

International Journal of Geography, Geology and Environment

P-ISSN: 2706-7483

E-ISSN: 2706-7491

NAAS Rating (2026): 4.5

IJGGE 2026; 8(4): 201-209

www.geojournal.net

Received: 18-02-2026

Accepted: 12-03-2026

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Impact of tourism on local ecosystems with special reference to water resources in Chittorgarh: Planning for a sustainable future

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DOI: <https://doi.org/10.22271/27067483.2026.v8.i4b.795>

Abstract

Tourism is a key driver of economic development in heritage-rich regions like Chittorgarh, Rajasthan. Tourism in Chittorgarh has grown rapidly, attracting visitors to its forts, wildlife sanctuaries and cultural events. However, rapid and often unregulated growth of tourism in recent years has also raised serious concerns regarding environmental sustainability. While this growth brings economic benefits, it also poses challenges to local ecosystems and water resources. The study aims to analyse tourism patterns, spatial distribution and examines the ecological impacts of tourism on local ecosystems and water resources in Chittorgarh district, using a combination of field observations, stakeholder interviews and secondary data. Thus, the research is based on both primary and secondary data sources, including field surveys and official tourism statistics. The findings indicate a significant increase in tourist arrivals, with a high concentration at major heritage and religious sites. The paper also highlights issues related to waste generation, increased pressure on water bodies and uneven tourism development across different locations. Special attention is given to how tourism affects the surrounding water sources through pollution and overextraction. The paper also identifies gaps in existing environmental management frameworks and proposes a sustainable planning model that integrates local community participation, eco-tourism practices and policy-level interventions. The rise of eco-tourism highlights efforts to mitigate these impacts and plan for a sustainable future. Sustainable tourism strategies are required to balance development and environmental conservation in the district. The findings underscore the urgent need for balancing tourism growth with ecological preservation not just in Chittorgarh, but in similar destinations across India.

Keywords: Tourism, local ecosystem, water resources, sustainable planning, environmental impact

Introduction

Tourism has emerged as one of the fastest-growing industries, playing a vital role in the global economy. Research indicates that the sector contributes nearly 11% to the world's gross domestic product (GDP), while engaging over 20 crores people both directly and indirectly in tourism-related activities, thereby generating around 3% of total global employment (M. K. Singh & Neog, 2020) ^[21]. Tourism also contributes to infrastructure development by improving transport facilities, accommodation and public services. In developing regions, it acts as an important instrument for regional development by creating alternative livelihood opportunities and supporting balanced economic growth. It supports various allied industries such as hospitality, transportation and handicrafts.

Tourism has emerged as a major driver of economic development and cultural exchange in India, contributing significantly to income generation, employment and regional connectivity. Tourism is one of India's largest service sectors (Narayan *et al.*, 2009) ^[14], which provides heritage, culture, business, medical and sports tourism. Heritage and cultural tourism has gained significant importance in India due to the country's rich historical legacy, diverse cultural traditions and architectural heritage. Heritage sites such as forts, palaces, monuments and historical towns attract large numbers of tourists and contribute to local economic development. However, increasing tourism activity in heritage areas also influences local communities and the surrounding environment, highlighting the need for careful assessment of tourism development in such areas.

Rajasthan, with its rich architectural heritage and cultural vibrancy, is among the most

visited states in the country. Tourism plays a vital role in the socio-economic development of Rajasthan. Within Rajasthan, Chittorgarh stands out as a prominent destination known for its historic fort complex, temples, and Rajput-era monuments, attracting both domestic and international tourists (Rajasthan Tourism Department, 2024)^[18].

Chittorgarh is an important heritage tourism destination in Rajasthan, primarily known for the Chittorgarh Fort, a UNESCO World Heritage Site. Chittorgarh, as part of the Hill Forts of Rajasthan, has been recognized internationally for its cultural and historical significance (UNESCO, 2013)^[25]. Chittorgarh, famed for its historical legacy and natural beauty, experiences high tourist footfall each year (Rajasthan Tourism Department, 2024)^[18], which has led to increased economic opportunities and infrastructure development in the area.

Although tourism contributes significantly to regional development, it also exerts increasing pressure on local ecosystems. While positive impacts include employment generation, income growth and infrastructure improvement, negative impacts such as environmental degradation, cultural changes and pressure on local resources have also been observed in many tourist destinations. The tourism sector is largely dependent on the volume of tourist arrivals; however, excessive growth in tourist numbers poses significant threats to wildlife, degrades natural beauty and disturbs the ecological equilibrium of the environment (Chandel, Rai, *et al.*, 2023; Kanga *et al.*, 2014)^[5, 10]. In the context of Chittorgarh, the rise in tourist inflows has led to growing concerns over its environmental impacts, particularly in terms of ecosystem degradation, pressure on water resources, waste generation and habitat disturbance, making the region suitable for studying the impacts of tourism development.

