Towards Sustainable and Congestion Resilient Urban Design for the New Satellite Hill Towns: The Case of Jathia Devi, Shimla, India

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Abstract

Shimla, the capital of Himachal Pradesh, highlights the pressing need for systematic and sustainable urban design, especially evident in emerging satellite hill towns like Jathia Devi. Formerly charming, Shimla now grapples with excessive structures and congestion, eroding its allure and posing hazards such as landslides. The scarcity of urban spaces compounds the issue.

Congestion arises from centralized urban amenities, stifling the city's core. To address this, the Himachal government proposes counter-magnet urban hubs such as Jathia Devi. This 13.24-hectare site near Shimla's airport offers an opportunity for re-imagining urban planning, prioritizing congestion mitigation and hill town aesthetics.

This research outlines a path for analysing hill sites and creating strategic maps for congestion-resilient urban design, securing the hill towns' allure. Using Jathia Devi as a case study, the research forges a framework in harmony with the hill landscapes. The goal is sustainable urban design: an integration of green spaces and amenities to reduce congestion.

The methodology includes site analysis, topographical mapping, infrastructure evaluation, and consideration of the surroundings. The paper proposes urban design principles promoting balanced growth, efficient transportation and community engagement. By drawing from literature, the study unveils strategies harmonizing expansion with the allure of the hill towns.

In conclusion, this research offers a road-map for congestion-resilient hill towns through site-specific analysis. By translating insights from Jathia Devi into strategies, the paper envisions a future where hill towns regain their charm, enhancing residents' and visitors' quality of life.

Keywords: Sustainable Urban Design, Hill Town Congestion, Satellite Towns, Site Analysis, Congestion Mitigation, Hill Town Aesthetics.

Introduction

Shimla is a hill town located in the Shimla district of the state of Himachal Pradesh. It has a unique combination of hills, spurs and valleys. It is formed by connecting 7 different hill spurs, namely: Jakhoo Hill, Elysium Hill, Museum Hill, Prospect Hill, Observatory Hill, Summer Hill, and Potters Hill. Shimla is located at an elevation of 2,500 meters above the sea

level. It was initially a small hill settlement having temples on the highest peak such as the Dhungi mata temple on Sanjauli hill. Later, it was discovered by the British and, amazed by its scenic beauty, natural hill character and mild climate, they declared Shimla as the summer capital of British India (Mehrotra, 2021).

The British introduced a lot of developments to this hill town with their technological advancements. They connected it with the lower planes by introducing a railroad between Shimla and Kalka, which is now a UNESCO heritage site. Further, to connect Shimla to the upper Himalayan hill towns, the British introduced a tunnel in the Dhalli area which helped ease out the grain and food supply transportation between upper Himachal and Shimla. In fact, it was a part of the state of Punjab before the partition of India and Pakistan. A few years after the partition, East Punjab was further divided into three regions based on geography and language. Hence, Hindi speaking natives residing on hilly terrains were identified as natives of the newly formed state of Himachal Pradesh, and Shimla was declared as the capital of Himachal Pradesh (Bhasin, 2007).

Due to this, a lot of developments have happened in Shimla. Urban magnets, such as IGMC SHIMLA have been proposed and developed in the core of it. Educational institutions also have begun to develop in this zone, following which military camp bases have also been set up. Later, the Apple Market, the largest business market of Himachal was established. These developments changed the agricultural economy of Shimla to a business, healthcare, and educational economy. These facilities attracted a lot of upper Himachal residents who didn't want to leave the hills yet were getting all the facilities of any developed town in the planes. The population influx was of agricultural background. Now, to survive in Shimla, they started the business of hospitality and, hence, the hotel industry boomed in the core of Shimla too. This added to the floating population of the hill town (Bhasin, 1992).

Fig. 1: Ridge plaza view of the church
Source: Author

Fig. 2: Built-up congestion in the Sanjauli town
Source: The tiles of India

Today, due to the concentrated urban magnets, it has exceeded its carrying capacity and has turned into a concrete jungle with haphazard developments. This development is so inappropriate and uncontrolled that the buildings have been built on the steepest of slopes, over natural rain water drainage causing massive built-up congestion on the sunny side of the slopes. The congestion is such that there are residential developments without any direct road access. This load on the 7 hills is causing massive environmental degradation, loss of natural hill character, climate change and natural disasters. In fact, tourists visiting Shimla do not experience natural scenic views any more, but only limited views of heritage buildings surrounded by massive built mass congestion (Shekhar, 2011).

The climate has been drastically affected by congestion as now Shimla experiences less snow fall and hot summers. Due to the unplanned and uncontrolled developments, land form changes have also occurred. This has led to massive damage to the natural terrain causing frequent disasters of landslides. Rapid growth and lack of building control governance have also led to unauthorized construction of high-rise buildings on the steep slopes, which is against the nature of hill towns and has caused severe damage during the events of the earthquake. Shimla falls in the seismic zone 4 (Kumar and Pushplata, 2015)

To limit this environmental degradation, the town and country planning department of Shimla has proposed counter magnets for the development of a special planning area surrounding the Shimla municipal planning area. These counter magnets have educational hubs, IT hubs, residential hubs, and recreational hubs. There are new roads proposed to connect these hubs not just to the core of Shimla but also to the plane cities located in the foot hills of the Himalayas and the upper Himachal cities and districts. In future, these counter magnets would be converted into satellite towns of Shimla. To avoid the planning of these towns leading to more congestion as that in Shimla, causing environmental degradation, steps need to be formulated to design Congestion Resilient Urban Design for Satellite Hill Towns. (Draft Development Plan, 2023)

There is very little research on congestion-resilient urban design for satellite hill towns despite the growing interest in urban designers role in mitigating the impact of congestion. While urban congestion is well-studied in the metropolitan areas, the distinct complexities and constraints of hilly terrains have been largely neglected. The absence of comprehensive urban planning and design strategies tailored to address congestion issues and promote resilience in such settings further exacerbates the problem.

