

Fungi, Forests, and Futures: Exploring The Tlahuica's Mycotourism Practices As A Model For Sustainable Development

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ABSTRACT

ABSTRACT: Mycotourism, a specialised form of ecotourism focused on fungal biodiversity, offers a sustainable development model for Indigenous communities. This study examines the mycotourism practices of the Tlahuica, an Indigenous group residing in Zempoala National Park, Mexico. Through the integration of Traditional Ecological Knowledge (TEK), the Tlahuica have developed sustainable foraging practices that promote biodiversity conservation while fostering cultural preservation and economic resilience.

Findings indicate that TEK plays a central role in educating visitors about the ecological significance of fungi, facilitating intergenerational knowledge transfer and strengthening community cohesion. Mycotourism has diversified the Tlahuica's income sources, providing employment opportunities and stimulating the local economy through the integration of cultural and ecological activities. However, the community faces significant challenges, including illegal logging, habitat degradation and limited institutional support, which threaten the sustainability of their practices.

Despite these obstacles, the Tlahuica have implemented adaptive strategies, such as controlled foraging and collaborations with conservation organisations, in order to mitigate environmental pressures and sustain their livelihoods. This study highlights the need for participatory governance frameworks that safeguard TEK and support Indigenous-led initiatives, demonstrating the potential of mycotourism as a replicable model for sustainable development in biodiversity-rich regions.

KEYWORDS: Mycotourism, sustainable development, Tlahuica, traditional economic knowledge, Zempoala national park

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INTRODUCTION

Mycotourism, a specialised form of ecotourism that involves the exploration and appreciation of fungal biodiversity, has emerged as an innovative method for sustainable development within indigenous communities. As a sustainable tourism model, it bridges the goals of environmental conservation, cultural preservation, and economic resilience. Mycotourism provides a platform for indigenous communities, such as the Tlahuica of Zempoala National Park in Mexico, to align their local practices with sustainability goals while maintaining their ecological and cultural heritage.

Rooted in the principles of Traditional Ecological Knowledge (TEK), mycotourism builds on generations of indigenous knowledge. Berkes (1999) defines it as a cumulative body of knowledge that evolves through the interaction of humans with their environment. For the Tlahuica community, TEK is the foundation of their mycotourism practices, informing methods such as selective mushroom foraging to ensure biodiversity regeneration. It also facilitates the intergenerational transfer of cultural and ecological wisdom, allowing the community to maintain its identity while adapting to changing conditions.

Nonetheless, despite its transformative potential, mycotourism faces significant challenges that threaten its sustainability. Environmental pressures, such as illegal logging, poaching, and climate change, degrade the delicate forest ecosystems that support

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fungal biodiversity. Furthermore, the lack of robust legal protections for indigenous knowledge systems and land rights exposes communities to exploitation. Addressing these challenges requires an approach that combines community-led initiatives with institutional support and policy reform.

This study aims to examine the Tlahuica's mycotourism practices, focusing on three key areas: the integration of TEK into their mycotourism practices, the ecological, economic, and social benefits, and the adaptive strategies they use to address challenges. By exploring these aspects, this research contributes to the growing body of knowledge on mycotourism as a sustainable development model and serves to highlight the critical role of legal and institutional frameworks in supporting indigenous-led ecotourism initiatives.

LITERATURE REVIEW

Traditional Ecological Knowledge

Traditional Ecological Knowledge (TEK) encompasses the accumulated knowledge, practices, and beliefs developed through generations of interaction between humans and their natural environments. Hoagland (2017, p.2) suggests that it is "abstract, qualitative, inclusive, intuitive, diachronic, and is formed from communal knowledge gained over time through practice and application". TEK is constantly evolving and adaptive and it is this adaptability that makes it a critical framework for addressing sustainability.

In the context of mycotourism, TEK guides sustainable foraging practices such as cutting mushrooms at the stem to promote regrowth and scattering the spores to enhance natural regeneration. These practices emphasise a balance and reciprocity with nature, ensuring biodiversity conservation whilst also supporting human livelihood. TEK also fosters an understanding of ecosystem dynamics, enabling communities to adapt to environmental pressures while maintaining ecological balance (Barroetaveña & Pildain, 2022).

Beyond its practical applications, TEK also has a significant educational role in mycotourism (Suazo & Viana-Lora, 2022). That is, the sharing of knowledge about fungi and sustainability with visitors serves to promote ecological awareness and cultural appreciation. Jiménez Ruiz, Thomé-Ortiz, Espinoza-Ortega & Vizcarra Bord (2017) argue that this educational aspect bridges traditional practices with contemporary conservation efforts, making TEK a vital tool for promoting sustainable tourism.

