

Article

Action Research with Artificial Intelligence in Sustainable and Experiential Tourism: A Case from Tlaxiaco, Mexico

Omar Jiménez-Márquez ^{1,*}, Rodolfo Martinez-Gutierrez ², Luis Alberto Manzano-Gómez ³,
Karina González-Izquierdo ⁴, Clara Ivette Rincón-Molina ³, Gaudencio Lucas-Bravo ⁵,
Reiner Rincón-Rosales ³ and Diana Rubí Oropeza-Tosca ^{4,*}

¹ Instituto Tecnológico de Tlaxiaco, Tecnológico Nacional de México, Boulevard Tecnológico Km. 2.5, Llano Yosovee, Heroica Ciudad de Tlaxiaco 69800, Oaxaca, Mexico

² Unidad Tomás Aquino, Instituto Tecnológico de Tijuana, Tecnológico Nacional de México, Calzada del Tecnológico S/N, Fracc. Tomás Aquino, Tijuana 22414, Baja California, Mexico; rodolfo.martinez@tectijuana.edu.mx

³ Instituto Tecnológico de Tuxtla Gutiérrez, Tecnológico Nacional de México, Carretera Panamericana Km. 1080, Tuxtla Gutiérrez 29050, Chiapas, Mexico; contacto@3rbiotec.com (L.A.M.-G.); clara.rm@tuxtla.tecnm.mx (C.I.R.-M.); reiner.rr@tuxtla.tecnm.mx (R.R.-R.)

⁴ Instituto Tecnológico de Villahermosa, Tecnológico Nacional de México, Carretera Villahermosa–Frontera Km. 3.5, Ciudad Industrial, Villahermosa 86010, Tabasco, Mexico; karina.gi@villahermosa.tecnm.mx

⁵ Secretaría Académica, de Investigación e Innovación, Tecnológico Nacional de México, Av. Universidad 1200, Col. Xoco, Alcaldía Benito Juárez, Ciudad de México 03330, Mexico

* Correspondence: omar_jm@tlaxiaco.tecnm.mx or omarjim_80@hotmail.com (O.J.-M.); oroepza.dianar@gmail.com or diana.ot@villahermosa.tecnm.mx (D.R.O.-T.); Tel.: +52-953-1115238 (O.J.-M.); +52-993-1525205 (D.R.O.-T.)

Abstract

This study analyzes how the integration of native maize cultivation, cultural identity, and technological innovation can promote sustainable and experiential tourism in rural Mexico. The research was conducted in the community of Llano de Guadalupe, Tlaxiaco, Oaxaca. The participatory Action Research process progressed through institutional coordination, participatory diagnosis, biofertilization training, monitoring activities, and community dissemination phases conducted between 3 March 2025 to 25 May 2026. The methodological process included institutional coordination, participatory diagnosis, semi-structured interviews, focus groups, field observations, and the implementation of agroecological practices based on biofertilization. An AI-assisted illustrated field notebook was co-designed to support intercultural education, knowledge exchange, and community participation. The study also incorporated collaborative storytelling, seed preservation practices, and the co-design of sustainable tourism routes grounded in local gastronomy, biodiversity, and agricultural traditions. Preliminary impact indicators showed the expansion of participation from two pilot producers to 54 local producers after community dissemination activities. Findings indicate that the integration of traditional ecological knowledge with generative artificial intelligence (GenAI) can strengthen community empowerment, intergenerational learning, and sustainable livelihoods while preserving biocultural heritage. The proposed circular framework connects ecological, social, cultural, and economic subsystems by transforming agroecological practices into educational and tourism assets. The results suggest that Indigenous and rural communities can lead sustainable destination development when supported through participatory governance, inclusive education, and context-sensitive technological innovation. The Tlaxiaco case offers a transferable framework for sustainable rural development that contributes to food sovereignty, biodiversity conservation, environmental stewardship, and local economic resilience.



Academic Editor: Alessandro Bonadonna

Received: 8 September 2025

Revised: 15 June 2026

Accepted: 16 June 2026

Published: 27 July 2026

Copyright: © 2026 by the authors.

Licensee MDPI, Basel, Switzerland.

This article is an open access article distributed under the terms and

conditions of the [Creative Commons](#)

[Attribution \(CC BY\)](#) license.

Keywords: native maize; sustainable tourism; experiential tourism; agroecology; generative artificial intelligence

1. Introduction

Rural territories can be understood as complex socio-ecological systems in which social, ecological, cultural, and productive components interact dynamically across multiple scales and levels. In these systems, outcomes do not follow linear cause-and-effect relationships but rather emerge from processes of feedback, adaptation, and co-evolution between human actors and ecosystems, which confers upon the system differentiated capacities for resilience and transformation [1,2]. Tlaxiaco is surrounded by majestic pine and oak forests, with altitudes ranging from 1850 to 3460 m above sea level. Nestled in the Mixtec Highlands of Oaxaca and close to several “Pueblos Mágicos” [3,4], Tlaxiaco presents a diverse landscape nourished by pristine spring waters and characterized by a mild temperate climate. Economically, Tlaxiaco’s population, approximately 40,000 residents, relies primarily on commerce, artisanal production, subsistence agriculture, and the service sector. Informal trade and remittances from migration also contribute significantly to household income, while agricultural activities in the surrounding communities maintain traditional milpa systems integrating maize, beans, and squash, which are vital for food security and local livelihoods [3–5].

Agroecology is defined as an integrative approach that articulates science, productive practice, and social movement, oriented toward the design and management of sustainable agri-food systems based on ecological principles, local knowledge, and social justice. Beyond an agricultural technique, agroecology recognizes traditional agriculture as a biocultural process that links production, territorial identity, and biodiversity conservation [6,7]. The surrounding ecosystems sustain remarkable biodiversity, including edible wild plants such as watercress, quelites, tomatillos, wild onions, and aromatic herbs that enrich the local gastronomy and reinforce biocultural identity [8,9].

Arriving in Tlaxiaco evokes a profound sense of peace and renewal: the crisp, ionized mountain air is filled with birdsong, echoing through panoramic views of green valleys and rugged peaks, where deer and rabbits may be seen roaming freely, in the Mixtec landscape [10–12]. These natural gifts [12] are paired with rich cultural traditions, including Holy Week celebrations and the emblematic “Fiesta de La Virgen de Santa María de la Asunción” held on 15 August. At the religious festival of Santa María de la Asunción, where a stewardship is held, delicious black mole is served with picadillo (a type of vegetable sauce), native beans, and rice, and the drinks include tepache and pulque (alcoholic beverage produced from various species of agave in the region) [5,13,14].

Additionally, the fair of the town is held on the third Sunday of October in honor of a virgin. Another important celebration is the Feast of San Isidro Labrador as patron saint of farmers, on 15 May, honoring the patron saint of farmers with rituals and community offerings. The people of Tlaxiaco embody a harmonious relationship with nature, where spiritual values, biodiversity, and collective responsibility come together in a living model of sustainability [5,13,15]. Tlaxiaco is composed of seven traditional neighborhoods, locally known as “barrios,” each with a strong cultural and religious identity centered on the veneration of a patron saint. These barrios are as follows: San Pedro, which celebrates Saint Peter on 29 June; San Sebastián, with festivities in honor of Saint Sebastian on 20 January; San Diego, honoring its saint on 5 February; San Miguel, dedicated on 29 September; San Nicolás, celebrated on 10 September; San Bartolo, which holds its celebration on 13 December; and the Seventh Barrio, which honors the Virgin of Guadalupe with grand celebrations

on 12 December [16]. These often include traditional Mass, candlelit processions, and offerings of food and flowers. These religious and cultural festivities are powerful expressions of Tlaxiaco's community identity [17]. They frequently feature music, dance, fireworks, and shared meals, creating opportunities for social cohesion and the intergenerational transmission of traditions. This is a town that blends Catholic traditions and beliefs in the Mixtec Gods [18]. Each barrio's celebration [19] contributes to the town's vibrant calendar of events and offers unique possibilities for sustainable and experiential tourism experiences [20] rooted in local spirituality and hospitality.

The culture of Tlaxiaco is deeply rooted in hospitality and generosity [21,22]. After each planting task, community members gather to rest and share knowledge about their crops while enjoying traditional local dishes such as black mole, picadillo, and vegetable soup [22]. They also drink mecate beer, a fermented barley beverage [23,24]. Locals embrace visitors with warmth, often offering more than expected as a gesture of respect and goodwill [25]. It is common for hosts to lead walking tours through the town, accompanied by lively regional brass band music, laughter, and celebration [26,27]. Cultural and religious traditions, particularly those linked to biblical events, are an essential part of community life, especially during Holy Week [16,28]. While Spanish is the primary language spoken, many residents use Mixtec words in everyday conversation [14,21], and some are fluent in the language, preserving this element of their heritage [29,30].

During Holy Week, artisans craft palm-based handicrafts [26] and share fruit-infused water with visitors, commemorating the biblical story of the Good Samaritan [31]. Local crafts include vibrantly woven baskets made from regional materials and colorful plastic strips, as well as embroidered bags, blouses, dresses, and traditional shirts that reflect the colors and identity of the surrounding Mixtec communities [32]. Some garments are made using traditional looms, creating culturally symbolic [33] and often valuable pieces of clothing [34].

One of Tlaxiaco's most cherished values is the conservation of nature and health through traditional knowledge of medicinal plants [35,36]. Families grow and pass down herbs from generation to generation, maintaining a strong tradition of herbalism [37]. Many common ailments are treated with plant-based remedies, though residents also seek medical care when necessary [38]. Sustainability is part of daily life, through a plant-based diet rich in homegrown vegetables [39], handmade tortillas [40,41] whose recipe is taught by mothers to their children, and a spiritual approach to land stewardship [42,43]. Helping those in need, offering shelter without expecting payment, and sharing milpa-grown foods such as beans [44,45], fresh cheeses [46,47], and handmade tortillas with visitors are not only customs but expressions of Tlaxiaco's enduring ethical and ecological worldview enjoying organic food such as vegetables [48] and cheese.

Visiting or working in Tlaxiaco evokes the feeling of a second home. As you walk through its streets, you encounter friendly vendors offering fresh, organically grown produce, strawberries, blackberries, onions, epazote, and tomatillos in a variety of colors and sizes, with the deep purple ones drawing particular attention [49,50]. One standout local refreshment is agua (water) de chilacayote [51], a traditional drink made from a fibrous, sweet squash from the milpa, naturally sweetened with unrefined cane sugar (panela). Transactions here go beyond commerce; they reflect a spirit of generosity. Vendors often give you more than what you paid for, along with an extra gift or kind words [52].

In restaurants, hospitality is a ritual. Diners are often treated to bonus servings of barbacoa, the finest cuts of lamb, or extra side dishes, and offered complimentary rounds of local fruit liqueurs, infusions of seasonal fruits blended with regional aguardiente [53]. Free-range eggs are another delicacy, with shells ranging in color from pale pink to soft green and sky blue, depending on the breed of hen [54]. Nearby, local mezcal masters cultivate

and distill mezcal with generations of wisdom [55]. They work with both cultivated and wild agaves, including the renowned espadín [56] and the prized papalomé [57], offering a sensory journey rooted in landscape, labor, and legacy. Every interaction in Tlaxiaco is an invitation to slow down, savor, and connect, where meals are shared, stories exchanged, and visitors welcomed not as strangers but as family [58].

Arriving in Tlaxiaco feels like being welcomed by lifelong friends. Locals greet visitors with warmth and familiarity, often offering personalized recommendations about where to go, what to do, or even accompanying them personally if needed. It is not uncommon for residents to offer their own homes for lodging, especially in rural communities, where multiple houses may share the same family plot, a tradition inherited from ancient times [16]. This deep-rooted hospitality is matched by a strong commitment to environmental care: the city center is remarkably clean, not by enforcement, but by a shared ethic among citizens who consciously avoid littering and work to preserve their surroundings [59].

Participatory education constitutes processes through which local actors collectively, reflectively and situated construct knowledge, based on the interaction between traditional knowledge and scientific knowledge, which favors the adaptive capacity of communities by promoting critical reflection, shared decision-making and collective action in the face of complex socio-environmental problems [60,61].

Tlaxiaco is distinguished by a spirit of solidarity that transcends ideological differences. Neighbors support and protect one another, especially in moments of territorial conflict or social need [62]. Even in communities facing some of the highest vulnerability rates in Mexico, families endure through the strength of their milpa-based food systems [63]. Their daily meals are simple but meaningful: beans harvested from their own plots, cheese made from the milk of cows fed with corn stalks, and handmade tortillas prepared from their own native corn [64]. What sets Tlaxiaco apart from other regions is its unwavering resilience in the face of economic challenges, its dedication to preserving cultural traditions amid the challenges of migration [65], and its ability to sustain environmental stewardship and community values through intergenerational education and cultural knowledge [66]. In Tlaxiaco, sustainability is not a concept; it is a lived experience, passed down with pride and purpose.

