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RECEIVED 26 September 2024

ACCEPTED 19 November 2024

PUBLISHED 24 December 2024

CITATION

Bhushan S, Dincă I and Shikha S (2024)
Evaluating local livelihoods, sustainable forest
management, and the potential for
ecotourism development in Kaimur Wildlife
Sanctuary, India.
Front. For. Glob. Change 7:1491917.
doi: 10.3389/ffgc.2024.1491917

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Evaluating local livelihoods, sustainable forest management, and the potential for ecotourism development in Kaimur Wildlife Sanctuary, India

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Effective forest management in India must address the economic needs of local communities, often displaced by restrictive policies. These marginalized local communities, despite their traditional knowledge, lack alternative income sources, necessitating integration into management or exploration of options like ecotourism. Recognized for balancing conservation and livelihood support, ecotourism offers a viable solution to enhance economic opportunities while conserving resources. This paper explores ecotourism's potential to boost local economies and examines how current management practices and alternative livelihoods can address resource scarcity in Kaimur Wildlife Sanctuary, India. The study employed a combination of qualitative research methods, including semi-structured interviews, surveys, on-site observations, focus group discussions, and literature reviews, along with a cross-sectional survey approach that integrated both qualitative and quantitative data collection to provide comprehensive insights. The study reveals that impoverished communities near forests, reliant on indigenous knowledge and resources, have been severely affected by forest degradation and current management practices. The findings highlight community-based ecotourism as a promising solution for sustainable income generation in the region, helping to mitigate resource degradation and support sustainable development. However, the region's ecotourism potential is hindered by inadequate infrastructure, training & opportunities, and public awareness. Developing ecotourism as an alternative income source, alongside an inclusive forest management strategy that integrates social diversity, livelihood generation, and conservation, is essential for promoting nature conservation, reducing poverty, and enhancing the well-being of local communities. Strengthening non-agricultural livelihoods and preserving indigenous knowledge through ecotourism is crucial for effective resource management, while the study underscores the importance of community involvement in forest governance, offering valuable insights for policymakers and conservationists in developing sustainable management strategies.

KEYWORDS

ecosystem management, sustainable development, ecotourism, indigenous knowledge, marginalized communities, Wildlife Sanctuary, poverty alleviation, inclusive forest governance

1 Introduction

Forests have been vital to surrounding communities, supplying essential resources such as food, shelter, and fuel, while also holding significant cultural, religious, and spiritual value. Estimates from the FAO (2014) and the World Bank (2004) indicate that approximately 1.6 billion people globally rely on forests for their livelihoods. In India, forestry is the second-largest land use after agriculture, with an estimated 275 million rural inhabitants about 27% of the country's population depending on forests for subsistence and income. This income largely comes from the sale of fuelwood, fodder, bamboo, and other non-timber forest products, with fuelwood meeting the domestic energy needs of 70% of India's rural population (FAO and UNEP, 2020).

Non-timber forest products such as firewood, fodder, and various items predominantly gathered by women provide shorter gestation periods and offer greater extraction potential than timber, which tends to be within the domain of men (Molinas, 1998; Agarwal, 2009; Coleman and Fleischman, 2012; Coleman and Mwangi, 2013). However, forest degradation over recent decades has disrupted these traditional livelihoods, diminished cultural and spiritual connections, raised global environmental concerns, and unequally impacted marginalized groups (Sunderlin et al., 2005; Davidar et al., 2010; Angelsen et al., 2014; Wunder et al., 2014; Newton et al., 2016; Banday et al., 2021). Lower-caste and Indigenous communities, who possess traditional forest knowledge and deep ties to these environments, have borne the brunt of this degradation, which has exacerbated existing social inequalities. The forest's decline has not only favored a small segment of society but has left many communities without access to sustainable livelihoods, contributing to uncertain futures. Furthermore, the degradation has intensified the labor demands on women, who are primarily responsible for collecting fuelwood, fodder, and fruits from the forest (Islam et al., 2015).

Forest conservation, crucial for both community sustainability and environmental quality, has therefore become a global priority. Numerous regions have initiated conservation measures, adopted modern methods, and engaged local institutions. However, for conservation strategies to be effective and enduring, it is essential to recognize the economic benefits of forest preservation. Unfortunately, many conservation policies have overlooked the basic needs of rural communities, neglecting the skills, values, and decision-making roles of approximately 90% of those most affected. This study aims to provide ecotourists with a thorough understanding of the impacts on these communities, focusing on the challenges posed by land conversion and their adaptation to alternative livelihoods. Ecotourism has emerged as a crucial market-based approach to forest conservation, offering an environmentally friendly income source that harnesses forest resources in a non-consumptive manner (Wunder, 1999; Boley and Green, 2016). By valuing forest-based recreational and wellbeing services, ecotourism bridges rural, urban, and natural environments (Lindberg et al., 1998; Battles et al., 2001; Termansen et al., 2008; Ahtikoski et al., 2011; Fredman et al., 2012; Heyman, 2012; Abildtrup et al., 2013; Korpela et al., 2014; De Meo et al., 2015; Dudek, 2017; Bötsch et al., 2018; Komossa et al., 2018; Shariff et al., 2020; Hruza et al., 2021; Tudoran et al., 2022; Rathmann, 2023; Ristić et al., 2024).

Defined by The International Ecotourism Society as responsible travel that benefits both the environment and local communities, ecotourism is grounded in principles of environmental protection, cultural respect, and economic benefits. World Tourism Organization (UNWTO) (2002) promotes sustainable tourism through community involvement and interpretive experiences. Advocates regard ecotourism as a conservation tool capable of generating employment and reducing poverty (Holland et al., 2003; Stronza, 2007; Wishitemi et al., 2015), though critics point to possible environmental harm, economic inequality, and adverse social effects (Gulinck et al., 2001; Coria and Calfucura, 2012). In forest villages, ecotourism can provide an ideal, ecologically sustainable source of income, potentially raising local living standards and reducing pressure on natural resources. This approach supports ecological balance, fosters regional and international cooperation, and facilitates knowledge exchange between rural and urban areas (Kahveci, 2022). As a sustainable model, ecotourism underscores the interconnectedness of tourism and development (Bansal and Kumar, 2011) and integrates environmental, socio-cultural, and economic systems (Wall, 1997). Its growth provides a unique opportunity to combine rural development, resource management, and conservation on a global scale (Hvenegaard, 1994).

India, with its diverse forests, abundant wildlife, and rich cultural heritage, is well-positioned to become a premier ecotourism destination. Despite ecotourism's potential to enhance sustainable forest management and provide alternative income sources, few studies have rigorously explored its role in supporting local communities and conserving forest cover (Pujar and Mishra, 2021). This study therefore evaluates ecotourism's potential as a sustainable income source and conservation tool in the Kaimur Wildlife Sanctuary, India. It investigates the interactions between local communities and forest resources, considering alternative income sources amid resource scarcity, and assesses how these can be integrated into sustainable conservation practices. Specifically, it examines ecotourism's role in addressing economic challenges and resource scarcity among marginalized communities, emphasizing the encouraging importance of community participation in forest management (Bhattacharya et al., 2010). The study posits that ecotourism, when aligned with inclusive forest management strategies, can serve as a sustainable solution for local livelihood needs, forest conservation, and mitigating adverse impacts from current management practices in Kaimur Wildlife Sanctuary. It hypothesizes that community-based ecotourism can enhance economic opportunities for marginalized groups while supporting long-term conservation goals by promoting local involvement in resource management."

1.1 The place of ecotourism between theoretical exploration and concrete socio-economic initiatives

Ecotourism is a conservation-oriented approach that seeks to protect natural resources while offering economic, social, and cultural benefits to local communities (Figure 1). It provides livelihood opportunities and supports the conservation of wildlife, bird habitats, rivers, mountains, deserts, coral reefs, and forests (Salafsky and Wollenberg, 2000; Abbot et al., 2001; Kiss, 2004; Shah, 2007; Dinca

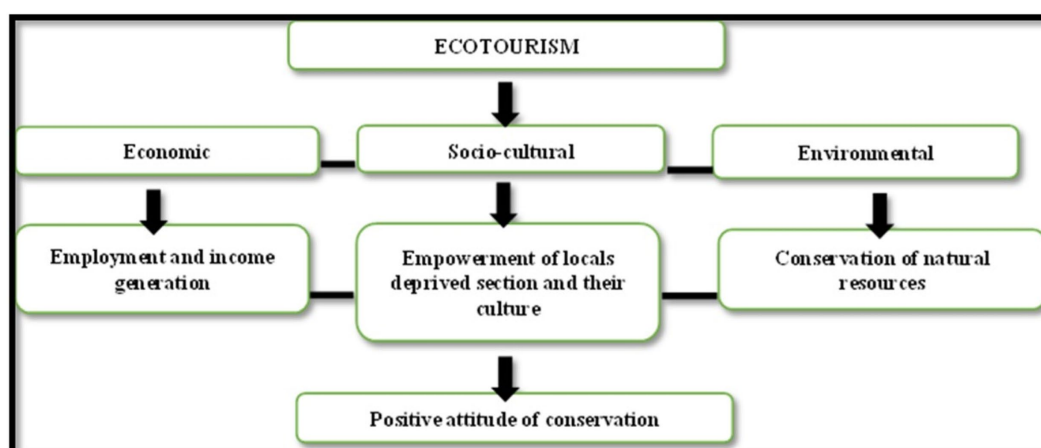


FIGURE 1
Framework of the study.

et al., 2023; Atchombou et al., 2023). Evidence suggests that income from tourism fosters positive attitudes toward conservation among local communities (Chen et al., 2005; Gyan and Nyaupane, 2011). Growing three times faster than conventional tourism, ecotourism is projected to capture 5% of the holiday market, highlighting its expanding influence on rural economies and biodiversity conservation goals (Blangy and Mehta, 2006; Das, 2011; Sharpley, 2006).

