Research Article

Urban health as a diagnostic lens for sustainability

Exposing policy myopia through Himalayan urbanisation

Mehul Chaudhary, Venu Shree

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Keywords: urban health; policy myopia; sustainability paradigms; land use land cover dynamics; Himalayan ecosystems.

Abstract. *Contemporary sustainability discussions revolve around the notions of resilience, liveability, social cohesion and green infrastructure. However, the integration of urban health within the policy planning remains explicitly limited. The research argues that urban health is often treated as secondary concern rather than an intrinsic indicator of socio-ecological well-being. Such treatment reflects a deeper limitation within the existing sustainability frameworks. These frameworks remain largely anthropocentric, growth oriented and insufficiently grounded in ecological and public health realities particularly in a fragile mountain ecosystem. Shimla, a major Himalayan city and deemed to be Smart City, is examined through spatio-temporal patterns of urban expansion with supervised classification of multi-decadal Landsat imagery. The analysis indicates a structural misalignment between urban growth trajectories and conditions required for socio-ecological well-being. Rather than interpreting these spatial changes as isolated planning failures, the findings are placed within a multi-level analysis of sustainability frameworks. These findings assess the nature and extent of urban health considerations being conceived, operationalised and monitored. The study stresses at the clear lack of understanding of regional, topographical realities while translating policy planning aimed at urban health. This policy myopia not only undermines the stated objectives of sustainable urbanism but also results in health vulnerabilities. The research advances urban health as a*

critical diagnostic lens through which the adequacy of sustainability frameworks can be evaluated, particularly in ecologically sensitive regions such as the Himalayas. The research finds that sustainability approaches which fail to stress on urban health inadvertently normalise socio-ecological degradation, thereby eroding the very conditions they seek to protect. The study concludes by outlining a health-centred, context-responsive planning outlook that repositions urban health as an organising principle for sustainable urbanism, rather than an auxiliary policy objective.

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1. Introduction: Urban health and sustainability

1.1 The sustainability paradox

Over the past decades, sustainability has emerged as a dominant paradigm guiding environmental governance, urban planning and global development policy. Since the publication of the Brundtland Report (World Commission on Environment and Development, 1987), sustainability has been institutionalised across international policy frameworks, national development agendas, and urban planning strategies. The proliferation of sustainability-oriented governance initiatives including climate adaptation policies, resilient city frameworks, and green urban development programmes reflects the widespread acceptance of sustainability as a normative and operational development objective. However, socio-ecological conditions in many urban regions continue to deteriorate. Rapid urbanisation, environmental degradation, climate vulnerability, and increasing socio-spatial inequality remain persistent global challenges, particularly in ecologically sensitive environments (Rockström et al., 2009; Steffen et al., 2015). Sustainability as a vision seems to have been morphed into phenomenon that prioritises economic growth while accommodating environmental management through technological and infrastructural adaptation (Dryzek, 2013; Scoones, 2016).

Urban environments exemplify this contradiction. Cities are frequently promoted as engines of sustainable development through efficiency-driven infrastructure, technological innovation, and smart urban governance models. However, empirical evidence indicates that rapid urban expansion often produces new patterns of environmental vulnerability, infrastructure stress, and

spatial inequality (Seto et al., 2012; Angelo & Wachsmuth, 2015). The persistence of such vulnerabilities raises critical questions regarding how sustainability is defined, measured, and implemented within urban governance systems. Addressing these questions requires moving beyond performance-based sustainability indicators, and toward evaluative frameworks which are capable of capturing the cumulative socio-ecological consequences of urban transformation.

1.2 Urban health as an overlooked sustainability indicator

Current sustainability assessments typically measure environmental performance through indicators related to resource efficiency, infrastructure development, while health outcomes are often treated as a consequential outcome. Such separation then leads to limit the capacity of development frameworks to understand how spatial transformations influence urban health. Thus, urban health remains an under-utilised framework for evaluating sustainability outcomes. Recent scholarship has emphasised the inseparability of urban health and ecological stability, particularly through the emergence of planetary health and healthy cities frameworks (Whitmee et al., 2015; Myers & Frumkin, 2020). Urban planning research similarly demonstrates that built environment characteristics including land use configuration, transportation systems, and service delivery play a major role in determining physical and mental health outcomes (Corburn, 2009; Giles-Corti et al., 2016). Therefore, urban health becomes an intrinsic property of socio-ecological systems which are shaped by environmental quality, infrastructure accessibility, and spatial development.

Reframing urban health as a critical indicator of sustainability shifts the evaluative focus from environmental performance metrics toward the lived experiences of socio-ecological vulnerability. Health-centred sustainability evaluation can help governance systems to detect early warning signals of environmental degradation, infrastructure overload, and spatial inequality that may not be captured through conventional planning indicators (Higgs, C., et al.; White et al., 2024). Despite its integrative potential, urban health remains marginal within mainstream sustainability governance, highlighting a critical blind spot in contemporary sustainability discourse. Such marginalisation only reflects deeper epistemological priorities embedded within current sustainability frameworks, where resilience and socio-ecological systems are often understood through technical and environmental metrics rather than lived wellbeing outcomes (Li et al., 2014; Sterling et al., 2017).

1.3 Fragility of Himalayan urbanisation

Ecologically fragile urban environments provide particularly revealing contexts for examining the limitations of sustainability governance. Mountain cities, characterised by steep terrain, limited land availability, fragile hydrological systems, and climatic variability, impose natural constraints on urban expansion that intensify the consequences of spatial transformation (Dey, P., et al., 2025). The Himalayan mountain range widely recognised as one of the world's most environmentally sensitive and climate-vulnerable mountain systems, has experienced rapid urbanisation in recent decades (Wang, Y., et al., 2019). Urban growth in mountain regions often accelerates environmental disturbance. Land transformation, slope modification, and vegetation loss can destabilise hydrological systems; thus, increasing disaster risk, and intensifying environmental exposure (Xu et al., 2009; Pathak, L., et al., 2025). These dynamics create socio-ecological conditions in which sustainability governance failures become more visible, making mountain urbanisation a valuable conceptual context for evaluating sustainability frameworks. Therefore, Himalayan urban centres function as amplified socio-ecological systems where cumulative impacts of growth-oriented planning, and governance fragmentation can be examined with much clarity. Understanding sustainability in such fragile environment provides critical insights into how sustainability governance performs under ecological constraint and vulnerability stress, offering lessons with broader global relevance (Li, et al., 2014; Dey, P., et al., 2025).