Native corn holds profound meaning for the people of Tlaxiaco, Oaxaca. Among locals, a common phrase captures this sentiment: “Corn is more valuable than money because it feeds me.” Passed down through generations, seeds of various colors and varieties are treasured among family members, shared between siblings, cousins, and elders, and carefully stored in trojes or sealed containers. These seeds are planted each spring and harvested at the end of summer, ensuring next year’s sustenance. The planting is often undertaken collectively, following the tradition of tequio [67], a communal labor practice rooted in reciprocity and solidarity.

Corn is not just a staple; it is the heart of the diet and culinary heritage. From handmade tortillas and soups to drinks and animal feed, the entire gastronomic landscape revolves around maize [68]. Families prepare tacos with cheese [69], beans [70], chorizo [71,72], or tasajo [73], and dishes with wild watercress or free-range eggs from their own hens. There is even friendly rivalry between families over who preserves the best maize variety. Some strains have become so adapted to specific microclimates and altitudes that they will not grow elsewhere, knowledge farmers intuitively understand despite limited formal education.

In Tlaxiaco, many families delay breakfast in favor of a more substantial late-morning meal, usually called “el almuerzo” (the lunch), which centers around corn-based foods [74] like tamales, atoles, and tortillas. These meals are often paired with atole de maíz, sweetened with panela [75] and served with pan de yema (yolk bread) or homemade pulque

bread. All corn colors are equally cherished: blue tortillas are often served with lamb barbacoa or eggs; white corn is used in dishes like “la masita” (little dough) [76], a thick soup made from cracked corn and lamb blood or meat, seasoned with spicy salsa, onion, and cilantro; red and yellow corn varieties are commonly used for everyday tortillas.

Children are introduced to the milpa (traditional intercropping system) [77] at an early age, playing in the fields until around age 8 or 9, when they begin helping with light tasks. By age 13 or 14, many are actively planting alongside their families during school breaks, although education remains a priority. Remarkably, many of these farmers hold university degrees, including master’s and doctoral-level qualifications. Before planting, it is customary to pour mezcal, aguardiente, or beer onto the soil as an offering, a spiritual act of asking permission from the earth to receive its gifts. In Tlaxiaco, native corn is not just food; it is memory, identity, ceremony, and a living symbol of resilience and self-reliance.

In Tlaxiaco, the intergenerational transfer of traditional knowledge is deeply rooted in family dynamics, with women playing a central role. Mothers are the primary transmitters of culinary traditions, teaching their daughters [78] and sons how to prepare tortillas, both soft and toasted, as well as how to care for backyard poultry and make fresh cheese. From a young age, girls learn to cook and to carefully measure and blend herbs from their home gardens for teas, infusions, and seasoning [79]. Meanwhile, men traditionally work in the milpa and tend to livestock, pausing at midday to enjoy energizing drinks such as agua de Jamaica (*hibiscus* water), bottled sodas, electrolyte beverages, beer, or mezcal. In earlier times, it was common to mix traditional drinks like pulque, mezcal, and beer into potent blends.

While younger generations attend school and may still learn to make tortillas or tend gardens, migration poses a growing challenge to cultural continuity [80]. Women often leave for cities to pursue university studies, and though they carry the knowledge, the daily practice of traditional cooking fades. Similarly, men who migrate to the United States risk losing the customs associated with native corn cultivation, symbolic planting rituals, and ecological stewardship. This disruption impacts more than culture; it also affects the health of the animals, resilience to drought, and the sustainability of ancestral food systems. Still, many families remain committed to passing these values on to their grandchildren, emphasizing the importance of native crops and traditional farming for food sovereignty and cultural identity.

This evolving context presents a unique opportunity for tourism rooted in both tradition and innovation [81]. Visitors are not only drawn to the flavors and stories behind each tortilla, herb, or ritual but also to the resilience and adaptability of the community. By integrating these cultural practices into tourism experiences, supported by educational tools and sustainable technologies, Tlaxiaco is forging a path where ancestral wisdom and modern innovation can coexist and thrive [82].

The three objectives of this study were successfully achieved. The first objective was fulfilled through the effective articulation between governmental authorities, academic institutions, and producers, resulting in coordinated fieldwork, participatory meetings, and collective decision-making processes that strengthened institutional trust and territorial collaboration. The second objective was accomplished through the contextualized and participatory application of biofertilizers, supported by an AI-assisted field notebook, which facilitated experiential learning, technical understanding, and agroecological reflection among native maize producers. The third objective was achieved by sharing producers’ experiences during community dissemination activities, including the expo-fair, which expanded the initiative’s reach from two initial producers to a broader network of 54 participants, reinforcing sustainable and experiential tourism as a strategy for safeguarding intangible heritage, agrobiodiversity, and local economic resilience.

Artificial Intelligence (AI) plays a crucial role in analyzing the information gathered during field research and contributes significantly to the design of innovative educational strategies and activities [83]. While rural communities in Tlaxiaco already possess deep ancestral knowledge passed down from parents and grandparents, such as how to preserve seeds, manage milpa resources, rotate crops, apply fertilizers, and determine optimal planting and harvesting times, they often lack the tools to transform these practices into marketable, sustainable experiential tourism activities. Their agricultural systems are well established, especially within the framework of circular economic practices. For example, families grow oats, wheat, beans, mustard, and barley to prepare the soil for milpa planting. Crop residues are stored and used to feed livestock, which in turn produce milk for cheese consumed at home or sold locally [84]. Beans are stored for future consumption, while squash and chilacayote are used in soups or refreshing traditional drinks. These tightly integrated cycles support household food security year-round [85].

Despite their knowledge, many families do not yet see a clear pathway to convert these traditional systems into viable tourism experiences. This is where AI can be transformative, by supporting the creation of customized training programs that help communities envision and design tourism products grounded in their everyday lives. These programs can foster alternative sources of income without requiring families to migrate in search of work or for younger generations to abandon agricultural, culinary, or artisanal traditions tied to maize culture [83].

Although Tlaxiaco receives visitors from across Mexico and abroad, the region still lacks adequate infrastructure to offer high-quality, multilingual guided tours, safe and tourist-oriented transportation, or hospitality services in communities prepared to host guests [86]. Elderly residents and women are particularly rich in culinary knowledge and are eager to share this cultural heritage with visitors, offering a unique opportunity for meaningful cultural exchange [87]. While younger generations understand both agricultural and household responsibilities, they often show decreasing interest in farming. However, when equipped with modern tools and knowledge, such as the ability to transform daily practices into income-generating tourism activities, they become more motivated to participate. Seeing tangible benefits from what they already know and do has the power to reignite their connection to tradition while securing their economic future.

The importance of this work lies in creating and diversifying employment opportunities through a tourism-focused approach [88], based on the primary source of income: corn cultivation for milk production and milpa-derived products among farmers in Llano de Guadalupe, located in the municipality of the Heroic City of Tlaxiaco, Oaxaca, Mexico. This is achieved through educational training programs designed with the support of artificial intelligence. The aim of this research is to demonstrate how, through the application of a field notebook (Appendix A Field Notebook) with individuals involved in milpa cultivation, a meaningful exchange of knowledge can take place within the community [89], fostering acceptance of proposals for community-based tourism initiatives [90]. These initiatives aim to involve residents and generate new expectations around employment opportunities linked to sustainable tourism.

This study is framed within the broader context of rural development challenges in Mexico, where dependence on external corn purchases due to supply shortages, limited employment diversification, and recurrent migration have deeply affected local economies. These conditions highlight the urgent need for sustainable alternatives that strengthen community autonomy and resilience. Within this scenario, experiential and sustainable tourism emerges as a viable strategy to conserve natural resources, revitalize cultural identity, and create dignified livelihoods. By integrating agroecological practices, cultural

narratives, and digital innovation, this project contributes to national and global discussions on sustainability, inclusive economic growth, and the regeneration of rural territories.

2. Materials and Methods

This study included follow-up activities, participatory validation, and iterative refinement processes conducted until 25 May 2026.

This study is framed within the principles of Action Research (AR), a cyclical and participatory process that emphasizes collaborative knowledge generation and iterative problem-solving cycles [91,92]. Beyond functioning solely as a case study, the project followed a continuous process of diagnosis, action, reflection, and adjustment, involving community members and researchers as co-participants throughout the research process. In total, eight researchers, four undergraduate students undertaking professional practice, and two local native maize producers, together with their families, voluntarily participated in the project, contributing both technical and experiential knowledge.

Action Research is particularly appropriate in rural contexts where knowledge is deeply embedded in everyday practices, communal labor (*tequio*), and the intergenerational transmission of agroecological and cultural knowledge [87]. The methodological design emphasized experiential learning and the co-construction of knowledge through field visits, observation guides, semi-structured interviews, participatory diagnosis, and focus groups as complementary qualitative techniques. Artificial Intelligence was incorporated as a supportive pedagogical tool to systematize information, design educational materials, and facilitate dialogue between traditional knowledge and contemporary sustainability strategies, without replacing or undermining local expertise and knowledge. This methodological alignment helped ensure that the research process remained ethically grounded, culturally sensitive, and directly linked to the objective of strengthening sustainable and experiential tourism through community empowerment.

The research was developed through an interinstitutional collaboration between the Instituto Tecnológico de Villahermosa, Tabasco, Mexico and the Instituto Tecnológico de Tlaxiaco, Heroica Ciudad de Tlaxiaco, Oaxaca, México, both members of the Tecnológico Nacional de México (TecNM), Mexico, with the purpose of formalizing partnerships for the development of a sustainable tourism project based on native maize cultivation [93,94].

The collaboration extended to other academic institutions and national research networks. Action Research is grounded in key methodological principles, including collective participation, reflexivity, contextualized knowledge production, and continuous improvement of practice. These principles emphasize the co-construction of knowledge with local actors, recognition of situated and experiential knowledge, and iterative cycles of planning, action, observation, and reflection [95,96].

Sustainable tourism is conceived as a territorial development approach that seeks to balance economic benefits with environmental conservation and the sociocultural well-being of host communities. In rural settings, this type of tourism emphasizes responsible management of natural resources, community participation, and the appreciation of local heritage, moving away from extractive models or unregulated tourism growth [95,96]. Complementarily, experiential tourism focuses on meaningful visitor engagement through direct interaction with the cultural, productive, and social practices of local communities. Unlike conventional tourism models, experiential tourism prioritizes immersion, learning, and intercultural exchange through activities linked to traditional agriculture, gastronomy, and the intergenerational transmission of knowledge [97,98]. Together, both approaches provide a conceptual basis for community-based tourism models that integrate sustainability, cultural identity, and local economic resilience.

Sustainable and experiential tourism refers to a community-centered approach to tourism that promotes environmental stewardship, cultural continuity, and economic resilience through the active participation of visitors in everyday rural practices. It integrates agroecological systems (such as the milpa in this case), traditional knowledge, gastronomy, and collective organization into meaningful learning experiences, helping that tourism activities respect ecological limits, strengthen biocultural identity, and generate equitable benefits for host communities.

From a systemic perspective, the articulation between agroecology, participatory education, and sustainable tourism allows us to understand experiential tourism as an emergent result of the interaction between traditional production systems, educational processes, and territorial dynamics. In this sense, experiential tourism arises when agroecological practices and ancestral knowledge are revalued through educational processes, generating new forms of economic diversification consistent with cultural identity, environmental sustainability, and the resilience of the socio-ecological system [1,95].

In sustainability-oriented and community-based contexts, Action Research enables social learning processes that strengthen adaptive capacity, governance, and resilience within socio-ecological systems [60,61].

This methodology is particularly relevant for agroecological and experiential tourism initiatives, where learning, production systems, and territorial governance are deeply interconnected [99,100]. In line with the participatory and action-oriented design described in the milpa-based sustainability framework [99] and the methodological model for sustainable tourism development in rural contexts [100], the present study adopts an Action Research perspective that integrates field immersion, producer training, and collective reflection. The methodological process combines participatory diagnosis, observation guides, interviews, and thematic analysis to co-construct knowledge with the main actors. This articulation allows agroecological practices, such as milpa cultivation and biofertilization, to move beyond production goals and become pedagogical components of sustainable and experiential tourism. Consequently, learning processes, community organization, and tourism diversification emerge as interdependent dimensions within a socio-ecological system grounded in traditional knowledge and territorial identity.

In rural and Indigenous territories, participatory Action Research has been widely recognized as an appropriate methodological framework to respect local knowledge systems, foster empowerment, and support community-led development processes [89,98].

This study followed an Action Research approach characterized by iterative cycles of planning, action, observation, and reflection conducted collaboratively with primary actors [101,102]. In line with participatory action research in sustainable and experiential tourism, the process emphasized collective inquiry, trust-building, and the practical transformation of traditional knowledge into community-defined tourism initiatives, ensuring that learning and decision-making remained situated in the territory [103,104]. Across cycles, evidence from field observation guides, semi-structured interviews, focus groups, and the field notebook was used to refine training actions and strengthen community capacities, consistent with sustainability-oriented co-creation and reflexive practice in action research processes [94,101].

A series of field activities and community engagements were carried out as follows:

A preliminary presentation and coordination session were held with academic partners from four TecNM institutions of Villahermosa, Tlaxiaco, Tuxtla Gutiérrez and Tijuana, Mexico and with members of biotechnology and native corn conservation networks.