According to the Annual Progress Report of the Rajasthan Tourism Department, Chittorgarh witnessed a substantial rise in tourist visits post-pandemic. In 2023, the district recorded 14,280,751 domestic and 3,469 foreign tourists. These figures surged in 2024 to 24,194,865 domestic and 12,283 foreign tourists, indicating a strong revival in tourism activity. This rapid growth highlights the popularity of Chittorgarh as a heritage destination. Such rapid growth reflects national patterns, as India has experienced expanding tourism flows in recent years (Ministry of Tourism, Government of India, 2023). However, the increasing influx of tourists has also raised concerns regarding its ecological sustainability, necessitating a closer examination of tourism's impact on the local environment and water resources. Such growth intensifies environmental vulnerabilities, particularly water scarcity, which is already critical in Rajasthan. Central Ground Water Board (Central Ground Water Board (CGWB), 2023)^[3] has reported critical groundwater depletion in Rajasthan, posing concerns for both residents and the tourism sector.

The pressure from increased tourism has direct and indirect effects on its natural environment, necessitating systematic approaches for sustainable management. The recent trends in tourism development have redirected the focus from mass

tourism to sustainable tourism (S. K. Singh & Kanga, 2018)^[23], which strictly controls tourism's effect on the environment (Nisa, 2017)^[16]. This emerging form of sustainable tourism, which emphasizes the protection of the environment, is known as "ecotourism". Ecotourism represents a form of tourism that integrates economic, environmental and socio-cultural dimensions in a sustainable manner (Chandel, Kanga, *et al.*, 2023)^[4]. Scholars argue that tourism growth must be balanced with ecological concerns. Eco-tourism is seen as a corrective strategy, with research highlighting the importance of awareness campaigns and policy interventions to guide public perception and behaviour (Narula & Kapur, 2018, 2009; Shekhar & Kothari, 2025a)^[15, 20].

Understanding the multidimensional impacts of tourism development is essential for ensuring sustainable tourism development. Therefore, impact assessment studies based on local perceptions and experiences play a crucial role in identifying challenges and guiding appropriate planning and policy measures. This study explores the environmental implications of tourism particularly its impact on local ecosystems and water resources in Chittorgarh. The research aims to assess the extent of these impacts, identify the contributing factors and examine the current sustainability measures being undertaken. By analysing tourism trends, water quality assessments and environmental indicators the study seeks to offer insights into sustainable tourism practices suited for heritage-rich regions like Chittorgarh. The findings are expected to contribute to policy discussions on water management, biodiversity conservation and sustainable tourism planning in the state of Rajasthan.

Although several studies have examined the socio-economic benefits of tourism development, limited empirical research has focused on its combined impacts on local ecosystems and water resources in heritage districts such as Chittorgarh. Moreover, community-level perceptions regarding these environmental changes remain underexplored. This highlights the need for a localized assessment to support sustainable tourism planning.

The present study aims to analyse the environmental and ecosystem impacts of tourism development in Chittorgarh district. The study also seeks to provide insights for sustainable tourism planning by examining the perceptions of local residents and stakeholders.

Objectives of the study

1. To analyse the trends and patterns of domestic and foreign tourist arrivals in Chittorgarh district and examine their implications for tourism development.
2. To assess the impacts of tourism activities on local ecosystems and water resources in Chittorgarh district, with particular emphasis on waste generation, biodiversity pressure, water demand, availability, and quality.
3. To evaluate existing tourism management and sustainability practices in the region and propose strategies for promoting environmentally sustainable tourism development.

Literature review

Tourism and the environment share an interdependent relationship. While tourism stimulates economies and infrastructure, it threatens natural resources if managed unsustainably. Scholars emphasize balancing development and conservation.

Tourism geography research highlights how spatial distribution, accessibility, and infrastructure shape patterns. Uneven tourist flow often causes over-concentration at major destinations while others remain underdeveloped.

Tourism significantly impacts regional development, traditionally viewed through economic lenses like employment and growth. However, studies also report environmental challenges, including waste, water use, land-use change, and ecosystem degradation, particularly where infrastructure is inadequate.

Research correlates tourist volume with environmental stress. The Tourist Area Life Cycle (TALC) model warns that unchecked growth leads to resource overuse and destination decline (Butler, 1980) ^[1]. Environmental degradation often peaks during stagnation due to overcrowding. Wall and Mathieson (2006) ^[28] note that tourism causes land degradation, pollution, habitat loss, and water stress. Regarding water, Gössling *et al.* (2012) ^[7] underline that tourism increases demand, especially in arid regions, intensifying competition between residents and visitors. Tourist services consume disproportionate water, negatively affecting local availability. Narula and Kapur (2018) ^[15] further highlight how tourism exacerbates pressure on fragile ecosystems and limited resources.

Studies in India reinforce these concerns. Ranwa (2021) ^[19] examined heritage tourism in Rajasthan, finding that rapid growth without planning accelerates ecosystem degradation. She emphasized that unchecked heritage tourism risks the degradation of tangible resources and the commodification of cultural practices like the Kalbeliyas' performances.

