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Energy, Transport and Low-Carbon Tourism Development

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Abstract: Tourism in Himachal Pradesh is economically significant but increasingly energy- and mobility-intensive. Hotel operations, expanding accommodation, construction materials, private tourist vehicles and the movement of supplies through steep terrain contribute to greenhouse-gas emissions while increasing the sector's exposure to climate risk. This study analyses the energy and transport dimensions of low-carbon tourism development in Himachal Pradesh. The analysis identifies four connected emission pathways, embodied emissions from tourism-led construction, operational energy use in accommodation, fossil-fuel dependence in heating and hospitality and transport emissions generated by visitor travel and construction logistics. These pathways are reinforced by congestion, seasonal peaks, dispersed destinations and the higher fuel requirements of mountain roads. Existing directions like energy-efficient buildings, renewable energy, demand-side flexibility, electric mobility, improved public transport and climate-sensitive land-use regulation, offer a foundation for transition, but fragmented governance and implementation gaps reduce their effectiveness. The study argues that low-carbon tourism cannot be achieved through isolated green hotels or vehicle substitution. It requires coordinated destination-level carbon management linking buildings, mobility, visitor flows, infrastructure and monitoring. The conclusion proposes a staged transition that first reduces energy and travel demand, then improves efficiency and finally substitutes low-carbon technologies within a broader framework of ecological and social safeguards.
Keywords: Low-carbon tourism; energy efficiency; transport emissions; hospitality; mountain mobility; Himachal Pradesh.

1. INTRODUCTION

Tourism is frequently presented as a relatively clean service activity, yet its operation depends on energy-intensive systems. Visitors travel to destinations, hotels provide heating, cooling, hot water, lighting and food and construction supplies the buildings and transport networks that make tourism possible. In mountain regions these requirements can be especially demanding. Steep gradients increase vehicle fuel consumption, winter conditions raise heating needs and dispersed destinations require long-distance movement of people and goods.

Himachal Pradesh's tourism economy illustrates this tension. Tourism supports livelihoods, regional income and infrastructure, but its expansion is associated with additional hotels, roads, traffic and energy consumption. The study connects tourism-led construction with deforestation, land conversion and emissions from cement and steel. It also identifies hospitality as a major tertiary-sector energy consumer and tourist transport as an important component of state emissions. These impacts matter because the same landscapes and climatic conditions affected by emissions are the foundation of the visitor economy.

Climate change creates a feedback loop. Tourism and associated construction contribute to emissions and ecological pressure, while rising temperatures, extreme rainfall and ecosystem instability threaten destinations and infrastructure (Pang *et al.,* 2012). A low-carbon strategy is therefore not simply an environmental obligation. It is a form of economic risk management intended to protect tourism assets, reduce operating costs and limit dependence on volatile fossil-fuel systems.

The policy challenge is to move beyond isolated interventions. An efficient hotel may still depend on high-emission visitor travel, electric vehicles may reduce local tailpipe pollution but add demand to a carbon-intensive grid, renewable-energy installations may deliver limited benefits if buildings remain inefficient. Low-carbon tourism requires an integrated sequence, avoid unnecessary demand and harmful land conversion, reduce energy and transport requirements, improve

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system efficiency and substitute renewable or low-emission technologies.

This study focuses on the relationship among tourism construction, accommodation energy, transport emissions, visitor flows and policy coordination. Its central argument is that carbon management must operate at destination scale rather than through disconnected building or transport programmes.

2. Research Problem and Objectives

The research problem concerns the widening gap between tourism growth and systematic carbon management. Accommodation and transport expand in response to visitor demand, but emissions are dispersed across private vehicles, hotels, supply chains, construction and public infrastructure. Responsibility is similarly fragmented across tourism, energy, transport, urban development and environmental institutions. Without an integrated framework, individual efficiency gains may be offset by growth in the total volume of buildings, traffic and energy use.