An initial field visit was conducted in the Microcuenca de Río Delgado, municipality of Heroica Ciudad de Tlaxiaco, Oaxaca, Mexico, where an observation guide was applied. This instrument analyzed the area's classification [85] (urban, semi-urban, rural), agricul-

tural landscape, tools and technologies used, observed farming activities, corn processing practices, cultural elements, and symbolic expressions [86].

A formal agreement was established with the local government (Ayuntamiento de H. Ciudad de Tlaxiaco) to support intersectoral collaboration, including representatives from agricultural and biological project departments.

A second field visit was conducted with a native corn producer who has preserved his seed varieties for four generations. A semi-structured interview addressed gender, age, main occupation, production practices, seed use and preservation, and cultural perceptions.

Researchers visited the Barrio de San Diego to assess conservation conditions for native corn and applied the same observation and interview instruments from previous visits [87].

A third visit was carried out in Barrio El Vergel with another native corn producer, where the same tools were used.

A follow-up session with researchers and the local government was held to formalize collaborative projects with maize-producing families. Llano de Guadalupe was selected due to favorable planting conditions and the community's willingness to participate.

Researchers visited local markets held twice a week (Tuesdays and Wednesdays) in Tlaxiaco and the neighboring community of Ojo de Agua. Participatory diagnostic and a focus groups were created to better understand the profiles and needs of local producers.

We used a participatory Action Research process conducted between March 2025 and May 2026. The first stage (one month) focused on institutional collaboration, linking academic, governmental, and social actors to establish agreements and coordinate fieldwork activities. The second stage (two months) consisted of a participatory diagnosis that included field visits to local plots, observation of potential sites for milpa planting, and the selection of two initial producers for the pilot phase. The third stage (two months) corresponded to the first biofertilization, where producers received training through the Field Notebook (Appendix A) designed to guide the application of biofertilizers and record field data. Finally, the fourth stage (one month) involved monitoring the development of the biofertilizer during its second application and the participation in an agricultural expo fair, where producers shared their experiences with other community members engaged in milpa cultivation.

In total, eight field visits were conducted, and the observation guide was applied during each visit. Eight semi-structured interviews were carried out, complemented by nine focus group sessions involving municipal authorities, community leaders, and local producers. Qualitative data were analyzed using thematic analysis, identifying key axes such as cheese production, coffee, tourism, honey, maize, bread, and handicrafts. Through six observation guides applied in the local market at the "Saturday market" and open interviews with government personnel, the key words that are repeated in the themes corresponding to the problems raised by the society of Tlaxiaco and the needs or economic activities carried out by the community are identified.

Field notes derived from the six observation guides applied at the Saturday market, together with open interviews conducted with key government personnel, were analyzed using an inductive qualitative approach. First, the field notes were read iteratively to identify meaning units and recurring key words. Second, these words and expressions were grouped into categories and overarching themes based on recurring patterns across data sources (observations and interviews), following a thematic analysis strategy. Third, a summative content analysis step was applied to detect recurrent keywords and expressions, particularly those associated with local challenges, community needs, and principal economic activities, which supported theme consolidation and interpretative depth. The final thematic structure was organized around the repeated community priorities

identified across the six observation instruments and open interviews [88–90]. In total, seven principal local actors belonging to the senior municipal government administration were interviewed.

Initially, two producers participated directly in the biofertilization process; however, after the knowledge exchange at the expo fair, the outreach expanded to 54 producers, each managing an average plot size of approximately two hectares.

Although formal producer associations are not yet established, the interactions and collective initiatives show strong potential for the future creation of social organizations related to native maize, artisanal production, and sustainable and experiential tourism.

A formal agreement was signed among the Instituto Tecnológico de Villahermosa, Villahermosa, Mexico, Instituto Tecnológico de Tlaxiaco, Heroica Ciudad de Tlaxiaco, Mexico and Instituto Tecnológico de Tuxtla Gutiérrez, Tuxtla Gutiérrez, Mexico to implement a sustainable development project aligned with the Agenda 2030 and the Sustainable Development Goals (SDGs), promoting food security in Tlaxiaco.

The biofertilization session utilized *Rhizobium*-based microbial inoculants and plant probiotic bacteria (PPB) for sustainable agriculture [104], where multi-phase inoculation and participatory evaluation are standard. Producers were interviewed regarding their willingness to incorporate sustainable and experiential tourism, receive visitors, and provide meals and lodging [105].

A subsequent visit to the Microcuenca de Río Delgado and the Capilla de Carrizal area was conducted to reassess tourism potential using the same observation guide.

A second round of biofertilization took place, and a specially designed field notebook with tourism-focused questions, co-created using generative artificial intelligence ChatGPT 4.5, OpenAI, USA (GenAI), was applied to collect data on local expectations and knowledge. This approach aligns with participatory data collection tools that integrate digital support for structured qualitative inquiry [106,107], and contributes to enhancing farmer engagement, iterative learning, and the contextualization of tourism experiences in agroecological settings [108,109].

The findings presented in this paper are based on multiple sources of qualitative data, including three participatory workshops, five interviews with participants, and direct field observations conducted in Tlaxiaco. In addition, AI-assisted field notebooks were generated using ChatGPT 4.5, OpenAI, USA. The integration of ChatGPT followed an iterative process: five researchers collaboratively designed prompts to structure the field notes, tested the outputs, and refined them through two cycles of iteration and a final revision process. The resulting content was subsequently reviewed with community members, whose feedback helped to ensure cultural and contextual accuracy [110,111].

The design of the illustrated field notebook was conducted through a participatory and transdisciplinary approach, integrating scientific content, local knowledge, and active methodologies adapted to the rural context of Tlaxiaco, Oaxaca, Mexico. Over the course of 152 interactions within a single collaborative design chat, pedagogical narratives, role-playing activities, community stories, and illustrated educational sheets with an intercultural focus were generated, based on needs identified in the field after the first application of the biofertilizer. The process included the formulation of specific prompts for each thematic block (biofertilization, SDGs, food sovereignty, and community tourism), as well as the production of visual and textual materials in Word and PDF formats, aimed directly at farming families in Llano de Guadalupe [83,112].

The design logic articulated science, cultural identity, and sustainable development, using artificial intelligence tools to co-create accessible, playful, and contextually relevant resources that strengthen productive capacities and foster appropriation of knowledge around native maize cultivation, thereby generating opportunities for experiential and

sustainable tourism. This approach reflects broader trends in participatory tourism design, where co-creation with local stakeholders enhances cultural relevance and sustainable outcomes [113–115].

Generative Artificial Intelligence (ChatGPT 4.5 by OpenAI, USA) was used in this study for grammar correction, English translation of research notes, and the design of tourism-related interview questions in the field notebook. All AI-generated contributions were reviewed and validated by the research team to ensure accuracy and contextual relevance.

The Field Notebook “Cuidando Nuestra Milpa con Biofertilization” (“Taking Care of Our Cornfield with Biofertilization”) was implemented after completing the second stage of the project. It functioned as a pedagogical and participatory tool that helped producers document their experiences during the biofertilizer application and share their reflections in a trusting environment. Thematic analysis was used to interpret qualitative data, focusing on recurring concepts and categories identified across interviews, observation guides, and focus groups [100].

A total of nine focus group sessions [100] were conducted, involving municipal authorities, community leaders, and local producers. These sessions allowed the identification of both consensus and divergent perspectives on the challenges and opportunities of sustainable and experiential tourism linked to maize cultivation. The iterative feedback gathered during these sessions directly informed the design of micro-tourism routes and the final structure of the field notebook.

The qualitative analysis followed a three-stage coding process. First, open coding was conducted to identify recurrent concepts and narratives emerging from interviews, focus groups, and observation guides. Second, axial coding grouped these concepts into broader thematic categories related to agroecology, cultural identity, gastronomy, tourism potential, and sustainability practices. Finally, selective coding enabled the integration of themes into an interpretative framework linking community knowledge, circular economy practices, and experiential tourism development.

To enhance methodological reliability, triangulation was conducted across interviews, field observations, focus groups, and field notebook entries. Preliminary interpretations were also discussed among researchers and community participants to improve contextual validity and interpretative consistency.

Ethical and Methodological Considerations on Generative AI

Generative Artificial Intelligence (ChatGPT 4.5 by OpenAI, USA) was used exclusively as a supportive pedagogical and organizational tool. The system assisted in structuring field notebooks, generating educational narratives, translating research notes, and refining interview questions. However, all AI-generated content was critically reviewed, validated, and culturally contextualized by the research team and community participants before implementation.

To reduce risks of algorithmic bias, cultural misrepresentation, or homogenization of Indigenous knowledge, no sacred, confidential, or community-restricted information was introduced into the AI system. Traditional knowledge remained under community ownership and was incorporated only through voluntary participation and informed dialogue.

The research team recognizes that generative AI systems may reproduce biases present in training datasets or oversimplify complex cultural realities. Therefore, AI outputs were never considered authoritative sources, but rather preliminary drafts subjected to collective revision and participatory validation.

This approach sought to position AI as a complementary tool for intercultural education rather than a replacement for local knowledge systems or community decision-making processes.

3. Results

3.1. *The Cultural and Agricultural Wealth of Tlaxiaco*

The cultural practices related to maize cultivation observed during field visits in Tlaxiaco reflect not only an agricultural system but also a living reservoir of genetic, ecological, and cultural diversity. Native maize varieties cultivated in the region are part of a broader pattern of highland diversity documented in Mexico, where significant intra- and inter-race genetic variability has been identified, particularly in traditional systems that conserve local landraces [116].

Studies conducted in Oaxaca further confirm that traditional management practices, such as seed exchange, selective planting, and community-based cultivation, maintain moderate levels of genetic diversity while limiting population differentiation among maize varieties [117]. In Llano de Guadalupe, the milpa system operates as a socio-ecological unit where biodiversity conservation, soil regeneration, and food sovereignty converge. The use of native rhizobia and plant probiotic bacteria in local agroecosystems aligns with emerging scientific evidence demonstrating the potential of native microbial inoculants to enhance plant growth and resilience under sustainable agricultural practices [118].

Beyond its agronomic value, maize holds deep cultural and political significance in Mexico, as highlighted in debates on indigenous rights and biocultural heritage [119]. Additionally, the successional dynamics of post-milpa fallows in Oaxaca demonstrate how traditional shifting cultivation contributes to forest regeneration and landscape resilience, reinforcing the ecological sustainability of these systems [120]. Together, these findings contextualize the milpa of Tlaxiaco as a dynamic agroecological system that integrates biodiversity conservation, communal labor traditions such as *tequio*, and sustainable land management practices, forming the foundation for both food security and culturally grounded rural development.

The cultural practices related to corn observed during field visits revealed the cultivation of milpa as both a family activity and a space for socialization. Farmers in Tlaxiaco, particularly in the community of Llano de Guadalupe, continue to practice *tequio* [121], a form of communal labor. On average, groups of eight to ten men gather early in the morning to begin sowing, each person carrying a personal bag filled with corn seeds. Notably, only one corn variety is sown at a time (e.g., red or blue), and another variety is not started until the first one is completed. Each farmer uses their own “*coa*”, a shovel instead of a traditional crescent-shaped implement (digging stick), a traditional regional tool designed with a pointed tip and a crescent-shaped blade. The pointed end is used to make a hole in the ground, while the crescent is used to cover it. This is part of the “*cajete*” planting technique [122], which creates a depression in the soil to retain moisture and protect the seed as it awaits the first rains of April or May.

Seeds are preserved in wooden storage rooms made of cured timber, which, due to the region’s cool climate, act as natural refrigeration systems. Smaller producers often store their seeds in tightly sealed bottles or containers. Rituals observed include asking Mother Nature for permission to plant and harvest, often pouring *mezcal*, *aguardiente*, *pulque* [123], or beer onto the soil as an offering. Refreshment breaks are a required part of the sowing process, typically at the halfway point. These include a wide range of beverages, from natural fruit waters and electrolyte drinks to beer and *mezcal*. In earlier generations, *pulque* was also commonly consumed. Alcohol is traditionally believed to help relieve

the muscular pain caused by the physical demands of planting, particularly the use of the digging stick “coa”, which requires skill and strength.

At the end of the sowing session, the wife [124] or partner of the farmer usually prepares a traditional meal. This may include tortillas made from the same corn harvest, fresh cheese produced from the family’s cows, papalomé mezcal [125] (a wild agave native to the region), and beans from the milpa. Depending on availability, the meal may also include free-range eggs, tasajo, chorizo, chicken, or salsa de tripas (trips). Sometimes, however, after significant alcohol consumption, not all participants are able to eat. Nevertheless, this process remains a vital space for social bonding and knowledge exchange. Young men begin participating in these activities, supporting their fathers and learning through practice.

The community shows deep respect for natural resources such as forests and freshwater springs, recognizing these as vital sources of life [126]. They actively prevent deforestation and protect water pipelines and waste systems. Corn is at the heart of both daily labor and gastronomy, shaping the rhythm of life. All planting customs, mezcal offerings, and tequio practices are intergenerational, passed down through observation and education from parents to children.