Geospatial approaches are increasingly recommended for monitoring and planning tourism in sensitive regions of Rajasthan, including Jodhpur and western desert areas (Chandel, Rai, *et al.*, 2023) ^[5]. Chandel *et al.* employed geospatial tools to assess tourism-driven land use change, showing urban expansion at the cost of agricultural and natural land. Inclusive approaches are also emerging in tribal tourism models that integrate community participation and sustainability. Chouhan developed a sustainable tribal tourism model for Rajasthan, showing that social, economic and environmental sustainability, along with infrastructural and institutional support, positively influence the long-term viability of tribal tourism by enhancing livelihoods, preserving native culture and promoting community participation (Chouhan, 2022) ^[6]. Research by Shekhar and Kothari emphasizes community-based tourism and conservation, showing that local participation can mitigate

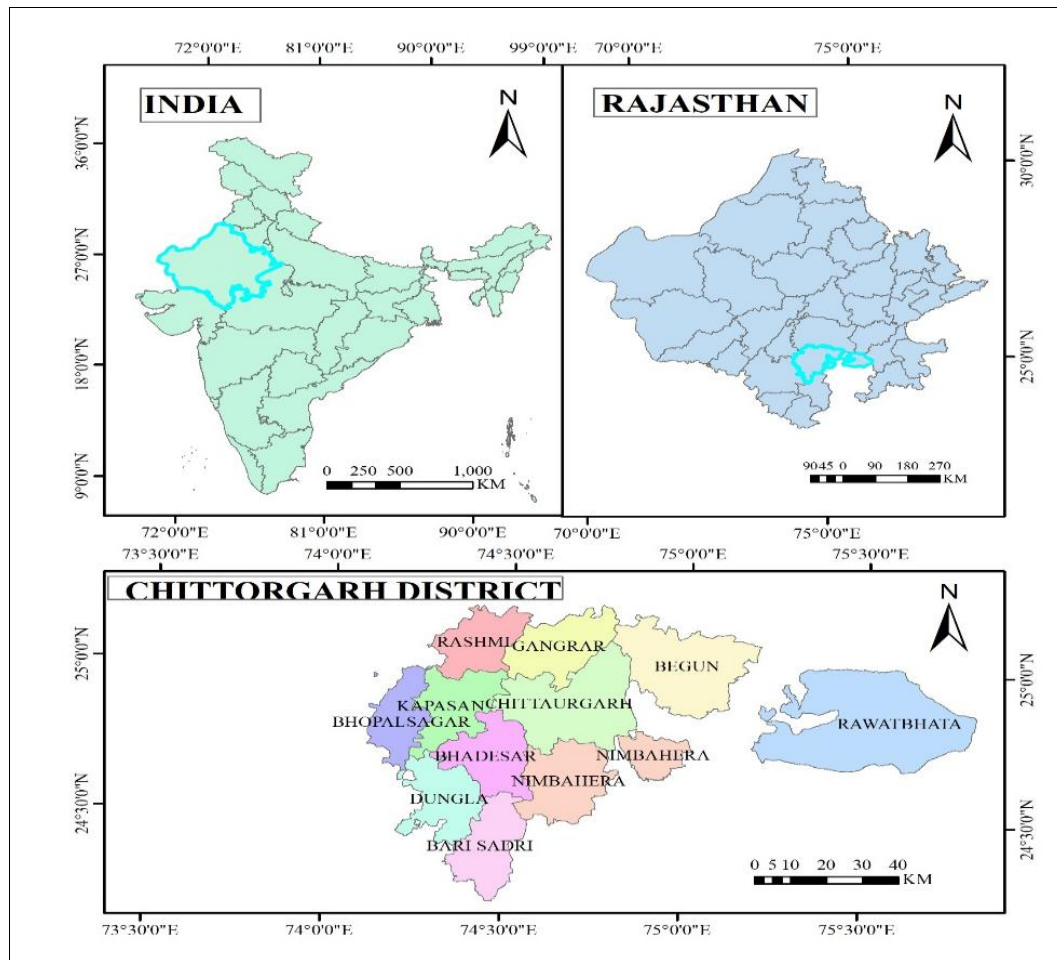
environmental pressures while ensuring cultural sustainability (Shekhar & Kothari, 2025b) ^[20]. Tourism growth also interacts with Rajasthan's acute water scarcity. Jain *et al.* assessed water resource management in Rajasthan, highlighting integrated approaches to balance tourism demand with local sustainability. The study shows how growing visitor numbers in heritage cities exacerbate stress on water resources already strained by climatic variability and over-extraction (Jain *et al.*, 2023) ^[9]. Reports warned that Rajasthan risks severe water depletion, with Jaipur and Chittorgarh among the most vulnerable (Times of India, 2019) ^[24]. These insights underline the importance of sustainable tourism frameworks that conserve ecosystems and safeguard scarce water resources critical for Rajasthan's heritage landscapes.

International conservation bodies have also raised concerns. UNESCO, in its State of Conservation report, warned of management challenges at Chittorgarh Fort, stressing that uncontrolled tourist inflows threaten both heritage preservation and ecosystem stability (UNESCO, 2023) ^[26]. These studies highlight the urgent need for integrated planning that incorporates environmental monitoring, water resource management and community engagement to ensure tourism in Chittorgarh supports development and sustainability goals. Research on sustainable tourism highlights the need for balanced development, proper resource management and community participation to minimize negative impacts.