In this context, the aim of this research is to develop a comprehensive and systematic approach towards sustainable and congestion-resilient urban design for the satellite hill towns, with a specific focus on the case of Jathia Devi in Shimla.

Its objectives are as follows:

- To identify the specific congestion-related challenges faced by hill towns, and gain a comprehensive understanding of the factors contributing to urban congestion on hilly terrains.
- To examine the effects on topography and geographical features in order to emphasize the importance of sustainable and congestion-resilient urban design solutions.
- To develop a systematic and context-specific urban design framework for the satellite hill towns, taking into account the identified challenges and the specific characteristics of the hill towns, to alleviate congestion and enhance resilience.

Further, the research poses the following question. What is the most effective and context-specific systematic approach to achieving sustainable and congestion-resilient urban design in satellite hill towns?

Background to the Issue

Urban Developments in Hill Towns

Hill towns, often steeped in historical and cultural significance, face a common challenge of balancing their heritage with the demands of modernization. This struggle becomes particularly evident in towns such as Mandi located in Himachal Pradesh. The coexistence of traditional architectural marvels and the inevitable push towards contemporary development creates a delicate

equilibrium. The consequences of unchecked expansion, such as congestion, inadequate infrastructure and environmental strain are not unique to Mandi. They are emblematic of the broader issues that many hill towns encounter due to rapid urbanization. Preserving the distinct charm, cultural heritage, and natural environment of these towns requires the implementation of comprehensive planning strategies that go beyond immediate development gains. Striking the right balance demands a holistic approach, encompassing meticulous urban planning, thoughtful infrastructure design, adherence to building regulations, and an unwavering commitment to safeguarding the historical and social fabric that defines these hill communities (Saini, et al., 2022).

Urban Developments and Ecological Sensitivity

Rapid developments in these delicate hill areas over the last few decades have led to issues such as soil erosion, unplanned developments, traffic congestions, and inadequate infrastructure. Migration and tourism have altered land use patterns, contributing to soil erosion and increased temperature. Excessive slope cutting, deforestation and commercial tree cutting have worsened erosion and have led to landslides. Land scarcity, compounded by slope characteristics and vegetation demands careful land management. Additionally, population pressure, livestock grazing and deforestation have degraded forest cover and land productivity. Despite limited carrying capacity, hill towns have become densely populated with high-rise structures, causing overcrowding and environmental strains (Sharma et al., 2022)

Built-up Congestion in the Hill Towns

There is an inter-play of aesthetics and visual discomfort in urban design contexts. Proper building orientation particularly maximizing southern sun exposure for thermal comfort, is crucial. The development pressure faced by picturesque hill towns has significantly altered their original charm. The construction of modern buildings in these towns, often using non-local materials and design techniques, has eroded their distinct urban character. Furthermore, hillside structures constructed without setbacks detract from scenic views and compromise the overall town landscape. This highlights the tension between aesthetics and functional design principles in these settings (Sharma, et al., 2022).

Sustainable Urban Developments of Historic Towns

Shimla is a historic town facing rapid urbanization, causing challenges of policy planning for sustainable urban development. There is a need for comprehensive and systematic policy guidelines that align with the unique cultural and architectural aspects of historic towns. There is a gap between policy intentions and on-ground implementation, which often results in inadequate protection of heritage elements, a lack of comprehensive zoning regulations, and a failure to integrate the natural environment with the built forms. It is recommended to have specific interventions, including heritage-specific legislation and regulations, as well as a bottom-up approach that considers the individual characteristics of each town for sustainable urban development (Kashkari & Brar, 2023).

Theoretical Basis

Inhabitant's satisfaction for sustainability

There are three key aspects to be considered when dealing with sustainability. They are: environmental, economic and social. Each aspect evaluates specific factors related to neighbourhood design. These factors are further assessed within sub-categories involving both physical and non-physical elements.

Environmental aspects encompass density, layout, land use, and connectivity/transport infrastructure. Social factors involve layout, land use, connectivity/transport infrastructure, building types and architectural character. Economic considerations mainly revolve around the layout and land use (Wijesundara, Weerasinghe & Perera 2021).

Influence of Culture on Urban Design

Culture plays a pivotal role in shaping spatial development and urban design. It influences everything from the layout of streets and buildings to the design of public spaces. Cultural norms, values and traditions often dictate architectural styles, building materials and the arrangement of

spaces. Local customs can impact the scale and function of the structures, determining whether a community prioritizes communal gathering areas or private spaces. Moreover, cultural practices may inform transportation systems, as well as the integration of natural elements into urban environments. Ultimately, understanding cultural influences is crucial for creating harmonious and functional urban spaces that resonate with the people who inhabit them (Priyomarsono, 2021)

New Satellite Towns

The satellite cities aim to achieve a harmonious balance between people and resources, focused on environmentally friendly developments. They aim to provide affordable housing for a significant portion of the population while transforming these satellite cities into smart urban centres. The main reasons behind establishing satellite urban cities are: alleviating congestion in the main cities, creating economic sub-centres, optimizing land usage, preserving ecological balance, converting labor force into workforce, and enhancing overall economic growth and resource management. Satellite towns like Gurgaon and Noida have effectively eased congestion in the metropolitan areas, offering opportunities for migrants to access proper housing, economic prospects and cultural diversity. This decongestion strategy can be seen as a form of "Density Optimization" (Krishnan and Sujith, 2021)

Smart Sustainable Cities

Key attributes of smart sustainable cities are as follows. Smart data is harnessed to advance sustainable development goals effectively. Urban performance, planning, and systems are elevated, fostering collaboration among urban regions to address environmental challenges, growth, and evolving socio-economic needs. Comprehensive monitoring, analysis, management, and control of IT and advanced communication tools optimize city operations, planning and functionality. Enhanced citizen engagement is prioritized, promoting digital inclusion, equity, safety, transportation efficiency and accessibility (Hafia Salim Abdulkareem & Dheah Hameed Basee).

