration of native plant species, all of which contribute to a loss in soil health and stability.

**Landslide Susceptibility:** Unregulated development on high slopes raises landslide hazards. Natural slopes are altered, and heavy concrete structures replace forests that would normally serve as natural stabilizers. During the monsoon rains, water infiltration destabilizes slopes that are no longer supported by tree roots, increasing the frequency and severity of landslides. Landslides cause infrastructure damage, harm lives, and contribute to soil and habitat loss.

**Flooding and Drainage Issues:** Natural drainage systems are frequently blocked or modified during urban expansion, resulting in flash floods and waterlogging in low-lying areas. Increased impermeable surfaces, such as roads and buildings, limit rainwater infiltration, resulting in faster and more intense runoff. Without suitable drainage systems, heavy rains quickly overwhelm the ground, generating floods that sweep away topsoil and worsen landslide hazards.

**Waste Accumulation and Pollution:** Increased urban garbage creation, particularly during tourist seasons, puts a strain on existing waste management facilities. Improper disposal procedures cause solid waste to clog drainage systems, pollute waterways, and contribute to flash flooding and sanitation difficulties. Polluted water bodies and accumulated trash worsen the environment, producing breeding grounds for illness and threatening community health.

**Climate Change Sensitivity:** Darjeeling's high altitude and sensitive ecosystems make it especially vulnerable to the effects of climate change, which are exacerbated by urbanization. Deforestation and urban pollution contribute to global warming, resulting in erratic rainfall patterns, rising temperatures, and greater vulnerability to extreme weather events. In addition to raising the risk of natural disasters like floods and landslides,

this unpredictability affects local livelihoods, especially those that depend on agriculture and tea plantations, which are particularly vulnerable to the effects of climate change. Rapid development in the Darjeeling hills destroys ecological balance and increases catastrophe susceptibility, testing the resilience of both the natural environment and local inhabitants. Sustainable urban development, which includes slope stabilization, reforestation, efficient waste management, and correct drainage, is critical for limiting these effects while preserving Darjeeling's distinctive environmental and cultural heritage.

### **Integrating Sustainability and Disaster Preparedness:**

Darjeeling Himalayan stability and disaster preparation effectively requires a versatile and active strategy that connects environmental integrity, community resilience, and a responsive regime. First, the shield-sensitive urban design must become a foundation of all construction activities, making the strategic use of terracing and maintenance walls to reduce the risk of thorough geo-technical evaluation, earthquake-resistant architecture, and landslides. Secondly, blue-green infrastructure should be widely adopted to increase environmental stability and reduce climate-related dangers; this includes bio-soil, rainwater conservation systems, urban forests, and green roof development that reduces surface flow, improves air quality, and preserves biodiversity. Third, empowering local partners by integrating domestic knowledge systems in training, awareness campaigns, participatory mapping, and hazard management plans to give institutional formation to reduce community-based disaster risk (CBDRR) by empowering local partners. A decentralized view of disaster preparation can increase ownership, improve responsibilities, and build social capital. Fourth, smart technology should be used like remote sensing, IoT-based slope monitoring, and a mobile-based initial precautions system to increase risk detection and communication. These tools must be complementary with powerful data-sharing protocols and an inter-organization combination structure. In addition, marginal communities, especially informal settlements in high-risk areas, actively engage in planning processes and further strengthen the inclusive urban regime system to ensure that basic services and protected housing are accessed. Pedagogical reforms must focus on updating and implementing the master plan, clarifying administrative overlaps between GTA and municipalities, and allocating the budget dedicated to climate resilience initiatives. Finally, sustainable tourism policy should be created to promote eco-tourism compatible with the goal of preservation, as well as limit seasonal additional burden on urban infrastructure. With an integrated, participatory, and place-specific structure, Darjeeling can become a model of sustainable hill urbanism that not only protects its unique environmental and cultural heritage but also ensures a safer and more resilient future for its residents.

## **CONCLUSIONS**

The urban growth of Darjeeling has expanded to high-risk areas characterized by steep slopes, volatile geology, and environmental sensitivity, increasing landslides, sudden floods, and water shortages. The study highlights how informal settlements, insufficient

solid waste management, old water infrastructure, and poorly applied building rules have significantly increased both environmental degradation and disaster risk. At the same time, low-level community awareness and fragmented institutional reactions limit the city's ability to prepare and mitigate and mitigate for climate-induced and geopolitical hazards. However, the research also highlights emerging opportunities for community-driven initiatives, green infrastructure, decentralized systems, and the promotion of sustainable and resilient urbanism through traditional environmental knowledge. Darjeeling's urban planning practice requires an exemplary change to adjust to its unique geographical and climatic reality. Correcting and applying sensitive urban master plans to the risk of earthquakes and slope instability, mapping scientific hazards and environmental restrictions, is essential to integrate with zoning laws and building regulations. Community-based disaster preparation, including a local warning system and Word-level risk reduction plan, must be institutional and supported through regular training and imitation. Eco-sensitive zoning, supported by an effective monitoring system, should prevent further occupation in important shields, forests, and exhaust corridors. The most important thing is that resilience in regional development strategies must be brought to the mainstream by incorporating climate adaptation, risk management, and sustainable infrastructure plans in the original order of local and state authorities. Darjeeling experience provides valuable insights for mountain cities across the Himalayas, which demonstrates the urgent requirements of inclusive and futuristic urban planning, integrated at the root of sustainability and disaster preparation.

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