1.4 Research aim and contribution

Against this background, this study critically examines contemporary sustainability governance through an integrative lens of urban health, using the Himalayan city of Shimla as an empirical context. The study seeks to address three interrelated objectives. First, it interrogates the conceptual limitations of sustainability discourse, particularly its anthropocentric and growth-compatible development paradigms. Second, it develops an interdisciplinary framework that positions urban health as a diagnostic lens for evaluating sustainability outcomes. Third, it applies this framework to examine how spatial transformation, ecological change, and governance fragmentation interact to shape socio-ecological vulnerability within fragile mountain urban systems. By integrating spatial analysis, policy evaluation, and socio-ecological interpretation, this study to contributes to the arguments that seek to re-envision sustainability as a governance paradigm centred on socio-ecological well-being rather than growth-compatible development. By positioning urban health as a diagnostic and

organising principle rather than a policy objective, the research challenges anthropocentric and growth-compatible sustainability paradigms that prioritise infrastructural and economic performance over socio-ecological well-being.

2. Anthropocentrism, growth and policy myopia in sustainability discourse

2.1 The evolution of sustainability: from ecological limits to managerial governance

The concept of sustainability emerged in response to growing global recognition of the ecological consequences of industrial expansion and resource exploitation. However, the institutionalisation of sustainability through the Brundtland Commission marked a critical conceptual shift. While "*Our Common Future"* successfully integrated environmental concerns into global development discourse, it simultaneously framed sustainability as a process compatible with continued economic growth and technological advancement (World Commission on Environment and Development, 1987). This formulation initiated a gradual transformation of sustainability from an ecological cautionary framework into a governance-oriented developmental paradigm. Over time, sustainability increasingly became associated with regulatory management, performance measurement, and technocratic policy instruments designed to balance environmental protection with economic expansion (Hajer, 1995; Meadowcroft, 2007; Jordan & Huitema, 2014). Contemporary sustainability governance reflects this transformation through its reliance on indicator-based evaluation frameworks, including global sustainability indices and policy performance metrics (Gudmundsson, 2003; Böhringer & Jochem, 2007; Turnhout et al., 2007; Bell & Morse, 2008). This has reoriented sustainability toward managerial rationality which emphasises quantifiable outcomes over systemic ecological understanding (Turnhout et al., 2014). The prioritisation of measurable performance indicators often simplifies complex socio-ecological interactions, favouring interventions that produce immediate policy visibility while neglecting cumulative and context-specific environmental consequences.

2.2 Anthropocentrism in sustainability paradigms

Despite its ecological vocabulary, contemporary sustainability discourse remains deeply rooted in anthropocentric epistemologies (Washington et al., 2017; Kopnina et al., 2018). Anthropocentrism positions human welfare as the central organising principle of environmental governance, framing natural systems primarily in terms of their utility for human survival, economic productivity, and

societal stability (Eckersley, 1992; Rolston, 1988). This is evident in dominant sustainability models that views ecosystems as service providers which support human development rather than as intrinsically valuable and interdependent systems (Norgaard, 2010). By translating ecological processes into economic and functional benefits, sustainability frameworks reinforce the perception of nature as a resource base rather than a co-evolving system within which human societies are embedded (McCauley, 2006; Gómez-Baggethun & Ruiz-Pérez, 2011). This often leads to prioritisation of ecological functions that generate measurable human benefits, and marginalisation of those that lack immediate economic or utilitarian visibility (Robertson, 2006; Kosoy & Corbera, 2010).

Anthropocentrism also expresses broader sustainability narratives associated with the Anthropocene, which frequently emphasise human agency as the dominant force shaping planetary processes (Crutzen, 2002). While this framework has drawn attention to the scale of human environmental impact, it has simultaneously reinforced conceptual hierarchies that position humanity as pivot managing ecological transformation (Swyngedouw, 2010). Eco-centric perspectives challenge this hierarchy by emphasising interdependence between human and non-human systems, arguing that sustainability requires reconfiguration of human development within ecological limits rather than technological or managerial control over environmental processes (Naess, 1973; Washington et al., 2017; Kopnina et al., 2018). Anthropocentric assumptions often manifest through planning frameworks that prioritise human economic and infrastructural needs while treating ecological considerations as constraints to be managed rather than foundational determinants of spatial development (Angelo & Wachsmuth, 2015). Consequently, environmental planning frequently becomes an exercise in optimising human activity within acceptable ecological risk thresholds (Alberti, 2008; Pickett et al., 2013). This structural anthropocentrism shapes urban governance priorities, influencing how sustainability interventions are designed, evaluated, and implemented.

2.3 Urban sustainability and development narratives

Urban sustainability has increasingly evolved within a policy environment that reconciles environmental responsibility with economic growth and urban expansion (While et al., 2004; Gouldson et al., 2015). Rather than challenging growth-driven urbanisation, many sustainability initiatives seek to render urban growth more efficient, technologically advanced, and environmentally optimised (Swyngedouw, 2010; Angelo & Wachsmuth, 2015). This is particularly evident in the formulation of smart city frameworks, green infrastructure programmes, and

climate-resilient urban development models, which frequently emphasise technological innovation and infrastructural modernisation as pathways to sustainability (March & Ribera-Fumaz, 2016; Kaika, 2017). Urban governance increasingly adopts strategies that integrate sustainability with economic development agendas, positioning environmental initiatives as mechanisms for enhancing urban competitiveness rather than as instruments for restraining ecological degradation (While et al., 2004; Bulkeley et al., 2011; Angelo & Wachsmuth, 2015). Such growth-compatible sustainability narratives generate spatial and ecological contradictions. Urban expansion into ecologically sensitive areas, intensification of built environments, and infrastructure-driven development frequently increase environmental vulnerability while simultaneously being framed as sustainable through selective performance indicators (Gouldson et al., 2015; Kaika, 2017). Thus, sustainability becomes aligned with urban growth trajectories rather than serving as a framework for evaluating their ecological and social viability. As a result, sustainability planning often focuses on mitigating the consequences of urban expansion without addressing its underlying drivers, reinforcing development pathways that generate cumulative socio-ecological pressures (Checker, 2011; Gouldson et al., 2015).