3.2. Circular Economy in Practice

In Tlaxiaco, families structure their daily activities around the resources available in their backyards or small plots. Many raise chickens, sheep, or cattle, which are fed with crops grown on their own land, such as barley, wheat, oats, corn, legumes, and mustard [83]. These harvests serve both human and animal needs. Cattle provide milk used to produce traditional cheese [127] from Tlaxiaco, Oaxaca, a slightly salted and fresh cheese [128], typically wrapped in banana leaves for distribution [84]. The same milk is used to make cottage cheese (requesón), often served with handmade tortillas made from native corn grown on-site [129].

Poultry is also raised on household scraps and grains. A variety of hens produce colorful eggs ranging from soft pink to shades of green and blue, which are commonly used in traditional meals. These eggs are typically fried or scrambled and paired with beans, cheese, and freshly made tortillas. A popular local variation includes cooking them with chorizo, a regional sausage crafted from pork and local chilies [130].

Sheep are raised primarily to prepare slow-cooked meat wrapped in maguey leaves [131], accompanied by blue or red native corn tortillas with salsa, onion, cilantro and lemon juice, a distinctive regional dish. The meat is also used in hearty broths, including red stews made with chili like mixiote [132], organ soups, and “menudo” (trips and stomach), which is served without spicy ingredients. Another culinary staple is “the little dough” (better known as “la masita”), a thick porridge-like dish made with ground corn and often enriched with meat or vegetables. Backyard poultry and livestock also benefit from leftover produce, reinforcing the self-sustaining nature of these systems [133].

Composting is widely practiced. Organic waste from kitchens, especially peels and remnants from fruits like peaches and apples, is mixed with manure to create nutrient-rich fertilizer for maize and fruit trees [134]. This integrated model supports food production and can significantly reduce the need for chemical inputs, lowering household expenses.

Meals are generally structured around a single main midday meal, known as almuerzo, which merges breakfast and lunch. This helps conserve both food and financial resources, with many families skipping dinner. Labor is often shared through tequio [85], a traditional practice where neighbors help each other with farming tasks, minimizing the cost of hired labor.

When available, spring water is used to irrigate fields, hydrate livestock, and for domestic tasks such as cooking, washing dishes, and laundry. In some cases, solar-powered pumps are used to access water. From the milpa, families harvest not only corn and beans but also leafy greens (quelites [135,136]), squash, tomatoes, and chayote. These ingredients are used in a variety of dishes, from soups and stews to salsas blended with proteins such as salted beef, pork ribs, and dried tripe. Locally grown vegetables like nopales and summer squash are also commonly used in everyday meals.

Orchards often include citrus fruits, lemons, limes, and oranges, as well as apples and peaches. Many households prepare traditional beverages using surplus fruits and grains, such as refreshing infusions made from squash, barley, or wheat. Additional organic products like hibiscus flowers are brought from nearby coastal areas to supplement the diet.

This deeply rooted circular system provides families with reliable access to food while reducing dependence on external sources [137]. In rural areas with larger plots, this model ensures a high level of food sovereignty. In urban parts of Tlaxiaco, although space is limited, residents often purchase fresh produce from nearby rural communities at lower prices. These farmers frequently offer generous portions, strengthening both the local economy and community ties. The abundance of native vegetables and fruits, including purple beans, heirloom tomatoes, figs, and berries, enriches the region's culinary landscape and strengthens household resilience through resource-conscious living.

3.3. Empowering Communities Through Education and Artificial Intelligence

A central outcome of this project was the co-creation of an educational fieldwork notebook, developed with the assistance of generative artificial intelligence (ChatGPT-4 by OpenAI). This tool was designed to support meaningful engagement between native corn producers and specialists in education and biotechnology, fostering mutual knowledge exchange and enabling the documentation of local practices with the potential to be adapted into sustainable tourism experiences.

The structure of the notebook was carefully crafted to serve both as a pedagogical tool and a participatory diagnostic instrument [83]. It consisted of the following sections:

1. Sociodemographic Data—to record basic information such as gender, age, occupation, and family role in agricultural activities.
2. Cultural and Agricultural Knowledge—questions related to native corn cultivation, seed preservation, planting cycles, and food preparation.
3. Community Perception and Symbolic Practices—to explore spiritual or ritual elements related to maize (e.g., mezcalt offerings, tequio [135]), and values passed between generations.
4. Circular Economy and Self-Sufficiency—assessment of how families manage agricultural byproducts, raise animals, and produce their own food (e.g., cheese, eggs, tortillas).
5. Tourism Readiness and Community Interest—evaluation of participants' openness to hosting tourists, offering meals or workshops, and their ideas for potential tourism activities.
6. Expectations and Educational Needs—space for the community to share what knowledge or support they would need to design and operate tourism experiences.

This notebook was not applied as a rigid questionnaire, but rather as a conversation guide that encouraged storytelling, reflection, and reciprocal learning. During interviews, farmers shared their lived experiences and ancestral wisdom, while researchers provided feedback and shared insights on sustainability and tourism development. The notebook thus became a collaborative learning tool, grounded in dialogue and co-construction.

The use of AI played a supportive role in designing culturally relevant questions, improving the clarity of educational objectives, and adapting the tool for low-literacy contexts. Importantly, community members showed no resistance to the AI-assisted format. Instead, they embraced the process with curiosity and enthusiasm, as the tool respected their voices and reflected their lived realities.

By combining digital innovation with participatory methodologies, this notebook not only gathered rich qualitative data but also empowered communities to reflect on their own knowledge systems, identify their strengths, and envision future possibilities. It laid the groundwork for future educational materials, such as illustrated manuals, audio guides, or workshops, that can be developed collaboratively to support rural tourism, agroecology, and economic resilience.

3.4. Toward Sustainable and Experiential Tourism

Based on the field observations and community dialogues, three micro-tourism routes were co-designed with local producers as part of the participatory training activities. The first route, “Ruta del Maíz”, begins with a community welcome by the host producer, followed by a traditional breakfast of black beans, handmade tortillas made with native maize, café de olla, and artisanal cheese. The journey continues through mountain trails with pine and oak forests, natural springs, and waterfalls, where visitors can taste freshly harvested pears. Participants then visit the dairy area and the milpa plots to share drinks in the spirit of tequio, before returning to the household for conversations in the local Mixtec language and a communal meal featuring seasonal dishes such as berros, tasajo, chorizo, chapulines, and agua de jamaica.

Two additional routes emerged from the participatory process: the “Gastronomic and Handicraft Route”, which includes visits to traditional food producers and craft markets, and the “Gastronomic Experience Route”, where visitors participate directly in preparing regional dishes, visiting milking cows, grinding sauces in a molcajete, cooking over wood fire, and brewing traditional coffee.

These routes embody the essence of sustainable and experiential tourism, linking agroecological practices, cultural identity, and local gastronomy while strengthening inter-generational knowledge transmission.

The fieldwork identified a range of sustainable and experiential tourism experiences that could be developed in Tlaxiaco, particularly focused on culinary heritage, agroecology, and immersive cultural participation. One of the most prominent experiences involves hands-on tortilla-making, led by local women who also teach visitors how to prepare traditional dishes such as molcajete-crushed tomato salsa. Guests can engage directly in the preparation process by cooking their own tortillas [136], frying tasajo, chorizo, or tripe, slicing freshly made Tlaxiaco cheese, or assembling tacos with spicy chicharrón salsa and seasonal watercress (berros) harvested directly from the plots.

Additional experiential activities include feeding livestock, irrigating corn fields, planting seeds, or collecting eggs from free-range hens. Visitors may also participate in guided nature walks through the community’s agricultural plots and surrounding forests, discovering the region’s rich biodiversity. Mushroom foraging can also be organized during the rainy season, typically from June onward, as such species are rarely found during the dry months of April and May [50].

Seasonal fruit harvesting offers another authentic tourism experience. Guests can collect capulín cherries, peaches, apples, or blackberries, wash them on-site, and enjoy them fresh from the tree. Corn, beans, and other milpa crops may also be harvested as part of hands-on agricultural activities. Moreover, milking cows, participating in traditional

cheese-making workshops, tortilla preparation sessions, and tastings of regional dishes are highly valued by the community and offer rich opportunities for cultural exchange.

During field visits, community members expressed their willingness to participate in tourism activities, offering meals in their homes, providing lodging in cabins adjacent to their primary dwellings, and guiding visitors through local landmarks. In fact, during pilot experiences, researchers and visitors from other states were warmly received and engaged in a variety of activities, including milpa planting, preparing chorizo and salsas, and exploring nearby natural springs, forests, and water sources. These visits also included discussions about local tools, agricultural practices, wildlife observation, and oral storytelling, including legends and mystical beliefs related to flora, fauna, hills, and ancestral customs.

The community shared Mixtec myths and traditional tales, as well as historical insights into inter-community relations across the region. This cultural wealth presents a compelling foundation for the development of structured tourism offerings, including visit protocols, sample menus, organized activities, and multilingual guides, designed to ensure that visitors engage respectfully with local customs and traditions.

By leveraging the tools and insights gathered through the AI-supported field notebook, it is possible to co-design tourism experiences that preserve cultural identity, strengthen native corn conservation, and promote sustainable land use. These activities may also contribute to the protection of surrounding forests, discourage illegal logging, and encourage the conservation of natural resources such as spring water, which plays a vital role in the region's ecological and cultural balance.

3.5. Sustainable and Experiential Tourism Based on Local Culture

The region of Tlaxiaco holds a unique wealth that combines ancestral agricultural practices, community knowledge, biodiversity, and a strong cultural identity. This combination allows for the development of a model of experiential and sustainable tourism, capable of generating economic, social, and environmental benefits without compromising the integrity of the environment or the community's traditions. The initiatives developed in Tlaxiaco are aligned with sustainable and experiential tourism, as they combine environmental protection, cultural revitalization, and community participation [138].

Among the tourism experiences identified are immersive activities in the daily life of farming families. Visitors can participate in making handmade tortillas, grinding tomatoes in a molcajete for salsa, cooking tasajo, chorizo, or tripe, and preparing artisanal cheese. These meals are enjoyed in community settings, using locally harvested ingredients such as tomatoes, watercress, beans, or freshly collected eggs.

Other activities include the harvesting of fruits and vegetables directly from family plots (such as peaches, apples, capulines, maize, or wild greens), milking cows, feeding poultry and livestock, as well as observing agroecological processes, such as the use of biofertilizers based on biofertilizers to improve native maize cultivation.

Guided tours of farmland and forests provide opportunities for landscape interpretation and learning about local flora and fauna, including seasonal practices such as wild mushroom foraging, birdwatching, or visiting springs and sacred water sources. During these activities, elders share legends, botanical knowledge, stories about the hills, and ritual practices such as pouring mezcal or aguardiente as an offering to the Earth before planting.

Tourism can also coincide with local religious celebrations, such as San Isidro Labrador Day, Holy Week, or patron saint festivities. During these events, visitors may observe or participate in traditional dances, processions, communal masses, and shared meals, where artisanal mezcal or tequila are offered as symbols of hospitality and gratitude. These festivals are part of a living heritage that strengthens Mixtec identity and promotes respect

for the community's spiritual traditions. These celebrations with communal meals are not merely culinary events but social institutions that reinforce reciprocity, identity, and collective memory, similar to other documented communal food traditions in Mexico [138].

During the pilot visits conducted as part of this project, participants from various states and sectors (academics, technicians, institutions) joined collective planting activities, shared meals, attended cheese-making workshops, and hiked through the forests. These interactions were well received by the community, who expressed their willingness to host tourists, provide food, share their stories, and offer lodging in family cabins or adapted spaces within their properties.

With the support of the field notebook co-created using artificial intelligence, it was possible to systematize family expectations, identify potential tourism routes and menus, and project an organized tourism model that respects traditional knowledge and customs while also promoting natural resource conservation, such as forests and spring water, and food sovereignty based on the milpa system.

If built by and for the community, experiential tourism in Tlaxiaco has the potential to become a tool for cultural, ecological, and economic regeneration [139], aligned with the Sustainable Development Goals (SDGs) and the priorities set forth in the municipality's Voluntary Local Review (VLR). It is not just about welcoming visitors, but about opening the territory to mutual learning, where each experience strengthens the dignity, knowledge, and self-determination of Indigenous peoples.

4. Discussion

The results presented in Tables 1 and 2 highlight the dynamic intersection between agricultural biodiversity, traditional gastronomy, and sustainable and experiential tourism in Tlaxiaco. This rural region showcases an integrated agroecological system deeply rooted in Indigenous knowledge and communal practices such as *tequio* [78], where collective labor strengthens the common good. These systems serve as examples of ecological sustainability, while also fostering social cohesion and economic viability, in alignment with the holistic principles documented in studies on food sovereignty and agroecology [3,4].