Creation and Perceptions of places

Physical elements, activities, and semantic meanings shape places, and underscore their multi-dimensional nature. While physical arrangements and activities influence places, human observers and users also play a crucial role through their expectations, experiences, and intentions. Environments that reflect people’s mental constructs and meanings associated with places can evolve, transfer, and possess attributes such as complexity and clarity. When designing or restoring spaces, architects must consider the interplay of time and place, honouring the originality and spirit of the location. This doesn't entail mere replication but rather a reinterpretation that maintains a living tradition, aligning with the authenticity phenomenologists seek. ‘Sense of place’ encompasses emotional dimensions, from joy to discomfort, while in religious and historical places, it's often referred to as the spirit of place. Orientation and recognition form the core of a person's connection to a place, cultivating a sense of place (Khorasgani1 et al.,2023)

Eco city

The objective of an eco-city is to safeguard both the natural environment and local cultural identities. This is achieved by highlighting the exceptional features of natural and landscape heritage while ensuring a seamless ecological connection between urban and natural spaces. Parks not only provide green spaces but also serve as connectors between residential neighborhoods, promoting both biodiversity and soft mobility. The ecocity aims to maintain a substantial green space ratio of 25m² per inhabitant. Furthermore, urban development regulations are designed to incorporate mandatory tree alignments along the main roads, allocate 20% of the local green spaces for children's playgrounds, and encourage features like green facades, green roofs, and green alleys, fostering a refreshing and verdant atmosphere in the city (Rharbi, & Inceoglu, 2022).

Popular urbanization

Popular urbanization centers need to foster the creation of popular cities through the active engagement of residents in social and political movements to attain improved living conditions and official recognition. Such urbanization fosters socially sustainable cities characterized by vibrancy, solidarity and a sense of place. Self-sustainability, a relatively recent term, aligns with the broader

notion of sustainability. It encompasses goals like meeting future generations' rights, maintaining positive built environment performance, rationalizing resource consumption, and reducing pollution. Self-social sustainability pertains to desired behavioural patterns that enable individuals to be sustained over time. Cities, viewed as self-developing systems, adapt internally to external influences. It's society's responsibility to determine what to preserve for the future. In the context of popular cities, social reserves represent concentrated urban areas united by informal cultural values related to gender, nationality and religion. These areas thrive on shared ancestry, traditions, and routines, often reflected in similar housing designs and materials. Social reserves strategically adapt to their built environment, reflecting their self-adaptive social systems and cultural preferences (AlShamari, 2022).

Congestion Resilient

Urban density and congestion resilience are influenced by the spatial distribution of different types of land, including open spaces, residential areas and green spaces, which play a crucial role in maintaining diverse functions and species diversity. The ‘source-sink’ landscape theory, rooted in landscape ecology, is introduced to evaluate urban density resilience by considering the interaction between landscape patterns and ecological processes. This theory identifies ‘source’ landscapes that intensify urban heat island (UHI) effects and ‘sink’ landscapes that mitigate UHI effects. The theory posits that the negative impacts of ‘source’ landscapes can be counterbalanced by ‘sink’ landscapes. Indeed, accessibility of these landscapes determines their spatial allocation balance. In fact, this study employs land use and land cover (LULC) classification, categorizing impervious urban surfaces as ‘sources’ and agricultural, forest, and water areas as ‘sinks.’ Calculations involve measuring distances between these patches and deriving a standardized index to determine urban density resilience. Higher index values indicate greater urban density resilience, while lower values signify lower density and resilience (Cao, 2021)

Research Methodology

This research employed a case study method. It followed the steps as follows.

Case study was selected on the basis that it is one of the counter magnet sites, a satellite hill town near Shimla. Jathi Devi was selected as the primary case study based on the presence of proposed roads which makes it prone to population influx and future congestion.

Identification of the problem and review of urban design of the core of Shimla: Creating GIS based maps to analyse the congestion in the core of the Shimla planning area with the help of a physical survey of the area and primary data collection.

Site analysis, data collection & mapping and a detailed site analysis wereas conducted to understand the geographical, environmental, cultural, and infrastructural context of the area. This includes collecting data on topography, geology, land use, cultural heritage, existing infrastructure, transportation networks and natural features.

Based on the findings from the site analysis and mapping, a systematic and context-specific urban design framework was developed for Jathia Devi. This framework addresses the congestion-related challenges while preserving the natural and cultural heritage of the area. It should incorporate principles of sustainable land use, efficient transportation, green spaces, and heritage preservation.

Case Study Area - An Overview

A draft development plan created by the town and country planning department of Shimla demarcates 6 counter magnet zones which are potential sites for satellite towns of Shimla. The residential, commercial, and IT hub counter magnet is proposed near the Shimla airport, which is accessible by SH-16 along with two proposed roads. One of these connects NH-5 to NH-205 and the other one connects SH-16 with upper Himachal. This counter-magnet will be developed as a satellite town, Jathia Devi, and has high potential to be developed as a model hill town for sustainable and congestion-resilient urban design.

