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Assessing Carrying Capacity of New Mahabaleshwar Hill Station

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***Abstract*— Hill stations in India are usually considered as escapes from the chaos of urban life. Even so, unplanned tourism can create chaos within them which may result in pressure on environmental resources, existing infrastructure and local ecosystems. New Mahabaleshwar Hill Station is an emerging and planned tourism destination being built with intent. But even with proactive planning, unregulated development may adversely affect the ecological balance and carrying capacity of the region.**

To balance the growth and sustainability in ecologically sensitive hill regions, the planned tourism development also requires the systematic assessment framework of carrying capacity of the region. The carrying capacity of New Mahabaleshwar have been evaluated in this study. As the region is situated in ecologically fragile Western Ghats, it faces environmental limitations on how much tourist activity can be absorbed without causing any harm. Physical, environmental and infrastructure parameters have been evaluated in this study through secondary data analysis, field study and carrying capacity methodologies.

The findings identify the issues such as tourist pressure, inadequate infrastructure, environmental sensitivity and developmental stress on the region. This research demonstrates how assessment of carrying capacity can serve as an important tool to evaluate the tourism pressure and support sustainable tourism planning in emerging destinations like New Mahabaleshwar.

***Index Terms*— Tourism Carrying Capacity, Sustainable Tourism Planning, Hill Station Tourism, Western Ghats, New Mahabaleshwar**

I. INTRODUCTION

Most hill stations in India were not built for tourism. The British established them as summer retreats, small towns in the hills where colonial administrators could escape the heat of the plains [1]. After independence, and especially from the 1990s onward, these places started attracting a different kind of visitor. Families on holiday, friends, weekend travelers from nearby cities. The numbers kept climbing higher. Several Western Ghats hill destinations now experience high seasonal and weekend tourist pressure, especially from nearby urban centres, creating stress on roads, water supply, waste systems, and local ecosystems [2]. Mahabaleshwar and the surrounding Satara corridor are a good example. The weather is mild, the hills are scenic, and Mumbai is only a few hours away. But the towns here were never laid out to absorb this kind of footfall. The roads are narrow, water supply is limited, solid waste piles up during peak season, and sewage systems, where they exist, were built for a fraction of current load. Residents complain about traffic jams and water shortages. Tourists complain about overcrowding. The environment, meanwhile, bears the cost silently: eroded trails, polluted streams, shrinking green cover [2]. None of this is sustainable. If hill tourism in the Western Ghats is to continue, it has to be managed within limits that the land and its infrastructure can actually support.

The idea for a New Mahabaleshwar Hill Station grew out of this problem. Old Mahabaleshwar, by most measures, has reached its limit. There is little room left for new construction, the roads cannot handle more vehicles, and the civic systems are stretched well beyond their design capacity. Rather than keep pushing growth into an already saturated town, the state government proposed building a planned extension across the surrounding talukas. A Draft Development Plan (DDP) was prepared for this purpose [3]. It lays out a phased development roadmap that extends to 2049 and, in its first phase alone, brings over 235 villages into the planning area. The plan covers a wide range of issues. Land-use zoning, tourism circuits, road construction and upgrades, tree planting, water and sewage infrastructure, and welfare programs for the local population.

Zoning maps and land-use regulations tell us where to build and where not to build. They do not tell us how many tourists the region can actually receive on a given day without damaging itself. Every new viewpoint or tourism circuit that gets built will attract more people. And if no one has calculated what the ecosystem can absorb, all the careful planning will not prevent the same overcrowding and degradation that the new project was supposed to solve [4].

This paper provides that number and assesses the Tourism Carrying Capacity (TCC) of the proposed New Mahabaleshwar Hill Station. We examine three factors: the space available for tourists, the area's ecological sensitivity, and the current state of infrastructure such as roads, water supply, and waste management. Based on this assessment, we identify the main tourist spots, look at the development challenges facing the region, and determine specific daily visitor limits.

II. STUDY AREA PROFILE

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The New Mahabaleshwar Hill Station nestled within the ecologically fragile Western Ghats is located in the Satara District of Maharashtra [2]. The region spans a total area of 1,153.32 square kilometers (115,332.58 hectares) and it encompasses 235 villages across Satara, Jaoli, Patan, and Mahabaleshwar talukas [3]. The region is bordered by dense forests on its northwest, west, and southwest sides which includes the Western Ghat area and the Koyna Wildlife Sanctuary, which extends south to form the Chandoli National Park [2], [3]. The entire delineated area falls within various Eco-Sensitive Zones, most notably the Western Ghats Eco-Sensitive Zone (WGESZ) [2]. It also encompasses the Sahyadri Tiger Reserve which is known for its rich biodiversity and endemic species [2].