As noted in the introduction, the effectiveness of TEK as a sustainability tool is increasingly undermined by environmental degradation and weak legal protections. Maffi (2005) stresses the importance of institutional safeguards to prevent this, suggesting that the preservation of TEK is essential not only for maintaining biodiversity but also for sustaining cultural and linguistic diversity.

Mycotourism as a Distinct Model

Mycotourism, defined by Jalinik, Pawłowicz, Borowik & Oszako (2024, p.2) as "recreation and tourism that is practiced with the intention of observing and collecting mushrooms", is a specialised form of ecotourism, focuses on fungal biodiversity and its integration with cultural and ecological education. By combining recreational activities with conservation and education, mycotourism provides a sustainable alternative to more extractive forms of tourism.

In various global contexts, such as Spain's Castilla and León region, mycotourism has demonstrated its potential to support rural development by creating employment opportunities, providing education, and promoting biodiversity conservation (Büntgen, Latorre, Egli & Martínez-Peña, 2017; De Frutos, Martínez-Peña & Aldea, 2012).

Research from other regions further illustrates the diverse benefits and challenges of mycotourism as a tool for sustainable development. In Poland, mycotourism has been identified as a sustainable approach to tourism development in rural areas, emphasising the importance of integrating local communities and preserving natural resources (Jalinik, Pawłowicz, Borowik & Oszako, 2024). In Argentina, Barroetaveña & Pildain (2022) discuss mycotourism's potential to connect traditional ecological knowledge with innovative practices, fostering sustainable development in the Patagonian region. This approach serves as a model for utilising natural resources responsibly while preserving cultural heritage.

Meanwhile, In Mexico's forested regions, communities have begun leveraging TEK to educate tourists about the ecological and cultural significance of fungi. This initiative serves as a response to the pressing challenges faced by such communities. The scientific understanding of fungi is enriched by the cultural vibrancy of local markets near these forests, within which mushrooms play an integral role in daily life. These marketplaces demonstrate how mycological resources function not only as ecological and economic assets but also as tools for cultural education, enhancing both community well-being and sustainable practices (Garibay-Orijel, Cifuentes, Estrada-Torres & Caballero, 2006; Moreno Fuentes, Garibay-Orijel, Tovar Velasco & Cifuentes, 2001).

Social Sustainability in Mycotourism

Social sustainability focuses on maintaining cultural identity, social cohesion, and equitable participation within communities that engage in mycotourism. By emphasising community-led initiatives, mycotourism empowers local populations to manage tourism in ways that align with their values and traditions.

One of the unique aspects of mycotourism is its ability to facilitate intergenerational collaboration. Guided tours and workshops often involve older community members sharing their knowledge of sustainable foraging practices while younger members act as

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guides and educators. This dynamic ensures the continuity of traditional knowledge while encouraging collaboration across age groups.

Equitable participation is another hallmark of socially sustainable mycotourism. Honey (2008) notes that community-led tourism ensures fair distribution of benefits, preventing the social inequities that often arise with externally controlled tourism models. Moreover, mycotourism activities that incorporate cultural elements, such as storytelling and traditional culinary practices, provide a platform for communities to share their heritage with visitors while at the same time fostering a sense of community pride and unity.

Economic Sustainability in Mycotourism

Economic sustainability in mycotourism is achieved through diversification of income sources, creation of local employment opportunities and support for entrepreneurial activities. In regions where mycotourism has been implemented, it has proven to be an effective driver of rural development. De Frutos et al., (2012) and Büntgen et al., (2017) highlight its ability to create jobs, particularly for younger generations, and to provide financial stability for communities. These jobs often extend beyond guiding tours to include ancillary activities such as craft making, food production, and hospitality services.

Economic sustainability in mycotourism also depends on integrating local products and services into tourism activities. For example, tourists may purchase locally made crafts, sample regional cuisine, or participate in workshops, creating a multiplier effect that benefits various sectors of the local economy (Boa, 2004).

Environmental Sustainability in Mycotourism

Environmental sustainability is central to the ethos of mycotourism, which prioritises biodiversity conservation and minimises ecological impacts. Honey (2008) defines sustainable tourism as a practice that balances resource use with ecological preservation, ensuring long-term benefits for both communities and ecosystems.

In the context of mycotourism, sustainable foraging techniques, such as avoiding overharvesting and promoting spore dispersal, play a crucial role in maintaining forest health and fungal diversity. These practices align with Holden & Fennell's (2013) vision of ecotourism as an approach that integrates environmental stewardship with community development.

Mycotourism also functions as an educational tool, helping visitors understand the ecological roles of fungi within forest ecosystems. Jiménez-Ruiz et al., (2017) insist that by raising ecological awareness among tourists, mycotourism contributes to broader conservation goals while encouraging a sense of environmental responsibility. This dual emphasis on education and conservation ensures that mycotourism remains a sustainable alternative to other forms of tourism, which may be considered of an exploitative nature.