For many rural areas, ecotourism offers economic opportunities, including employment, small business development, and skill-building (Scheyvens, 2000; Jalani, 2012). Indigenous communities benefit through income diversification and improved living standards (Stronza, 2007). Well-implemented ecotourism initiatives can strengthen livelihoods by promoting employment in tourism services, such as eco-lodges, restaurants, souvenir shops, and transportation (Ashley and Roe, 2002; Goodwin, 2002; Mustika et al., 2012; Reimer and Walter, 2013). Studies in India's Sunderbans region show that income from tourism supports annual household consumption, supplementing subsistence farming (Guha and Ghosh, 2007). Although seasonal, ecotourism income encourages resource conservation and can finance education, building human capital within communities (Stronza, 2007; Surendran and Sekar, 2011).

Ecotourism also plays a role in challenging traditional gender roles. Horton (2009) notes that ecotourism often expands women's responsibilities beyond domestic tasks, while Scheyvens (2000) highlights its potential for indirect empowerment through improved access to essential services. In India, eco-development initiatives, such as those by Mishra et al. (2009), have prioritized marginalized groups, linking environmental sustainability with financial, institutional, and social empowerment. However, while ecotourism can positively affect socio-cultural conditions, it also has risks, including overcrowding, increased crime, cultural erosion, and health risks. For instance, increased tourism has led to overcrowding in protected areas like Kanha and Corbett National Parks, disrupting wildlife and displacing local communities (Banerjee, 2010; Wunder, 1999). The International Ecotourism Society defines ecotourism as "responsible travel to natural areas that conserves the environment and improves the welfare of local people" (Das and Chatterjee, 2015). Similarly, Kimengsi (2014) emphasizes the role of ecotourism in enhancing livelihoods and

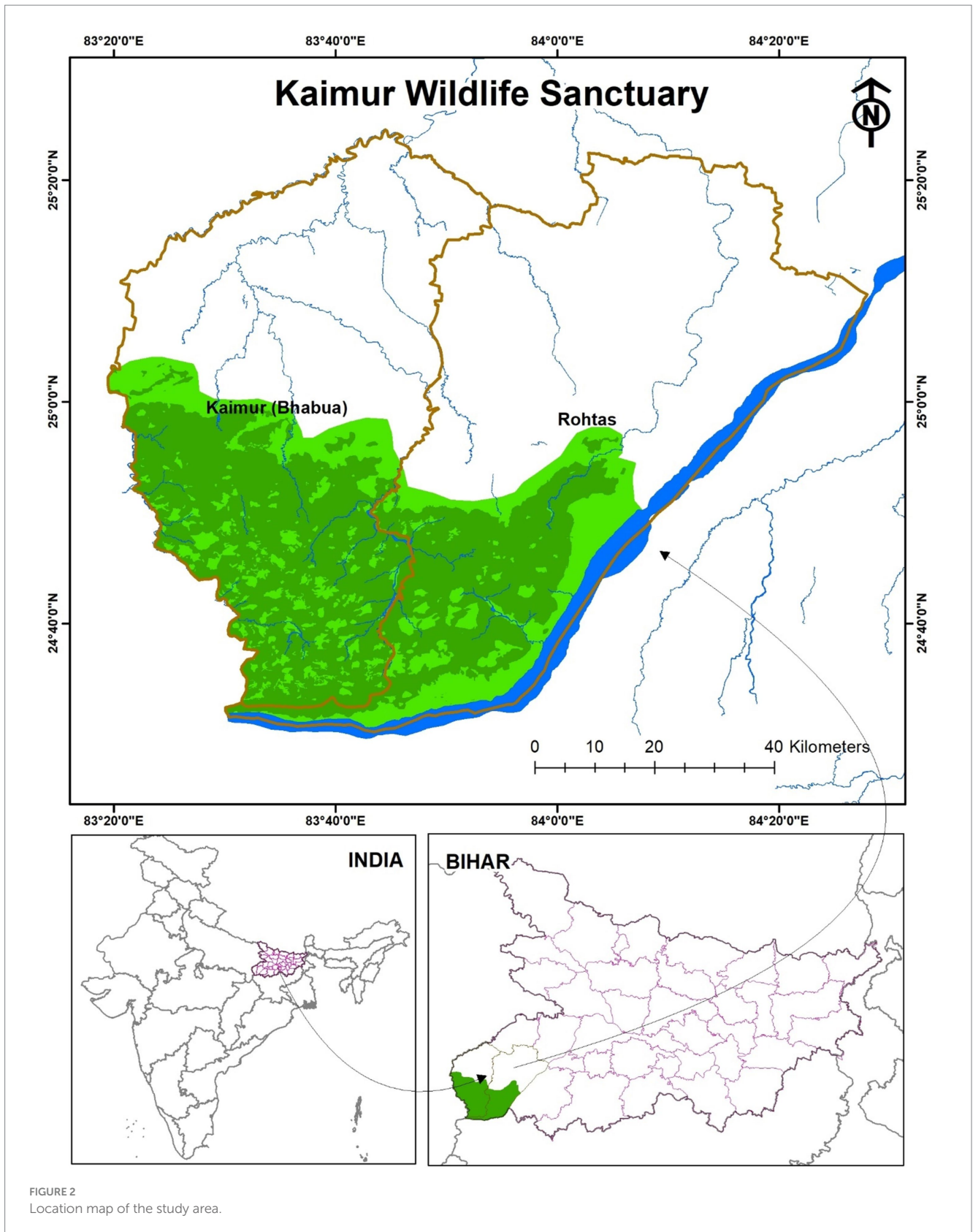
conserving natural resources, including forests. Recognized as a sustainable development strategy, ecotourism provides environmental, economic, and social benefits but also faces challenges, such as uneven benefit distribution, limited local knowledge, environmental degradation, and social disruption (Kiper, 2013; Kumar et al., 2020).

Ecotourism principles advocate for sustainable practices that address social, political, and environmental issues while benefiting local populations (Das and Chatterjee, 2015). Key themes in ecotourism development include poverty reduction, community engagement, and environmental conservation (Andereck et al., 2005; Clifton and Benson, 2006; Stronza and Gordillo, 2008). As one of the fastest-growing sectors in tourism, ecotourism has proven its positive economic impact by generating jobs and improving quality of life (Eshun et al., 2016; Hugo and Nyaupane, 2010). Environmental sustainability is central to successful ecotourism, with stakeholder participation essential for balancing economic, social, and environmental impacts. Québec Declaration on Ecotourism (2002) emphasizes the importance of integrating environmental conservation with social equity and economic development. Equitable and sustainable ecotourism requires a multidisciplinary approach to address governance and climate challenges, emphasizing holistic development that preserves socio-cultural integrity and supports local livelihoods (Johnson et al., 2019).

2 Materials and methods

2.1 Study site

The study was conducted in villages surrounding the Kaimur Wildlife Sanctuary (KWS), located in the Kaimur and Rohtas districts of Bihar, India (Figure 2). Bihar, in eastern India, is known for its agricultural productivity and dense population but has limited forest coverage, comprising only 7.85% of the state. However, the Kaimur and Rohtas districts have the highest forest cover in Bihar, with forests accounting for 24% of the area (State Forest Report, Forest Survey of India, 2021). Established in 1979 and spanning approximately 1,342 km² (Table 1), KWS borders the provinces of Jharkhand and



Uttar Pradesh. It is notable for its natural features, including densely forested plateaus, waterfalls, lakes, ancient rock art, and lush hills. KWS experiences a tropical climate with three distinct seasons: summer (March–June) with temperatures reaching 40–45°C, a monsoon season

(July–September) with 1,100 mm of rainfall and temperatures of 25–35°C, and winter (October–February) with temperatures from 10 to 25°C. Local wind patterns and high evapotranspiration rates during summer are offset by monsoon rains. The sanctuary’s soils, which

TABLE 1 Forest distribution and growth status in the region (Source: State Forest Report, Forest Survey of India).

	Total forest cover (2001) (km ²) (%)		Total forest cover (2021) (km ²) (%)		Total change (km ²) (%)	Per Capita forest area (ha)
	Dense	Open	Dense	Open		
India	416,809 (12.68)	258,729 (7.87)	407,750 (12.40)	304,499 (9.26)	36,711 (5.15)	0.059
Bihar	3,372 (3.58)	2,348 (2.49)	3,592 (3.81)	3,707 (3.94)	1,579 (21.63)	0.007
Kaimur Wildlife Sanctuary	842 (11.67)	863 (11.96)	860.5 (11.93)	902.5 (12.51)	57 (3.26)	0.038

include red, laterite, and alluvial types, are shaped by the local geology and climate and support diverse vegetation. While red and laterite soils are iron-rich but low in nitrogen, phosphorus, and potassium, fertile alluvial soils found in valleys support diverse plant growth. Soil textures vary from sandy to clayey, facilitating water infiltration, though erosion remains a risk on steeper slopes (Anand and Peters, 2022; Anand et al., 2022; Sen et al., 2014).