In terms of regional connectivity, the region has close proximity to two major national corridors: NH-166E, which connects Karad to Chiplun, and SH-58, and both of these link the study area with the major urban centers like Satara, Pune, Kolhapur, Mumbai, and Goa [3]. Also, the Satara Railway Station is located 55 kilometers away, the Karad Railway Station 90 kilometers away, and the Pune Railway Station and Pune International Airport both located at a distance of 120 kilometers [3].

The land use patterns of the region reflect its environmental sensitivity [3]. According to the Existing Land Use (ELU), only 1.15% (13.34 square kilometers) of the total area is classified as developable land, while 62.36% (719.22 square kilometers) is agricultural land, and 36.48% (420.76 square kilometers) is non-developable land, which includes reserved forests, protected forests, wetlands, and water bodies [3]. The forest cover is 29.06% of the total area, and water bodies are 7.42% [3]. Residential, commercial, and industrial uses make up only 0.53%, 0.07%, and 0.01% of the existing land use, respectively [3].

The Draft Development Plan proposed for 2024 to 2049 introduces modifications to this baseline [3]. The Proposed Land Use (PLU) shows 50.29% of the area is agricultural land and 28.75% is forest cover, while allocating a highly controlled 1.29% (14.86 square kilometers) specifically for a Tourism Development Zone (TDZ) where low-impact ecotourism facilities can be established [3].

III. LITERATURE REVIEW

The Conceptual Evolution of Ecotourism Carrying Capacity

When ecotourism first appeared in the late 1980s, it was a reaction to what people were seeing on the ground. Popular natural areas were being damaged by large numbers of tourists, and there was a growing feeling that travel to such places needed to work differently [5]. The goal was to reduce the environmental footprint of tourism, help conserve biodiversity, and make sure that the communities living in and around these areas actually benefited. Ecotourism was meant to be educational, too. Visitors would see how ecosystems function, learn about local traditions, and through that process, become invested in preserving them. That was the theory. What happened after the pandemic told a different story. Global tourism began recovering sharply, with international tourism reaching about 65% of pre-pandemic levels by the end of 2022 [6]. In ecologically sensitive destinations, this rebound renewed concerns about crowding, waste, and infrastructure pressure. Carrying capacity, as a planning concept, came into sharper focus because of exactly this problem.

Any destination has a breaking point. Push past it often enough, and the damage becomes permanent. Most researchers define tourism carrying capacity as the largest number of visitors a site can hold at one time without causing lasting physical, ecological, or cultural harm, and without spoiling the quality of the visit [8].

Measuring this is harder than defining it, because multiple things need to be looked at together [4]. How much physical space is there, and how much does each person need, That is the spatial question. How much trampling, noise, and waste can local ecosystems absorb before soil starts compacting, plants start dying, and animals start leaving, That is the ecological question. Can the water pipes, sewage lines, and garbage trucks handle the load, That is infrastructure. Then there are social questions. At what point do locals start resenting tourists, At what point do tourists themselves feel that a place is too crowded to enjoy, And on the economic side: when does tourism money start pushing out the farming, fishing, or forestry that people depended on before.

The Cifuentes Arias Methodological Architecture

Several methods exist for putting numbers to these questions, but the one that Miguel Cifuentes Arias published in 1992 remains among the most commonly used, especially for protected areas and ecologically sensitive sites [4]. Its appeal lies in the sequential logic. You do not get one number and stop. Instead, you start with a physical estimate and then pass it through a series of filters, each one based on local environmental or managerial conditions, until you reach a figure that is both realistic and enforceable. Three stages, three formulas.

Physical Carrying Capacity (PCC)

Stage one gives us Physical Carrying Capacity. In plain terms, this is the maximum number of visits a space could absorb in a day if nothing else mattered except floor area and opening hours [4]. It depends on three things: the total area visitors can use, the space each person needs, and how many batches of visitors can rotate through during the day. The formula:

$$PCC= V/a \times Rf$$

Where A is the usable area in square metres, a is the space each visitor occupies (also in square metres), and Rf is how many times visitors rotate through in a day. V/a gives us the number of people the site can hold at any one moment. In a managed, paved area, 1 square metre per person might be acceptable. On an open forest trail or a beach, 10 square

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metres per person is more realistic [4].

Visitors do not all show up at opening time and leave together at closing. They drift in and out. So the same patch of ground can serve several groups, as long as the groups do not overlap. The rotation factor captures this:

$$Rf = T_o / T_d$$

T_o is daily operating hours, T_d is the average length of one visit. What comes out of this stage is a space and time.