Rajasthan's tourism has been the subject of region-specific studies, but in Chittorgarh limited academic work examines environmental and water-related consequences of tourism growth. Rajasthan Tourism Department reports focus on arrivals and infrastructure, leaving ecological impacts and local community perspectives underexplored. This study addresses that gap through field observation, analysing spatial patterns, infrastructure, environmental impacts and planning measures, especially regarding water resources there.

Study area

The study was conducted in Chittorgarh district of Rajasthan, a region renowned for its rich cultural heritage and major tourist attractions such as Chittorgarh Fort and surrounding historical sites. Chittorgarh district, located in southern Rajasthan, is known for its historical significance, dry semi-arid climate and the iconic Chittorgarh Fort - a UNESCO World Heritage Site. The district experiences a significant influx of domestic and international tourists annually. The study area includes major tourist destinations within the district and the surrounding environment, where local communities directly experience the effects of tourism development.



Source: The Map is made by using ArcGIS 10.8

Fig 1: Locational map of Chittorgarh

Methodology and Data Sources

This study uses a mixed-methods approach by combining quantitative and qualitative techniques to assess the environmental impacts of tourism on ecosystems and water resources in Chittorgarh. The study is based on both primary and secondary data sources. Secondary data on domestic and foreign tourist arrivals were obtained from the Department of Tourism, Government of Rajasthan. Additional information on water resources, groundwater conditions, climate, land use, and environmental characteristics was collected from government agencies, including the Central Ground Water Board (CGWB), Forest Department, and other relevant institutions. Academic journals, government reports, policy documents, and published studies were also reviewed to establish the conceptual and analytical framework of the study.

While Primary data were collected through field surveys of major tourist sites in Chittorgarh district. Direct field observations were undertaken to identify visible indicators of environmental stress such as waste accumulation, crowding, pressure on water resources, and degradation of surrounding ecosystems. A structured questionnaire survey was also administered to gather information on awareness, attitudes, and perceptions related to environmental sustainability and tourism impacts.

The data is analysed using both quantitative and qualitative methods. Descriptive statistical techniques, including percentages, growth rates, and trend analysis, are used to examine temporal variations in tourist arrivals. Tourism-related water demand was estimated using established per

capita consumption norms reported in relevant literature and government guidelines. Qualitative information obtained from interviews, field observations, and documentary sources was analysed through thematic content analysis. This method is used to identify recurring issues related to water stress, ecosystem degradation, waste generation, and sustainability challenges. The integration of these methods facilitated a comprehensive assessment of tourism-induced environmental impacts in the study area.

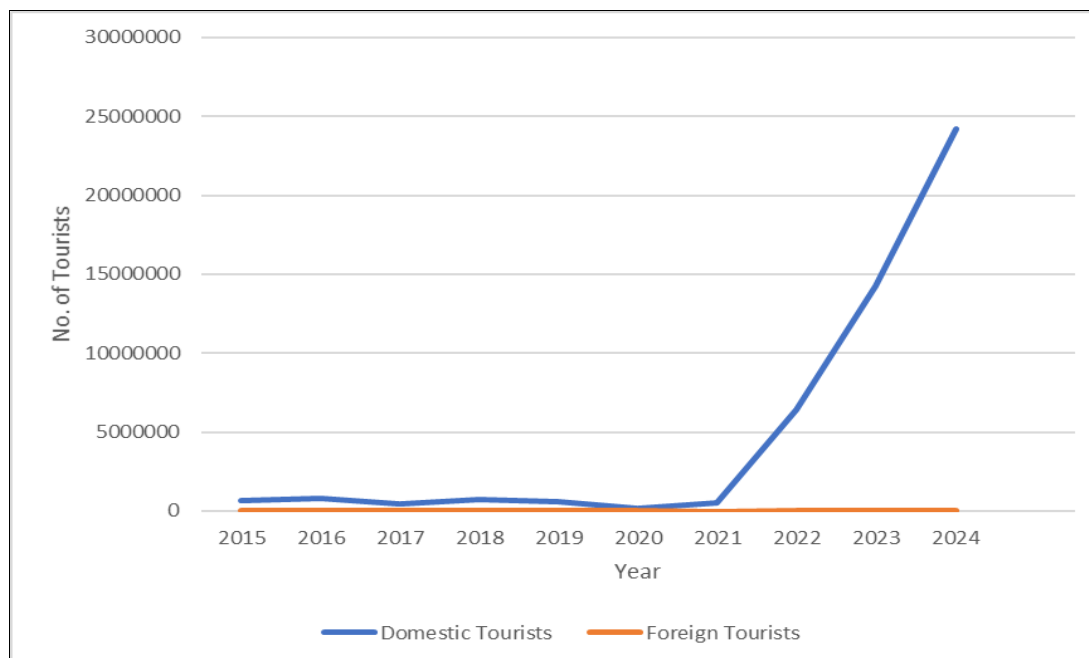
Results

The findings of this study provide a multi-dimensional view of tourism's environmental impact on Chittorgarh, focusing on ecosystem stress and water resource usage. The results are based on secondary data analysis, field observations and related academic studies.