The study has five objectives. First, it identifies the principal energy and transport emission pathways associated with tourism development. Second, it analyses how mountain geography and seasonal visitor concentration shape these emissions. Third, it evaluates mitigation measures for buildings, hospitality operations and mobility. Fourth, it considers the governance and monitoring requirements of destination-level decarbonisation. Fifth, it proposes a staged low-carbon tourism framework.

3. METHODOLOGY

The study applies the qualitative secondary-source research design. The data sources includes government and institutional reports, policy documents, statistical material and published research concerning tourism, construction, energy, transport and climate change issued by agencies such as the Himachal Pradesh Tourism Department, the Ministry of Statistics and Programme Implementation (MoSPI) and the Ministry of Environment, Forest, and Climate Change (MoEFCC). The sources were analysed thematically to identify carbon-generating activities, mitigation options and institutional linkages. The contribution is conceptual and policy-oriented, it reorganises existing evidence into a destination-level low-carbon framework.

4. Carbon Pathways in Tourism Development

4.1 Embodied emissions and tourism-led construction

Tourism growth creates demand for hotels, resorts, roads and visitor facilities. The production of cement and steel and the transport of construction materials generate substantial emissions. At the global level, infrastructure stocks represented a very large accumulated carbon burden, demonstrating the significance of material-intensive development (Müller *et al.,* 2013). In Himachal Pradesh, the environmental effect is compounded when construction removes forests or modifies land that previously functioned as a carbon sink.

Embodied emissions are often locked in before a tourism facility begins operation. They are influenced by the scale of construction, material quantities, source distances, building life and the decision to build new rather than retrofit existing stock. Carbon management should therefore begin at project conception. Avoiding unnecessary floor area, extending the life of existing buildings and selecting durable lower-carbon materials can reduce emissions that cannot later be recovered through operational efficiency.

Land conversion also changes climate vulnerability. Removing vegetation can increase runoff and surface temperatures, while construction on sensitive slopes raises exposure to landslides and erosion. The relationship is circular, tourism infrastructure contributes to climatic and ecological pressure and then becomes vulnerable to the resulting hazards (Gómez-Villarino *et al.,* 2020; Pang *et al.,* 2012).

4.2 Operational energy in accommodation

Hospitality buildings have high energy requirements because they provide continuous services to guests. Heating, cooling, hot water, lighting, kitchens, laundry and equipment operate across long hours and fluctuate with occupancy. The hospitality buildings is among the major energy consumers in the tertiary sector (Moiá-Pol *et al.,* 2017). Tourism growth increases both the number of establishments and the level of service expected from them.

In Himachal Pradesh, hotels and resorts rely on grid electricity as well as LPG and fuelwood for hospitality needs. Evidence from Manali indicates significant emissions associated with these energy sources (Sood *et al.,* 2014). Fuelwood use has implications beyond direct combustion because unsustainable extraction can weaken forest functions. Grid electricity may also carry indirect emissions depending on the generation mix and the timing of demand.

Energy demand is seasonal. Peak tourist periods can coincide with heating, cooling or water-pressure constraints, creating concentrated loads. This makes efficiency and demand management especially important. Buildings that reduce heat loss, use efficient equipment and manage occupancy-based loads can lower both annual consumption and peak stress.

4.3 Visitor mobility and mountain transport

Tourism depends on movement and private cars, buses and aviation generate emissions before visitors reach a hotel. The tourist peaks are periods of increased fossil-fuel consumption and vehicular emissions (Kumar & Poonam, 2023; Manisha *et al.,* 2023). Congestion in popular destinations causes idling and slow movement, further reducing efficiency.

Mountain terrain adds a structural disadvantage. Steep gradients increase fuel demand, while narrow roads and limited alternatives can concentrate traffic. Construction logistics add heavy vehicles transporting cement, steel, machinery and other materials under similarly carbon-intensive conditions (Department of Science & Technology, Government of India, 2017; Handa *et al.,* 2019). Tourism and construction transport therefore share infrastructure and contribute to cumulative corridor emissions.