Real Carrying Capacity (RCC)

Space alone does not determine how many visitors are safe. The second stage brings in the environment. Real Carrying Capacity takes the PCC and applies corrective factors for site-specific conditions like rainfall, slope steepness, or sensitive wildlife seasons [4]. Each factor pulls the number down. The formula:

$$RCC = PCC \times (Cf_1 \times Cf_2 \times \ldots \times Cf_n)$$

Each Cf sits between 0 and 1. It is calculated from:

$$Cf_I = 1 - M_l / M_t$$

M_l is the magnitude of the limiting condition. For rainfall, that might be 120 days of heavy monsoon per year. For wildlife, it might be 3 months of breeding season when trails close. M_t is the total magnitude of that same variable across the whole reference period [4].

Every site has its own set of constraints. In a monsoon region, weeks of continuous rain will shut trails down completely. Where terrain is steep and has loose soil, footpaths degrade fast under heavy use. And in areas where wildlife breeds or nests during particular months, access may need to be cut off or heavily restricted to avoid disturbing animals during vulnerable periods.

Effective Carrying Capacity (ECC)

A forest might tolerate 10,000 visitors a day ecologically, but if there are only two rangers, no waste bins, and one blocked toilet, those 10,000 visitors will cause damage anyway. The third stage accounts for this. Effective Carrying Capacity adjusts the ecological limit downward based on how well the local administration can actually manage the site [4]. The formula:

$$ECC = RCC \times MC$$

MC is management capacity, a coefficient between 0 and 1. It reflects staffing levels (rangers, guides, cleaners), physical infrastructure (toilets, parking, wastewater treatment), and budget.

Poor management means a low MC which means fewer visitors allowed. Better management raises MC and raises the ceiling. This is the part of the model that makes it useful for planning, not just assessment. It tells administrators exactly what investments would let them safely host more people [4].

IV. METHODOLOGY

The methodology adopted for this study integrates the planning-based assessment techniques with ecotourism carrying capacity evaluation methods to determine the sustainable tourism threshold for the New Mahabaleshwar Hill Station region. This study primarily relies on secondary data obtained from the Draft Development Plan prepared by MSRDC, URDPFI Guidelines, government reports, and tourism carrying capacity literature [3], [4], [9].

The assessment was carried out in two stages. The first stage involved the baseline carrying capacity estimation using water availability analysis, density pattern assessment, and hill-station development norms prescribed as per government planning policies [3], [10]. These approaches helped in establishing preliminary tourism thresholds based on infrastructure availability and planning standards.

In second stage Cifuentes Arias ecotourism carrying capacity methodology was applied [4]. The assessment was conducted sequentially through Physical Carrying Capacity (PCC), Real Carrying Capacity (RCC), and Effective Carrying Capacity (ECC).

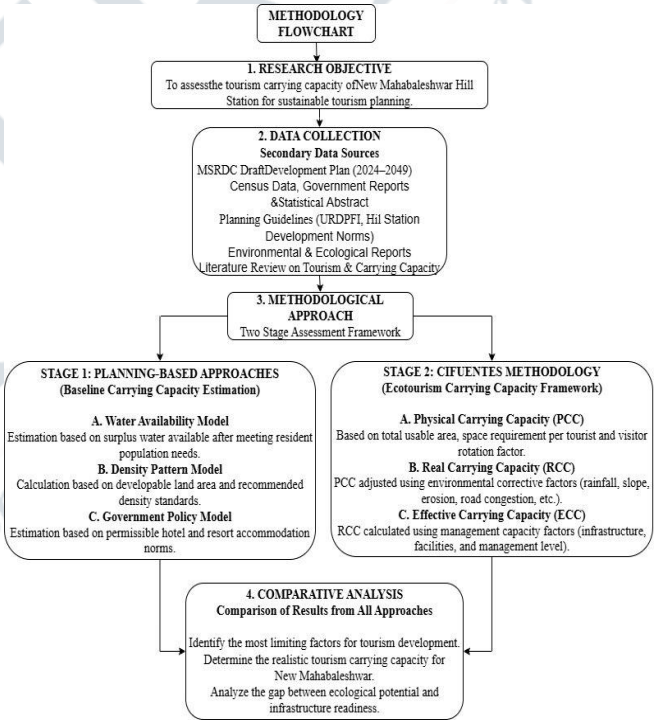


Fig. 1. Methodological framework for assessing carrying capacity of New Mahabaleshwar Hill Station

V. QUANTITATIVE CARRYING CAPACITY ASSESSMENT OF THE NEW MAHABALESHWAR HILL STATION

We carried out a carrying capacity assessment for the NMHS planning region using four approaches. The four approaches were: water availability, density patterns, government policy on hill station development, and the Cifuentes Arias method.