The sanctuary hosts a diverse range of species, including Sambar (*Rusa unicolor*), Chital (*Axis axis*), and the endangered Blackbuck (*Antelope cervicapra*), alongside various primates, reptiles, and numerous bird species. These forests are vital to local livelihoods, providing timber, fuelwood, fodder, and fruit. A popular winter tourism destination, KWS features wildlife such as Blackbuck, Chital, Sambar, Chinkara, Blue Bull, Grey Quail, Francolin, and Peafowl (Tahoor et al., 2016). The tropical dry deciduous forests support significant flora, including Indian Rosewood (*Dalbergia latifolia*), Teak (*Tectona grandis*), and Tendu (*Diospyros melanoxylon*), with Tendu leaves used locally for Bidi production. Mahua (*Madhuca longifolia*) fruits are also harvested for traditional beverages, underlining the forest's importance for local communities.

The socio-economic landscape of KWS is diverse, with many residents from marginalized scheduled castes and tribal communities who rely heavily on forest resources. Significant land-use changes in recent decades have converted forest areas to agricultural land due to population pressure. Although government programs have expanded agricultural cultivation, many marginalized and indigenous populations continue to depend on forest resources rather than agriculture or animal husbandry. Despite diverse social backgrounds, communities around the sanctuary share a reliance on forest resources (Bose et al., 2012), facing pervasive poverty, economic inequality, and restrictive forest management policies that limit forest access and NTFP collection. Afforestation projects primarily employ locals as guards but rarely involve them in broader forest management. Recognizing KWS's importance, the government plans to designate the sanctuary as Bihar's second Tiger Reserve, aiming to enhance conservation efforts, promote ecotourism, and support sustainable livelihoods.

2.2 Data collection and analysis

This study used a mixed-methods approach, combining quantitative and qualitative data collection techniques for a comprehensive analysis. Quantitative data were gathered through structured surveys across nine villages in the study area. A stratified random sampling method was employed, dividing villages into three groups based on proximity to the ecotourism site and forest resource

availability: low forest cover (high resource scarcity), medium forest cover (moderate scarcity), and high forest cover (low scarcity). Three villages from each group were selected, totaling nine villages with 327 households and 1,157 residents (652 males and 505 females). The survey included sections on demographics, natural resource dependency, economic conditions, involvement in ecotourism, environmental conservation attitudes, alternative income sources, community conservation roles, and institutional support. A pilot study with 10 households in Masani village validated and refined the survey format. Data collection occurred from February to May 2024. Qualitative data were collected through semi-structured interviews, focus group discussions, and direct observations to gather in-depth information on villagers' attitudes, motivations, and experiences. Focus group discussions included village forest conservation committees, with representation from various social and gender groups. Key informant interviews were conducted with forest officials, panchayat representatives, and senior villagers to provide insights into community roles in conservation. Observations during field visits supplemented the qualitative data.

The study utilized both primary and secondary data sources. Primary data included household interviews, focus group discussions, and key informant interviews. Secondary data sources included the Forest Survey of India, Census of India, and relevant NGO reports. Data were analyzed using SPSS (version 25) and visualized in Excel. Descriptive statistics and econometric methods assessed the impacts of deforestation on livelihoods and explored ecotourism's potential in the area. Key demographic variables, such as household position, gender, age, and employment status, were measured, along with socio-economic conditions and livelihoods, using a five-point Likert scale (1 = strongly disagree to 5 = strongly agree) to gauge attitudes. Additionally, a case study approach (Yin, 2011) examined the interactions between ecotourism and livelihoods, focusing on poverty reduction. Findings from this approach are context-specific and may not be generalizable to other settings (Veal, 2006; Yin, 2009).

3 Results

3.1 Relationship between forest resources and local communities

The relationship between forest resources and local communities in the Kaimur Wildlife Sanctuary (KWS) is deeply interwoven, driven by historical reliance, economic needs, and cultural traditions. As a key ecological zone in Bihar, KWS supports local livelihoods but also faces conservation challenges due to its heavy utilization. Local communities, comprising various social groups, have historically

depended on KWS forests for sustenance through food, fuel, fodder, medicinal plants, and materials for handicrafts. Timber extraction has long been a mainstay for construction and industry, while wood serves as fuel and building material for livestock shelters (Hegde and Enters, 2000; Dash et al., 2016). Non-timber forest products (NTFPs) like Tendu leaves, used for rolling traditional cigarettes, and wild fruits and berries provide both nutrition and income. This dependence fostered sustainable practices rooted in local ecological knowledge, preserving forest health for generations. However, rising population pressures and socio-economic shifts have driven increased and unsustainable resource extraction, leading to deforestation and habitat degradation. To address these issues, there is a critical need for forest management strategies that balance conservation with the essential needs of local communities.

The economy of communities surrounding Kaimur Wildlife Sanctuary (KWS) is closely tied to forest resources, with nearly half (46.5%) of the population reliant on forest-related activities, including non-timber products and firewood, underscoring the urgent need for sustainable forest management (Figure 3). Labor activities account for 30.4% of occupations, reflecting a dependence on low-income, unskilled jobs due to limited resources, which highlights the necessity for alternative livelihoods and skill development. Agriculture comprises 18.3% of employment, likely constrained by limited arable land and challenging conditions, while only 4.8% engage in other occupations, pointing to a need for economic diversification through small businesses and training. Additionally, many residents combine agriculture with forest-based activities like harvesting non-timber

forest products (NTFPs) such as fruits, nuts, and medicinal plants, providing critical income for marginalized groups (Harbi et al., 2018). Forests also supply livestock fodder and fuelwood, vital for rural daily life. However, this reliance on forest resources presents sustainability challenges, as forest degradation reduces access to essential resources, exacerbating poverty and inequality. In response, some individuals turn to illegal logging or poaching, intensifying environmental strain and threatening biodiversity.

Grazing and the collection of non-timber forest products (NTFPs), such as Tendu leaves, fruits, and medicinal plants, are essential for the livelihoods of many families in Kaimur Wildlife Sanctuary (KWS), with some residents also employed in conservation roles by local officials. Fuelwood and fodder are commonly gathered due to their free availability, while fruit and timber collection vary according to economic status, with timber use decreasing due to conservation efforts. Formal employment in forestry remains limited (12.68%), and engagement in ecotourism is minimal (0.05%), highlighting the untapped potential for sustainable livelihood alternatives (Table 2).

The dependency on forest resources underscores the need for sustainable management and economic diversification to alleviate ecological stress and improve community resilience. The challenging KWS terrain and socio-economic disparities, particularly among indigenous and lower-caste groups, have intensified reliance on forest resources. Forest degradation and restrictive policies have deepened poverty, while agriculture is largely controlled by upper-caste groups. As forest resources decline, many residents are pushed into labor markets or low-skill forest-related jobs, often with limited scope for applying their

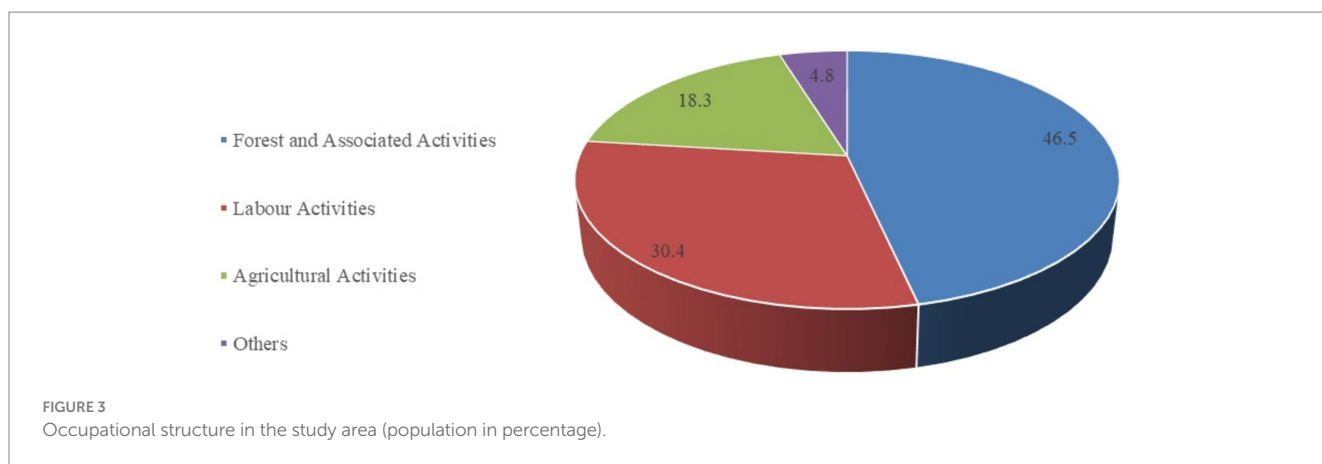


TABLE 2 Engagement in forest and associated activities by the local households (Source: Field Survey in Kaimur Wildlife Sanctuary, Annex 1).