Beyond the specific context of Tlaxiaco, these findings illustrate a replicable framework for sustainable rural development grounded in three interrelated dimensions: (1) Environmental sustainability, achieved through agroecological management, biodiversity conservation, and the use of microbial biofertilizers that enhance soil health while reducing chemical dependency; (2) Cultural sustainability, which preserves traditional gastronomy, local seed varieties, and ancestral practices as living heritage and educational assets; and (3) Economic sustainability, which is fostered through experiential tourism and travel microenterprises that generate equitable income and reduce rural migration.

This triadic framework can be applied to other rural and Indigenous territories where cultural identity, ecosystem services, and social organization intersect. The model encourages a transition from extractive economic logics toward circular, sustainable, and participatory systems, consistent with the principles of the 2030 Agenda and the Sustainable Development Goals (SDGs 2, 8, 11, 12, and 15). Furthermore, the integration of digital technologies, such as artificial intelligence tools for education, communication, and design, enhances local capabilities and democratizes access to innovation.

In this sense, the Tlaxiaco experience demonstrates that sustainable and experiential tourism can act as a catalyst for systemic change, connecting local traditions with global sustainability frameworks. By articulating science, culture, and technology, it provides a conceptual and practical foundation for a local model of development, one that values local knowledge while addressing global challenges such as food security, biodiversity loss, and social inclusion.

Table 1. Summary of Agricultural and Gastronomic Practices in Tlaxiaco.

Practice Type	Description	Local Ingredients/Tools	Seasonality	Contribution to Sustainable and Community-Based Tourism
Maize Cultivation	Milpa planting with intercropping and tequio participation	Native corn, coa, mezcal	March–April	Promotes agrobiodiversity, collective work, and cultural identity; model for agroecological education and seed conservation.
Maize Harvesting	Once the husk and stalk are dry, the maize is ready to be harvested	Picker, tenate (basket), troje (storage shed)	August–November	Demonstrates circular food systems and traditional post-harvest management practices that ensure food sovereignty.
Cheese Production	Traditional fermentation for 6 to 72 h and wrapped in banana leaves	Raw cow milk, salt, banana leaves	Year-round	Strengthens local micro-enterprises and adds value to agro-livestock integration; supports experiential tourism through artisanal production.
Tortilla Making	Hand-formed and comal-cooked tortillas prepared by women	Corn (white, blue, yellow), lime	Daily	Represents culinary heritage and women’s leadership; key attraction for cultural and gastronomic tourism.
Mushroom Foraging	Seasonal collection in forests during the rainy season	Forest mushrooms	June–August	Promotes conservation and sustainable use of forest resources; connects biodiversity with cuisine.
Salsa Preparation	Tomato and chili salsa ground in a molcajete and served with meats	Tomatoes, chiles, molcajete	Daily	Encourages the preservation of traditional culinary techniques and intergenerational knowledge transmission.
Boiled Beans (Frijoles sancochados)	Cooked with spring water	Pork lard, salt, garlic, onion, epazote	Daily	Illustrates sustainable use of natural water sources and traditional cooking methods in rural households.
Creole Hen Broth (Caldo de gallina criolla)	Cooked with spring water	Rice, hoja santa, tomato, garlic, salt, onion	Weekly	Reflects seasonal cooking and ecological gastronomy; supports self-sufficiency and healthy diets.
Compost Production	Organic food scraps and animal waste used for natural fertilization	Manure, kitchen waste	Year-round	Embodies circular economy principles by reducing waste and regenerating soil fertility; applicable to sustainable tourism models.

Table 2. Availability and conditions for sustainable and experiential tourism activities in Tlaxiaco.

Activity	Willingness to Host Visitors	Available Infrastructure	Comments	Broader Relevance/Framework Contribution
Traditional tortilla-making demonstration	High	Comal, space in homes	Women are enthusiastic about sharing this tradition	Strengthens gender inclusion, food heritage preservation, and experiential learning aligned with SDG 5 (Gender Equality) and SDG 12 (Responsible Consumption).

Table 2. *Cont.*

Activity	Willingness to Host Visitors	Available Infrastructure	Comments	Broader Relevance/Framework Contribution
Milpa field tour	Medium	Pathways, shaded areas	Best during planting or harvesting seasons	Demonstrates agroecological knowledge and the circular nature of traditional systems, serving as an educational reference for sustainable and experiential tourism as well as sustainable farming.
Cheese-making workshop	Medium–High	Holstein cows, tools	Requires sanitary precautions	Integrates rural production with tourism; offers a model for agrotourism linking food sovereignty and value-added dairy products.
Mushroom foraging	Low (seasonal)	Forest access	Only possible during the rainy season	Promotes seasonal biodiversity appreciation and ecological awareness; supports conservation-based tourism models.
Hosting visitors at home	Medium	Cabins, extra rooms	Requires prior notice and flexibility	Encourages intercultural exchange and local entrepreneurship; a foundation for sustainable and experiential tourism.
Forest walk and flora/fauna photography	High	Natural trails	Birds, salamanders, orchids, bromeliads, agave, juniper, and more can be observed	Fosters biodiversity conservation and environmental education within low-impact tourism circuits.
Observation of springs and irrigation channels	High	Access to natural water bodies	Ideal for connecting with nature and learning about traditional water management	Illustrates traditional ecological knowledge in water conservation, supporting climate adaptation strategies.
Visits to caves, marine fossils, and rock paintings	High	Rural trails, pedestrian access	Requires hiking on uneven terrain and prior scheduling	Enhances geotourism and cultural heritage preservation; contributes to educational tourism models.
Traditional food tasting	High	Community kitchens	Dishes include chicken soup, beans with cheese, handmade tortillas, chicharrón or tripe salsa, carnitas	Integrates gastronomy and sustainability, showcasing how local food systems contribute to cultural and economic resilience.
Pulque bread-making workshop	High	Wood-fired oven, local ingredients	Uses pulque, eggs, sugar, salt, lard; requires advance notice	Demonstrates the recovery of ancestral fermentation techniques; connects traditional foodways with identity-based tourism.
Observation and feeding of poultry (chickens, turkeys)	High	Chicken coops, available feed	Visitors can feed corn, oats, and alfalfa; suitable for families and children	Promotes family-friendly tourism, circular resource use, and education on self-sufficient food systems.

The seasonal rhythm of agricultural practices, particularly the planting and harvesting of native maize through the milpa system, exemplifies a continuous cycle of food availability and environmental regeneration. The coexistence of crops, livestock management (such as

Holstein cows and poultry), and composting practices reflect an advanced understanding of resource optimization. These findings resonate with complex systems theory, in which the interdependence of components enhances resilience and adaptability [5]. The incorporation of traditional ecological knowledge into everyday practices ensures both cultural continuity and environmental sustainability.

Culinary traditions such as handmade tortillas, pulque bread, and the use of spring water for cooking highlight the value of food not merely as sustenance but as a vehicle for identity, memory, and celebration. This aligns with previous research recognizing food heritage as an essential component of intangible cultural heritage [8]. The community's strong willingness, especially among women, to host visitors for activities such as culinary demonstrations and tastings reveals significant potential for developing a form of tourism that is culturally rooted and respectful of local rhythms and dynamics.

Beyond the local context of Tlaxiaco, these findings contribute to a broader understanding of how agroecological systems can support sustainable and inclusive models of rural development. The interaction between biodiversity, gastronomy, and participatory tourism exemplifies a scalable model that integrates environmental stewardship with social innovation. Similar approaches could be adapted in other rural territories, where the preservation of traditional food systems and ecological knowledge can serve as catalysts for sustainable livelihoods.

This perspective positions sustainable and experiential tourism not only as an economic strategy but as a holistic sustainability mechanism, capable of strengthening local governance, fostering gender inclusion, and enhancing resilience to climate and market fluctuations. Moreover, the integration of digital tools, such as artificial intelligence for educational co-creation and participatory design, represents a novel path for empowering communities through accessible, intercultural, and technology-supported learning experiences.

Table 2 expands the analysis of community practices by linking each activity to broader sustainability goals and theoretical perspectives, illustrating how Tlaxiaco's model can be adapted to other rural contexts pursuing sustainable and experiential tourism approaches. In Tlaxiaco, activities such as gastronomy-based workshops, biodiversity observation, and participation in rural life exemplify the integration of environmental, cultural, and educational dimensions of sustainability. While some experiences, such as mushroom foraging or cave exploration, are constrained by seasonality and accessibility, others, like tortilla-making, pulque bread workshops, and compost observation, are viable year-round and align with low-impact tourism strategies that foster continuous community engagement.

Beyond the local scope, these practices reflect a replicable framework for rural innovation, where sustainable and experiential tourism acts as a mechanism for agroecological transition, food sovereignty, and cultural continuity. This aligns with the principles of sustainable and experiential tourism, emphasizing environmental care, cultural appreciation, and the empowerment of host communities rather than mere visitation. The model also demonstrates the relevance of digital tools and participatory design, such as AI-assisted educational resources, to strengthen training and communication within sustainable and experiential tourism processes.

Nevertheless, challenges persist in formalizing and scaling these experiences without compromising authenticity or ecological balance. Future research should explore capacity-building strategies, fair-trade certification models, and partnerships among communities, academia, and local governments. Such collaborations can strengthen entrepreneurial competencies, environmental stewardship, and adaptive governance mechanisms.

Ultimately, the Tlaxiaco model offers a conceptual framework applicable to other rural territories seeking to harmonize cultural heritage, sustainable agriculture, and responsible tourism. By integrating traditional knowledge with innovation, it advances a holistic

understanding of sustainability that supports the Sustainable Development Goals (SDGs 1, 5, 8, 12, and 15) and illustrates how sustainable systems can emerge from the convergence of local wisdom and modern tools.

The activities described in Table 2 were derived from the participatory fieldwork using observation guides and focus groups, which served as the foundation for defining the tourism routes. The statements included in the table were validated through thematic analysis of producers' narratives and field notebook entries.

4.1. Description of the Components of a Self-Sufficient, Agroecological, and Culturally Rooted Farm in Tlaxiaco

Figure 1 illustrates the functional and cultural organization of a self-sufficient family farm in a rural community of Tlaxiaco, Oaxaca. It reflects an agroecological model that integrates productive, domestic, and community spaces, grounded in ancestral knowledge and a deep spiritual connection to the land. This arrangement not only ensures household resilience but also represents a replicable framework for sustainable rural development in similar territories.

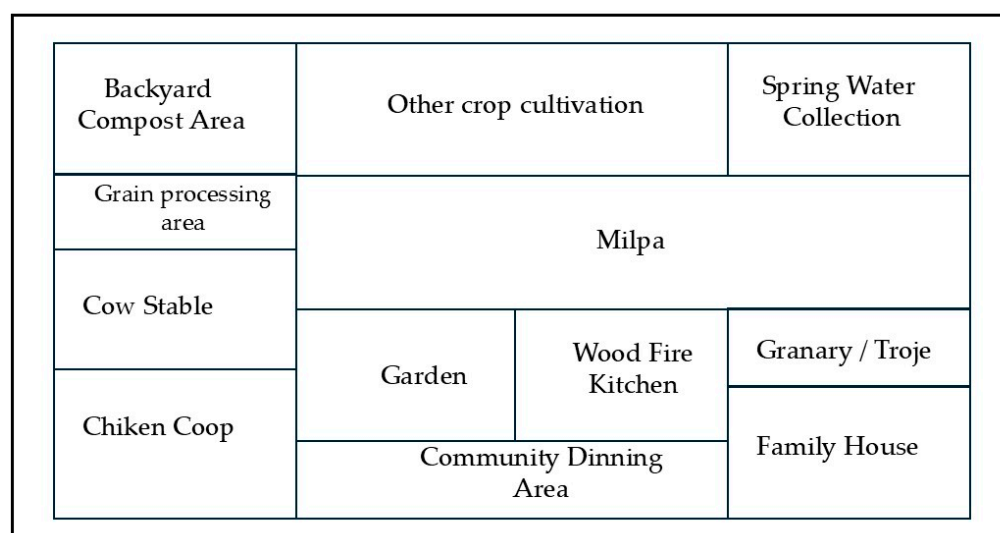


Figure 1. Conceptual framework of the self-sufficient agroecological household system in Tlaxiaco.

The self-sufficient, agroecological, and cultural farm in Tlaxiaco is organized into several interconnected areas that together form a holistic and sustainable rural system. At the heart of this model lies the milpa, a traditional intercropping system where maize, beans, squash, chilacayote, and wild greens (quelites [140]) are cultivated. This practice strengthens year-round food security and contributes to soil fertility and biodiversity conservation.

Complementing the milpa, there is an additional crop cultivation area where families grow vegetables, herbs, chili peppers, and other seasonal plants that diversify their diets and strengthen the household economy [141]. A garden space, common in all homes, provides flowers, medicinal plants, and a pleasant setting for recreation and emotional well-being.

Animal husbandry also plays an important role. Holstein cows are sheltered in a stable and fed with fodder grown on the same plot, providing fresh milk for traditional cheese-making. Chickens and turkeys are raised in a chicken coop and fed with corn, oats, and alfalfa. These animals offer eggs and meat for family consumption, as well as for community events or family and religious celebrations [142].