2.4 The marginalisation of urban health in sustainability planning

One of the most significant consequences of anthropocentric and growth-oriented sustainability paradigms is the systematic marginalisation of urban health as a major planning consideration (Kickbusch, 2010; Rydin et al., 2012). Although health is widely recognised as an outcome influenced by environmental and spatial conditions, it is rarely integrated as a foundational indicator within sustainability governance frameworks (Mori & Christodoulou, 2012; WHO, 2016). Instead, urban health is frequently addressed through sector-specific interventions that operate independently of spatial planning and environmental governance processes (Corburn, 2009). frameworks often fail to incorporate these interconnections systematically (Rydin et al., 2012). The fragmentation of governance structures contributes to this marginalisation. Environmental management, infrastructure planning, and public health administration frequently operate within separate institutional domains, limiting opportunities for integrated policy design (Kickbusch, 2010; WHO & UN-Habitat, 2016). Consequently, sustainability policies tend to address environmental risk through regulatory or technological interventions without fully considering the cumulative health implications of spatial transformation and ecological degradation (Whitmee et al., 2015). Furthermore, sustainability assessment

metrics typically prioritise environmental performance indicators such as emission reduction, resource efficiency, and infrastructure capacity, while neglecting health-related dimensions that capture lived environmental experience (Böhringer & Jochem, 2007; Mori & Christodoulou, 2012). This separation reinforces a reactive approach to health governance, in which public health interventions respond to environmental hazards after they emerge rather than anticipating and preventing socio-ecological health stress through integrated planning (Rydin et al., 2012).

2.5 Policy myopia as an outcome of contemporary sustainability governance

The convergence of managerial sustainability governance, anthropocentric development paradigms, and growth-oriented urban planning generates a condition that can be conceptualised as policy myopia (Harvey, 1989; Swyngedouw, 2009). Policy myopia refers to governance frameworks that prioritise short-term, measurable outcomes while overlooking long-term socio-ecological consequences and context-specific environmental dynamics (Boston, 2017). Sustainability governance is often faced with what have been termed "super wicked problems" that are characterized by the interdependence of environmental, social, and economic processes that operate over large spatial and temporal scales (Rittel & Webber, 1973; Levin et al., 2012). However, policy frameworks designed to address these challenges often operate within administrative performance structures, and funding mechanisms that favour immediate and visible outcomes (Pierson, 2004; Meadowcroft, 2011). Such mismatches contribute to governance strategies that focus on symptom management rather than structural transformation (Ostrom, 2009; Geels, 2011).

Such policy myopia is further expanded due to the translation of global sustainability frameworks into local planning contexts without adequate consideration of regional ecological characteristics and socio-spatial vulnerabilities (Bulkeley, H., 2006). This translation may obscure terrain-specific environmental risks, climatic variability, and localised patterns of urban exposure, leading to interventions that replicate policy templates rather than responding to ecological realities (Cash et al., 2003; Anguelovski et al., 2016). Additionally, institutional fragmentation and knowledge politics within sustainability governance can limit the integration of interdisciplinary evidence, reinforcing decision-making processes that prioritise technical expertise over regional, socio-ecological understanding (Folke et al., 2005; Turnhout et al., 2013). Collectively, these governance dynamics produce sustainability policies that appear environmentally progressive while failing to address the structural conditions that

generate socio-ecological vulnerability. Therefore, urban health, by the virtue of linking environmental exposure, spatial development, and social well-being, offers a potential diagnostic lens through which the adequacy of sustainability governance can be critically assessed.

3. Urban health as a diagnostic lens for sustainability

3.1 Reframing urban health

Urban health has historically been conceptualised within biomedical and epidemiological frameworks that primarily focus on disease prevention, healthcare provision, and clinical outcomes (Rosen, 1993; Susser & Susser, 1996). While these approaches have contributed significantly to improving public health governance, they often treat health as a sectoral concern that operates independently of spatial planning, environmental governance, and socio-ecological processes (Marmot, 2005; Kickbusch, 2010). This limits the ability of sustainability planning to address the cumulative environmental and infrastructural conditions (Solar & Irwin, 2010). Recent urban planning scholarship demonstrates that built environment characteristics including density patterns, land use configuration, environmental exposure, and infrastructure distribution play a central role in shaping physical and psychological health outcomes (Dannenberg et al., 2003; Barton & Grant, 2006; Corburn, 2009). Research linking urban sprawl, transportation systems, and environmental exposure to chronic disease prevalence further reinforces the understanding that health outcomes are spatially produced and environmentally mediated (Ewing et al., 2003; Frumkin et al., 2004). These perspectives collectively suggest that health cannot be treated as an isolated outcome of development but must instead be understood as a reflection of broader socio-ecological conditions (Diez Roux & Mair, 2010). Reframing urban health as a spatial and environmental condition allows it to function as a bridge between environmental sustainability and social well-being (Northridge et al., 2003). This expanded understanding positions urban health as an emergent property of urban socio-ecological systems rather than as a niche policy outcome (Sallis et al., 2016). This provides a foundation for evaluating sustainability interventions through their cumulative effects on ecological resilience (Folke et al., 2005).