Major forest-related activities	Percentage of households involved in primary activities (mean population involved)	Weight of products collected weekly (kg)	Time Spent in the forest in a year (days)
Fuel wood collection	93.5	82.67	185
Fruits collection	59.90	4.8	62
Fodder collection for livestock	92.45	17.65	127
Employment in forestry and associated activities	12.68	-	22
Timber collection	32.69	45	30
Collection of other forest products	27.45	10–12	15–20
Involvement in ecotourism	0.05	-	20–25

traditional knowledge. The region's limited development in manufacturing and services further restricts economic opportunities, reducing income and limiting upward mobility. Although significant research exists on forests and livelihoods, there remains a critical need to understand the interactions between forest resources and caste dynamics in India, where caste continues to influence social and economic relations.

In the Low Scarcity Region (LSR), the primary livelihood activities involve the collection of forest products, chiefly fuelwood, fruits, and fodder, predominantly for personal consumption, with a portion sold in nearby markets. The income generated from forest-related activities in this region is influenced by both the quality and accessibility of the available resources. Conversely, the Moderate Scarcity Region (MSR) exhibits the highest forest income compared to the High Scarcity Region (HSR) and LSR. This income disparity can be attributed to the presence of supplementary income sources in the MSR, coupled with improved market access, which facilitates greater sales of forest products than those observed in HSR and LSR. In MSR, sales of fuelwood constitute the primary income source derived from forest resources, driven by proximity to markets, enhanced transportation infrastructure, and easier access to forested areas. The time spent in forested environments and the distance traveled for resource collection are significantly affected by the level of resource scarcity, which is greatest in HSR and least in LSR (Table 3).

Beyond economic reliance, forests are vital to the cultural and social structures of local communities. Traditional beliefs, practices, and livelihoods are intricately linked to forest ecosystems. Numerous indigenous communities maintain distinct cultural connections to specific trees, animals, and landscapes, which are fundamental to their identity and heritage. Festivals, rituals, and customs often celebrate this relationship with nature, fostering a sense of stewardship and responsibility toward forest conservation. Furthermore, forests provide opportunities for social cohesion and community engagement.

Emerging community-based organizations and local cooperatives are promoting sustainable practices, eco-tourism, and crafts that embody traditional knowledge. These initiatives empower communities, enabling them to achieve economic benefits from forest conservation while nurturing pride in their cultural heritage.

3.2 Forest management and co-benefits for nature and community

The Kaimur Wildlife Sanctuary (KWS), located in the northern plains of Bihar, represents a critical site for forest conservation, biodiversity, and socio-economic upliftment. Given the ecological richness and socio-cultural diversity of the area, sustainable forest management in KWS focuses on aligning conservation goals with community needs, producing dual benefits for both nature and local populations. This approach of forest management is integral for maintaining ecological balance, safeguarding biodiversity, and enhancing the quality of life for local communities, particularly those economically dependent on forest resources. Key strategies in forest management include zoning, community involvement, and controlled access to ensure conservation and sustainable resource use. Zoning divides KWS into core, buffer, and transition zones: core areas are strictly protected for wildlife, buffer zones support low-impact ecotourism, and transition zones allow sustainable use by local communities, achieving a balance between ecosystem preservation and community needs. Community involvement is integral, as residents, many of whom traditionally rely on forest resources, actively participate in afforestation, nursery work, and forest monitoring, fostering a sense of ownership and strengthening conservation efforts. Controlled access and visitor capacity management limit ecological disturbance in high-demand areas, with eco-friendly infrastructure like wooden walkways to protect habitats while enriching

TABLE 3 Summary statistics (mean) of forest activities among various degradation regions.

Indicator	HSR (1)	MSR (2)	HSR (3)	LSR (4)	MSR (5)	LSR (6)
Fuel wood collection weekly (in kg)	76.95	82.9	76.95	91.81	82.9	91.81
	(-5.94)		(-14.86)**		(-8.91)*	
Fruit collection monthly (in kg)	1.22	2.04	1.22	2.8	2.04	2.8
	(-0.82)**		(-1.58)**		(-0.75)**	
Land cultivated (in Bigha ^a)	3.23	2.75	3.23	1.15	2.75	1.15
	(0.48)		(2.07)**		(1.59)**	
Income from forest monthly (in Rs. ^b)	543.7	1,966.2	543.7	82.09	1,966.2	82.09
	(-1,422)**		(461)**		(1,884)**	
Number of livestock	3.93	2.20	3.93	5.29	2.20	5.29
	(1.72)*		(-1.36)		(-3.09)**	
Spent days in the forest (monthly)	8.01	15.14	8.01	11.6	15.14	11.6
	(-7.13)**		(-3.58)**		(3.54)**	
Time reaches into forest (in hours)	2	1.41	2	1.02	1.41	1.02
	(0.59)**		(0.98)**		(0.38)**	
Distance covered to reach to forest (in km)	4.59	3.17	4.59	2.32	3.17	2.32
	(-1.42)**		(2.27)**		(0.84)**	

Figures within brackets refer to difference values of mean between columns (1, 2), (3, 4), and (5, 6) with independent sample t-test; **, * indicate significance at the 1 and 5%, respectively. ^aIn Bigha (1 Bigha = 0.25 hectare). ^bIncome measured in 2024 Rupees (Rs. 83 = 1 USD). HSR, High Scarcity Region; MSR, Moderate Scarcity Region; LSR, Low Scarcity Region.

visitor experiences. This balanced approach aligns tourism, conservation, and community empowerment to preserve KWS's unique environment.

Co-benefits for nature and community within the region encompass biodiversity conservation, habitat restoration, and sustainable resource utilization, alongside economic opportunities, empowerment, and improved living standards for residents. Initiatives such as reforestation and habitat restoration are crucial for reviving degraded areas, enhancing biodiversity by supporting various native species and promoting ecosystem resilience. Sustainable practices, including controlled harvesting of non-timber forest products, prevent over-extraction, ensuring essential resources remain available for future generations while providing locals with supplementary income. Ecotourism creates employment opportunities in guiding, hospitality, and handicrafts, alleviating poverty, and income inequality, while community-led marketplaces enable direct benefits from tourism revenues. KWS's focus on skill development, particularly for women and marginalized groups, equips locals with training in guiding and eco-lodge management, enhancing employability and reinforcing the conservation mission by empowering residents as active environmental stewards. Furthermore, improved access to health and education funded by tourism revenues elevates living standards, reduces reliance on unsustainable practices, and fosters social cohesion by promoting shared responsibility for the forest, thereby strengthening community ties and contributing to overall wellbeing.

The forest management framework also integrates traditional ecological knowledge, utilizing indigenous practices like rotational grazing and seasonal harvesting to support sustainable resource use while honoring local cultural traditions. This approach fosters a conservation model that respects local heritage while promoting sustainable development. To maintain positive outcomes for both nature and community, KWS employs regular monitoring and evaluation, tracking indicators such as biodiversity, community income from tourism, and visitor satisfaction. This adaptive, data-driven strategy enables timely adjustments, ensuring that conservation goals and community benefits remain aligned. The forest management strategy in Sanctuary serves as a holistic model for sustainable development, one that merges ecological preservation with socio-economic progress. By fostering collaboration between local communities, government bodies, and conservation organizations, KWS promotes a balanced approach to managing its rich forest resources. This model not only ensures the long-term conservation of the sanctuary's unique ecosystems but also empowers local communities through economic opportunities, skill development, and enhanced living standards. Through its integrated approach, KWS stands as a promising example of how protected areas can provide co-benefits for nature and humanity, contributing to sustainable forest management and community resilience in the face of ecological and socio-economic challenges.

3.3 Current state of tourism and ecotourism in the region

Despite its rich biodiversity, scenic landscapes, historical landmarks, indigenous cultural heritage, religious sites, and numerous waterfalls, remains relatively underdeveloped as a tourism destination compared to other wildlife sanctuaries in India (Patel and Anuragi, 2023). Currently, KWS primarily draws local tourists and a limited number of adventure seekers interested in its natural

beauty and historical sites. Although key attractions (Table 4 and Figure 4) resonate with local and regional visitors, the sanctuary's full tourism potential is still largely untapped. Traditionally, religious sites such as Mundeshwari Temple and Gupteshwar Cave have attracted visitors, gradually gained regional significance and drawn pilgrims from other parts of the state. Beyond its cultural importance, the area's natural beauty also appeals to visitors from neighboring states for picnics, adventure activities, and wildlife observation. Recognizing the ecological and cultural significance of KWS, the state government has recently launched initiatives to enhance its tourism profile. These efforts include the introduction of boating and fishing activities at Karamchat and Jagdahwan Dam Lakes, the development of an eco-park near Karakat Waterfall, and the installation of trails and recreational amenities around Telhar Waterfall and Manjhar Lake. To improve accessibility, transportation infrastructure has been upgraded, and facilities such as a museum, stairways, and shelters have been added near Mundeshwari Temple (Table 4 and Figure 4).

Additionally, new guesthouses, hotels, and restaurants have been established to accommodate non-local visitors, and temporary facilities are provided during religious festivals with support from government bodies and local communities.