The sustainability of the system is reinforced through integrated resource management. In the backyard compost area, organic waste, such as manure and kitchen scraps, is recycled into natural fertilizer to nourish the crops. In addition, there is a spring water collection zone that provides water for irrigation, human consumption, and livestock care, reinforcing the autonomy of the production system.

After harvesting, maize is processed in a grain shelling area where the kernels are separated and safely stored. These grains are kept in a traditional troje or granary, designed to keep them dry and ventilated, protected from moisture and pests throughout the year.

Food is prepared in a wood-fired kitchen, where ancestral culinary practices are preserved by cooking handmade tortillas, beans, tamales, and pulque bread. These meals are often shared in a community dining area, where guests who participate in tequio or tourists can eat. It is a welcoming space for gathering with neighbors, relatives, and visitors during celebrations or communal workdays.

Lastly, the family house serves as the heart of the home, where everyday decisions are made and cultural values are passed down from generation to generation. The house also includes guest rooms or independent annexed spaces available to host visitors, offering experience of community hospitality and supporting rural and experiential tourism activities.

This agroecological system functions not only as a production model but also as a living example of sustainable and experiential tourism that supports resilient and sustainable livelihoods. Its design illustrates how traditional Mixtec ecological knowledge and social organization can inspire frameworks for climate resilience, biodiversity conservation, and cultural continuity. The integration of circular economy principles, through composting, water reuse, and intergenerational learning, demonstrates a model adaptable to other rural contexts seeking to harmonize food sovereignty, tourism, and sustainability.

4.2. Description of a Circular Model in Experiential and Sustainable Tourism

The implementation of a circular model in the Tlaxiaco case study reveals how sustainability principles can be operationalized through sustainable and experiential tourism initiatives [143]. At the core of this model is the integration of agroecological production [144] (e.g., native corn cultivation with biofertilization [145]), cultural identity (e.g., storytelling, seed conservation, traditional food preparation), and education (e.g., field notebooks, AI-assisted learning). This circular model (Figure 2) reinforces value chains by transforming agricultural practices into educational and tourism experiences without generating additional waste or relying on external chemical inputs from other countries.

This study is anchored in the conceptual distinctions between sustainable tourism and experiential tourism. Sustainable tourism emphasizes the responsible use of natural and cultural resources, aiming to minimize environmental impacts and strengthen local economies through long-term, community-oriented practices. Experiential tourism, on the other hand, focuses on learning through participation and intercultural exchange in locally meaningful activities such as gastronomy, agroecology, and artisanal production. In Tlaxiaco, these two perspectives converge around biocultural diversity, communal organization, and food systems (the milpa and associated practices), providing a grounded platform that links cultural identity, environmental management, and rural development pathways [4–8,15,19,87,143].

Each component of the system feeds back into the other: agricultural biodiversity enhances the cultural narrative; cultural heritage becomes a learning asset for visitors; and visitors contribute economically and symbolically to the preservation of the territory. The reuse of knowledge, seeds, soil nutrients, and community narratives creates a sustainable and experiential tourism cycle that strengthens both the ecosystem and the local economy. This model not only reduces environmental impact but also encourages dignified liveli-

hoods and reinforces the autonomy of original communities in defining their own paths to sustainable development.

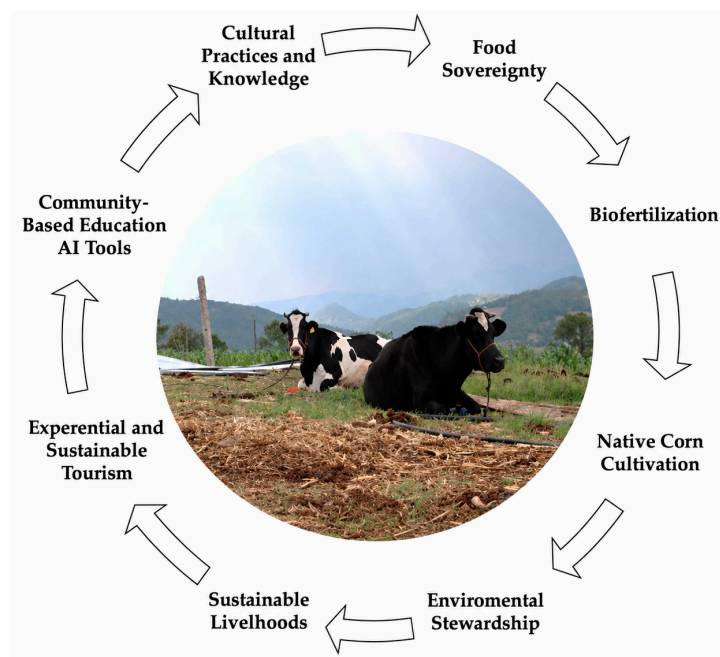


Figure 2. Circular framework for sustainable and experiential tourism based on native maize systems in Tlaxiaco.

Figure 2 synthesizes the relational dynamics identified during the Action Research process, illustrating how agroecology, cultural identity, participatory education, and experiential tourism interact as interconnected subsystems within a circular sustainability framework. The model also identifies potential transferability conditions for other rural and Indigenous territories characterized by strong biocultural heritage and community-based governance.

The Circular Economy Model for Sustainable and Experiential Tourism [146] in Tlaxiaco (Figure 2) integrates native corn cultivation, biofertilization, community knowledge, sustainable and experiential tourism [83] into a regenerative loop that enhances local livelihoods and environmental resilience. At its core is the cultivation of native maize using traditional seeds and agroecological practices (Appendix B) supported by biofertilization with biofertilizers, a species originally isolated from high mountain pine forests in southern Mexico, such as those around Tlaxiaco [147], which reduces chemical inputs and restores soil health. Knowledge is preserved and transmitted through intergenerational learning and AI-assisted educational tools like field notebooks. Visitors can engage in immersive experiences, such as touring the milpa, participating in food preparation, and learning about cultural practices, thereby supporting local economies. The income generated from tourism can be reinvested in seed conservation, community education, and infrastructure improvements, strengthening sustainable development initiatives in Tlaxiaco and aligning with models of alternative and experiential tourism described for the Río Delgado micro-basin [148]. Organic residues are composted, contributing to soil regeneration, while youth involvement ensures continuity and innovation. This circular model promotes food sovereignty, biodiversity conservation, and climate resilience, demonstrating how cultural identity, science, and sustainability can converge to create a replicable model of rural development rooted in community participation [149].

Although the present study was primarily qualitative and exploratory, preliminary indicators suggest positive trends in community participation (Table 3), knowledge ex-

change, and territorial engagement. The expansion from two initial producers to fifty-four participating farmers reflects a significant increase in local interest and social diffusion of the initiative.

Table 3. Preliminary impact indicators of the participatory tourism and agroecological model in Tlaxiaco.

Indicator	Initial Stage	Final Stage
Participating producers	2	54
Institutions involved	5	9+
Field visits	0	8
Focus groups	0	9
AI-assisted educational materials	0	1 field notebook + materials
Tourism routes co-designed	0	3
Families willing to host visitors	Low	Medium-High
Biofertilization training sessions	0	2

Note: (9+) More than nine educational and government institutions are collaborating during the final stage.

To enhance the empirical traceability of the intervention, preliminary impact indicators were systematized from participatory activities, field observations, focus groups, and producer engagement throughout the Action Research process conducted between 3 March 2025 and 25 May 2026.

This study presents certain limitations associated with the qualitative and participatory nature of Action Research. The findings are grounded in a specific territorial and cultural context, which may limit direct generalization to other regions. Additionally, the impact indicators presented remain preliminary and exploratory, since long-term quantitative monitoring of economic, agricultural, and tourism outcomes has not yet been completed. Future studies should incorporate longitudinal assessments, participatory indicators, and mixed-method approaches to evaluate the sustained social, environmental, and economic impacts of experiential tourism initiatives supported by agroecological innovation and artificial intelligence.

5. Conclusions

This study contributes to both the theory and practice of sustainable and experiential tourism by integrating Action Research principles [150] with AI-assisted participatory tools [151,152] to foster sustainable rural development. The case of Tlaxiaco demonstrates how ancestral agricultural knowledge, cultural identity, and technological innovation can converge to build sustainable and experiential tourism models rooted in local realities yet adaptable to global sustainability challenges.

From a theoretical perspective, this research advances the understanding of sustainable and experiential tourism as an evolving field that merges agroecology, digital transformation, and participatory methodologies [85,153]. By framing the project within Action Research, the study highlights how iterative cycles of diagnosis, action, and reflection can generate locally grounded solutions while contributing to global debates on sustainable transitions and digital inclusion in rural contexts [139].

From a practical standpoint, the study shows that tools such as biofertilization with biofertilization [147] and AI-assisted field notebooks can empower families to reinterpret their agroecological practices and transform them into meaningful tourism experiences and sales creating distribution channels for regional products [154] without compromising tradition. The co-designed educational materials and immersive visitor interactions foster intercultural scientific communication, experiential learning, and community resilience,

illustrating how digital innovation can complement Indigenous knowledge systems and preserves ecosystems [155]. The conclusions according to the objectives are as follows:

This study demonstrated that the application of biofertilizers using a didactic tool developed with Artificial Intelligence can effectively train native maize producers and promote experiences of sustainable and experiential tourism. This participatory approach linked science, education, and local knowledge, empowering rural families to reinterpret their agroecological practices as cultural and tourism experiences without losing authenticity or traditional meaning.

We established collaboration between governmental, academic, and social actors. The interinstitutional collaboration between academic, governmental, and social sectors proved fundamental for achieving sustainability outcomes. The participatory alliances facilitated resource mobilization, technical training, and shared decision-making. These networks strengthened the community's ability to coordinate agroecological activities and to visualize tourism not merely as an economic option but as a form of collective learning and cultural exchange.

We applied biofertilizers through contextualized and participatory training. The use of Biofertilization biofertilizers under local conditions demonstrated both environmental and educational benefits. Producers learned to apply biofertilizers while understanding soil fertility, native seed preservation, and biodiversity conservation. The Field Notebook (Appendix A) co-designed with the community became a bridge between scientific and ancestral knowledge, enabling reflection on agroecological practices and reinforcing sustainable habits in daily production.

The experience was shared to strengthen sustainable and experiential tourism through the conservation of intangible heritage and agrobiodiversity. The experiential component was reflected in the creation of three tourism routes ("Ruta del Maíz", "Gastronomic and Handicraft Route", and "Gastronomic Experience Route"), each integrating agroecology, gastronomy, and community hospitality. These activities positioned local producers as cultural ambassadors and educators, fostering intercultural dialogue and awareness of sustainability values. By transforming agricultural learning into tourism experiences, communities strengthened their collective identity and generated opportunities for dignified livelihoods.

This study contributes to the theory and practice of sustainable and experiential tourism by demonstrating that sustainable and experiential tourism can emerge organically from agroecological knowledge and participatory education. It highlights how digital tools such as AI-assisted materials and field notebooks can facilitate communication, inclusion, and the co-construction of knowledge. The Tlaxiaco case offers a replicable model for other rural territories seeking to integrate sustainability, culture, and education in tourism initiatives grounded in local autonomy and environmental stewardship.

The Tlaxiaco experience provides a replicable framework for sustainable and experiential tourism that bridges cultural identity, food sovereignty, and environmental stewardship through the management of this model [156,157]. It underscores that sustainable development must be built with and for communities, valuing their stories, landscapes, and seeds as essential foundations for a more equitable and sustainable future.

Limitations and Future Prospects

This study is based on a localized case in the community of Llano de Guadalupe, Tlaxiaco, which limits the generalizability of the results to broader contexts. The implementation of the biofertilization process and experiential tourism strategies is still in its early stages, requiring continuous evaluation over longer timeframes to assess environmental, social,

and economic impact. Infrastructure limitations, such as access to technology, roads, and basic services, also represent challenges to the scalability of the model.

Despite these limitations, the Tlaxiaco model offers valuable insights for future replication in other rural and originary communities. Strengthening institutional collaboration, integrating formal education and AI tools, and ensuring long-term community participation will be key to scaling the impact. Future research should focus on monitoring the resilience of agroecosystems, evaluating visitor satisfaction, and exploring business models that maintain cultural integrity while generating economic opportunities.

Author Contributions: Conceptualization: O.J.-M. and D.R.O.-T.; Methodology: O.J.-M., D.R.O.-T., L.A.M.-G., R.R.-R. and K.G.-I.; Software: D.R.O.-T. and K.G.-I.; Validation: O.J.-M., R.M.-G. and D.R.O.-T.; Formal analysis: O.J.-M.; Investigation: O.J.-M., D.R.O.-T., R.R.-R., K.G.-I., C.I.R.-M. and L.A.M.-G.; Resources: O.J.-M., D.R.O.-T., G.L.-B., R.R.-R. and R.M.-G.; Data curation: K.G.-I., O.J.-M., D.R.O.-T. and C.I.R.-M.; Writing—original draft: D.R.O.-T. and O.J.-M.; Writing—review and editing: D.R.O.-T. and O.J.-M.; Visualization: D.R.O.-T., K.G.-I. and L.A.M.-G.; Supervision: D.R.O.-T., O.J.-M., G.L.-B., R.R.-R. and C.I.R.-M.; Project administration: D.R.O.-T., O.J.-M. and G.L.-B. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Secretaría de Ciencia, Humanidades, Tecnología e Innovación (SECIHTI), Mexico, through the research project IH-2025-G-308.