Challenges for Mycotourism

Despite its benefits, mycotourism is not without challenges. For example, Thome Ortiz (2016) provides a case study of San Francisco Oxtotilpan which highlights several issues associated with developing mycotourism in Mexico. Although the region (the State of Mexico) possesses significant natural and cultural resources, tourism remains in its early stages and the existing infrastructure, limited to basic lodging and dining facilities, lacks the integration needed to create a cohesive tourism product.

While mycotourism offers opportunities to stimulate local economies and diversify production systems, it also demands careful regulation to mitigate the sociocultural impacts of increased tourist activity. For example, balancing the influx of visitors with the preservation of traditional knowledge and local ways of life requires regulatory frameworks and participatory governance models that actively involve the community. Without such mechanisms, the risks of overexploitation, cultural commodification, and ecological degradation increase significantly.

Furthermore, the case of San Francisco Oxtotilpan demonstrates the complexity of creating a sustainable mycotourism model. Effective strategies would require not only infrastructure investment but also capacity-building programmes, systems for monitoring and regulation and long-term quality control mechanisms. These elements are necessary to meet the expectations of contemporary tourists who increasingly seek unique and culturally enriching experiences. However, the resources and institutional support required to implement these strategies remain significant barriers for the community.

For regions like San Francisco Oxtotilpan, the situation is further complicated by external pressures such as market demands, the vulnerability of local ecosystems and the marginalisation of indigenous communities. Addressing these challenges requires not only local initiatives but also supportive institutional policies that prioritise the equitable distribution of benefits and the preservation of cultural and ecological heritage.

Legal and Institutional Frameworks

As referred to above, the sustainability of mycotourism relies heavily on the presence of supportive legal and institutional frameworks. Communities engaged in mycotourism often face challenges related to land rights and intellectual property. Sierra-Huelsz, Gerez Fernández, López Binnquist, Guibrunet & Ellis (2020) stress that the lack of legal protections for TEK and community land ownership undermines the sustainability of such initiatives.

Collaborative governance models that involve community members, government agencies and conservation organisations are essential to addressing these challenges. Ostrom (1990) emphasises the significance of participatory frameworks in managing

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common-pool resources, stating that locally driven solutions are often more effective and equitable in achieving sustainable outcomes. Additionally, institutional support is critical for scaling mycotourism initiatives while safeguarding cultural and ecological assets. For example, Baycan & Stough (2013) advise that without proper governance, the commercialisation of traditional knowledge can eventually erode its authenticity.

METHODOLOGY

This study employs a qualitative research approach to explore the Tlahuica community's mycotourism practices within Zempoala National Park. The fieldwork was conducted by the researchers in July, 2024 over the course of four days.

The Tlahuica and Zempoala National Park: Background and Context

The Tlahuica, one of Mexico's 68 officially recognised Indigenous Peoples, reside within the forested landscapes of Zempoala National Park and its surrounding highlands, situated within both the states of Morelos and Mexico. Their deep connection to the environment shapes their cultural identity and livelihoods, as they rely on the region's natural resources for sustenance, traditions, and economic activities (Aldasoro Maya, 2012).

Established in 1936, the park forms part of the Chichinautzin Biological Corridor and spans 4,790 hectares of pine, fir, and oak forests, interspersed with seven lagoons. Located approximately 65 km south of Mexico City and 38 km northeast of Cuernavaca, the park's name, derived from the Nahuatl word *Tzompahuacan*- "place of many waters"—reflects its abundance of lakes and springs (Bonilla Barbosa & Viana Lases, 1997). This diverse habitat supports rich biodiversity, including numerous fungal species. As mentioned, the Tlahuica have long relied on the natural resources within the park, particularly its forests and fungi, which are integral to their cultural heritage and diet. However, the Tlahuica face significant challenges in preserving their way of life within Zempoala National Park with illegal logging poses a direct threat to the park's ecosystems. Additionally, the lack of adequate legal protections for their land rights and TEK limits their ability to effectively manage and safeguard their natural resources (Aldasoro Maya, 2012).

Research Design

This study adopts an interpretive approach, which emphasises understanding the meanings and experiences of participants within their social and cultural contexts. The focus on mycotourism practices necessitates a methodology that allows for an exploration of both observable behaviours (e.g., foraging techniques) and subjective perspectives (e.g., cultural values and challenges). The combination of interviews and participant observation provides a holistic view of the phenomenon.