The Bihar government has recently intensified efforts to enhance tourism appeal in the Kaimur Wildlife Sanctuary (KWS), with plans to designate it as a tiger reserve and allocate funds to develop attractions such as waterfall sites and boating activities near man-made dams. Although some level of community participation exists, primarily in guiding services and handicraft production, these initiatives remain minimal. Government and NGO-led projects have introduced conservation efforts and preliminary tourism development through pilot projects involving local communities, yet the overall tourism infrastructure in KWS remains underdeveloped. Key limitations include inadequate infrastructure, such as poor road conditions, limited accommodations, and a lack of organized guided tours, which restrict visitor numbers. Additionally, KWS's offerings are under-promoted outside the local region, further limiting its recognition as a tourist destination. Despite the sanctuary's high potential for advancing sustainable conservation and economic growth, organized and environmentally conscious tourism practices that would benefit both local communities and biodiversity are not yet widely implemented.

KWS faces significant limitations in eco-friendly infrastructure, lacking designated nature trails, interpretation centers, and eco-lodges essential for attracting eco-tourists. Although opportunities for wildlife observation, hiking, and cultural tourism exist, they remain underdeveloped, with inadequate facilities to support large-scale tourism. Basic amenities, such as accommodations, transportation, and visitor services, are sparse, and access to key attractions is impeded by poorly maintained roads. Unlike other established nature destinations, KWS has a low profile, primarily due to limited promotional efforts and scarce accessible information. While some localized initiatives exist, they are fragmented and lack a cohesive strategy for regional tourism development. Conservation efforts are further constrained by limited resources and funding, with minimal local community involvement in tourism. Cultural and historical sites, such as ancient temples and archeological landmarks, remain largely under-promoted, and adventure activities like trekking, hiking, and camping are in early stages with few organized tours or facilities.

TABLE 4 Current tourism and ecotourism activities in the region.

Category of current ecotourism activities							
Passive educational—recreational ecotourism	Difficulty level	Distance (km)	Modes of transportation	Time required	Target audience	Visitor flow level	Benefits of activities and experiences developed
Interpretive nature trails	Very accessible	1–3	Pedestrian routes	1–2 h	Families, school groups, nature lovers	Moderate	Educational insights on local flora and fauna, promotes awareness of biodiversity and conservation efforts
Historical tours at Rohtasgarh Fort	Moderate	5–7	Mixed (pedestrian + motor vehicles)	3–4 h	History enthusiasts, cultural tourists	High	Provides cultural enrichment, supports local artisans and historians, increases awareness of local heritage
Eco-museum and interpretive centers near Mundeshawari	Very accessible	–	Pedestrian routes	1–2 h	All age groups, especially families	High	Educational displays on forest ecology, enhances visitor knowledge on conservation and cultural heritage
Active recreational ecotourism and authentic experiences							
Trekking routes in KWS	Difficult	8–10	Pedestrian routes	4–6 h	Adventure tourists, young adults	Low to moderate	Encourages physical activity, deepens connection with nature, generates local employment for guides and porters
Bird-watching tours at Jagdahwan Lake and Karkatgarh waterfall	Moderate	2–4	Pedestrian routes, nautical	2–3 h	Bird enthusiasts, researchers	Moderate	Enhances biodiversity appreciation, generates income for local guides
Boating at Durgawati Jalasay	Very accessible	1–2	Nautical equipment	1 h	Families, nature enthusiasts	High	Provides recreational enjoyment, supports local income through boat rentals
Village tours and cultural performances	Very accessible	1–2	Pedestrian + motor vehicles	1–2 h	Cultural tourists, all age groups	Moderate	Promotes local culture, supports artisans, enhances community pride and income
Forest bathing and meditation spots (Manjhar Kund) and Telhar	Moderate	2–3	Pedestrian routes	2–3 h	Wellness tourists, adults seeking relaxation	Moderate	Promotes mental wellbeing, supports local wellness product sales (e.g., herbal items)
Additional ecotourism experiences							
Cycling routes in buffer zones	Moderate	5–10	Bicycles	2–3 h	Youth, adventure seekers	Low to moderate	Encourages eco-friendly travel, boosts local economy through bicycle rentals
Agro-tourism and traditional craft workshops	Very accessible	1–3	Pedestrian routes	1–2 h	Families, tourists interested in sustainability	Moderate	Provides hands-on cultural experiences, supports local artisans, and promotes agricultural diversity
Guided nature walks	Very accessible	1–2	Pedestrian routes	1–2 h	All age groups	Moderate	Encourages conservation learning, promotes environmental stewardship

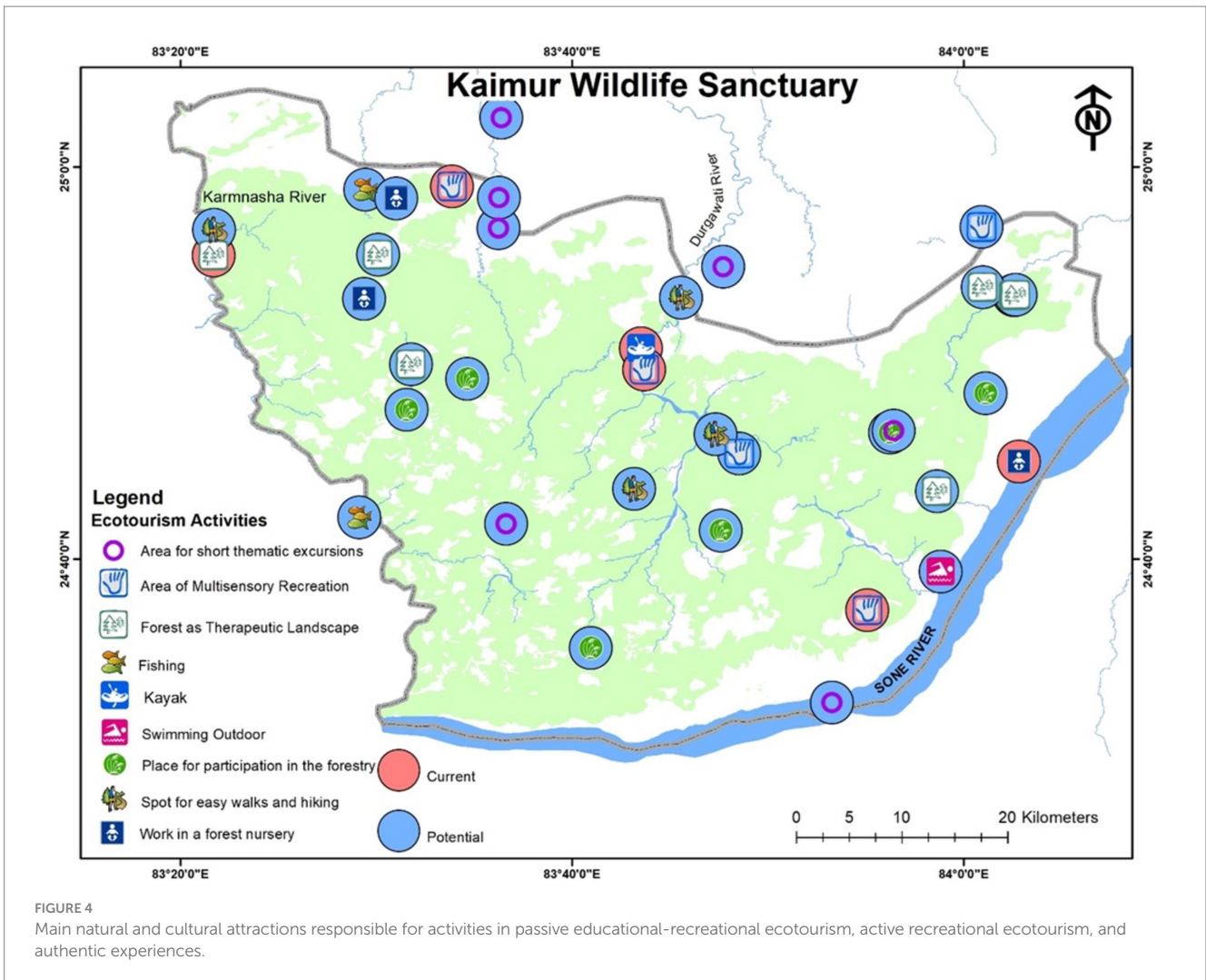


FIGURE 4 Main natural and cultural attractions responsible for activities in passive educational-recreational ecotourism, active recreational ecotourism, and authentic experiences.

3.4 Ecotourism: the region’s top alternative income source

Ecotourism has the potential to become a leading alternative income source for communities surrounding Kaimur Wildlife Sanctuary (KWS) in Bihar, India, due to unique ecological, economic, and social factors. KWS is rich in biodiversity, encompassing diverse ecosystems, scenic landscapes, and species-rich habitats—including deciduous forests and bamboo groves that support wildlife such as tigers, leopards, and a variety of bird species. This natural wealth presents significant appeal to both domestic and international visitors interested in wildlife, nature, and conservation, aligning ecotourism development with conservation priorities (Stylidis et al., 2022). The local communities in Kaimur have a deep cultural connection to the forest and possess extensive indigenous knowledge that could be preserved and shared through ecotourism. By involving locals in eco-guided tours, traditional crafts, and cultural storytelling, ecotourism provides them with economic benefits while offering visitors an authentic cultural experience. This approach enhances KWS’s appeal as a destination for cultural and nature-based tourism.