3.2 Urban health as an integrative sustainability indicator

Urban health offers a unique capacity to integrate multiple dimensions of sustainability that are often treated separately within conventional governance

frameworks (Northridge et al., 2003; Sallis et al., 2016). Sustainability assessments typically rely on indicators that measure environmental performance, economic efficiency, or infrastructure development independently, resulting in fragmented evaluation systems that fail to capture cumulative socio-ecological interactions (Morse, 2015; Turnhout et al., 2007). Urban health, by contrast, reflects the combined influence of environmental quality, spatial equity, resource distribution, and infrastructure adequacy, thereby functioning as a holistic indicator of urban sustainability (Barton & Grant, 2006). The healthy cities movement and subsequent planning-health integration research have demonstrated that urban environments influence health through interconnected pathways involving environmental exposure, accessibility to services, social inclusion, and ecological stability (Hancock, 1993; Corburn, 2009; Rydin et al., 2012). These interactions highlight the importance of recognising health as a lived experience of sustainability, shaped by everyday environmental conditions rather than abstract policy targets (Diez Roux & Mair, 2010). Contemporary sustainability scholarship increasingly emphasises the need to shift evaluation frameworks from purely economic or resource efficiency metrics toward broader well-being indicators. Moreover, health outcomes often serve as early warning signals of socio-ecological stress. Therefore, urban health aligns with this paradigm shift by capturing the social and environmental dimensions of sustainability through measurable and experiential indicators of well-being (WHO, 2016).

3.3 Urban health as a diagnostic framework

Beyond its role as an integrative indicator, urban health can function as a diagnostic framework for evaluating sustainability governance. Sustainability governance frequently relies on quantitative indicators that assess environmental performance through metrics such as emission reduction, infrastructure efficiency, or resource utilisation. While such indicators provide valuable monitoring tools, they often fail to capture the complex socio-ecological interactions through which environmental and planning decisions influence human well-being (Böhringer & Jochem, 2007; Mori & Christodoulou, 2012). Urban ecosystems research emphasises that sustainability outcomes emerge due to interrelationship between environmental conditions, institutional governance, and human behaviour (Ostrom, 2009; Folke et al., 2010). Hence, urban health outcomes provide a cumulative reflection of governance effectiveness because they capture the lived consequences of spatial planning, infrastructure development, and environmental management decisions.

Urban health can therefore be interpreted as a diagnostic lens that reveals policy blind spots and governance failures. When sustainability policies prioritise infrastructure expansion or economic competitiveness without accounting for spatial and ecological vulnerabilities, health stresses often emerge. By tracing these relationships, urban health allows for critical evaluation of sustainability governance beyond the limits of conventional performance indicators. Furthermore, urban health operates as an interdisciplinary governance tool that connects planning, environmental management, and public health administration (Kickbusch, 2010; WHO & UN-Habitat, 2016). By integrating these domains, health-centred evaluation frameworks can facilitate more comprehensive sustainability governance capable of addressing cumulative socio-ecological challenges. Such integration is particularly important in contexts where fragmented institutional responsibilities limit the capacity of individual policy sectors to address complex environmental vulnerabilities.

3.4 Diagnostic relevance in ecologically fragile urban areas

The diagnostic capacity of urban health becomes particularly significant in ecologically fragile urban environments. In such areas, environmental transformation often produces accelerated and amplified impacts. Mountain ecosystems are characterised by steep terrain, fragile soil stability, limited resource availability, and climatic variability, all of which constrain urban expansion and increase exposure to environmental risk (Messerli and Ives, 1997; Wester et al., 2019). Ecological transformations and disruptions in such areas very rapidly convert into environmental vulnerabilities. Climate change further exacerbates these vulnerabilities by accelerating glacial retreat, altering precipitation patterns, and increasing the frequency of extreme weather events across Himalayan ecosystems (Xu et al., 2009). Within such fragile socio-ecological systems, urban health provides a particularly sensitive indicator of sustainability performance. Because environmental disruptions often produce immediate consequences. Therefore, urban health outcomes can reveal sustainability challenges that remain obscured within conventional planning metrics. Himalayan urban centres can act as ideal ecosystems to understand the cumulative impacts of sustainability governance. By applying an urban health diagnostic framework to these contexts, it becomes quite possible to assess and evaluate the adequacy of sustainability planning in such fragile ecosystems where ecological and human vulnerabilities are tightly interlinked.

4. Study area and methodological approach

4.1 Study area: Shimla

Shimla, prior to its development as a hill station was described as an "obscure village". The village was named 'Shimla' after the temple of Goddess Shyamala located in the village. Another legend is that 'Shimla' or 'Simla' is named as is pronounced by the hill people. Shimla is located at an elevation of 2130 m above mean sea level on a ridge. It is situated on the last Traverse spur of the Central Himalayas, at 31°40 North to 31°100 North latitude and 77°50 East to 77°150 East longitude. It is the largest hilltop town of Northern India (A. Kumar & Pushplata, 2015; TCPO, 2022). Shimla Planning Area is spread over an area of 22,450 hectares. Municipal Corporation Shimla, and Special Area Development Authorities of Kufri, Shoghi and Ghanahatti are four main zones/areas of Shimla Planning Area (A. Kumar & Pushplata, 2015).

Figure 1. Map of India (Source: Wikimedia Commons)

Figure 2. Map of Himachal Pradesh (Source: Wikimedia Commons)

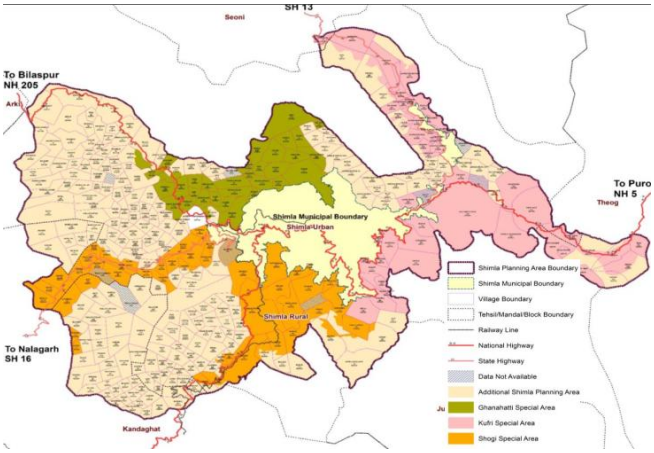

Figure 3. Map of Shimla planning area (Source: TCPO, Govt. of HP)

The city is spread over seven hill spurs, namely, Jakhoo Hill, Elysium Hill, Museum Hill, Prospect Hill, Observatory Hill, Summer Hill, and Potters Hill. These spurs are interconnected by roads. Thus, the development pattern in Shimla is governed by topographical constraints such as steep slopes, elongated hilly spurs, forest areas and zones of perpetual sunshades. The town of Shimla sits at a ridge line and is quite accessible by various modes of transportation. The nearest International Airports from Shimla are Chandigarh Airport and Delhi Airport, roughly 115 km and 365 km respectively by road. Being a major town, Shimla commands very strong influence on the nearby towns which act as countermagnets having varying characters of their own. The major reason for Shimla having a much greater influence on the surroundings lies in it being the summer capital and the administrative centre of the state of Himachal Pradesh.