Data Collection Methods

Semi-Structured Interviews

Semi-structured interviews were conducted with key informants, including community leaders, mycotourism guides and residents actively involved in mycotourism activities. A total of 15 participants were interviewed, representing diverse roles within the community to capture a range of perspectives. The interviews focused on three key areas:

- (i) Integration of TEK: Practices, beliefs, and knowledge systems underpinning mycotourism.
- (ii) Benefits of mycotourism: Ecological, economic, and social impacts on the community.
- (iii) Challenges and strategies: Environmental pressures, governance issues, and adaptive measures.

Participant Observation

Participant observation was conducted during mycotourism activities, including guided foraging tours and community workshops. This method allowed for the direct observation of TEK in practice and provided insights into the interactions between guides, tourists, and the environment. The focus of the observation included:

- (i) Sustainable foraging techniques and ecological practices.
- (ii) Guide-tourist interactions and educational strategies.
- (iii) Community involvement in organising and managing tourism activities.
- (iv) Challenges encountered during tours, such as environmental degradation or visitor behaviour.

Sampling and Recruitment

Purposive sampling was employed to select participants with significant knowledge or experience in mycotourism. Community leaders facilitated introductions to ensure ethical engagement and cultural sensitivity. Participants had to be actively involved in mycotourism or knowledgeable about TEK and its application. Participation was voluntary and informed consent was obtained before data collection. Participants were briefed on the study's objectives and assured of their anonymity and confidentiality.

Data Analysis

A thematic analysis approach was used to analyse the data, which involved identifying, analysing, and interpreting patterns or themes within the data. This included:

- (i) Familiarisation: Transcripts of interviews and observation notes were reviewed to identify recurring ideas and concepts.
- (ii) Coding: Data were systematically coded to organize key themes related to the research objectives.
- (iii) Theme development: Codes were grouped into overarching themes.

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- (iv) Interpretation: Themes were analysed in relation to the study’s objectives and existing literature, ensuring a rigorous and contextualised understanding of the findings.

Ethical Considerations

Ethical research practices were adhered to throughout the study, which included:

- (i) Informed consent: Participants were fully informed about the purpose, methods, and potential uses of the research before agreeing to participate.
- (ii) Confidentiality: Pseudonyms were used to protect participants' identities, and data were securely stored.
- (iii) Cultural sensitivity: The research design and methods were adapted to respect the Tlahuica community’s cultural norms and practices.

Table 1 below highlights the specific details and line of questioning of the methodology

Table 1: Research methodology- details and focus

<i>Aspect</i>	<i>Details</i>	<i>Focus of line of questioning</i>
<i>Research design</i>	A qualitative, interpretive approach designed to explore the integration of TEK and the ecological, economic, and social dimensions of mycotourism. The design considers the challenges faced by the Tlahuica, such as habitat degradation, illegal logging, poaching, and insufficient legal protections.	Understanding the interplay between TEK, sustainability, and community-led tourism practices, as well as the community’s adaptive responses to challenges.
<i>Sampling and recruitment</i>	Purposive sampling of 15 participants, including community leaders, guides, and residents actively involved in mycotourism. Community leaders facilitated introductions to ensure the inclusion of individuals with direct experience and knowledge of challenges such as resource scarcity and external exploitation.	Exploring participants’ roles in addressing challenges to mycotourism, such as environmental degradation and balancing tourism activities with conservation.
<i>Semi-structured interviews</i>	Conducted with selected participants to explore their experiences, focusing on TEK, the benefits of mycotourism, and the strategies employed to address challenges. The flexible format allowed participants to discuss sensitive topics such as governance issues and land-use conflicts.	Investigating how mycotourism helps mitigate challenges like economic instability, ecological pressures, and cultural commodification, while promoting resilience.
<i>Participant observation</i>	Observed guided tours, foraging practices, and workshops to document TEK application and community interactions. Observations also focused on the environmental and organizational challenges affecting mycotourism activities.	Capturing how challenges, such as resource depletion and tourist management, are addressed through sustainable practices and community collaboration.

FINDINGS

Integration of Traditional Ecological Knowledge (TEK)

Participants consistently emphasised the role of TEK in shaping mycotourism practices. Sustainable foraging techniques were highlighted as essential for biodiversity conservation. Several participants shared that these methods have been practiced for generations, with younger community members learning directly from elders. Observation during tours confirmed the active use of TEK, as guides educated visitors about the ecological roles of fungi and the importance of preserving forest ecosystems. However, some participants expressed concerns about losing control of TEK as it becomes increasingly commercialised.

Ecological Benefits

Mycotourism was observed to promote conservation through its focus on sustainable resource use. Specific practices, such as limiting visitor numbers and using designated trails, were implemented to reduce habitat disturbance. Additionally, the emphasis on education during mycotourism activities played a key role in fostering ecological awareness. Participants highlighted how guided tours often included explanations of fungi's roles in nutrient cycling, soil health, and forest ecosystems, deepening both locals' and tourists' appreciation for the delicate balance of these habitats.