Ecotourism also aligns well with conservation goals by offering a sustainable alternative to resource-extractive industries that typically

lead to deforestation and habitat degradation. As an eco-friendly revenue source, ecotourism incentivizes local communities to conserve and sustainably manage the sanctuary’s resources. Income generated from ecotourism can be reinvested into conservation initiatives, such as forest monitoring and wildlife protection, creating a positive feedback loop that benefits both the environment and the community. Moreover, ecotourism can generate diverse job opportunities for local residents, including roles as tour guides, hospitality staff, artisans, and service providers. This inclusivity makes it accessible to individuals with limited formal education, helping to alleviate poverty and support economic development. Additionally, ecotourism has a ripple effect that stimulates other sectors, such as handicrafts, food production, and transportation, broadening the economic benefits. For many residents who depend on forest resources for their livelihoods, ecotourism offers a sustainable alternative, reducing pressure on local resources and fostering more sustainable resource management practices.

The results, summarized in Table 5, offer insights into community perceptions of forest conservation and the potential for ecotourism within the region. Overall, the responses reflect a somewhat reserved and neutral stance among residents toward conservation and tourism initiatives. The community shows moderate agreement that their livelihoods are connected to

TABLE 5 Community perceptions of the forest conservation and ecotourism potential.

Livelihood	Study area	
	Kaimur Wildlife Sanctuary (n = 327)	
	Mean	Std. Deviation
My livelihood depends on accessing resource from sanctuary	3.61	3.33
I rely on the surrounding forest for the collection of wood	4.04	3.69
I require access to, and use of the forest area for my cultural, recreational, and traditional activities	3.59	3.30
I hunt in the forest area to secure a source of food and income	3.03	2.85
Forest degradation has affected the income and livelihood	3.57	3.26
Current Forest conservation efforts change life and livelihood positively	2.00	1.84
Ecotourism have potential to develop in the region	4.03	3.66
Ecotourism can be best alternative source of income	3.55	3.23
Ecotourism can bring economic benefit and desirable employment opportunities for residents	3.72	3.36
Ecotourism activities and disrupt the local people's lifestyle and culture	2.20	2.02
Ecotourism can benefit only dominant and business class people	3.10	2.80

Five-point Linkert scale, where: 1 = strongly disagree, 2 = disagree, 3 = Neutral, 4 = Agree, and 5 = strongly agree.

resources from the sanctuary, though responses reveal variation, especially in terms of forest use for fuelwood collection, an activity essential to many but marked by differing views (evidenced by a high standard deviation). This variability highlights both the central role of wood collection for sustaining local livelihoods and a reliance on the sanctuary's resources. The findings point to ecotourism as a promising economic opportunity, though community involvement remains limited, which could impact the viability of alternative livelihood strategies linked to tourism. While there is general optimism about ecotourism's potential to support local economies, concerns remain about the risk of exclusive benefits accruing to dominant groups and possible disruptions to traditional lifestyles. The analysis underscores a strong dependence on forest resources, mixed perceptions of the conservation benefits, and a cautious optimism regarding ecotourism's future role in supporting sustainable livelihoods for local communities.

Among its notable sites, Karkatgarh Waterfall, once a crocodile hunting ground for Mughal and British officials, now offers tranquil scenic views, with its surrounding sandstone formations adding geological interest. Another key attraction (Figure 5), Rohtasgarh Fort, showcases impressive Mughal architecture and a rich history, with its 16th-century structures reflecting a blend of cultural and religious significance. Other popular sites include Jagdahwahan Lake, created by the Jagdahwa Dam, and Manjhar Kund, a series of waterfalls with religious and scenic significance. The historic Shergarh Fort, built by Sher Shah Suri, sits on the Kaimur plateau, offering panoramic views and access to unique fort features, including secret tunnels and Rani Pokhara. Additionally, Mundeshwari Temple, one of India's oldest functioning temples, and Telhar Waterfall attract visitors for their historical and natural value (Figure 5).

In Kaimur, ecotourism aligns with government conservation policies and sustainable development goals, making it attractive to government agencies, conservation organizations, and NGOs, which can provide essential support in the form of funding, training, and infrastructure development. This support could help address challenges related to infrastructure, training, and public awareness,

aiding the region in its early stages of ecotourism development. Additionally, global demand for eco-friendly travel destinations is increasing, with travelers seeking destinations that emphasize environmental and cultural preservation. Kaimur's rich biodiversity and cultural heritage align well with this trend, offering the potential to attract a growing eco-conscious market and provide a steady income source for local communities. Compared to agriculture, which is highly vulnerable to seasonal and climate variations, ecotourism offers a more resilient income source that is less affected by environmental factors, thereby contributing to greater economic stability for residents. Ecotourism, particularly when managed by local communities, empowers residents by directly involving them in natural resource management and economic gain. This approach fosters a sense of pride, responsibility, and cohesion, promoting community stewardship and sustainable tourism practices essential for the sanctuary's long-term sustainability. Region is positioned to become a model for ecotourism due to its rich biodiversity, varied landscapes (Figure 6), and cultural heritage. Government initiatives and conservation programs further strengthen ecotourism's potential to support local communities economically, socially, and environmentally. By balancing economic growth with conservation, ecotourism in Kaimur offers a sustainable pathway for forest management, poverty alleviation, and regional development, ultimately benefiting both the sanctuary and the people who depend on it.

3.5 Potential ecotourism activities in the region

The region and its surrounding areas present substantial ecotourism potential (Figure 6), with a diverse range of wildlife, scenic waterfalls, lakes, and caves that cater to nature and adventure enthusiasts.

The region's rich cultural heritage including ancient temples, rock paintings, and local traditions—appeals to cultural and historical tourists. A shift toward ecotourism enables the region to adopt

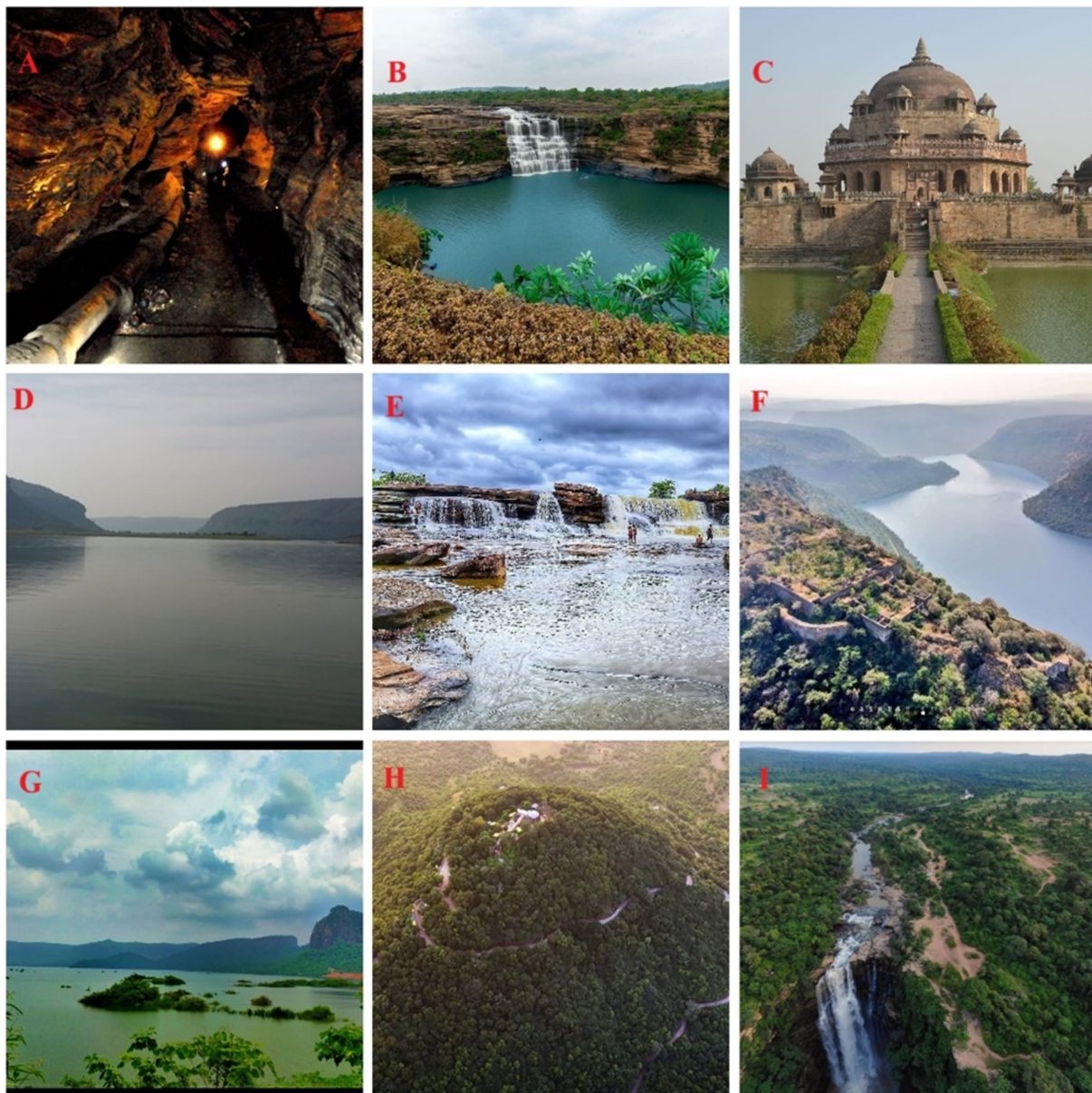


FIGURE 5

Natural and cultural ecotourism resources in the study area. (A) Gupteshwar Dham (Cave); (B) Karkatgarh Waterfall; (C) Rohtasgarh Fort; (D) Jagdahwahan Lake; (E) Manjhar Kund; (F) Shergarh Fort; (G) Karamchat Water Dam and Lake; (H) Mundeshwari Temple and Museum; (I) Telhar Waterfall & Lake.