Institutional Review Board Statement: Ethical review and approval were waived for this study in accordance with Mexican legislation, namely the Ley General de Salud and the Reglamento de la Ley General de Salud en Materia de Investigación para la Salud, as well as the internal guidelines of the Instituto Tecnológico de Villahermosa, Tecnológico Nacional de México, because the study involved educational and social research, did not collect sensitive personal data, and posed no risk to the participants.

Informed Consent Statement: Informed consent for participation was obtained from all subjects involved in the study.

Data Availability Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Acknowledgments: The authors sincerely thank all institutions, authorities, researchers, students, collaborators, community leaders, producers, and communities for their valuable support, collaboration and participation throughout this research project. During the preparation of this manuscript, the authors used ChatGPT (OpenAI, GPT-4.5, 2025 version, OpenAI, USA) for the purposes of language editing, organization of ideas, generation of text drafts, and translation support. The authors have thoroughly reviewed and edited the output and take full responsibility for the content of this publication.

Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

AI	Artificial Intelligence
IT	Instituto Tecnológico
RIESS	Red de Investigación de Economía Social y Solidaria
SDGs	Sustainable Development Goals
TecNM	Tecnológico Nacional de México
VLR	Voluntary Local Review

Appendix A

Field Notebook

The Field Notebook “Cuidando Nuestra Milpa con biofertilizantes” is a participatory and educational tool created for rural families in Llano de Guadalupe, Tlaxiaco, as part of an action research project. It integrates scientific knowledge, in biofertilization, with traditional agricultural practices, food sovereignty, and sustainable development. Through milpa observations, storytelling, illustrated glossaries, and the planning of experiential tourism routes, the notebook fosters intergenerational learning and highlights the importance of preserving native corn and promoting agroecological practices aligned with the Sustainable Development Goals (SDGs).

This notebook provides evidence of community engagement and educational outreach while serving as a model of intercultural science communication tailored to rural agricultural contexts. It demonstrates how complex systems theory can be applied to sustainability by combining ecological, social, and economic subsystems in practice. Moreover, it supports the development of experiential tourism, participatory learning, and agroecological education. Its structure and methodology make it a replicable educational tool for other rural communities involved in sustainable agriculture and sustainable and experiential tourism initiatives.

Appendix B

Figure A1 shows a young milpa (traditional cornfield) in Tlaxiaco, Oaxaca, at an early stage of growth after planting. Neatly aligned rows of native corn plants sprout from rich, dark soil, indicating recent cultivation, supported by biofertilization techniques with the use of biofertilizers. In the background, a few community members can be seen walking through the field, underscoring the human connection to land and labor. The landscape is framed by mountainous forested hills under a partly cloudy sky, highlighting the region’s highland geography and agroecological setting. This image visually captures the integration of agriculture, community life, and natural beauty that defines the Tlaxiaco milpa system.



Figure A1. Landscape that captures the integration of agriculture, community life, and natural beauty of the Tlaxiaco milpa system.

Figure A2 captures the moment of preparing the biofertilizer mixture for the second application in a milpa in Llano de Guadalupe, Tlaxiaco. A large blue container is filled with a diluted solution containing a beneficial bacterium used to naturally enhance nitrogen

fixation in native corn crops. Surrounding the barrel, community members and researchers stand ready to proceed with the application process. This preparation exemplifies a collaborative effort to promote agroecological practices in Mexico that reduce reliance on chemical inputs and improve soil fertility through microbial biotechnology, following best practices for plant growth-promoting rhizobacteria (PGPR) deployment [158].



Figure A2. Preparation of the Second Biofertilization Mixture with Biofertilization.

Figure A3 shows a praying mantis (*Mantodea*), photographed during a field visit in the Tlaxiaco region, Oaxaca. This green insect, well-camouflaged among the vegetation, was observed on a damp log near a biofertilized milpa. Its presence reflects the ecological balance and biodiversity found in agroecological systems managed without agrochemicals. The mantis is a natural predator of pests and serves as a biological indicator of environmental health [155], reinforcing the importance of conserving rural habitats as part of sustainable practices and experiential tourism offerings that include local fauna observation.



Figure A3. Praying Mantis in a Biofertilized Milpa Ecosystem.

References

1. Folke, C. Resilience: The emergence of a perspective for social–ecological systems analyses. *Glob. Environ. Change* **2006**, *16*, 253–267. [CrossRef]
2. Ostrom, E. A general framework for analyzing sustainability of social–ecological systems. *Science* **2009**, *325*, 419–422. [CrossRef] [PubMed]
3. Dirzo, R.; Brodhead, A.; Gregory, H. *Bio-Cultural Diversity and Community-Based Conservation in Oaxaca*; Stanford Report; Stanford University: Stanford, CA, USA. Available online: <https://bosp.stanford.edu/explore/short-term-programs/bio-cultural-diversity-oaxaca> (accessed on 15 June 2025).
4. Reyes-Santiago, M.D.R.; Méndez-García, E.; Sánchez-Medina, P.S. A mixed methods study on community-based tourism as an adaptive response to water crisis in San Andrés Ixtlahuaca, Oaxaca, Mexico. *Sustainability* **2022**, *14*, 5933. [CrossRef]
5. García-Padilla, E.; DeSantis, D.L.; Rocha, A.; Fucsko, L.A.; Johnson, J.D.; Lazcano-Villarreal, D. Biological and cultural diversity in the state of Oaxaca, Mexico: Strategies for conservation among Indigenous communities. *Biol. Soc.* **2022**, *5*, 48–72. [CrossRef]
6. Altieri, M.A.; Toledo, V.M. The agroecological revolution in Latin America: Rescuing nature, ensuring food sovereignty and empowering peasants. *J. Peasant Stud.* **2011**, *38*, 587–612. [CrossRef]
7. Francis, C.; Lieblein, G.; Gliessman, S.; Breland, T.A.; Creamer, N.; Harwood, R.; Salomonsson, L.; Helenius, J.; Rickerl, D.; Salvador, R.; et al. Agroecology: The ecology of food systems. *J. Sustain. Agric.* **2003**, *22*, 99–118. [CrossRef]
8. Leigh, D.S.; Kowalewski, S.A.; Holdridge, G. 3400 years of agricultural engineering in Mesoamerica: Lama-bordos of the Mixteca Alta, Oaxaca, Mexico. *J. Archaeol. Sci.* **2013**, *40*, 2061–2072. [CrossRef]
9. Hernández-Aguilar, J.A.; Durán, E.; Cortina-Villar, H.S.; Velázquez, A. Landscape approach to support regional action in communal forest management: The case of the Mixteca Alta, Oaxaca, Mexico. *Investig. Geogr.* **2022**, *109*, 106–127. [CrossRef]
10. Schmal, J. The Mixtecs and Zapotecs: Two Enduring Cultures of Oaxaca. Indigenous Mexico. Available online: <https://www.indigenousemexico.org/articles/the-mixtecs-and-zapotecs-two-enduring-cultures-of-oaxaca> (accessed on 15 June 2025).
11. One Earth. Sierra Madre del Sur Pine-Oak Forests. Available online: <https://www.oneearth.org/ecoregions/sierra-madre-del-sur-pine-oak-forests/> (accessed on 15 June 2025).
12. Phillips, T. Fewer wildfires, greater biodiversity: What is the secret to the success of Mexico’s forests? *The Guardian*, 1 May 2024. Available online: <https://www.theguardian.com/global-development/2024/may/01/fewer-wildfires-great-biodiversity-what-is-the-secret-to-the-success-of-mexicos-forests> (accessed on 15 June 2025).
13. Cagle, N. Wildlife & Forest Management in Oaxaca: Prioritizing Biodiversity and Connectivity in Indigenous Communities of Oaxaca, Mexico. Available online: <https://sites.nicholas.duke.edu/nicolettecagle/cagle-lab/applied-conservation-ecology/wildlife-forest-management-in-oaxaca/> (accessed on 15 June 2025).
14. de Avila, A. Mixtec Plant Nomenclature and Classification. Ph.D. Dissertation, University of California, Berkeley, CA, USA, 2010.
15. Geoparque Mundial UNESCO Mixteca Alta. Patrimonio. Available online: <https://geoparquemixtecaalta.org/patrimonio/> (accessed on 16 June 2025).
16. Olivera, M. Notas sobre las actividades religiosas en Tlaxiaco. *An. Inst. Nac. Antropol. Hist.* **1982**, *17*, 129–151.
17. Ávila Quiroz, M.B.; Pérez León, M.I.; Nahmad Sitton, S. Niviñuun, gente del pueblo. La autoidentificación de un poblado mixteco en la costa de Oaxaca. *Intersticios Soc.* **2019**, *18*, 213–246. [CrossRef]
18. Hernández-Rodríguez, G.M.E.; Mariaca-Méndez, R.; Vásquez-Sánchez, M.Á.; Eroza-Solana, E. Influencia de la Cosmovisión del Pueblo Mixteco de Pinotepa de Don Luis, Oaxaca, México, en el uso y Manejo del Caracol Púrpura, *Plicopurpura pansa* (Gould, 1853). UNAM–CEPHCIS. Available online: <https://investigacion.cephcis.unam.mx/generoyrsociales/wp-content/uploads/2015/01/Hern%C3%A1ndez%20Rodr%C3%ADguez%20Griselda%20Ma.%20Eugenia.pdf> (accessed on 16 June 2025).
19. Secretaría de Turismo del Estado de Oaxaca. *Evaluación de la Vocación Turística: Municipio de Heroica Ciudad de Tlaxiaco, Oaxaca*; Gobierno del Estado de Oaxaca, Dirección de Planeación y Desarrollo Turístico, Departamento de Vocaciones Turísticas: Oaxaca, Mexico, 2020. Available online: <https://www.oaxaca.gob.mx/sector/wp-content/uploads/sites/65/2020/01/Heroica-ciudad-de-Tlaxiaco.pdf> (accessed on 16 June 2025).
20. Van Vleet, E.; Bray, D.B.; Durán, E. Knowing but not knowing: Systematic conservation planning and community conservation in the Sierra Norte of Oaxaca, Mexico. *Land Use Policy* **2016**, *59*, 504–515. [CrossRef]
21. García Leyva, J. Al Rescate de la Lengua de la Lluvia. Ojarasca, la Jornada, No. 287, 13 March 2021. Available online: <https://ojarasca.jornada.com.mx/2021/03/13/al-rescate-de-la-lengua-de-la-luvia-287-1506.html> (accessed on 19 May 2025).
22. El Diario Mixteca. Tlaxiaco Celebrates with Rich Black Mole, Picadillo, and Stuffed Soup—Delicacies During August Festivities #Mixteca #SantaMariadelaAsunción. Available online: <https://www.facebook.com/share/p/16njujSjMB/> (accessed on 16 June 2025).
23. Cerveza de Mecate Tlaxiaqueña. Authentic Mecate Beer from Tlaxiaco. Available online: <https://cervezademecatetlaxiaco.blogspot.com/2012/09/autentica-cerveza-de-mecate-tlaxiaqueña.html> (accessed on 16 June 2025).