4.2 Methodological framework

This study adopts a mixed-method analytical framework that integrates spatial analysis, policy evaluation, and socio-ecological interpretation to examine the sustainability implications of urban expansion in Shimla. The research design is structured to evaluate how patterns of spatial transformation interact with planning governance and environmental vulnerability, thereby enabling assessment of sustainability outcomes through the diagnostic lens of urban health. Spatial transformation in Shimla was examined using multi-temporal satellite imagery derived from the Landsat programme, which provides consistent and reliable medium-resolution earth observation data suitable for long-term landscape change analysis (Garg, A., Sharma, S., 2025). Satellite images representing selected temporal intervals were processed to capture changes in land use and land cover patterns associated with urban expansion. The selected datasets enabled evaluation of built-up growth, vegetation change, and alteration of open land and natural surfaces over time.

The evolution of the landscape of a specific area over time was assessed through land use and land cover (LULC) change analysis, which provides important evidence for urban and environmental planning. LULC maps for Shimla Municipal Corporation were prepared for the census years 2001, 2011, and 2021 in ArcGIS using Landsat 7 imagery for 2001 and 2011 and Landsat 8 imagery for 2021. The satellite data were obtained from the United States Geological Survey Earth Explorer platform. Bands 1 to 7 were stacked sequentially to generate composite imagery, and the municipal boundary of Shimla was superimposed to isolate the study area. The ESRI land cover classification framework was adapted to define six land-cover classes suitable to Shimla's mountainous urban

morphology: agriculture land, built-up area, dense vegetation, barren land, range land, and sparse vegetation. A minimum of 15 training samples were selected for each class using contemporaneous high-resolution Google Earth imagery as reference to improve class discrimination, and supervised classification was performed to generate the LULC maps. The years 2001, 2011, and 2021 were selected because they correspond to India's decadal census cycle, thereby allowing land transformation to be interpreted alongside demographic and planning transitions. For accuracy assessment, independent validation points were interpreted using high-resolution Google Earth imagery and evaluated through confusion matrix analysis. The raster outputs were subsequently converted into polygons for area calculation. To detect changes in land cover, polygons of each class were dissolved and intersected, and change detection analysis was performed to quantify built-up expansion.

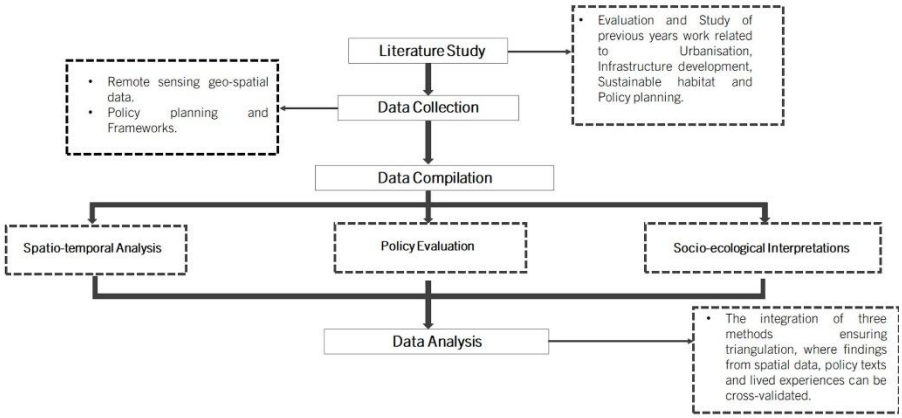

Figure 4. Methodological approach to the study (Source: Author)

To complement spatial analysis, the study examined key urban planning and development policy documents relevant to Shimla's urban governance framework. Policy document selection was guided by relevance to statutory planning, urban governance, and sustainability-oriented interventions within Shimla Planning Area. The review focused on key planning and policy documents produced between 2005 and 2024, including the Shimla Development Plan, municipal planning provisions, Smart City proposals, and sectoral infrastructure documents issued by state and local planning authorities. Documents were

selected based on their direct role in shaping land use regulation, infrastructure planning, and environmental governance. Analytical interpretation was conducted through thematic reading, with attention to recurring themes related to sustainability objectives, ecological sensitivity, infrastructure priorities, and health-related planning considerations. Particular attention was given to identifying terrain-sensitive planning considerations, ecological risk management strategies, and health-related environmental indicators. The integration of spatial and policy analysis provides a methodological foundation for applying the urban health diagnostic framework proposed in this study. By examining the interaction between spatial development patterns and planning frameworks, the methodological approach allows for interpretation of sustainability outcomes through their cumulative implications for environmental stability, infrastructure functionality, and social well-being. This integrated analytical design provides the empirical basis for assessing how urban expansion in Shimla reflects broader structural challenges within sustainability governance.

5. Results and Discussion

5.1 Spatio-temporal analysis

The spatio-temporal transformation of Shimla's urban landscape reveals patterns of development that align closely with growth-compatible sustainability paradigms. Multi-temporal land use analysis indicates a persistent expansion of built-up areas between 2001 and 2021, with urban growth extending along ridge corridors and progressively occupying slope-sensitive zones that were historically characterised by forest cover and open land. Rather than demonstrating spatial restraint or ecological sensitivity, the observed expansion reflects development trajectories that accommodate economic and infrastructural growth within the language of sustainability. The overall classification accuracies were 84.6%, 87.2%, and 89.8% for 2001, 2011, and 2021 respectively, with corresponding kappa coefficients of 0.79, 0.84, and 0.878, indicating satisfactory to very good agreement across all temporal datasets. For the 2021 classification, 147 validation points distributed across the six land-cover classes produced an overall accuracy of 89.8% and a kappa coefficient of 0.878, indicating very good classification reliability for medium-resolution spatial analysis in mountainous urban terrain.