sustainable practices that protect the environment and provide economic benefits to local communities, especially marginalized groups affected by forest degradation. Historically, marginalized communities in the area have been impacted by forest degradation, losing traditional sources of income, and often facing low-paying, labor-intensive jobs. Ecotourism offers an alternative income stream that promotes forest conservation and sustainable resource use, potentially reducing poverty, decreasing income disparities, and enabling investments in health and education. A comprehensive ecotourism plan should actively integrate these communities, utilizing their indigenous knowledge and craftsmanship to support both environmental conservation and socio-economic advancement. Potential ecotourism initiatives include developing themed trails,

adventure routes, and observation points to showcase the sanctuary's ecosystems. Establishing interpretive centers could transform the forest into an eco-museum that highlights its ecological and cultural significance (Shamsoddini, 2015). Recreational activities such as trekking, bird-watching, and forest bathing, alongside conservation projects like afforestation and nursery work, can be promoted. Immersive experiences in local traditions, agro-tourism, and traditional crafts, complemented by eco-friendly accommodations, would enhance the authenticity of the rural experience for visitors. Cultural tourism can be further enriched through village tours, traditional performances, and interactions with artisans. An interdisciplinary approach to education for sustainable development, emphasizing forest conservation, could engage both tourists and



FIGURE 6
Scenic landscapes of Kaimur Valley and settlements (Foothills zone of Kaimur Hills).



FIGURE 7
Boating activities near the Karamchat water dam (Manmade).

residents, while multisensory nature walks and recreational spaces could strengthen visitors' connection to the environment (Annan-Diab and Molinari, 2017).

The proposed ecotourism developments aim to enhance visitor experiences while fostering local community involvement. At Gupteshwar Cave, eco-friendly pathways, guided tours, and a visitor center will accommodate 1,000 daily visitors, engaging about 100 local families. Karkatgarh Waterfall will feature viewing decks, nature trails, and an eco-lodge for 1,000 visitors, employing 30 families in

hospitality and crafts. Restoration of Rohtasgarh Fort will provide historical tours and cultural performances for 200 visitors, utilizing local historians. Jagdahwan Lake will offer eco-friendly boating and picnic areas for 400 visitors, managed by locals. Manjhar Kund will create meditation areas for 300 wellness tourists, with 35 locals providing spiritual services. Shergarh Fort will develop trekking routes and an eco-lodge for 250 adventure tourists, while Karamchat Water Dam and Lake will support boating (Figure 7) and fishing for 500 visitors, managed by locals. Telhar Waterfall & Lake will feature

eco-lodging and wellness retreats for 350 tourists, with 35 locals employed in hospitality. Lastly, Mundeshwari Temple will include a museum and cultural tours for 400 pilgrims, benefiting 40 local families. A centralized marketplace near key tourist hubs will promote indigenous arts and crafts, generating sustainable income for over 300 local families and drawing approximately 3,200 daily visitors. This initiative aims to strengthen the local economy, integrate communities into tourism, and preserve the area's natural and cultural heritage.

Recreational opportunities will emphasize the forest's multifunctionality, offering relaxation through therapeutic and sensory experiences, while low-impact activities like relaxation and participation in a panoramic view (Figure 8), hiking, biking, swimming, and wildlife observation encourage environmental appreciation (Figure 9). Social inclusion and wellbeing will be prioritized, with local communities involved in designing and managing activities, while regular surveys will help refine these offerings to ensure they meet visitor and community needs (Table 6).

Monitoring and evaluation efforts will track environmental impacts and community benefits, with activities adjusted as needed to minimize harm and optimize outcomes. Periodic reviews and stakeholder feedback will support sustainability, with collaborative efforts from government, NGOs, and local communities ensuring alignment with conservation and community goals. Sustainable conservation strategies will involve zoning and management, designating core, buffer, and transition areas to control tourist activity and safeguard core conservation zones. Visitor capacity will be regulated with strict limits on access to sensitive areas, preventing ecosystem degradation. Essential infrastructure for ecotourism will include thematic paths

(Figure 10), wooden walkways, observation platforms, cycling routes, and equestrian trails to enhance visitor experiences while protecting the environment (Figure 11).

These measures will support passive, active, and educational-recreational ecotourism experiences. Community involvement is crucial, with a focus on economic empowerment through participation in ecotourism management, revenue-sharing, and job creation, particularly for women.

Local economic opportunities will be supported by skill development in guiding, hospitality, and handicrafts, with cooperative models ensuring fair benefit distribution. Promoting local products through marketplaces for crafts and organic goods will support women entrepreneurs, providing targeted assistance to strengthen their roles in the local economy.

4 Discussion

The findings from this study underscore the dual challenge facing forest management in Kaimur Wildlife Sanctuary: the need to protect forest resources while also addressing the livelihood needs of the surrounding marginalized communities (Figure 12). One example is the harvesting of the fruit locally known as *Makoh*, which is gathered both for subsistence and for occasional sale in markets, particularly during festivals when demand is higher.

The exploration of ecotourism as a sustainable solution is particularly significant given its potential to bridge this gap by aligning conservation goals with sustainable agricultural activities and economic incentives for residents and the investment in eco-park-type visiting-observation infrastructure (Figures 13, 14).



FIGURE 8
Relaxation and participation in a panoramic view for a group of visitors.



FIGURE 9
The spectacular association between the steep walls, the volume of water, and the layer of mature tropical forest with seasonal rhythm encourages visitors to appreciate the value of the surrounding environment.

TABLE 6 Potential tourist activities in the study area (Source: Field Survey, Annex 1).

Activities	Description	Benefits
Nature and wildlife activities	<ol style="list-style-type: none"> 1. Wildlife safaris 2. Bird watching tours 3. Nature walks and botanical tours <p>Organized guided jeep or walking safaris to spot wildlife like tigers, leopards, sloth bears, deer, and various bird species along the trekking route. Bird-watching tours and guided walks will focus on the region's flora, including medicinal plants and unique tree species in the upper and foothill areas near the river.</p> <p>Location: Kaimur forest range (450 m), Gupteshwar Cave, Jagdahwan and Karamchat Lakes, Manjhar and Telhar Kund, Adhaura forest</p>	Provides an immersive experience that raises awareness about wildlife conservation, educates visitors on local plant life and their ecological importance, attracts bird watchers and ornithologists, promotes the region as a bird-watching hotspot, and creates earning opportunities for locals.
Adventure and outdoor activities	<ol style="list-style-type: none"> 1. Trekking and hiking 2. Camping 3. Rock climbing and rappelling <p>Developing trails of varying difficulty levels to explore waterfalls, caves, and scenic viewpoints, establishing eco-friendly camping sites, and utilizing the region's rocky terrain for adventure sports like rock climbing and rappelling.</p> <p>Location: Gupteshwar Cave, Mundeshwari Hill, Heartshape Valley, and Karkatgarh, Manjhar Waterfall</p>	Attracts adventure tourists and promotes physical activity. Provides a rustic and immersive nature experience, ideal for adventure seekers and nature lovers.
Cultural and educational activities	<ol style="list-style-type: none"> 1. Cultural tours and workshops: 2. Historical and archeological tours 3. Environmental education programs <p>Organizing visits to local villages, craft workshops, and cultural performances; offering guided tours of ancient temples, rock paintings, and archeological sites; and conducting workshops on conservation, sustainable practices, and local ecology in the foothills and nearby plantation areas.</p> <p>Location: Adhaura, Karar, and Karkatgarh, Mundeshwari, and Gupteshwar Cave, Adhaura block</p>	Provides an authentic cultural experience that supports local artisans, educates visitors about the region's historical significance, attracts history buffs, raises environmental awareness, and promotes sustainable tourism practices.
Water-based activities	<ol style="list-style-type: none"> 1. Boating and kayaking 2. Fishing tours <p>Offering non-motorized boating or kayaking and organizing sustainable fishing tours with catch-and-release practices in designated areas.</p> <p>Location: Jagdahwan and Karamchat Lakes, Sone River, local ponds</p>	Provides a serene and eco-friendly way to explore the water bodies.
Wellness and leisure activities	<ol style="list-style-type: none"> 1. Yoga and meditation 2. Retreats picnicking areas <p>Set up retreats for yoga and meditation in serene natural settings, and designate picnic areas near waterfalls and lakes with proper waste management facilities.</p> <p>Location: Telhar Kund, Manjhar Kund, Karkatgarh Waterfall</p>	Attracts wellness tourists seeking relaxation and spiritual experiences, while offering a relaxing activity for families and groups, encouraging responsible tourism.
Community and conservation initiatives	<ol style="list-style-type: none"> 1. Volunteer programs 2. Local market tours <p>Offer tourists opportunities to participate in conservation projects, like wildlife monitoring and tree planting, at nearby project sites. Also, provide guided tours of local markets where visitors can buy handicrafts, organic produce, and traditional items.</p> <p>Location: Adhaura, Chuan, Karar, and other villages, Bhagwanpur, Chainpur, Bhabhua, Sasaram, Chenari, Kudra, and Mohania</p>	Engages visitors in meaningful conservation activities, supports local economies, and offers an authentic shopping experience for tourists.