Tourist Inflow Trends

Yearly Trends (2015-2024)

- Tourist arrivals grew from 679,567 in 2015 to 24.2 million in 2024.
- After a slump during COVID-19 (2020-2021), inflows skyrocketed from 505,900 (2021) to 24.2 million (2024).
- The CAGR (2015-2024) is approx. 48.5%, one of the steepest tourism growth rates in Rajasthan.
- Foreign tourists declined sharply from 52,340 arrivals in 2016 to just 12,283 in 2024, reducing from 5.7% in 2015 to 0.05% in 2024. It shows Chittorgarh's reliance on domestic tourism.



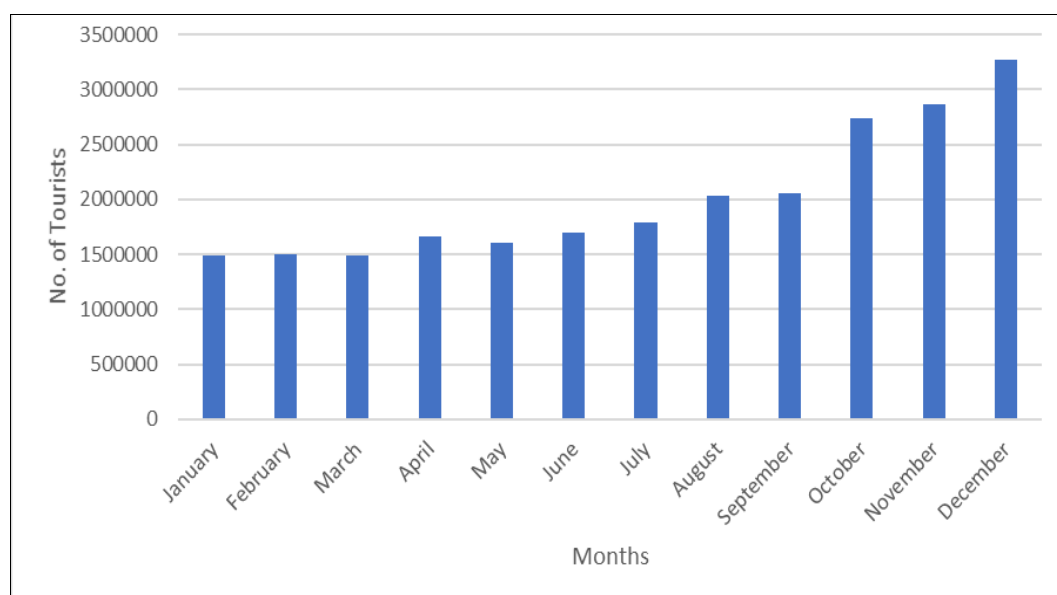
Source: RTI reply from Department of Tourism, Government of Rajasthan

Fig 1: Annual Number of Tourists visiting Chittorgarh for year 2015-2024

The analysis of yearly tourist inflow reveals an upward trend, indicating rapid expansion of tourism activities in the district. The sharp rise in visitor numbers in recent years has intensified pressure on natural resources, particularly water demand, land use and waste generation.

Monthly and Seasonal Trends (2024)

- Annual Total: 24,207,148 (Domestic: 24,194,865; Foreign: 12,283).
- Peak season: Winter season - October-December = 8.88 million arrivals (36.6% of the year's tourism) showing strong seasonality.
- Monsoon season (July-September) is also significant with 5.88 million arrivals (23.3%), indicating that rains do not deter visitors.
- Lean months: Jan-March ≈ 4.47 million (18.5% of the annual arrivals).
- Highest month: December (3.27 million, 13.5% of annual arrivals).
- Lowest month: May (1.61 million, 6.6% of total arrivals).
- Foreign tourists: Peak in February (2,208 arrivals), aligning with Rajasthan's traditional attraction for winter international tourism.
- Overall foreign share remains negligible (0.05% of total).
- Monthly data for 2024 highlight strong seasonality, with peak inflow occurring during winter and festive periods. These months experience maximum stress on water supply systems, waste management infrastructure and local ecosystems. In contrast, off-season months show comparatively lower environmental pressure. This clustering demonstrates that tourism pressures are temporally concentrated rather than evenly distributed.



Source: Department of Tourism, Government of Rajasthan

Fig 3: Month-wise tourist arrivals in Chittorgarh, 2024

Site level Trends (2023-24)

At the site level, religious tourism dominates the district's profile. Sanwaliya Ji Temple alone attracted 10.7 million visitors in 2024, accounting for nearly 44% of total arrivals. Together, religious sites (Jogniya Mata Temple, Shani Temple, Aali and Avari Mata Temple) accounted for the majority of visitors, demonstrating the prominence of pilgrimage-driven inflows.

Among heritage attractions, Chittorgarh Fort drew 902,000 visitors in 2024, including 11,352 foreign tourists, marking a sharp increase from 2023. The majority of tourists visited the Chittorgarh Fort and nearby attractions like Meera Temple, Kalika Mata Temple and Padmini Palace. This site remains the flagship attraction, but also the most vulnerable to overcrowding and water use (Gaumukh Kund, stepwells).