The GHG Platform India identified the energy sector, with transport as a major component, as responsible for 49% of statewide emissions (GHG Platform India, 2018). Although this percentage is not a tourism-only estimate, it demonstrates the importance of mobility and energy policy to any credible low-carbon tourism strategy.

4.4 Supply chains and indirect emissions

Hotels depend on food, beverages, cleaning products, furnishings and maintenance supplies. Supply-chain emissions can be substantial with the importance of food and tobacco production within hospitality-related emissions (Xia *et al.,* 2022). Long supply distances add transport demand, while high service standards can increase material consumption and waste.

Local procurement can reduce some transport emissions and support regional livelihoods, but its climate benefit depends on production methods, seasonality and logistics. The relevant principle is not that every local product is automatically low carbon, but that procurement decisions should account for distance, production impact, packaging and waste.

5. Climate and Ecological Consequences in Himachal Pradesh

Tourism-led construction and mobility alter the environmental systems on which tourism depends. Deforestation and land conversion reduce carbon sinks and can intensify runoff, soil erosion and slope instability. Increased traffic contributes to greenhouse gases and local air pollution. High energy demand creates operating emissions, while resource extraction and construction amplify ecological stress (Kajal, 2021).

The Climate Statement 2023 identified that year as the seventh warmest with temperature 0.70 degrees Celsius above the 1981-2010 average. The same period demonstrated the state's exposure to intense rainfall and flood losses (India Meteorological Department & Government of Himachal Pradesh, 2024). These observations do not mean tourism construction alone caused a particular event. They illustrate the climatic context in which land conversion, weakened vegetation and exposed infrastructure become increasingly consequential.