Economic Benefits

Participants mentioned that mycotourism has diversified income sources, reducing dependence on traditional farming and creating jobs, particularly for younger members who work as guides. Local businesses also benefit from increased tourism. Observations revealed active integration of local products, such as mushroom-based dishes, preserved mushrooms, dried mushrooms, blackberry liquor and even a Christmas basket, into tourism offerings. In addition, workshops on sustainable foraging and cooking with mushrooms have provided new opportunities for knowledge sharing, while attracting niche tourist groups interested in gastronomy and environmental education. These activities not only boost direct income but also strengthen the community's economy through secondary benefits, such as the demand for transportation, lodging, and other services. The seasonal nature of mycotourism has encouraged communities to develop complementary activities during off-seasons, ensuring a more consistent flow of income throughout the year.

Social Benefits

Participants frequently expressed pride in sharing their cultural heritage with visitors. Intergenerational involvement in mycotourism activities, such as guiding and teaching foraging techniques, was observed to strengthen community bonds. This has also facilitated the transfer of TEK between older and younger generations. Moreover, the collaborative nature of mycotourism has fostered a sense of unity and purpose within the community, as members work together to organise tours, workshops, and cultural events. These activities provide a platform to celebrate and preserve traditional practices while adapting them to modern contexts. Additionally, interactions with tourists have encouraged communities to share their identity and traditions, further motivating efforts to document and formalise their knowledge for future generations. Mycotourism has also helped build relationships with external organisations, creating networks of support that contribute to both social and cultural resilience.

Challenges and Adaptive Strategies

Environmental challenges, including illegal logging, poaching, and climate change, were identified as significant barriers to sustainability. Participants observed that declining mushroom populations have already affected some tours. Additional concerns include the degradation of critical habitats due to unregulated land use and the encroachment of external activities, such as unauthorised development within forested areas.

To address these issues, community leaders have implemented strategies such as controlled foraging, visitor education and zoning of foraging areas. They have also introduced seasonal restrictions on mushroom collection to allow for ecosystem recovery and have partnered with conservation groups to promote reforestation efforts and habitat restoration. Despite these proactive measures, participants highlighted that financial and technical limitations restrict the effectiveness of these strategies. The absence of clear institutional frameworks to protect indigenous rights and traditional practices exacerbates the problem, making long-term planning and resource management difficult.

Furthermore, the lack of enforcement of environmental laws allows illegal activities to persist, undermining community-led efforts. Participants expressed a desire for more collaboration with governmental agencies and NGOs to strengthen resource management practices, secure legal protections, and provide training programs that equip community members with the skills needed to mitigate environmental threats effectively. These adaptive strategies highlight the community's resilience, but systemic support remains essential for ensuring the long-term viability of mycotourism initiatives.

Table 2 below demonstrates the key findings of the research

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Table 2: Key findings

<i>Category</i>	<i>Key findings</i>
<i>Integration of TEK</i>	<p>TEK serves as a guiding framework for sustainable foraging practices (e.g., cutting mushrooms, scattering spores).</p> <p>Promotes a reciprocal relationship with the forest, ensuring biodiversity conservation and resource regeneration.</p> <p>Critical for intergenerational knowledge transfer, preserving cultural heritage and ecological practices.</p> <p>Guides the educational aspect of mycotourism, fostering ecological awareness and reinforcing community identity.</p>
<i>Ecological benefits</i>	<p>Promotes conservation through sustainable resource use.</p> <p>Reduces pressures from unsustainable practices, such as illegal logging.</p> <p>Practices like limiting visitor numbers and using designated paths minimise habitat disturbance.</p>
<i>Economic benefits</i>	<p>Diversifies income sources and provides financial stability.</p> <p>Creates job opportunities, particularly for younger members, reducing urban migration.</p> <p>Enhances the local economy through the integration of local products and services into tourism activities.</p>
<i>Social benefits</i>	<p>Strengthens community cohesion and cultural identity.</p> <p>Involves multiple generations, fostering collaboration and knowledge transfer.</p> <p>Provides a platform for sharing cultural heritage with visitors.</p>
<i>Environmental challenges</i>	<p>Significant threats include illegal logging, poaching, and climate change.</p> <p>Direct impacts observed on mushroom populations and forest ecosystem sustainability.</p>
<i>Adaptive strategies</i>	<p>Controlled foraging practices to reduce overharvesting.</p> <p>Designated pathways for tours to minimise habitat disturbance.</p> <p>Visitor education to promote sustainable practices among tourists and community members.</p>
<i>Legal and institutional issues</i>	<p>Lack of legal protections for land rights and TEK.</p> <p>Barriers to fully controlling and sustaining mycotourism practices.</p> <p>Stronger institutional support needed to safeguard cultural and ecological resources.</p>

DISCUSSION

The findings provide valuable insights into the integration of TEK in mycotourism, the ecological, economic, and social benefits derived from these practices, and the strategies employed by the Tlahuica community to address challenges.