In contrast, Bassi Wildlife Sanctuary saw a decline from 3,612 visitors in 2023 to just 2,678 in 2024, indicating that eco-tourism remains underdeveloped.

Tourist activity is highly concentrated around major pilgrimage and heritage sites, leading to localized environmental stress. These high-density zones experience greater waste accumulation and ecosystem disturbance compared to peripheral areas.

Impact on Water Resources

Water Demand from Tourism

Parallel to this tourism boom, evidence from hydrological studies indicates severe stress on water resources. According to the Hydrogeological Atlas (2013) ^[8], Chittorgarh receives an average 848 mm annual rainfall, but distribution is erratic, ranging from 525 mm in Bhopalsagar to 1,368 mm in Begun.

Tourism's rapid growth in Chittorgarh has significantly increased pressure on local water resources. Based on the Bureau of Indian Standards (IS 1172:1993), average domestic urban water consumption is estimated at 100-150 litres per capita per day. In line with this, domestic tourists are assumed to use approximately 135 litres/day, while foreign tourists, who typically consume more due to hotel amenities such as laundry, packaged water and air-conditioning, are estimated at 200 litres/day (United Nations World Tourism Organization, 2013).

The expansion of tourism activities in Chittorgarh district has led to an increase in water demand, particularly in areas surrounding major tourist sites. Growth in hotels, guest houses, restaurants and associated facilities has intensified groundwater extraction and municipal water consumption.

Seasonal Stress on Water Availability

Seasonal variation in tourist arrivals has created uneven pressure on local water resources. This seasonal variation puts substantial pressure on Chittorgarh's water resources, especially during peak tourist seasons which coincide with dry months (October- December). Such surges place added pressure on existing surface water sources- notably Bassi, Orai, Ruparel and Bujhara Dams- which already face challenges of erratic rainfall, low percolation due to shallow soils, and frequent droughts that cause seasonal drying of streams (Central Ground Water Board, 2017; Zonal Master Plan, 2023) ^[2, 29].

During my field observations near Chittorgarh Fort and Gaumukh Kund, local guides reported water shortages in nearby settlements coinciding with festival tourism peaks,

while shopkeepers in the surrounding wards reported recurring disruptions in piped supply during festival weeks. Studies confirm both quantity and quality issues, Chittorgarh city also faces potable water shortages because of poor quality, uneven distribution and over-extraction (Pathania & Bageshwari, 2011) ^[17].

Groundwater Stress

Official records indicate that several blocks within the district fall under the 'over-exploited' groundwater category. Over nine blocks are over-exploited for groundwater, and both Chittorgarh and Nimbahera blocks are notified meaning no new abstraction is permitted (Central Ground Water Board, 2017; Hydrogeological Atlas of Rajasthan, 2013) ^[8]. While multiple factors contribute to groundwater stress, the growing water demand from tourism activities in high-density visitor zones may add additional pressure on already stressed water resources.

Chittorgarh district is experiencing severe groundwater stress, with an estimated groundwater exploitation rate of around 116%, placing most blocks in the over-exploited category (CGWB, 2017). Water quality assessments further reveal that only 55.9% of tested sources are potable, while the remaining sources are affected by fluoride contamination, elevated total dissolved solids (TDS) and hardness (P. Mali *et al.*, 2021) ^[12]. The groundwater quality assessment of Chittorgarh district highlights significant variation in total dissolved solids (TDS), which ranged from 110 ppm to as high as 2,920 ppm, with a mean concentration of approximately 600 ppm (N. L. Mali & Yadav, 2018) ^[11]. While values below 500 ppm are generally considered good for drinking purposes, higher concentrations indicate increasing salinity and potential health concerns. Tanker supply is common in summer. These combined issues of over-extraction and declining quality exacerbate the vulnerability of Chittorgarh's water resources, particularly as tourism and agriculture intensify demand.

Water Quality Concerns

Alongside the quantitative stress on groundwater, increasing tourism in Chittorgarh also contributes to deteriorating water quality. Field observations revealed littering and wastewater overflow around Gaumukh Kund at the Fort. Similar issues have been documented in Rajasthan's other heritage cities, where tourism-driven waste has increased biological oxygen demand (BOD) and coliform levels in surface waters (R. B. Singh *et al.*, 2019). With over 24 million visitors recorded in 2024, such pollution loads are likely to escalate, threatening both public health and the sustainability of tourism infrastructure. This underscores the urgent need for wastewater treatment, proper solid waste management and eco-sensitive planning around high-traffic religious and heritage nodes.

Waste Generation and Environmental Observations

Tourism activities in Chittorgarh district have also contributed to increased waste generation at major tourist destinations. A large number of visitors at sites such as Chittorgarh Fort and Shri Sanwaliya Ji Temple often lead to the accumulation of solid waste including plastic bottles, food packaging and other disposable materials. Improper disposal of waste can affect the aesthetic value of these heritage and religious sites and may also create

environmental problems.

Field visits and on-site observations at key tourist locations revealed:

- **Waste Generation:** Solid waste accumulation near Chittorgarh Fort and Meera Temple, especially during peak seasons. Higher visitor numbers have resulted in greater volumes of solid waste, with inadequate waste management infrastructure in heritage sites leading to littering and pollution.
- **Pressure on local water bodies** like Gambhiri River and seasonal wells for drinking and sanitation.