Fig. 3: The State of Himachal Pradesh
Source: Author

Fig. 4: District of Shimla
Source: Author

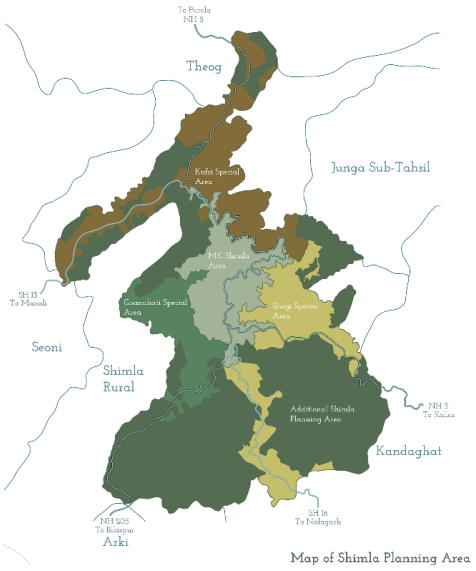

Fig. 5: Shimla Planning Area
Source: Author

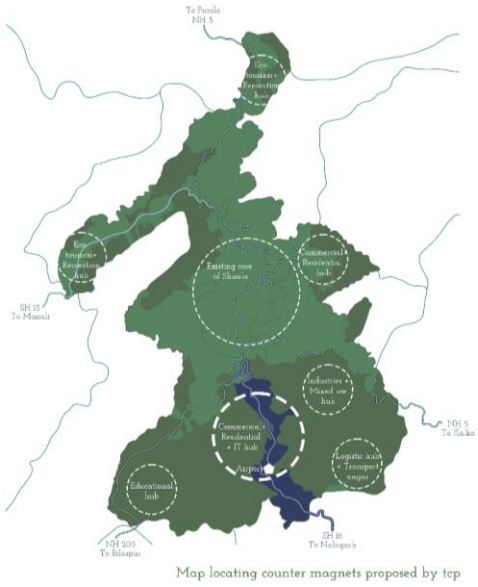

Fig. 6: Counter Magnets
Source: Author

Fig. 7: Proposed Roads by TCP Shimla
Source: Author

Fig. 8: Case Study Site of Jathia Devi
Source: Author

Findings

The existing core of Shimla

Built-up congestion in the core of Shimla is studied using image survey of the area and GIS mapping of the region falling into four visibly congested wards, namely: Ward no. 1 - Bharari, Ward nos. 2 to 14 - Ram Bazaar, Ward nos. 3 to 15 - Lower Bazaar and, Ward nos. 4 to 16 - Jhakhu. The study finds out the built up congestion distribution based on land use maps and building use maps created using GIS, and primary and secondary data collected from the field survey and government offices respectively.

Fig. 9: Reserved green forests in Shimla: A view from the helipad Sanjauli at Shimla.
Source: Author

Fig. 10: Figure ground map of the wards (ward 1 bharari, 14 Ram bazar, 15 lower bazar, 16 Jhakhu)
Source: Author

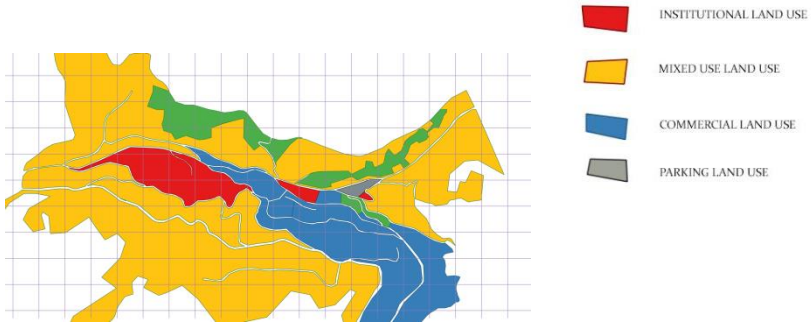

Fig. 11: GIS generated Land use map of ridge, mall road, lakkar bazar, middle bazar, lower bazar region (falls under wards 1, 14, 15 and 16)
Source: Author

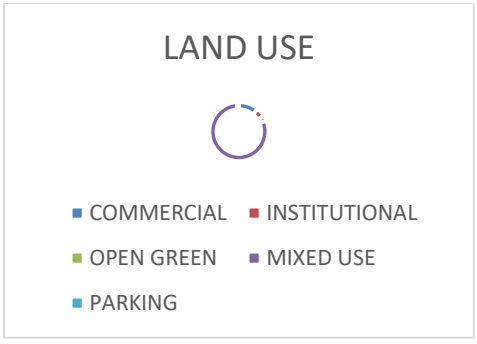

Fig. 12: Land use distribution t of ridge, mall road, lakkar bazar, middle bazar, lower bazar region (falls under ward 1, 14, 15 & 16)
Source: Author

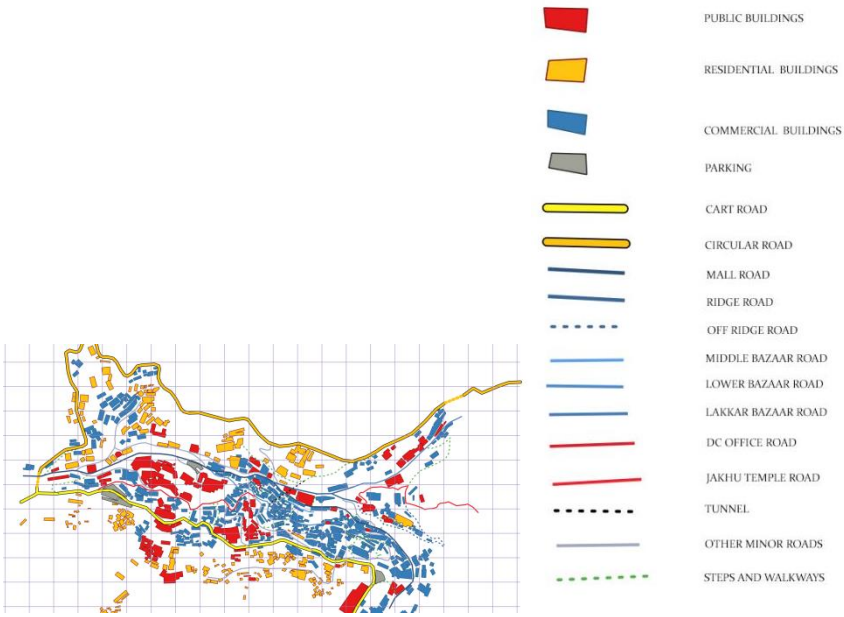

Fig. 13: GIS generated Building use map of ridge, mall road, lakkar bazar, middle bazar, lower bazar region (falls under ward 1, 14, 15 & 16)
Source: Author