Integration of Traditional Ecological Knowledge

The findings affirm that TEK serves as the foundation of the Tlahuica's mycotourism practices, guiding sustainable foraging techniques and fostering environmental stewardship. Practices such as cutting mushrooms at the stem and scattering spores,

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observed during the study, are consistent with Berkes' (1999) conceptualisation of TEK as an adaptive knowledge system rooted in a reciprocal relationship with nature. This integration of TEK not only ensures resource regeneration but also reinforces the community's identity as custodians of the environment.

The educational component of TEK, in which guides share their knowledge with tourists, extends its impact beyond the community. This aligns with Jiménez-Ruiz et al., (2017), who highlight the potential of TEK to raise ecological awareness among visitors. The intergenerational transfer of TEK observed in this study further underlines its role in cultural resilience, ensuring the continuity of sustainable practices and reinforcing the Tlahuica's cultural heritage in the face of external pressures.

Nonetheless, the findings also highlight the vulnerabilities in preserving TEK. External threats, such as environmental degradation and a lack of legal protections, reflect the concerns mentioned by Sierra-Huelsz et al., (2020). Without institutional safeguards, TEK risks being commodified or eroded.

Ecological, Economic, and Social Benefits

Ecological Benefits

The ecological benefits of mycotourism are evident in the community's conservation efforts, such as limiting visitor numbers and designating paths to minimise habitat disturbance. These practices can be affiliated with Honey's (2008) framework for sustainable tourism, which prioritises environmental stewardship alongside community benefits. The educational aspect of mycotourism further amplifies its ecological impact by fostering a deeper appreciation of fungi's ecological roles among tourists, serving to promote long-term environmental awareness.

Economic Benefits

Mycotourism contributes to the economic sustainability of the Tlahuica community by diversifying income sources and creating employment opportunities, particularly for younger members. This finding is associated with De Frutos et al., (2012), who emphasise the potential of mycotourism to enhance rural livelihoods. The integration of local goods and services into tourism activities observed during the study demonstrates how mycotourism generates additional economic benefits, creating a multiplier effect that strengthens the local economy.

Social Benefits

On a social level, mycotourism fosters cultural pride and community cohesion by providing a platform for the Tlahuica to share their heritage with visitors. This collaborative dynamic, observed during tours, reinforces Thomé-Ortiz's (2016) assertion that ecotourism strengthens social bonds and intergenerational knowledge transfer. The active involvement of multiple generations in mycotourism activities highlights its role in preserving cultural practices while addressing contemporary economic and environmental challenges.

Challenges and Adaptive Strategies

Environmental Challenges

The study highlights illegal logging and poaching as significant threats to the sustainability of mycotourism. These challenges are consistent with Aldasoro Maya's (2012) findings on the ecological pressures faced by the Tlahuica in her doctoral thesis. The observed decline in mushroom populations and habitat degradation demonstrates the urgent need for adaptive strategies to mitigate these impacts.

Adaptive Strategies

The Tlahuica community's adaptive strategies—such as controlled foraging, visitor education, and the use of designated paths—demonstrate their proactive approach to addressing these challenges. These measures are in accordance with Garibay-Orijel et al., (2006), who emphasise the importance of community-led conservation efforts in sustaining ecotourism initiatives. However, the effectiveness of these strategies is constrained by the lack of external support, highlighting the need for collaborative frameworks that involve both community and institutional stakeholders.

Legal and Institutional Support

The findings establish the critical role of legal and institutional support in sustaining mycotourism. The absence of clear policies safeguarding TEK and land rights leaves the Tlahuica vulnerable to exploitation, limiting their capacity to manage tourism practices effectively. This confirms Briedenhann and Wickens' (2004) insistence that without proper governance, the commodification of TEK can erode its authenticity and sustainability.

Institutional support is essential not only for protecting TEK but also for enabling the Tlahuica to scale their mycotourism initiatives. Honey (2008) advocates for participatory governance frameworks that empower communities to lead tourism efforts while ensuring equitable benefit-sharing. In the case of the Tlahuica, such frameworks could enhance their capacity to address environmental and economic challenges while safeguarding their cultural and ecological assets.

Broader Implications

The findings illustrate how mycotourism is associated with the principles of sustainable development by integrating cultural preservation, environmental conservation, and economic resilience. The Tlahuica's practices demonstrate the potential of

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indigenous-led tourism to address global challenges such as biodiversity loss and rural poverty, while at the same time enabling cultural and ecological awareness among tourists.