This spatial trajectory reinforces the persistence of anthropocentric planning logics in which environmental systems are reconfigured to support urban growth rather than acting as regulatory constraints on development. The reduction of ecological buffering landscapes, particularly slope-stabilising vegetation,

demonstrates how sustainability governance often facilitates growth through infrastructural adaptation rather than spatial limitation. The supervised classification of Landsat imagery for 2001, 2011, and 2021 indicates a consistent expansion of built-up areas within Shimla Municipal Corporation (SMC). Between 2001 and 2011, approximately 4.18 km² of new built-up area was added, followed by an additional 3.73 km² between 2011 and 2021. Although some localized reductions in built-up classification were observed reflecting reclassification or redevelopment, the overall trajectory points toward intensified urban consolidation and outward expansion. Simultaneously, significant transitions occurred within vegetated classes. Dense vegetation experienced notable fluctuations, with a recorded loss of approximately 4.3 km² during the first decade (Appendix A).

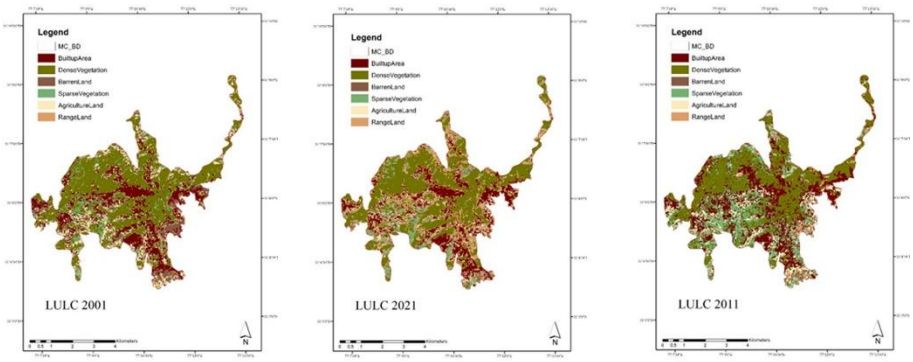

Figure 5. Land use, land cover change in Shimla MC (Source: Author)

Table 1. Overall accuracy assessment (Source: Author))

Classification accuracy assessment for multi-temporal LULC Maps		
Year	**Overall Accuracy (%)**	**Kappa Coefficient**
2001	84.6	0.79
2011	87.2	0.84
2021	89.8	0.87

Sparse vegetation and agricultural lands similarly exhibited conversion patterns, frequently transitioning into built-up or barren categories. While some gains in

dense vegetation were recorded in certain sub-periods, these were spatially uneven and often occurred in peripheral zones rather than compensating for central ecological disruption. In a mountain ecosystem characterized by steep slopes (ranging from 0° to 71°) and high ecological sensitivity, such transitions are not spatially neutral. Vegetation in Himalayan towns functions not merely as aesthetic or recreational space, but as a critical ecological regulator that stabilises slopes, moderates microclimates. The conversion of vegetated surfaces into impermeable built-up land, therefore, represents a reconfiguration of ecological infrastructure into constructed form. Rather than reflecting organic urban growth, these transformations signal a reallocation of ecological buffers toward growth-oriented land use priorities (Appendix B).

Overlay analysis further indicates that built-up expansion has increasingly occurred along south-facing slopes and within zones historically associated with drainage pathways and agricultural terraces. South-facing slopes, comprising nearly 58% of SMC's municipal area, offer favourable conditions for physical development due to solar exposure. However, their intensified occupation also concentrates construction pressure in topographically sensitive areas. New construction clusters frequently overlap with historical drainage channels, contributing to chronic water stagnation during monsoon seasons. The disruption of natural runoff systems amplifies flash flood risks and exacerbates slope instability. These spatial patterns reveal that urban expansion in Shimla is guided primarily by accessibility, market viability, and development feasibility rather than ecological thresholds. In this context, the growth trajectory of the city increasingly conflicts with the biophysical constraints of its mountain terrain.

5.2 Ecological transformation

The spatial expansion of urban development in Shimla has generated ecological transformations that extend beyond land cover change, reflecting the progressive erosion of mountain ecosystem resilience. The reduction of forest cover and open land has altered hydrological regulation processes, increased surface runoff and modifying natural drainage networks. Vegetation loss within slope systems has also increased susceptibility to landslide hazards and soil instability. In mountain urban environments, vegetation performs critical ecological functions by stabilising fragile terrain and regulating hydrological cycles. The removal of these ecological buffers accelerates the translation of environmental disturbance into infrastructural and human vulnerability. These ecological disruptions are further intensified by climatic variability, which has increased rainfall irregularity

and extreme weather events across Himalayan ecosystems, thereby amplifying environmental exposure risks.

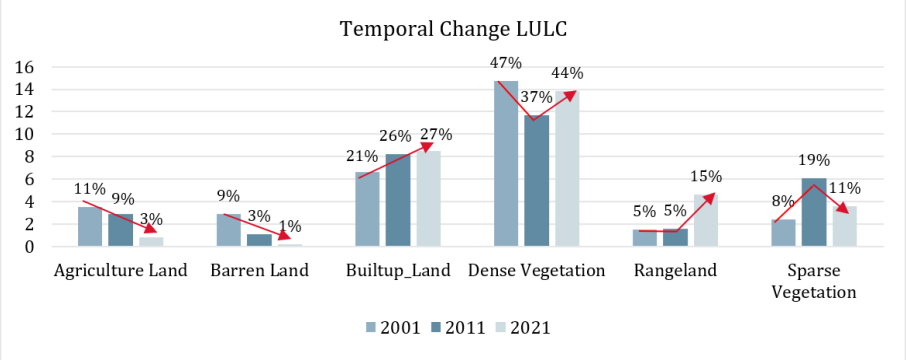

Figure 6. Temporal change in Shimla MC (Source: Author)

The ecological transformations observed in Shimla demonstrate the limitations of sustainability frameworks that treat ecosystems as service providers supporting development rather than as foundational regulatory systems. The fragmentation of ecological landscapes reduces environmental resilience and increases infrastructural sensitivity to climatic stress, reinforcing the argument that sustainability governance must move beyond managerial environmental performance indicators toward integrated socio-ecological evaluation. These findings provide empirical support for the critique of instrumental ecological governance.