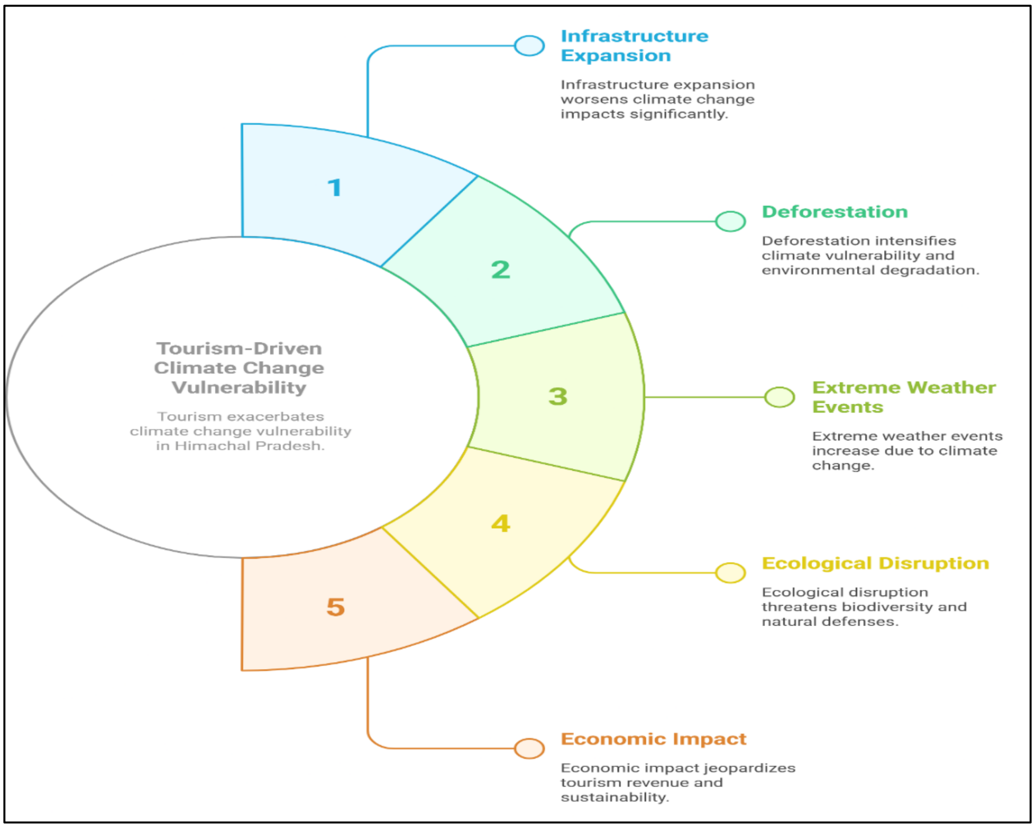

Figure 1: Impact of Tourism on Himachal Pradesh

Figure 1 presents tourism impacts as an interconnected system rather than a linear chain. Infrastructure expansion, resource demand, emissions and environmental change feed back into destination vulnerability. The supports a key proposition of this study that carbon reduction should be integrated with land-use and resilience planning rather than treated as a separate accounting exercise.

6. Building and Hospitality Mitigation

6.1 Efficiency before supply substitution

Energy efficiency offers an immediate pathway for reducing hospitality emissions. Efficient envelopes, insulation, windows, equipment and controls lower energy requirements without reducing guest comfort. The energy-efficiency measures in hotels as a promising mitigation direction (Cingoski & Petrevska, 2018). Efficiency should precede major renewable-energy investment because a smaller and better-managed load requires less generating capacity.

Retrofitting is particularly important. Existing accommodation will continue operating even if new construction adopts stronger standards. Energy audits can identify heating, hot-water, lighting and equipment losses, while staged retrofits allow smaller enterprises to spread costs. Public support should be linked to measured reductions rather than technology purchase alone.

6.2 Renewable energy and demand-side flexibility

Renewable-energy systems can replace fossil-fuel consumption in hotel operations. Their effectiveness increases when paired with storage, load scheduling and demand-side flexibility. Flexible demand can shift heating, water and other manageable loads to periods when renewable electricity is more available, helping address variability in supply (Golmohamadi, 2022).

However, renewable installation does not remove the need for monitoring. A facility may add solar generation while total energy consumption continues rising. Performance indicators should therefore include consumption per occupied room, peak demand and the share of energy supplied from renewable sources. Destination-level monitoring can reveal whether efficiency gains are being offset by increasing room stock or occupancy.

6.3 Building energy codes and performance gaps

Building energy codes and financial incentives can encourage efficient design and equipment, but predicted performance may differ from actual operation. There is a gap between modelled and realised building energy performance as a continuing challenge (Rotimi *et al.,* 2017). Causes can include construction quality, equipment settings, guest behaviour, maintenance and occupancy patterns.

Compliance should therefore extend beyond design approval. Commissioning, post-occupancy measurement and periodic reporting are needed to verify outcomes. Smaller establishments require simplified tools and technical support so that monitoring does not become limited to large hotels.

6.4 Low-carbon materials and lifecycle decisions

Construction mitigation should address the lifecycle of tourism assets. Lower-carbon materials, reuse and reduced waste can limit embodied emissions. Durable design lowers the frequency of replacement, while adaptable buildings can respond to changing tourism demand without demolition. Green infrastructure can add carbon-storage and cooling benefits while managing runoff (Gómez-Villarino *et al.,* 2020).

The most effective measure may sometimes be to avoid new construction. Better use of existing accommodation, renovation of underused stock and visitor-distribution strategies can reduce pressure for continuous expansion. This connects carbon management with tourism planning and carrying capacity.

7. Low-Carbon Mobility for Mountain Destinations

7.1 Public and shared transport

Reducing dependence on private cars is central to tourism decarbonisation. Improved buses, coordinated connections, shared transfers and destination shuttles can reduce the number of vehicles entering congested areas. Public transport must be reliable, safe and integrated with visitor information; otherwise travellers will continue preferring private vehicles.

Park-and-ride systems can keep high-emission congestion outside sensitive destination cores. Their effectiveness depends on parking regulation and convenient onward transport. Mobility planning should also connect major arrival points with hotels, pilgrimage sites and adventure gateways.