If not properly managed, this waste can negatively affect the surrounding ecosystem and the overall visitor experience. Therefore, effective waste management practices and increased awareness among tourists are necessary to minimize the environmental impacts of tourism.

Chittorgarh district is not only known for its heritage and religious tourism but also for its rich biodiversity, particularly in and around the Bassi Wildlife Sanctuary and the forested zones near Menal and Bhainsrorgarh. The Bassi Sanctuary, covering about 13,869 ha, harbors species such as panther, hyena, chinkara, jackal, and numerous waterbirds, in addition to dry deciduous forest vegetation (Zonal Master Plan, 2023) ^[29]. Despite this ecological wealth, eco-tourism in the district remains marginal, with only 2,678 visitors recorded in 2024, a decline from 3,612 in 2023, compared to millions visiting heritage and religious sites.

The limited promotion of biodiversity-based tourism reduces both conservation funding and community incentives to preserve ecosystems. If strategically developed with community-based eco-tourism models, biodiversity tourism could not only diversify the district's tourist portfolio but also contribute to reducing pressure on heritage cores and enhancing sustainable livelihoods.

Stakeholder Perspectives

Stakeholders associated with tourism activities in Chittorgarh play an important role in managing environmental impacts at tourist destinations. Local authorities, tourism department officials, site management staff, shopkeepers and local residents are directly involved in maintaining tourism infrastructure and services. Their perspectives highlight the challenges related to waste management, water availability and maintenance of tourist facilities at major sites such as Chittorgarh Fort and Shri Sanwaliya Ji Temple.

Many stakeholders emphasize the need for improved waste disposal systems, better visitor awareness and stronger coordination between tourism authorities and local communities. Their insights indicate that sustainable tourism management requires active participation from both government agencies and local stakeholders to minimize environmental pressure and ensure the long-term conservation of these important tourist destinations.

Interviews with local residents, villagers, visitors, shopkeepers, transport operators and hotel owners highlighted:

- Solid waste management remains a major challenge.
- Shopkeepers and local residents indicated that tourist activities lead to increased use of plastic and improper waste disposal.
- The need for better awareness among tourists regarding

cleanliness and environmental conservation.

- Lack of coordination between different departments was identified as a key issue in effective tourism management.
- Limited adoption of eco-friendly practices in the hospitality sector.
- Lack of awareness and enforcement regarding waste segregation and water reuse.
- The importance of community participation and improved infrastructure planning was strongly emphasized for sustainable tourism development.

Discussion

Analysis of tourism data for Chittorgarh reveals a significant upward trend in visitor numbers in recent years. The rise in domestic tourism from approximately 14.2 million in 2023 to over 24.1 million in 2024 (Rajasthan Tourism Department, 2024) ^[18] has significantly increased pressure on Chittorgarh's ecosystem.

The study reveals that tourism in Chittorgarh, while economically significant, is exerting increasing pressure on the region's fragile ecological balance and water resources. Peaks in domestic tourism, particularly during festivals and long weekends, are directly correlated with seasonal spikes in water demand, higher solid waste generation and overcrowding at ecologically sensitive sites. These findings align with national and global concerns regarding the environmental sustainability of heritage tourism, especially in semi-arid zones like Rajasthan.

Unbalanced Growth of Tourism

The analysis of tourist trends indicates a significant increase in tourist arrivals in Chittorgarh district, particularly in recent years. However, tourism activities are highly concentrated at a few major destinations such as Chittorgarh Fort and Shri Sanwaliya Ji Temple. This spatial concentration leads to uneven development, where some sites experience excessive tourist pressure while others remain underdeveloped.

While economically beneficial, the growth of tourism underscores the urgent need for sustainable tourism planning to safeguard Chittorgarh's ecological integrity and water security. However, this growth has occurred without corresponding investments in sustainable infrastructure. This supports Butler's Tourism Area Life Cycle (TALC) model, where unchecked expansion can lead to environmental decline and tourist dissatisfaction if not managed proactively.

Environmental Implications of Tourism

The findings of the study highlight that increasing tourism activities have significant environmental implications, particularly in terms of water demand and waste generation. The rising number of tourists contributes to higher consumption of water resources and increased solid waste at major tourist sites. These impacts are more visible during peak tourist seasons, indicating the need for effective resource management and environmental planning.

Stress on Water Resources

Tourism-related water demand is considerable in the context of Chittorgarh's limited water availability. The district's reliance on groundwater, seasonal rivers (e.g., Gambhiri) and tank systems makes it highly vulnerable to water

scarcity. Given the ZMP's note of low percolation, seasonal drying of nallahs and erratic rainfall, any increase in tourism infrastructure (hotels, resorts, camping, boating) will raise local water demand particularly in peak seasons and dry months which could compete directly with local households, livestock and wildlife at critical water points (dams, springs). The ZMP's regulation of commercial water extraction and promotion of rainwater harvesting is therefore essential.