Baseline Carrying Capacity Assessment Models

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We began with three simpler models to get a rough baseline before applying Cifuentes. Each one looks at a different kind of constraint: how much water is available, how dense the population can safely get, and what government policy allows [3]. In all three, tourists are split into day visitors (70% of arrivals) and overnight visitors (30%).

Water Availability Model

Water was the first constraint tested. The resident population of 95,362 consumes water at a standard rate of 55 litres per person per day, which adds up to 5.244 million litres daily [3]. Available supply is 6.117 million litres per day. That leaves 8,73,000 litres of surplus for tourists. Overnight tourists use about 200 litres each, day tourists about 45 litres. Blending at the 30:70 split:

Blended Consumption Rate = (0.30×200) + (0.70×45) = 91.5 ≈ 92 litres per person per day.

Dividing surplus water by that rate:

A = 8,73,000 / 92 ≈ 9,489.13

Water, then, caps the region at 9,489 tourists per day [3].

Density Pattern Model

Next, density. The developable area is 1,334.66 hectares [3]. Current population density is low, but the area is classified as both a hill station and an eco-sensitive zone, so density cannot be left uncontrolled. URDPFI Guidelines indicate lower density norms for hill areas, with small-town hill-area densities ranging up to 75 persons per hectare [9]. Therefore, this study adopts 75 persons per hectare as a conservative upper-bound planning assumption for the NMHS region. Multiplied out:

Total Human Capacity Limit = 1,334.66×75 ≈ 1,00,100

total persons. Take away the 95,362 residents, and 4,738 remain for tourists. Rounded: 4,739 per day.

Tourist Capacity Threshold = 1,00,100 - 95,362 = 4,738

This is the tightest of the three baselines [3].

Government Hill Station Policy Model

Based on the hill station development norms applied in the NMHS planning framework, the permissible hotel and resort zone within the developable area amounts to 66.74 hectares out of 1,334.66 hectares [3], [10], the overnight capacity is:

Permissible Overnight Tourists per Day (30%) = 66.74 ×50 ≈ 3,337

If those overnight guests are 30% of the total, day visitors (70%) come to:

Permissible Day Tourists per Day (70%) = (3,337 × 0.70) × 0.30 ≈ 7,786

per day. Adding both: 3,337 overnight plus 7,786 day visitors, or 11,123 total under this model [3].

Baseline Model Synthesis

The density figure (4,739) is the most conservative by a wide margin. The water model (9,489) and the policy model (11,123) are more comparable. Averaging those two gives about 10,306. But the Western Ghats warrant caution. We set the recommended baseline at 10,000 to 10,500 tourists per day [3].

Ecotourism Carrying Capacity (Cifuentes Methodology)

We then applied the Cifuentes Arias model to the Tourism Development Zone (TDZ) to get more precise spatial and ecological limits.

Physical Carrying Capacity (PCC)

Starting point: The TDZ covers 1,486.23 hectares, which is 1,48,62,300 square metres. We used 100 square metres per person, a conservative standard for ecotourism [4]. Rotation factor of 2 (12 operating hours, 6-hour average visit). Physical carrying capacity:

PCC = (1,48,62,300 /100) × 2 = 297,246

visits per day.

Real Carrying Capacity (RCC)

Now the ecological filters. We identified three corrective factors specific to this part of the Sahyadri range. Monsoon rainfall (0.67): about 120 days per year when trails are unsafe. Slope erosion and landslide hazard (0.80): the Ghats and the Koyna basin have steep, unstable slopes. Road congestion and viewpoint crowding (0.90): single-lane ghat roads and cliff-edge viewpoints where overcrowding becomes a safety problem [3]. Applied together:

RCC = 2,97,246 × 0.67 × 0.80 × 0.90 = 1,43,391

visits per day. The ecology alone halves the number.

Effective Carrying Capacity (ECC)

Then management. And here the numbers get sobering. Solid waste: no formal system, though 19.66 tons per day is projected by 2049. Sewage: no treatment plants operating. Water: a shortfall of 1.09 million litres per day expected by 2049. Roads: 57% paved. Healthcare: 316 clinics, none equipped as hospitals [3]. Management capacity: 40%, or a coefficient of 0.40. Applied:

ECC = 1,43,391 × 0.40 = 57,356

visits per day. That is the real ceiling: 57,356.