7.2 Electric mobility and its constraints

Electric vehicles offer the possibility of reducing tailpipe emissions and local air pollution. Himachal Pradesh has pursued electric-mobility directions, but limited charging infrastructure, high vehicle costs and the carbon content of electricity as constraints (Khan, 2025). Electrification is therefore necessary but insufficient.

Charging should be planned along tourist corridors and at accommodation clusters without creating unmanageable peak loads. Fleet applications like buses, taxis and institutional vehicles, may provide early opportunities because routes and charging needs are more predictable. The climate benefit should be evaluated against the electricity mix and combined with renewable-energy expansion.

7.3 Managing visitor peaks and travel demand

Low-carbon transport policy should not focus only on vehicle technology. Seasonal peaks increase traffic, idling and infrastructure demand. Visitor scheduling, advance booking, parking controls and promotion of longer stays can reduce repeated high-volume movements. Diversifying tourism across destinations and seasons may distribute traffic, although it must not transfer ecological pressure to unprepared areas.

Information can support behaviour change. Visitors need clear guidance on public transport, shared mobility and destination restrictions before travel. Tourism businesses can contribute through bundled transit, shuttle services and incentives for low-carbon arrival.

7.4 Construction logistics

The movement of building materials is a significant but often overlooked part of tourism emissions. Consolidated deliveries, local sourcing where sustainable, cleaner heavy vehicles and project scheduling can reduce repeated trips. Material-efficiency measures also lower transport by reducing the volume moved to and from sites. Construction approvals for major tourism projects should include a logistics and emissions plan.

8. Destination-Level Carbon Governance

8.1 Why isolated measures are inadequate

A green hotel certification does not account for the emissions generated by guest travel or destination infrastructure. An electric-vehicle policy does not control the embodied emissions of new accommodation. Separate programmes may produce local improvements while total tourism emissions rise. Destination-level carbon governance is needed to connect buildings, mobility, construction and visitor flows.

The Himachal Pradesh State Action Plan on Climate Change provides a policy basis for energy-efficient buildings and sustainable tourism, while the Tourism Policy promotes environmentally responsible development (Government of Himachal Pradesh, 2019; Government of Himachal Pradesh, 2021). The implementation challenge is to translate these directions into measurable local systems.

8.2 Measurement and reporting

Tourism carbon management requires a practical inventory. Data should cover accommodation energy by source, visitor transport modes, public and commercial fleets, major construction activity and renewable-energy use. Absolute emissions should be considered alongside intensity measures such as energy per occupied room or emissions per visitor-night. Intensity can improve while total emissions still rise, so both are necessary.

Reporting requirements should be proportionate. Large hotels and projects can provide detailed data, while smaller establishments can use simplified energy and occupancy templates. Aggregated destination information can guide infrastructure investment without exposing commercially sensitive records.

8.3 Institutional coordination and finance

Tourism, transport, energy, urban development and environmental agencies influence different parts of the carbon system. A destination plan should assign clear responsibilities for building standards, public mobility, charging, visitor management and monitoring. Local bodies and tourism businesses need representation because implementation occurs at site level.

Financial incentives can accelerate efficient buildings, renewable energy and clean fleets. However, incentives should reward verified performance and avoid subsidising unnecessary expansion. Green investment should be aligned with carrying capacity and social access so that decarbonisation does not become a label for environmentally damaging construction.

8.4 Equity and the distribution of transition costs

Low-carbon policy changes the costs faced by businesses, workers and visitors. Large hotels may be able to finance energy systems and reporting, while homestays and small guest houses may struggle with upfront investment. Transport restrictions may reduce congestion but disadvantage workers or residents if affordable alternatives are unavailable. A fair transition therefore requires differentiated obligations and support without weakening environmental outcomes.

Shared infrastructure can lower costs. Common charging hubs, district-level technical assistance, bulk procurement of efficient equipment and aggregated retrofit finance can make transition measures accessible to smaller enterprises. Public transport improvements should serve residents throughout the year, not operate only as premium tourist services. When local communities receive reliable mobility and cleaner public space, decarbonisation produces wider development benefits.