Water quality concerns further complicate sustainability. Fluoride contamination and nitrate pollution not only endanger public health but also risk alienating higher-spending segments of tourists who expect reliable potable water (P. Mali *et al.*, 2021; Hydrogeological Atlas of Rajasthan, 2013)^[8, 12].

Ecological and Heritage Site Degradation

The impact of tourism on different types of tourist sites in Chittorgarh district varies significantly. Major heritage sites such as Sanwaliya Ji Temple and Chittorgarh Fort experience high tourist pressure, leading to issues such as overcrowding, waste generation and strain on infrastructure. Field observations at the Chittorgarh Fort and nearby locations revealed littering, especially plastic waste, around viewpoints and shrines.

In contrast, ecological sites like Bassi Wildlife Sanctuary receive relatively low tourist inflow. While this reduces immediate environmental pressure, it also indicates underutilization of eco-tourism potential in the district. The limited number of visitors may be due to factors such as lack of awareness, inadequate infrastructure and accessibility issues. Sanctuary area is relatively compact and contains threatened taxa; even well-managed ecotourism (trails, birding) can fragment habitat if trails, parking and campsites are poorly sited.

This contrast highlights the uneven spatial distribution of tourism in the district, where certain sites are overburdened while others remain underdeveloped. This imbalance suggests the need for redistribution of tourist flow through better promotion and infrastructure development at lesser-known sites.

Gaps in Local Governance and Policy

The perspectives of stakeholders further support the findings, as local authorities, residents and tourism-related businesses have highlighted challenges related to infrastructure, waste management and resource availability. Stakeholders noted a lack of effective regulation on solid waste management. Though Rajasthan has framed eco-tourism and heritage conservation policies, implementation at the district level remains weak, often due to inadequate coordination between the tourism, municipal and forest departments. The lack of coordination and limited awareness among tourists have been identified as key issues. This suggests that sustainable tourism development requires active involvement of stakeholders along with effective policy implementation. This highlights a need for integrated environmental governance, which links tourism planning with ecological zoning, carrying capacity assessments and resource audits.

Conclusion and recommendations

Based on the above analysis, the conclusion can be drawn that tourism development in Chittorgarh district has shown

significant growth, particularly at major heritage and religious sites such as Chittorgarh Fort and Shri Sanwaliya Ji Temple. However, this growth is spatially uneven, with certain destinations experiencing high tourist pressure while others, such as Bassi Wildlife Sanctuary, remain underutilized.

Tourism in Chittorgarh illustrates the double-edged nature of tourism growth: while it strengthens the local economy and enhances heritage visibility, it also places immense seasonal pressure on water resources, waste management and fragile ecosystems. Bassi Wildlife Sanctuary is surrounded by 42 villages that depend directly on its forests for grazing, fuelwood and non-timber products.

The findings clearly indicate that Chittorgarh is approaching a critical threshold where unchecked tourism could compromise both environmental sustainability and the tourist experience itself. Stakeholder interviews further confirmed that despite existing environmental concerns, there is limited institutional action and insufficient enforcement of sustainability guidelines.

The study highlights key challenges including increasing demand for water resources, waste generation and infrastructure pressure at major tourist sites. These issues indicate the need for balanced and sustainable tourism development in the district. Effective planning, improved infrastructure and stakeholder participation are essential to ensure long-term sustainability of tourism in the region.

7.1 Sustainable Tourism Strategies

This study calls for an urgent shift toward sustainable tourism planning that prioritizes:

- Improvement in solid waste management systems.
- Promotion of eco-tourism at Bassi Wildlife Sanctuary. Diversification of tourism through eco-tourism and cultural initiatives at under-visited sites like Bassi.
- Integrated policy implementation involving tourism, forest, municipal and cultural departments.
- Development of infrastructure at lesser-known sites in Chittorgarh district to reduce pressure on major destinations.
- Awareness campaigns for tourists regarding cleanliness and conservation.
- Better coordination among tourism authorities and local stakeholders.
- Promotion of eco-friendly tourism practices. Community-based eco-tourism, integrating local villages into tourism benefits to reduce forest dependence. Community participation and awareness, making local stakeholders active partners in conservation.
- Efficient water management in hotels and tourism facilities. Water resource management through rainwater harvesting and recycling in all tourism facilities, alongside restoration of traditional baories and kunds. For long-term sustainability, tourism planning must address both quantity and quality of water resources. On the quality front, fluoride and nitrate monitoring must be integrated into public health planning. (ZMP promotes rainwater harvesting & reuse).
- Adoption of geospatial technologies to monitor land use changes and assess environmental impact.
- Spatial zoning of tourism infrastructure: Use the ESZ maps to keep accommodation, parking and high-use

facilities outside sensitive corridors and proximate to larger roads - restrict new hotels within 1 km as per ESZ rules.

By embedding sustainability into every layer of tourism governance, Chittorgarh can preserve its ecological balance while continuing to attract visitors from around the world. Unless policy measures such as eco-tourism zoning, waste treatment and community-based resource management are operationalized, Chittorgarh may face unsustainable ecological stress despite its tourism success. The lessons from this case are also relevant to other heritage tourism destinations across India, particularly in arid and semi-arid regions.

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