FIGURE 10
Trekking route to Heart shape valley, KWS.

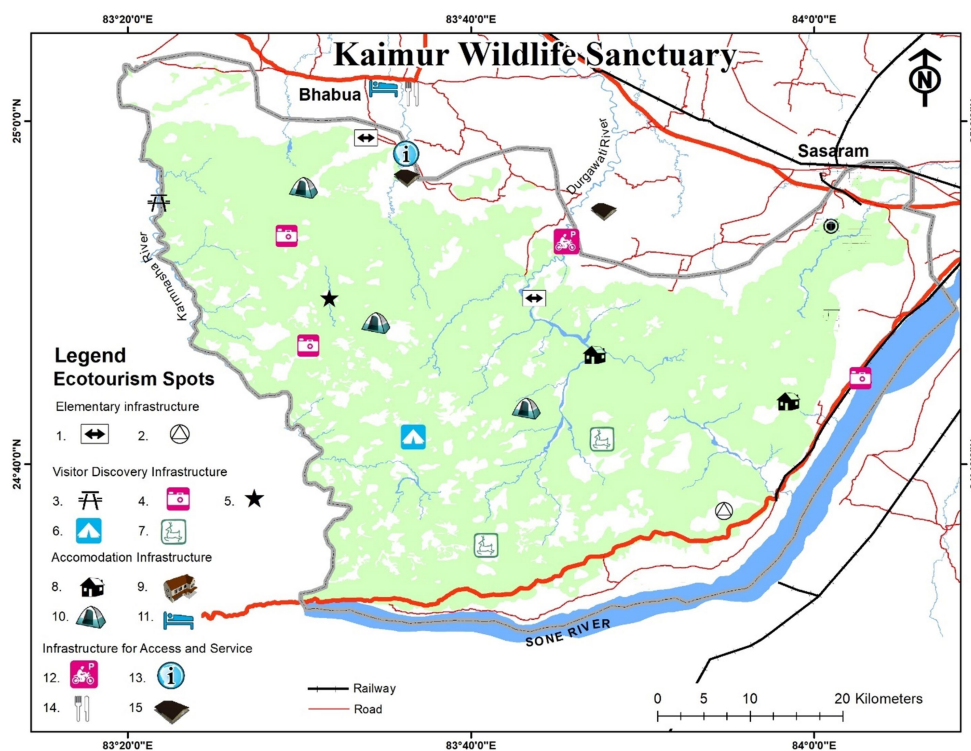


FIGURE 11
The thematic infrastructure serving ecotourism activities within KWS. In Legend: *Elementary eco-tourism infrastructure for guidance and information*: 1. Orientation indicators; 2. Informative-explanatory and interpretative panels; *Visitor Discovery Infrastructure*: 3. Wooden alleys and pots for access to protected biocenoses and swamps; 4. Natural point of view; 5. Point for the reference forest ecosystem; 6. Temporary shelter for ecotourists; 7. Sanctuary and point for wildlife observation; *Accommodation infrastructure in adapted local structures*: 8. A local's house; 9. Agritourism guesthouse; 10. Place for tents and camping; 11. Hotel; *Infrastructure for access and services, other than accommodation*: 12. Parking; 13. Tourist information point; 14. Restaurant; 15. Market/point for selling handicrafts or agricultural products.



FIGURE 12
Collection of forest products by local indigenous people (Fruit named "Makoh").



FIGURE 13
Transitional and sustainable economic use between the forest reserve and the adjacent agricultural lands, primarily used for subsistence cultivation of paddy and wheat, in KWS.

In line with previous studies, the results suggest that community-based ecotourism, when effectively managed, can empower local populations, alleviate poverty, and contribute to environmental

sustainability by fostering local ownership and stewardship of forest resources (Tiwari et al., 2024). The results affirm the hypothesis that ecotourism can serve as a viable alternative income source for local



FIGURE 14
Mundeshwari Wildlife Eco-Park, near Mundeshwari Temple, Kaimur.

communities, which often depend on forest resources for subsistence. As found in similar studies on ecotourism in similar forested regions in India, the development of ecotourism can reduce the communities' dependency on direct forest extraction by offering alternative sources of income (Rampheri and Dube, 2021; Scheyvens, 1999). However, unlike other regions with established ecotourism infrastructure, Kaimur Wildlife Sanctuary faces unique challenges that need to be addressed to realize its ecotourism potential fully. These challenges include limited infrastructure, lack of training and awareness, and insufficient government support.

The limitations in infrastructure and the low public awareness regarding ecotourism were identified as major barriers to the successful implementation of ecotourism in Kaimur. These findings highlight the need for investments in infrastructure such as transportation, communication networks, and basic amenities to make the sanctuary more accessible and appealing to potential tourists. Additionally, training and awareness programs that equip locals with hospitality skills, environmental knowledge, and cultural interpretation skills are essential for creating a knowledgeable and engaged workforce capable of meeting the demands of ecotourism. Other studies on ecotourism have shown that successful programs often hinge on community training initiatives that enhance local capacity, suggesting that similar approaches could be beneficial for Kaimur (Scheyvens, 1999). The study's insights emphasize the value of indigenous knowledge, which has historically guided sustainable forest use in the region. Incorporating this knowledge into ecotourism and forest management strategies not only preserves cultural heritage but also reinforces sustainable practices. Community members' intimate understanding of local ecosystems could be leveraged in eco-guided tours, traditional craft production, and the creation of interpretive programs for tourists. This approach aligns with

sustainable ecotourism models observed in other parts of India, where indigenous knowledge plays a crucial role in both conservation and tourist attraction efforts.

The Sanctuary exemplifies the complex relationship between conservation and economic development. While ecotourism presents an opportunity for sustainable income, it is essential to maintain ecological integrity and avoid over-commercialization, which could lead to environmental degradation. Monitoring and regulating tourism activities to ensure minimal impact on local biodiversity will be fundamental to achieving a balance between conservation and economic benefits. Moreover, adaptive management practices that are responsive to changes in the ecosystem and community needs could help in sustaining the benefits of ecotourism over the long term. While the study provides valuable insights, several limitations must be acknowledged. The cross-sectional design, while effective for capturing a snapshot of current conditions, may not fully capture the long-term effects of ecotourism on community livelihoods and forest conservation. Future longitudinal studies could provide a more detailed understanding of how ecotourism initiatives evolve over time and impact resource use patterns. Additionally, further research into specific ecotourism models, including agro-ecotourism and cultural ecotourism, could reveal additional avenues for economic development in the Kaimur region.

5 Conclusion

This study highlights the significant role of community-based ecotourism in the sustainable management of Kaimur Wildlife Sanctuary (KWS) and its potential to address the socio-economic needs of local communities. As forest resources continue to be strained

by unsustainable practices, ecotourism presents a promising alternative that aligns conservation goals with livelihood generation. The results indicate that ecotourism could serve as a sustainable income source, reducing local dependency on direct forest extraction and supporting conservation efforts. However, realizing this potential requires overcoming critical barriers, including inadequate infrastructure, limited public awareness, social disparity, market-based opportunities, and the absence of comprehensive training programs for residents.

To maximize the effectiveness of ecotourism in KWS, several recommendations emerge from this study. First, investment in eco-friendly infrastructure such as improved transportation networks, lodging facilities, and nature trails is essential for enhancing accessibility and visitor satisfaction. Second, community training programs focused on environmental stewardship, hospitality, and cultural heritage interpretation are vital to develop a skilled local workforce. Such training would empower residents, particularly marginalized groups, to take active roles in ecotourism, fostering both economic independence and a sense of environmental stewardship. Third, integrating indigenous knowledge into ecotourism strategies can enhance the authenticity of visitor experiences and promote sustainable practices rooted in local traditions. Incorporating this knowledge in eco-tours, craft production, and interpretive programs will preserve cultural heritage while also enhancing conservation efforts. Fourth, ongoing monitoring and adaptive management are necessary to ensure ecotourism's ecological sustainability. Regular assessments of environmental impact and visitor satisfaction will allow for data-driven adjustments, helping to balance economic and conservation goals effectively.

For future research, longitudinal studies are recommended to evaluate the long-term impacts of ecotourism on community livelihoods and forest conservation. Additionally, exploring specific ecotourism models such as agro-ecotourism and cultural ecotourism could identify diverse opportunities for economic development in the Kaimur region. By fostering community engagement and addressing these identified barriers, ecotourism in KWS can become a model for sustainable forest management, offering lasting benefits to both biodiversity and local communities.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors without undue reservation.

Ethics statement

This study was approved by the Ethics Committee of Kalindi College, University of Delhi and informed consent was obtained from the participants. Written informed consent was obtained from the [individual(s) and/or minor(s)' legal guardian/next of kin] for the publication of any potentially identifiable images or data included in this article.

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Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

Acknowledgments

We would like to thank the three editors-in-chief and the reviewers for their comments and advice. This study was part of the research activities included in the EU Erasmus+ program project, KA 107, for the period 2022-2025. These activities involved the authors of this study, along with the University of Oradea, Romania, and the University of Delhi, India, as institutional partners in the EU Erasmus+ project.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/ffgc.2024.1491917/full#supplementary-material>

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