The treatment of workers also matters. Retrofit, renewable-energy and electric-mobility programmes create new skill requirements. Training and recognised certification can help existing construction, maintenance and transport workers access these opportunities. Without such measures, the economic gains of low-carbon investment may flow mainly to outside firms while local workers remain in insecure roles.

9. A Staged Low-Carbon Transition

The evidence supports a four-stage transition. The first stage is avoidance which incudes, prevent ecologically harmful land conversion, unnecessary floor area and avoidable private-vehicle demand. The second is demand reduction through efficient buildings, compact service design, visitor management and better use of existing assets. The third is system efficiency through public transport, efficient equipment, logistics coordination and demand-side flexibility. The fourth is substitution through renewable energy, electric mobility and lower-carbon materials.

This sequence matters because technology alone can reproduce growth in a different form. More efficient hotels may lower energy intensity while the number of rooms expands rapidly. Electric cars can reduce tailpipe emissions while congestion, road expansion and electricity demand continue rising. A staged approach keeps total demand and ecological limits visible.

Low-carbon policy must also support local livelihoods. Public transport, building retrofits and renewable systems can create employment, but small operators need finance and skills. Carbon rules that only large businesses can meet may consolidate the sector and exclude community enterprises. Proportionate support and shared infrastructure are therefore necessary for an inclusive transition.

The staged framework also helps identify rebound effects. Lower operating costs from efficiency may encourage additional consumption, faster electric mobility may increase total travel and a destination marketed as green may attract more visitors than its infrastructure can sustain. Monitoring must therefore examine total energy use, traffic and construction, not merely the performance of individual technologies. Absolute ecological limits remain relevant even when carbon intensity improves.

Finally, carbon governance should be connected with adaptation. Efficient buildings are easier to power during disruption, public transport can support evacuation and access and local renewable systems can improve energy security. Conversely, poorly located low-carbon infrastructure remains exposed to floods or landslides. The strongest policies deliver both emission reduction and resilience while avoiding the transfer of risk to local communities.

10. Policy Recommendations

First, major tourism destinations should prepare integrated carbon-management plans covering accommodation, visitor transport, public infrastructure and construction. Second, new tourism projects should report anticipated embodied and operational energy impacts and demonstrate that existing-building reuse or retrofit alternatives were considered. Third, a staged hotel retrofit programme should support insulation, efficient equipment, renewable energy, metering and performance verification, with accessible finance for small establishments. Fourth, public and shared transport should be prioritised on major tourism corridors through reliable services, integrated ticketing, destination shuttles and park-and-ride systems. Fifth, electric-mobility investment should initially target predictable fleets such as buses and taxis, supported by strategically located charging and cleaner electricity. Sixth, visitor-flow tools, including parking controls, advance information, seasonal management and longer-stay incentives, should reduce peak travel demand rather than relying solely on vehicle replacement. Seventh, construction approvals for major tourism facilities should include material-efficiency and logistics plans to reduce embodied and freight emissions. Finally, state and local institutions should report both absolute tourism-related emissions and intensity indicators. Incentives and certifications should depend on measured outcomes and compliance with ecological safeguards.

11. CONCLUSION

Tourism in Himachal Pradesh is embedded in an energy- and transport-intensive system. Construction creates embodied emissions and land-use change, hotels consume electricity and fuels, visitor mobility and construction logistics generate transport emissions and seasonal peaks concentrate demand. These processes contribute to climate change while increasing the vulnerability of tourism assets and destinations.

A credible low-carbon strategy must connect buildings, energy, mobility and visitor management. Efficiency, renewable energy, electric vehicles and green materials are valuable, but their benefits will remain limited if overall demand, land conversion and congestion continue rising. Destination-level governance can align individual actions with total emissions and ecological capacity.

The appropriate transition begins by avoiding unnecessary demand and damaging development, then reducing energy and travel requirements, improving system efficiency and substituting low-carbon technologies. If supported by measurement, coordinated institutions and accessible finance, this staged approach can protect Himachal Pradesh's tourism economy while reducing its contribution to climate and environmental risk.

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