Table 3 below provides the key points of this discussion.

Table 3: Key points of discussion

<i>Category</i>	<i>Key points</i>
<i>Integration of TEK</i>	TEK guides sustainable foraging practices (e.g., cutting mushrooms, scattering spores) and fosters environmental stewardship, aligning with Berkes (1999), who conceptualises TEK as an adaptive knowledge system rooted in reciprocal relationships with nature. It serves as an educational tool, raising ecological awareness among visitors (Jiménez-Ruiz et al., 2017) and ensuring intergenerational knowledge transfer. However, TEK faces vulnerabilities due to environmental degradation and insufficient legal protections, reflecting concerns raised by Sierra-Huelsz et al., (2020).
<i>Ecological benefits</i>	Conservation efforts, such as limiting visitor numbers and using designated paths, enhance environmental sustainability. These practices align with Honey (2008), who emphasises sustainable tourism’s prioritisation of environmental stewardship, and Holden & Fennell (2013), who highlight ecotourism’s role in environmental education. Mycotourism also fosters ecological awareness among tourists, promoting long-term conservation values.
<i>Economic benefits</i>	Mycotourism diversifies income sources, creates jobs, and reduces urban migration, as supported by De Frutos et al. (2012), who highlight its potential for rural livelihoods. The integration of local products and services into tourism activities strengthens local economies, generating a multiplier effect that enhances economic resilience (Aldasoro Maya, 2012).
<i>Social benefits</i>	Mycotourism strengthens community cohesion and cultural pride by providing shared tourism activities, aligning with Thomé-Ortiz (2016), who identifies ecotourism as a tool for enhancing social bonds. It also fosters intergenerational collaboration and cultural knowledge transfer, reinforcing the social sustainability of indigenous-led tourism initiatives.
<i>Environmental challenges</i>	Illegal logging, poaching, and climate change pose significant threats to forest ecosystems and mushroom populations, reflecting Aldasoro Maya’s (2012) findings on the ecological pressures faced by the Tlahuica. These challenges highlight the urgent need for sustainable resource management and community-led conservation strategies.
<i>Adaptive strategies</i>	Strategies such as controlled foraging, visitor education, and designated pathways mitigate ecological challenges, aligning with Garibay-Orijel et al., (2006), who emphasise the importance of community-led conservation. These strategies demonstrate the Tlahuica’s proactive efforts to sustain their mycotourism practices despite external pressures.
<i>Legal and institutional support</i>	The lack of legal protections for TEK and land rights limits the Tlahuica’s capacity to manage and sustain mycotourism, as cautioned by Briedenhann & Wickens (2004), who warn of the risks of commodification without proper governance. Institutional support is critical for scaling initiatives, supporting Honey’s (2008) advocacy for participatory governance frameworks that empower communities and ensure equitable benefits.

CONCLUSION

This study aimed to explore the Tlahuica's mycotourism practices within Zempoala National Park, focusing on the integration of TEK, the ecological, economic, and social benefits of mycotourism, and the adaptive strategies employed to address challenges. The findings confirm that mycotourism serves as a valuable model for sustainable development, rooted in TEK, and addressing the dimensions of cultural preservation, environmental stewardship and economic resilience.

Revisiting the Research Objectives

This study set out to examine the integration of TEK, the ecological, economic, and social benefits of mycotourism, and the adaptive strategies employed to address challenges by the Tlahuica indigenous community of the Zempoala National Park.

Integration of TEK

TEK emerges as the foundation of sustainable mycotourism, providing a framework for ecological stewardship and cultural preservation. Its role in guiding sustainable resource management reveals the interconnectedness of cultural practices and environmental health. Techniques such as selective foraging, rooted in TEK, ensure biodiversity regeneration while fostering an ethical approach to tourism activities. Moreover, the educational value of TEK, as seen in its dissemination to visitors, underscores its capacity to bridge indigenous knowledge systems and modern ecological awareness.

The findings reveal that the intergenerational transfer of TEK is critical to its preservation, ensuring that younger generations remain connected to traditional practices while adapting to contemporary challenges. This cultural resilience parallels global conservation goals by reinforcing the symbiotic relationship between cultural heritage and ecological sustainability. However, TEK is increasingly vulnerable to external pressures such as environmental degradation and insufficient legal protections, which threaten its integrity and long-term viability. Addressing these challenges requires institutional interventions that prioritise the safeguarding of TEK as both a cultural and ecological asset.

Ecological, Economic, and Social Benefits

The integration of conservation practices within mycotourism activities demonstrates its potential as a tool for ecological sustainability. Practices such as controlled foraging, designated pathways, and visitor education mitigate the environmental impacts of tourism, ensuring the health of natural ecosystems. By aligning tourism activities with conservation objectives, mycotourism promotes biodiversity preservation while offering visitors a deeper understanding of the ecological importance of fungi.