The gap here is stark. The ecology allows 1,43,391. The administration can handle 57,356 [3]. Everything between those two numbers is capacity that exists in nature but cannot be used safely because the infrastructure is not there.

VI. RESULTS AND DISCUSSION

The numbers tell a clear story. Physical capacity: 2,97,246 visits per day. After monsoon, slope, and road corrections: 1,43,391. After management filters: 57,356. Each stage cuts the number around half. The management coefficient of 0.40 is what drives the final figure down so sharply. Missing wastewater treatment, no waste system, half the roads unpaved. Exceed 57,356 under these conditions and the consequences follow quickly: sewage in the rivers, garbage in the forests, taps running dry.

The DDP responds to this with a Hub-and-Spoke layout across 13 sectors [3]. Heavy infrastructure goes to the hubs.

Urmodi gets a seaplane aerodrome and large parking. Koyna gets an airstrip. From the hubs, visitors fan out to the spokes on transport designed to be gentle on the ground. In Rajvaibhav, which includes the Kas Plateau, private motor vehicles are banned. Visitors use a virtual interpretation centre and electric Segways. Tapola runs on narrow-gauge rail and jetty networks. Solashi Valley gets cable cars instead of new roads. Network totals: 19.53 km of electric vehicle routes, 48.18 km of cycle tracks, 73.27 km of nature trails. The point of all this is to keep 57,356 daily visitors moving through the region without breaking the forest canopy or compacting the soil beneath it.

VII. CONCLUSION

What happens at New Mahabaleshwar will say something about whether India can plan a hill station before it fails, rather than after. This study provides the numbers that New Mahabaleshwar needs before that point is reached. Real carrying capacity: 143,391 visits per day. Effective carrying capacity, given current infrastructure: 57,356. For the most fragile areas, a peak season cap of 10,000 to 10,500 is safer, with upward revision possible as roads, sewage plants, and waste systems come online.

Four steps follow, One: a four-tiered zoning system. The ecotourism zone (fragile evergreen forest) admits only small, guided groups on low-impact trails. The nature tourism zone (major viewpoints, less fragile terrain) replaces private vehicles with electric shuttles. Commercial zones become pedestrian-only town centres. Residential zones enforce building heights below the canopy line and ban expansion into forest [3]. Two: MSRDC must get sewage treatment and composting (rated for 19.66 tons per day). Otherwise the Krishna and Koyna rivers take the hit. Three: construction and road cutting on steep slopes should be restricted in accordance with Maharashtra hill-station planning regulations and eco-sensitive-zone safeguards [10]. Landslide risk during monsoons is high. Four: actively support village homestays and agrotourism. Small homestays in farming areas keep revenue local, support rural incomes, and spread visitors across the landscape instead of packing them into resort clusters. If the region gets this right, ecotourism works for both conservation and the people who live here.

REFERENCES

[1] D. Kennedy, The Magic Mountains: Hill Stations and the British Raj. Berkeley, CA: University of California Press, 1996.
[2] M. Gadgil et al., 'Report of the Western Ghats Ecology Expert Panel,' Ministry of Environment and Forests, Government of India, New Delhi, 2011.
[3] Maharashtra State Road Development Corporation (MSRDC), 'Draft Development Plan for the New Mahabaleshwar Hill Station Area, 2024–2049,' Government of Maharashtra, Mumbai, 2024.
[4] M. Cifuentes, *Determinación de capacidad de carga turística en áreas protegidas*, CATIE, Serie Técnica, Informe Técnico No. 194, Turrialba, Costa Rica, 1992.
[5] H. Ceballos-Lascuráin, Tourism, Ecotourism, and Protected Areas: The State of Nature-Based Tourism around the World and Guidelines for Its Development. Cambridge: IUCN, 1996.
[6] United Nations World Tourism Organization (UNWTO), 'Tourism Recovery Accelerates to Reach 65% of Pre-Pandemic Levels,' UNWTO World Tourism Barometer, vol. 20, no. 5, 2022.
[7] E. P. Odum, Fundamentals of Ecology, 3rd ed. Philadelphia, PA: W.B. Saunders, 1971.
[8] A. Mathieson and G. Wall, Tourism: Economic, Physical and Social Impacts. London: Longman, 1982.
[9] Ministry of Urban Development, 'Urban and Regional Development Plans Formulation and Implementation (URDPFI) Guidelines,' Government of India, New Delhi, 2014.
[10] Government of Maharashtra, Urban Development Department, 'Hill Station Development Policy,' Notification No. TPS-1893/1231/C.R.123/96/UD-13, Mumbai, 1996.