5.3 Infrastructure stress and urban vulnerability

The spatial transformation of Shimla has produced pronounced mismatches between urban growth and infrastructure capacity, illustrating how growth-led planning can generate lived socio-ecological vulnerability. Rapid expansion of built-up areas has intensified demand for water supply, waste management, transportation infrastructure, and public services, often exceeding the functional capacity of existing systems. Seasonal water shortages and uneven distribution of water resources have become recurring urban challenges, reflecting the difficulty of sustaining population growth within hydrologically constrained mountain environments. Waste management and sanitation infrastructure have similarly

struggled to adapt to increased tourism and residential density, resulting in environmental contamination and public health risk exposure.

Figure 7. Densely developed core area of Shimla MC (Source: Author)

Figure 8. Southern slope manipulation in Shimla (Source: Author)

The expansion of informal and semi-formal settlements in terrain-sensitive areas has intensified spatial inequality in infrastructure provision, increasing vulnerability to environmental hazards and service inaccessibility. These infrastructural vulnerabilities illustrate how sustainability governance frameworks that prioritise economic growth and urban modernisation may inadvertently intensify environmental and social risk when spatial expansion outpaces service integration. Infrastructure stress functions as a key mediator between environmental transformation and human well-being, demonstrating how socio-spatial vulnerability emerges through the cumulative interaction of planning decisions, ecological change, and service distribution inequality. These findings provide empirical grounding for interpreting urban health as an integrative indicator of sustainability governance effectiveness.

5.4 Policy myopia and sustainability governance misalignment

The spatial and infrastructural transformations identified in Shimla reveal significant misalignments between sustainability policy commitments and urban development outcomes, illustrating the phenomenon of policy myopia conceptualised. Planning frameworks, including statutory master plans and Smart Cities initiatives, articulate sustainability objectives that emphasise environmental protection, infrastructure efficiency, and urban liveability. However, empirical spatial analysis demonstrates that urban expansion continues to occur within ecologically sensitive zones, indicating a disconnect between policy intent and implementation outcomes. This governance disjunction reflects sustainability frameworks that prioritise short-term development visibility and infrastructure expansion while overlooking long-term socio-ecological vulnerability (Appendix C).

Policy evaluation indicates that sustainability initiatives frequently rely on performance metrics related to infrastructure provision, tourism growth, and urban competitiveness, which may obscure terrain-specific ecological risks and cumulative environmental exposure patterns. The fragmentation of governance across sectoral programmes further limits integrated planning, resulting in parallel policy initiatives that fail to address interconnected sustainability challenges. The persistence of development in hazard-prone zones and the absence of health-sensitive environmental indicators within planning frameworks demonstrate how sustainability governance can produce symbolic compliance without achieving substantive socio-ecological resilience. These governance dynamics illustrate the structural reproduction of anthropocentric and growth-oriented sustainability paradigms, reinforcing the argument that

policy frameworks often accommodate development pressures rather than regulating them.

5.5 Urban health as the diagnostic reveal

In the study, urban health is applied primarily as a conceptual-analytical framework through which the cumulative implications of spatial transformation, infrastructure stress, and ecological vulnerability are interpreted. Direct quantitative health indicators such as morbidity records, disease incidence, or environmental exposure datasets at spatially disaggregated scale were not consistently available for Shimla during the study period. Therefore, health implications are inferred through established spatial attributes including infrastructure stress, ecological disturbance, terrain-sensitive expansion, and service pressure. The cumulative interaction between spatial expansion, ecological transformation, infrastructure stress, and governance misalignment provides empirical validation for interpreting urban health as a diagnostic lens for sustainability evaluation. The spatial concentration of development in ecologically sensitive zones increases exposure to environmental hazards, while infrastructure overload reduces accessibility to essential services that directly influence social well-being. Areas experiencing rapid land transformation and infrastructure pressure frequently correspond with increased environmental risk and reduced urban liveability, illustrating how health outcomes reflect the success or failure of sustainability planning interventions. By evaluating spatial development through its implications for social well-being, urban health enables critical assessment of sustainability governance beyond conventional environmental or infrastructural performance metrics.

The empirical patterns observed in Shimla demonstrate that urban health functions as an integrative evaluative framework capable of revealing structural sustainability blind spots. The diagnostic application of health-based interpretation highlights how planning decisions, environmental transformation, and governance fragmentation collectively shape urban vulnerability, reinforcing the conceptual proposition that sustainability must be evaluated through its capacity to support socio-ecological well-being.

5.6 Shimla: an amplified sustainability contradiction

While the spatial transformations observed in Shimla are influenced by local geographic and institutional conditions, they also reflect broader structural challenges within sustainability governance in ecologically fragile urban environments. Mountain cities amplify sustainability contradictions because

ecological carrying capacity, infrastructure limitations, and environmental vulnerability interact more intensely than in lowland urban systems. The accelerated translation of ecological disturbance into human vulnerability within such contexts provides insight into the limitations of growth-oriented sustainability planning. The patterns of spatial expansion, infrastructure stress, and environmental vulnerability identified in the study highlight the need for planning frameworks that integrate ecological sensitivity, terrain-responsive development, and health-centred sustainability evaluation. These findings hold broader relevance for mountain urbanisation globally and underscore the importance of reorienting sustainability governance toward socio-ecological resilience rather than growth-compatible urban expansion.

6. Re-envisioning sustainability through urban health

6.1 Moving beyond growth-compatible sustainability

The empirical and conceptual findings of this study highlight the need to reconsider the foundational assumptions underpinning contemporary sustainability governance. While sustainability discourse has increasingly emphasised environmental responsibility and urban resilience, development trajectories often suggest that sustainability functions as a managerial paradigm rather than transformative framework. The spatial expansion patterns observed in Shimla demonstrate how sustainability policies frequently accommodate urban growth through infrastructural and technological adaptation rather than through ecological restraint or terrain-responsive planning. Re-envisioning sustainability therefore requires moving beyond anthropocentric frameworks that prioritise economic expansion and urban competitiveness as central development goals. Instead, sustainability must be reconceptualised as a governance paradigm grounded in ecological limits, socio-spatial equity, and human well-being. This shift requires recognising that urban growth is not inherently synonymous with physical development and that sustainability governance must actively regulate spatial expansion in accordance with environmental resilience.