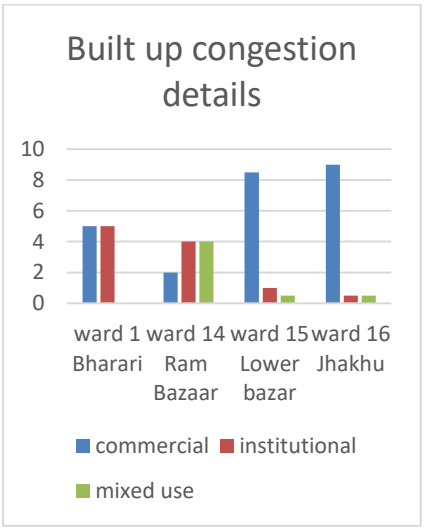

Fig. 14: Built up congestion distribution of ridge, mall road, lakkar bazar, middle bazar, lower bazaar region (falls under ward 1, 14, 15 & 16)
Source: Author

Fig. 15: Built up congestion around Ram bazaar ward viewed from the mall road.
Source: Author

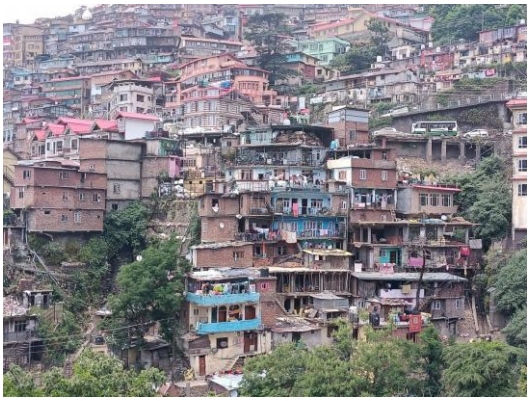

Fig. 16: Built up congestion around Ram Bazaar ward, viewed from the multi-story car parking lot near the lift.
Source: Author

Fig. 17: Built up congestion around Ram Bazaar ward, viewed from the multi-story car parking lot near the lift.
Source: Author

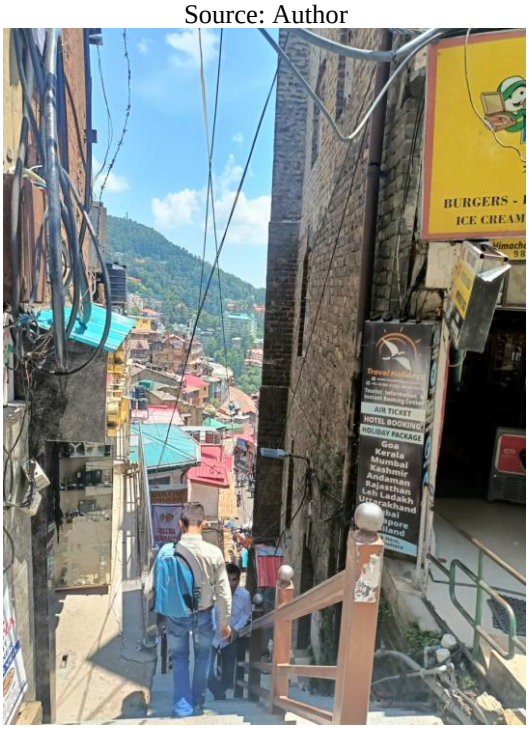

Fig. 18: Steps leading from the mall road to the lower bazaar - view demonstrating the extent of built up congestion
Source: Author

Site Analysis of the New Satellite Town - Jathia Devi

Jathia Devi, nestled in the hills, boasts a unique set of geographical and environmental characteristics that demand careful consideration for congestion-resilient urban design. This site analysis delves into the specific findings that are crucial for developing a sustainable, efficient, and visually appealing urban solution for this hill town.

Table 1: Site characteristics and urban design decisions for creating a congestion-resilient hill towns. Source: Author

No	Type of map	Constitution of the Map
1	Geology Map	Shows the geological composition of the site, including rock types, formations, and soil characteristics.
2	Cultural Context Map	Identifies cultural landmarks, historical sites, and heritage elements in the area, providing insight into the town's cultural significance.
3	Scenic Views and Natural Hill Character Map	Highlights viewpoints and areas with exceptional natural beauty, contribute to the town's visual appeal.
4	Contours and Site Section Map	Displays elevation contours, helping to visualize the site's topography and variations in height. Site sections provide cross-sectional views.
5	Hill Shade Analysis Map	Utilizes shading to depict how light and shadows interact with the terrain, enhancing understanding of slopes and land forms..
6	Site Flora and Fauna Map	illustrates the distribution of plant and animal species, aiding in ecological assessments and conservation efforts.
7	Relief Map	A three-dimensional representation of the site's topography, giving a tactile sense of elevation differences.
8	Gradient Analysis Map	Depicts changes in slope intensity across the site, helping in understand potential drainage patterns and erosion risks.
9	Slope Orientation Map	Indicates the direction each slope faces, influencing factors like sunlight exposure and micro-climates.
10	Ridge Valley Analysis Map	Identifies ridges and valleys, crucial for planning development and preserving natural drainage courses.
11	Summit Basin Analysis Map	Maps high points and depressions, assisting in water flow analysis and open space planning.
12	Existing Services Map	Displays current infrastructure like roads, utilities, and buildings, guiding design decisions and avoiding conflicts.
13	Land Suitability Map	Evaluates different areas for their appropriateness for specific uses, aiding in efficient land allocation and zoning.

Identifying the geology

Identifying hill slopes, soil type, ridge lines, spur lines, valley lines and rivers is important to avoid any clash between the existing natural hill character and the proposed settlement and infrastructure. Valley lines denote the natural drain channels on hills. These help in preventing flooding on hills. Hence, retaining them is advisable.