Economically, mycotourism offers a pathway to income diversification, reducing dependence on traditional subsistence activities and fostering financial stability. The creation of jobs, particularly for younger members of the community, addresses rural-urban migration by providing meaningful employment within local contexts. Furthermore, the integration of local products and services into mycotourism activities enhances its economic impact, creating opportunities for entrepreneurship and contributing to broader regional development.

Socially, mycotourism fosters community cohesion by providing a platform for cultural exchange and intergenerational collaboration. The pride derived from sharing cultural heritage with visitors strengthens community identity, while collaborative activities reinforce social bonds. These findings highlight mycotourism's potential to address global sustainability challenges by balancing environmental conservation, economic resilience, and cultural preservation, particularly in ecologically rich but economically vulnerable regions.

Adaptive Strategies

The findings exhibit the proactive measures taken by the community to mitigate environmental and socio-economic challenges. Strategies such as controlled foraging, visitor management, and environmental education exemplify how mycotourism practitioners address habitat degradation, climate change, and over-tourism. These adaptive practices demonstrate the resilience and resourcefulness of communities in maintaining ecological balance while meeting the demands of sustainable tourism.

However, the absence of robust institutional support constrains the scalability and long-term viability of these strategies. Policy reforms that address land-use conflicts, strengthen legal protections for TEK, and promote participatory governance are essential to overcoming these barriers. Collaborative frameworks involving government agencies, conservation organizations, and local stakeholders can provide the necessary support for communities to expand their mycotourism initiatives while safeguarding their cultural and ecological assets.

Research Limitations

While this study provides valuable insights, it is important to acknowledge its limitations, which highlight areas for further exploration:

- (i) **Sample size:** The study relied on a relatively small sample of participants, which may limit the generalisability of the findings. Expanding the scope of future studies to include a broader range of participants could provide a more comprehensive understanding of mycotourism practices and their impacts.

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- (ii) Context-Specific focus: The findings are rooted in the specific cultural and ecological context of the Tlahuica community, which may not fully reflect the dynamics of mycotourism in other regions. Comparative studies across diverse geographic and cultural settings could enrich the understanding of mycotourism as a global phenomenon.
- (iii) Observer bias: The presence of the researchers during participant observation may have influenced the behaviour of participants, potentially affecting the authenticity of observed practices. Employing mixed methods, such as combining ethnographic observation with survey data, could mitigate this limitation.
- (iv) Temporal scope: This study captures a snapshot of mycotourism practices and challenges, but the dynamics of ecological and economic changes over time remain unexplored. Longitudinal studies could provide insights into how mycotourism evolves in response to shifting environmental and socio-economic conditions.

Suggestions for Further Research

Building on the findings of this research, future studies could explore several avenues to deepen the understanding of mycotourism and its potential:

- (i) Comparative analysis: Investigate how mycotourism practices vary across different indigenous communities and ecological contexts to identify commonalities and region-specific challenges.
- (ii) Policy and governance: Assess the impact of existing legal frameworks and governance structures on the sustainability of mycotourism initiatives. Such studies could provide evidence-based recommendations for policy interventions that empower local communities.
- (iii) Tourist perceptions: Examine how tourists perceive mycotourism experiences and how these perceptions influence their ecological awareness and behaviors. Understanding the tourist perspective could inform strategies for enhancing visitor engagement and satisfaction.
- (iv) Resilience and adaptation: Explore how communities adapt their mycotourism practices in response to environmental pressures, market dynamics, and socio-political changes. Such studies could highlight strategies for building resilience in the face of uncertainty.

Final Thoughts

This study reveals the transformative potential of mycotourism as a sustainable development model that integrates cultural preservation, ecological conservation, and economic resilience. By leveraging TEK and fostering community-led initiatives, mycotourism offers a means of addressing global sustainability challenges while empowering local communities.

However, the findings also highlight the fragility of these efforts in the face of external pressures such as environmental degradation, market demands, and inadequate institutional support. Addressing these challenges requires a collaborative approach that prioritises the rights and agency of indigenous communities. Policies that safeguard TEK, promote equitable benefit-sharing, and foster participatory governance are essential to ensuring the long-term viability of mycotourism.

The broader implications of this research extend beyond the studied context, offering insights into how indigenous-led tourism models can contribute to global sustainability goals. By advancing research and policy in this field, the full potential of mycotourism as a vehicle for cultural preservation, environmental stewardship, and economic development can be developed. Ultimately, this study reinforces the importance of balancing ecological, cultural, and economic priorities to foster harmony between people and the planet.

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