6.2 Urban health as an intrinsic sustainability paradigm

The diagnostic application of urban health developed in this study offers a potential pathway for reorienting sustainability evaluation and governance. Positioning urban health as a sustainability paradigm shifts governance priorities from performance metrics toward experiential indicators of socio-ecological resilience. This perspective emphasises the importance of planning systems that

prioritise environmental stability, equitable service distribution, and vulnerability-sensitive development. The integrative nature of urban health allows sustainability governance to detect early warning signals of ecological stress and infrastructure overload, enabling anticipatory policy interventions rather than reactive infrastructural adaptation. Furthermore, the urban health framework promotes interdisciplinary governance by linking planning, environmental management, and public health administration.

By positioning urban health at the centre of sustainability governance represents more than an analytical reframing; it constitutes a paradigmatic shift in how sustainability is conceptualised, evaluated, and pursued. A health-centred sustainability paradigm interprets environmental stability, infrastructure provision, and spatial equity not as parallel objectives to be balanced, but as interdependent conditions that collectively shape socio-ecological well-being. Therefore, sustainability success is assessed through long term social well-being and urban resilience, rather than physical development, or technological advancements.

6.3 Reorienting sustainability governance

The findings of this study suggest that sustainability governance must move beyond sectoral policy fragmentation toward integrated socio-ecological planning approaches. The governance misalignments observed in Shimla illustrate how parallel policy initiatives in infrastructure development, environmental management, and public health often operate without sufficient coordination, limiting their capacity to address interconnected sustainability challenges. Socio-ecological sensitivity should become a foundational principle of sustainability planning, particularly within ecologically fragile urban environments. Terrain-responsive planning, ecological risk assessment, and vulnerability mapping should be integrated into spatial planning frameworks to ensure that development trajectories align with environmental constraints. Such approaches require moving beyond standardised urban development models toward context-specific planning strategies that recognise the unique socio-ecological dynamics of mountain cities and other fragile ecosystems.

Reorienting governance also necessitates the incorporation of qualitative indicators related to environmental exposure, spatial inequality, and infrastructure accessibility into sustainability evaluation frameworks. By prioritising these indicators, sustainability governance can better capture the cumulative impacts of urban transformation on human well-being and environmental resilience, enabling more equitable and ecologically responsive

planning interventions. Within a health-centred sustainability framework, governance decisions are justified not primarily through projected economic returns or infrastructural performance, but through their anticipated effects on socio-ecological vulnerability and long-term well-being. This reorientation prioritises precaution, terrain-responsiveness, and cumulative impact assessment over short-term optimisation, enabling planning systems to recognise environmental thresholds and human exposure as fundamental constraints on development.

6.4 Towards a health-centred vision of sustainability

The case of Shimla demonstrates that mountain cities provide an important pedestal for rethinking sustainability governance. Ecological fragility, terrain constraints, and climatic variability amplify the visibility of sustainability contradictions, allowing the cumulative impacts of growth-oriented planning to become more rapidly apparent. These conditions highlight the limitations of conventional sustainability frameworks and underscore the urgency of developing governance models that prioritise ecological stability and human vulnerability reduction. Re-envisioning sustainability ultimately requires a normative shift toward health-centred urban development that places socio-ecological well-being at the core of planning and governance frameworks. Such a vision does not reject urban growth but instead calls for development trajectories that are guided by regional, context-specific thresholds. By repositioning health as a central evaluative principle, sustainability governance can move beyond symbolic environmental commitments toward substantive socio-ecological transformation.

7. Conclusions

Contemporary sustainability discourse has occupied a paradoxical position within global development practice. While sustainability has emerged as a dominant framework for guiding environmental governance and urban planning, it often operates within conceptual boundaries that allow growth-oriented development to continue largely unquestioned. This study contributes to an emerging body of scholarship that interrogates the structural assumptions embedded within sustainability governance. By examining sustainability through the integrative lens of urban health, the research highlights how environmental transformation, spatial planning decisions, and governance fragmentation converge to shape lived experiences of socio-ecological vulnerability. The implications of this perspective

extend beyond specific case contexts. If sustainability is to function as a meaningful framework for navigating the environmental and social uncertainties of contemporary urbanisation, it must move beyond anthropocentric and growth-compatible development narratives. Such a shift necessitates planning paradigms that prioritise ecological carrying capacity, vulnerability-sensitive spatial development, and equitable access to environmental and infrastructural resources.

The significance of fragile urban ecosystems, including mountain cities and other environmentally sensitive regions, lies in their capacity to expose sustainability contradictions with heightened clarity. In such contexts, ecological disturbance, infrastructural stress, and social vulnerability interact more rapidly and visibly, offering critical insight into the structural limitations of prevailing sustainability frameworks. Lessons derived from these amplified environments underscore the need for governance models that integrate ecological sensitivity with interdisciplinary planning and long-term resilience thinking. Ultimately, re-envisioning sustainability requires moving beyond the pursuit of development trajectories that seek to balance economic growth with environmental management. Instead, sustainability must be reconceptualised as a normative and governance paradigm centred on socio-ecological well-being. By framing sustainability through the diagnostic and normative lens of urban health, this research contributes to a broader intellectual effort to reimagine sustainability as a lived, relational, and socio-ecologically grounded practice. In an era defined by accelerating environmental change and urban expansion, the capacity to evaluate development through its implications for ecological resilience and human vulnerability may offer one of the most critical pathways for advancing genuinely sustainable futures.

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Authors

Mehul Chaudhary, mehulchaudhary0997@gmail.com

Venu Shree *(corresponding author),* venushree@nith.ac.in

Department of Architecture, National Institute of Technology, Hamirpur, India.

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