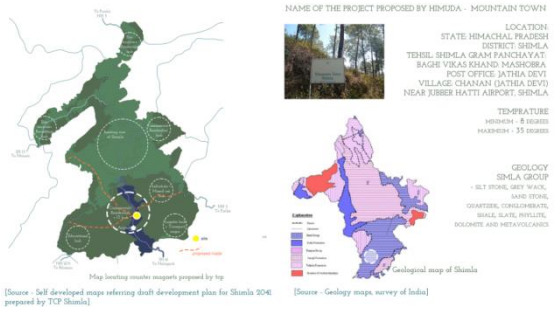

Fig. 19: Geology of the site (←north)
Source: Author

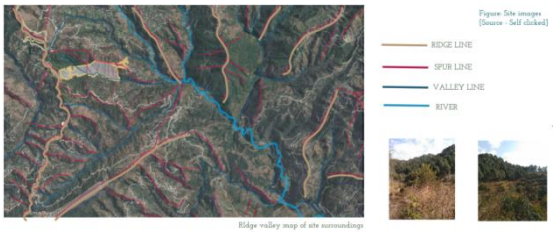

Fig. 20: Ridge, spur, valley and river lines laid over open source satellite image (←north)
Source: Author

Cultural context

A notable finding underscores the significance of conducting a thorough site surrounding analysis. This analysis delves into the existing built infrastructure in the vicinity, which may serve as attractive hubs for the influx of people. It also elucidates the increasing demand for additional infrastructure in satellite towns, aimed at accommodating the needs of the surrounding areas. Within the immediate vicinity of the site, this study identifies two schools, one government and one private, a village settlement, a temple, a club house near the temple, and a bus stop. These elements collectively shape the context within which thoughtful urban planning and development decisions must be made.

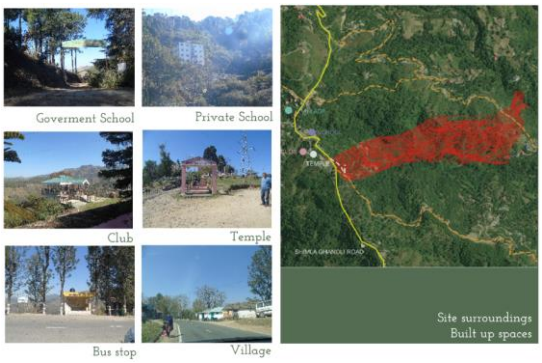

Fig. 21: Surrounding context of the site
Source: Author

Scenic views and natural hill character

An essential finding underscores the necessity of conducting comprehensive surrounding analysis, encompassing the natural hill characteristics and scenic vistas within and around the site. This in-depth examination serves as a cornerstone for planning and design, ensuring an unobstructed line of sight that preserves the integrity of views, both within the site and from the site towards the neighbouring hills and valleys. Furthermore, this discovery highlights the importance of strategically designing roadside rest areas to appreciate the scenic beauty and crafting public spaces that offer picturesque views. Additionally, it emphasizes the principle that no architectural mass should impede the rightful view from openings in other buildings.

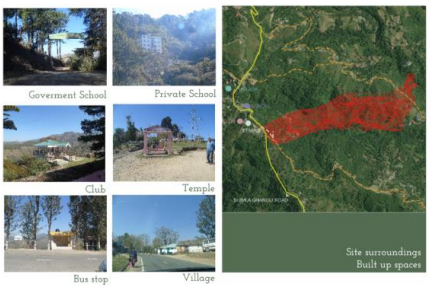

Fig. 22: Views within and from the site
Source: Author

Contours and site sections

A key finding underscores the substantial importance of contours and site sections, both within the site itself and in the broader context of the surrounding environment. These elements provide invaluable insights into the hillscape, guiding the strategic placement of buildings, pedestrian pathways, open areas and road connections. Crucially, this finding emphasizes the need to consider not only the site's own slope but also the orientation it will face. This comprehensive understanding aids in evaluating the scenic views, hill shading effects, and the prevention of potential visual congestion due to the built-up structures.

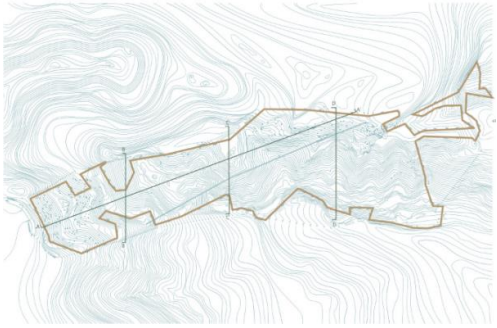

Fig. 23: Contour survey map contours within site by HIMUDA, contours surroundings the site traced using open source mapcarta data
Source: Author

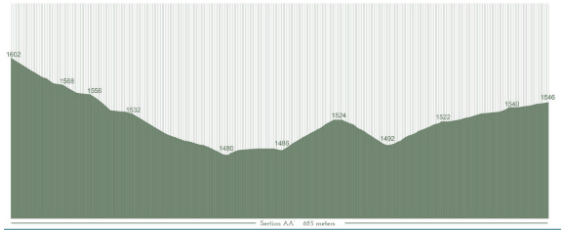

Fig. 24: Section AA' using AutoCAD
Source: Author

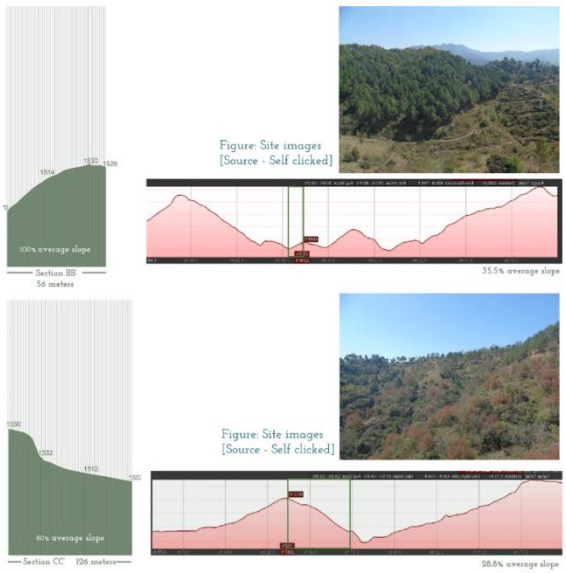

Fig. 25: Section BB' and CC' using AutoCAD and open source Google Earth data
Source: Author

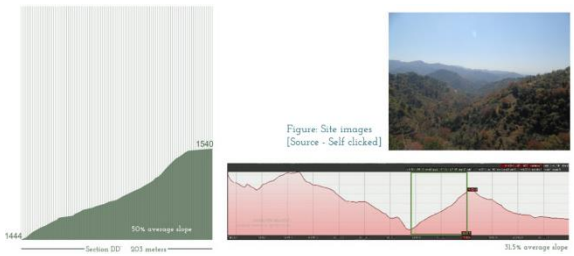

Fig. 26: Section DD' using AutoCAD and open source Google Earth data
Source: Author

Hill shade analysis

A critical finding underscores the significance of conducting hill shade analysis to assess the shading effects on every slope, utilizing both contemporary tools like GIS and conventional physical models. This analysis serves as a pivotal step in establishing land use zoning and identifying potential future snow accumulation zones, where snow removal could pose significant challenges. The conclusion drawn from this finding advises against construction in these identified areas.

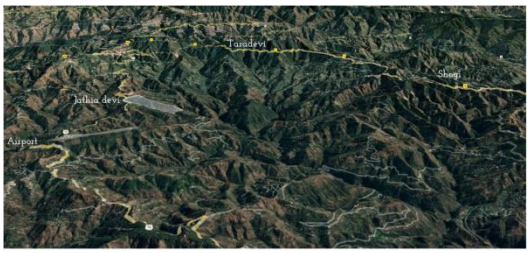

Fig. 27: Regional hill shade analysis using open source Google Earth data
Source: Author

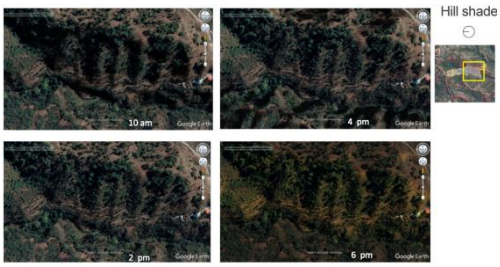

Fig. 28: Site hill shade analysis using open source Google Earth data
Source: Author

Fig. 29: Site hill shade analysis using a physical model of the hill site
Source: Author

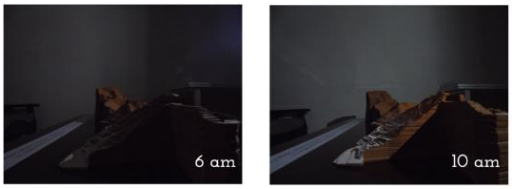

Fig. 30: Site hill shade analysis using a physical model of the hill site
Source: Author

Site Flora and Fauna

A finding of ecological importance reveals that hills are highly sensitive ecosystems, demanding vigilant preservation efforts to safeguard their delicate balance and microclimate. These actions are imperative not only for the well-being of local fauna and flora but also for the prevention of potential disasters. The key discovery lies in the necessity of conducting comprehensive site surveys, which combine GIS mapping for pinpointing green zones and manual assessments to catalogue and classify the diverse plant and animal species inhabiting these areas.

Fig. 31: Dense natural green covers marked on site
Source: Author

Relief map

Sites on hills have various contour undulations and it is important to understand them by preparing relief maps that help planners, designers and architects carry out the macro level zoning based on the elevation levels and understand the elevation difference within site.

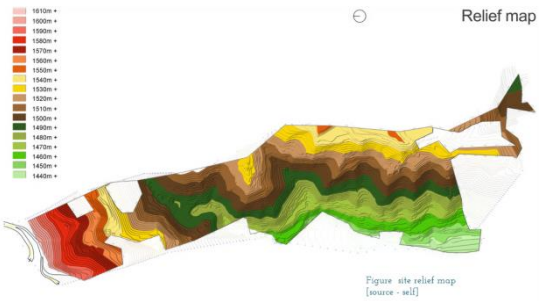

Fig. 32: Relief map showing elevation levels of the site
Source: Author

Gradient analysis map

Slope gradients on hillside sites have been meticulously analysed, ensuring a comprehensive understanding of the contours of the terrains. The approach involves dividing the sites into manageable scale grids and meticulously mapping both buildable and non-buildable slope areas.

Different slopes have been strategically utilized for various specific purposes. For instance, slopes ranging from 0 to 15 degrees have been thoughtfully designated for playgrounds and parks. In cases where the slopes fall within the 15 to 25 degree range, cut and fill construction methods have been successfully employed. Additionally, slopes measuring 25 to 35 degrees have been skilfully utilized for hybrid construction, incorporating pillars and cut and fill techniques.

When dealing with slopes exceeding 35 degrees, soil type assessments have been conducted to determine the feasibility of supporting pile foundations and cantilever structures. It is important to note that, in adherence to the best practices, traditional construction methods have not been employed on 45-degree slopes, which constitute a 100% gradient.

The slope gradient analysis has also played a pivotal role in identifying navigable slopes for transportation planning. A holistic approach has been taken by focusing on steep and shallow slopes, carefully projecting the height differences between different levels of built masses. All our efforts in this regard are seamlessly integrated into a landscape design that harmoniously complements the natural character of the hill, preserving its integrity and structural course.

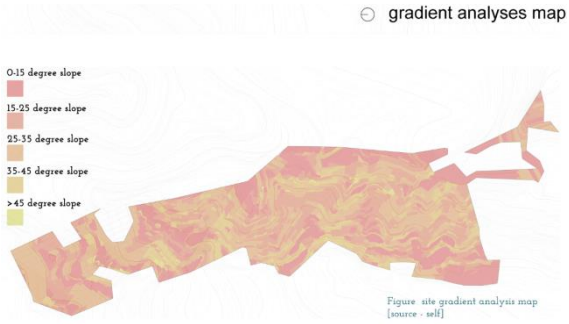

Fig. 33: Gradient analysis map
Source: Author

Slope orientation map

Sites on hills have various slope faces. Unlike in the planes, in slopes there are different solar exposure faces governed by spur and ridge lines within one site. North facing slopes are snow prone and are not suitable for development in terms of built up and habitation in general.

Fig. 34: Slope orientation map
Source: Author

Ridge valley analysis map

Sites on hills have a series of ridge and valley lines. These demonstrate the natural drain channels of the hill site coming from the surrounding hills and from the larger part of the same hill. The ridge lines, also marked for spur lines show the changes in slope orientations, which further govern the solar exposure on that face.

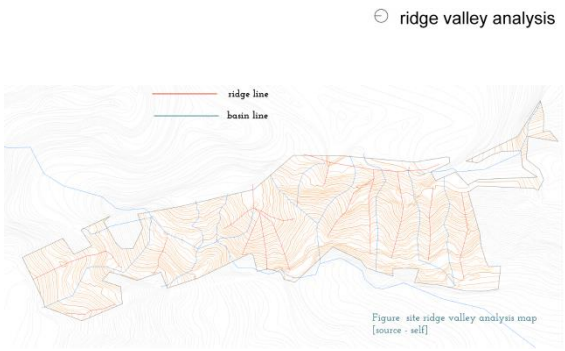

Fig. 35: Ridge valley map
Source: Author

Summit basin analysis map

Sites on hills have the lowest points of depression where all valley lines meet. These become potential sites for rainwater catchment and harvesting. The points where all the ridge lines meet are the highest summits that offer a great view of the site and the surroundings. Summits are often considered best for locating plazas, markets, playgrounds, parks and gathering places. Summits have good solar exposure. Hence, removing snow from summits is easy. This makes managing the pedestrian networks easier. Often, there is a large flat land placed on summits to support these activities. It is also advisable to not construct on the actual summit as the building mass would destroy the natural hill character by disturbing the peak of the hill.

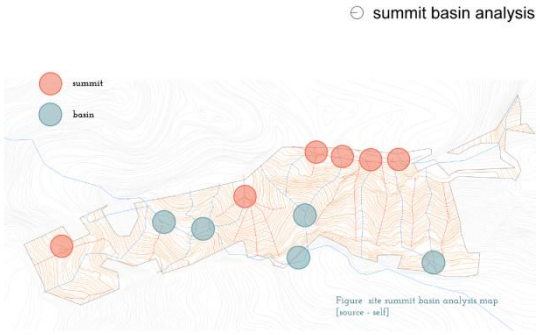

Fig. 36: Summit basin analysis map
Source: Author

Existing services map

Sites on hills might not have much provision for the existing services. However, it is crucial, as is in the case of planes to consider the underwater pipelines and the overhead high tension wires before zoning safe to construct areas.

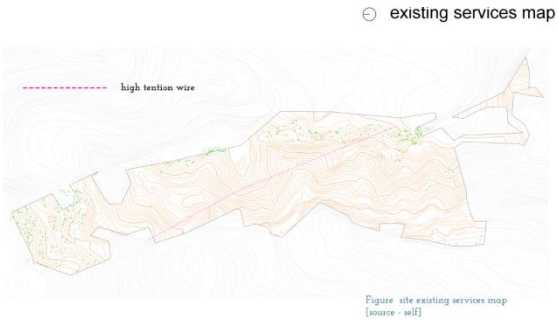

Fig. 37: Existing services map
Source: Author

Land suitability map

In the hill town urban design, the diverse site conditions have been taken into account and carefully integrated into the planning approach. With a comprehensive understanding gained from previous site analyses, all the mapping data have been effectively overlapped to create zoning that clearly demarcates areas suitable for construction and open spaces for circulation.

This thoughtful zoning strategy ensures that any excessive built-up construction is avoided in hill town designs. By doing so, urban development is harmonized with the unique topography and natural beauty of the hill sites.

Fig. 38: Land suitability map
Source: Author

Table 2: Framework for Systematic Approach towards Sustainable and Congestion Resilient Urban Design for New Satellite Hill Towns
Source: Author

No	Parameters	Deatil Explaination
1	Preserving Natural Hill Character	Hill towns' natural beauty and landscapes are identified through site analysis. This preserves the town's unique features while accommodating development, maintaining visual appeal and ecological balance.
2	Minimizing Environmental Impact	Site analysis identifies environmental risks such as landslides, erosion, and runoff. Urban designs can then incorporate measures to reduce impacts, enhance resilience to natural disasters.
3	Efficient Transportation Networks	Site analysis helps plan transportation routes for hill towns, optimizing connectivity, and reducing congestion on steep slopes.
4	Sustainable Land Use	Existing land use patterns are analyzed to identify opportunities for mixed land use. This promotes compact development, reducing congestion by minimizing travel distances and encouraging walking-ability.
5	Incorporating Green Spaces	Site analysis locates suitable areas for parks and recreational spaces in hill towns. These spaces enhance aesthetics, provide environmental benefits, and offer accessible green areas for residents.
6	Cultural and Heritage Preservation	Site analysis identifies heritage sites, ensuring their preservation during urban development. This maintains cultural identity, pride, and tourist attractions in hill towns.

Conclusions

In this paper, a structured framework is presented for creating urban design strategies that can withstand congestion challenges in satellite hill towns, with a specific focus on the case of Jathia Devi in Shimla. The approach integrates urban planning, environmental studies, and geo-spatial analysis to highlight the critical role of site analysis in shaping sustainable solutions.

The research underscores the importance of preserving the natural hill character, minimizing environmental impacts, and improving transportation networks. By incorporating mixed land use and green spaces, congestion can be effectively reduced and a more livable urban environment can be created. Through active stakeholder engagement, these strategies provide a clear roadmap for sustainable development, aligning the aspirations of residents with long-term resilience goals.

It's important to note that there is no one-size-fits-all solutions in this context. Site-specific variations and evolving needs necessitate flexible implementation. The evaluation framework serves as a guide for ongoing adaptive planning, ensuring a continuous process of urban improvement.

This paper contributes valuable insights to the field of sustainable urban planning, using the Jathia Devi case study to inform similar satellite hill towns worldwide. Further research and collaboration to promote prosperity and congestion-resilience in hill towns are needed. By safeguarding their natural beauty, urban development can be harmonized with ecological conservation, leaving a lasting legacy for future generations. Amidst the complexities of urbanization, the systematic approach provides a sustainable path forward not only for Jathia Devi in Shimla but also for other hill towns in India and elsewhere.

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