24. Vive Tlaxiaco. Mecate Beer and Local Delicacies from Tlaxiaco. Available online: <https://www.facebook.com/share/p/196Pziq1aE/> (accessed on 16 June 2025).
25. Bueno-Sánchez, J.A. Crónicas de Oaxaca: Visita a Tlaxiaco. *El Imparcial Oaxaca*, 16 June 2025. Available online: <https://imparcialoaxaca.mx/opinion/cronicas-de-oaxaca-visita-a-tlaxiaco/> (accessed on 16 June 2025).
26. Honorable Ayuntamiento de Tlaxiaco. Semana Santa en Tlaxiaco 2025: Demostración artesanal de tejido de fibras vegetales. *Tlaxiaco Gobierno Municipal*, 11 April 2025. Available online: <https://tlaxiaco.gob.mx/32/semana-santa-en-tlaxiaco-2025/> (accessed on 16 June 2025).
27. Albarrán, A. Tlaxiaco disfruta de sus calendas. *El Imparcial de Oaxaca*, 10 August 2024. Available online: <https://imparcialoaxaca.mx/los-municipios/tlaxiaco-disfruta-de-sus-calendas/> (accessed on 16 June 2025).
28. Velázquez, P. Calenda en Honor a la Virgen de la Asunción/Tlaxiaco, Oaxaca. YouTube, 17 August 2025. Available online: <https://youtu.be/vLk1CQJGhmg> (accessed on 15 June 2026).
29. Instituto Nacional de los Pueblos Indígenas (INPI). Etnografía del Pueblo Mixteco—Ñuu Savi. Gobierno de México. 2018. Available online: <https://www.gob.mx/inpi/articulos/etnografia-del-pueblo-mixteco-nuu-savi> (accessed on 16 June 2025).
30. Rieger, I.A. Chameleonic traditions in the festive practices of a Mixtec transnational community. *Rev. Reflex.* **2019**, *98*, 111–129. [CrossRef]
31. Vive Tlaxiaco. Día de la Samaritana: Una Tradición Muy Oaxaqueña. Facebook 2025. Available online: <https://www.facebook.com/ViveTlaxiaco/posts/667464355640847/> (accessed on 16 June 2025).
32. Echavarría, M. Tejiendo México: El algodón coyuchi en San Juan Colorado y la lana de Teotitlán. *Travesías Digital*, 30 November 2020. Available online: <https://www.travesiasdigital.com/comercial/tejiendo-mexico-con-lincoln-por-oaxaca-san-juan-colorado-teotitlan-del-valle/> (accessed on 16 June 2025).
33. Klein, K. (Ed.) *The Unbroken Thread: Conserving the Textile Traditions of Oaxaca*; Getty Conservation Institute: Los Angeles, CA, USA, 1997. Available online: https://www.getty.edu/conservation/publications_resources/pdf_publications/pdf/unbroken_thread_eng_vl.pdf (accessed on 16 June 2025).
34. García, E.; Vinebaum, L. The Museo Textil de Oaxaca: "A Live Space for the Textile Arts": Interview with Ana Paula Fuentes. *Textile* **2016**, *14*, 122–135. [CrossRef]
35. La Brisa de Mi Huerto. Venta de té Limón. Facebook 2025. Available online: <https://www.facebook.com/groups/765771927644267/posts/1702061110682006/> (accessed on 16 June 2025).
36. Velázquez, P. Barbacoa's "La Mesa del Rincón" en Tlaxiaco, Oaxaca. YouTube, 26 April 2021. Available online: <https://www.youtube.com/watch?v=qehij8EwJuQ> (accessed on 15 June 2026).
37. López, R. Prevalece la medicina indígena tradicional en Tlaxiaco. *El Imparcial de Oaxaca*, 13 May 2019. Available online: <https://imparcialoaxaca.mx/los-municipios/prevalece-la-medicina-indigena-tradicional-en-tlaxiaco/> (accessed on 16 June 2025).
38. Instituto Mexicano del Seguro Social (IMSS). *Compromiso Cumplido: Tlaxiaco Cuenta con Nuevo Hospital Rural de IMSS-Bienestar*. Comunicado No. 165/2020; IMSS: Ciudad de México, Mexico, 2020. Available online: <https://www.imss.gob.mx/prensa/archivo/%20202004/165> (accessed on 16 June 2025).
39. Páez-Tinoco, M.C. Unidades de Producción Familiar de Trigo en la Mixteca de Oaxaca. Master's Thesis, Instituto Tecnológico del Valle de Oaxaca, Oaxaca, Mexico, 2023. Available online: <https://rinacional.tecnm.mx/jspui/bitstream/TecNM/6744/1/TESIS%20MARIA%20CRISTINA%20PAEZ%20TINOCO.pdf> (accessed on 16 June 2025).
40. Katz, E.; Vargas, L.A. Cambio y continuidad en la alimentación de los mixtecos. *An. Antropol.* **1990**, *27*, 15–51.
41. Delgado-Nute, M. Celebrando a las Palmeadoras. *Fundación Tortilla*, 7 October 2021. Available online: https://fundaciontortilla.org/Cultura/celebrando_a_las_palmeadoras (accessed on 16 June 2025).
42. Ortega-Ortega, T.; Vázquez-García, V.; Flores-Sánchez, D.; Núñez-Espinoza, J.F. Agrobiodiversity, gender and food sovereignty in Tlaxiaco, Oaxaca. *Rev. Mex. Cienc. Agríc.* **2017**, *8*, 3673–3684. [CrossRef]
43. Vázquez-García, V.; Núñez-Espinoza, J.F.; Ortega-Ortega, T. Estructura y resiliencia social en comunidades indígenas: El caso de la Unión de Palmeadoras de Tlaxiaco, Oaxaca, México. *Redes* **2018**, *29*, 206–225. [CrossRef]
44. Martínez-López, L.; Zapata-Martelo, E.; Ayala-Carrillo, M.R.; Martínez-Corona, B.; Vázquez-Carrillo, G.; Jacinto-Hernández, C.; Espinosa-Calderón, A. Practical and theoretical knowledge of corn and beans in the Triqui High Region, Oaxaca. *Rev. Mex. Cienc. Agríc.* **2018**, *9*, 207–220. [CrossRef]
45. Espinosa-Pérez, E.N.; Ramírez-Vallejo, P.; Crosby-Galván, M.M.; Estrada-Gómez, J.A.; Lucas-Florentino, B.; Chávez-Servia, J.L. Classification of native populations of common bean from south-central Mexico by seed morphology. *Rev. Fitotec. Mex.* **2015**, *38*, 29–38.
46. El Yolomecano. Elaboración del Queso | Población de la Capilla del Carrizal, Tlaxiaco, Oaxaca. YouTube 2022. Available online: <https://youtu.be/2o3gezgxWk?si=B50uztRYbFwLPsf2> (accessed on 16 June 2025).
47. Velázquez, P. Quesos de Mexicalcingo, Tlaxiaco, Oaxaca. YouTube, 29 May 2021. Available online: <https://youtu.be/H6-72SIAS4g> (accessed on 15 June 2026).

48. López, R. En Ojo de Agua, Tlaxiaco, logran alimentación sana para sus familias. *El Imparcial de Oaxaca*, 20 February 2019. Available online: <https://imparcialoaxaca.mx/los-municipios/en-ojo-de-agua-tlaxiaco-logran-alimentacion-sana-para-sus-familias/> (accessed on 16 June 2025).
49. Hecho en Oaxaca. Guisado de frutas, platillo de salvaguarda en Tlaxiaco. *Leche con Tuna*, 4 March 2022. Available online: <https://lechecontuna.com/2022/03/04/guisado-de-frutas-platillo-de-salvaguarda-en-tlaxiaco/> (accessed on 16 June 2025).
50. Municipio de Tlaxiaco. Mercado: Día de Plaza en Tlaxiaco. *Leche con Tuna*, 12 August 2023. Available online: <https://lechecontuna.com/2023/08/12/dia-de-plaza-en-tlaxiaco/> (accessed on 16 June 2025).
51. Martínez, D. Agua de Chilacayote. YouTube, 3 December 2013. Available online: <https://youtu.be/fDzLsxlqX1s> (accessed on 15 June 2026).
52. Ayuntamiento de Tlaxiaco. Día de la Samaritana. Available online: <https://tlaxiaco.gob.mx/53/dia-de-la-samaritana-2/> (accessed on 16 June 2025).
53. Peach, Y. La Mesa del Rincón: Un Rincón de Tradición en Tlaxiaco. *Leche con Tuna*. Available online: <https://lechecontuna.com/2024/04/25/la-mesa-del-rincon-un-rincon-de-tradicion-en-tlaxiaco/> (accessed on 16 June 2025).
54. El Universal Oaxaca. Huevos de Colores de Oaxaca y el Origen de su Peculiar Pigmento. *El Universal*. Available online: <https://oaxaca.eluniversal.com.mx/mas-de-oaxaca/huevos-de-colores-de-oaxaca-y-el-origen-de-su-peculiar-pigmento/> (accessed on 16 June 2025).
55. Gobierno del Estado de Oaxaca. Huajuapán de León Celebra la Feria del Mezcal de la Mixteca, Cuarta Edición. Gobierno del Estado de Oaxaca. Available online: <https://www.oaxaca.gob.mx/comunicacion/huajuapán-de-león-celebra-la-feria-del-mezcal-de-la-mixteca-cuarta-edicion/> (accessed on 16 June 2025).
56. Vázquez García, V.; Ramírez Castillo, R.; Hernández Juárez, M. Género, clase y etnicidad en la producción de mezcal. Una genealogía familiar en Valles Centrales, Oaxaca. *EntreDiversidades* **2024**, *21*, e202403. [CrossRef]
57. García Mendoza, A.J.; Franco Martínez, I.S. *Fichas Técnicas de los Agaves de Oaxaca: Anexo del Proyecto NE012*; Comisión Nacional para el Conocimiento y Uso de la Biodiversidad (CONABIO): Ciudad de México, Mexico, 2018. Available online: http://www.conabio.gob.mx/institucion/proyectos/resultados/NE012_Anexo_Fichas_agave.pdf (accessed on 25 May 2025).
58. Redacción, D.M. Tlaxiaco Vive Fiesta de Fraternidad. *Diario de la Mixteca* 2017. Available online: <https://www.diariodelamixteca.com/tlaxiaco/tlaxiaco-vive-fiesta-de-fraternidad.html> (accessed on 16 June 2025).
59. Chávez García, M. La morfogénesis urbana de la Heroica Ciudad de Tlaxiaco, Oaxaca. *Anu. Espac. Urbanos Hist. Cult. Diseño* **2016**, *23*, 35–56. [CrossRef]
60. Sterling, S. Transformative learning and sustainability: Sketching the conceptual ground. *J. Educ. Sustain. Dev.* **2011**, *5*, 17–33. [CrossRef]
61. Wals, A.E.J.; Benavot, A. Sustainability education and social learning. *Sustainability* **2017**, *9*, 1647. [CrossRef]
62. VIVE Tlaxiaco. La Samaritana en Tlaxiaco Oaxaca. Available online: <https://www.facebook.com/ViveTlaxiaco/posts/666574489063167> (accessed on 16 June 2025).
63. Pérez García, C. Así se Come en Tlaxiaco. NVI Noticias, 2019. Available online: <https://www.nvinoticias.com/gastronomia/asi-se-come-en-tlaxiaco/40256> (accessed on 17 June 2025).
64. Chefs Jaime y Ramiro. Todas las Delicias que uno Encuentra en el Mercado de Tlaxiaco. YouTube, 2022. Available online: <https://youtu.be/RhW2BJU14HA> (accessed on 17 June 2025).
65. Secretaría de Economía. Distribución Geográfica de Remesas en la Heroica Ciudad de Tlaxiaco. Data México, 2025. Available online: <https://www.economia.gob.mx/datamexico/es/profile/geo/heroica-ciudad-de-tlaxiaco#remittances> (accessed on 17 June 2025).
66. Lugo-Espinosa, G.; Acevedo-Ortiz, M.A.; Aquino-Bolaños, T.; Ortiz-Hernández, Y.D.; Ortiz-Hernández, F.E.; Pérez-Pacheco, R.; López-Cruz, J.Y. Cultural Heritage, Migration, and Land Use Transformation in San José Chiltepec, Oaxaca. *Land* **2024**, *13*, 1658. [CrossRef]
67. CIMMYT. Tequio Fortalece la Cadena de Valor del Maíz en Oaxaca. 31 August 2020. Available online: <https://www.cimmyt.org/es/noticias/tequio-fortalece-la-cadena-de-valor-del-maiz-en-oaxaca/> (accessed on 23 June 2025).
68. Chávez Servia, J.L.; Diego Flores, P. Familias campesinas y variación fenotípica de poblaciones nativas de maíz en la región de Tlaxiaco, Oaxaca. *Desarro. Ambiente Cult.* **2011**, *1*, 28–38. [CrossRef]
69. Tech & Leadership. Puesto de Queso Fresco y Tamales en Tlaxiaco, Oaxaca. YouTube, 2024. Available online: <https://youtube.com/shorts/MPJgBpOs8Kg?si=pdYIMHqpUKoMk7y> (accessed on 24 June 2025).
70. Rivera López, F.; Wickson, F.; Hausner, V.H. Bridging different perspectives for biocultural conservation: Art-based participatory research on native maize conservation in two indigenous farming communities in Oaxaca, Mexico. *Environ. Dev. Sustain.* **2020**, *22*, 7427–7451. [CrossRef]
71. Cocina Con Gabby. Chorizo Oaxaqueño Casero | Con un Gran Sabor y Color Unas de las Mejores Recetas que Puedes Hacer. YouTube. Available online: <https://www.youtube.com/watch?v=-4U-4nY8B3Y> (accessed on 24 June 2025).

72. Semblanza Oaxaqueña. Carnita de Chicharrón, Chorizo, Manteca, Carne Enchilada, Costilla y más en el Mercado Municipal de Tlaxiaco. Facebook. Available online: <https://www.facebook.com/share/v/16Y1Ms7mB8/> (accessed on 24 June 2025).
73. Semblanza Oaxaqueña. Tasajo del Bueno en el Mercado Municipal de Tlaxiaco. Facebook. Available online: <https://www.facebook.com/share/p/1HXBYN8RhR/> (accessed on 24 June 2025).
74. Secretaría de Turismo del Estado de Oaxaca. ¡El maíz es la Base de la Alimentación Oaxaqueña! Celebración del Día Estatal del Maíz Nativo. 29 September 2024. Available online: <https://www.facebook.com/share/p/1Bh8SFmvpF/> (accessed on 24 June 2025).
75. Pérez, W. Bajo el calor del atole. *Fundación Tortilla*, 1 November 2022. Available online: https://fundaciontortilla.org/Cocina/bajo_el_calor_del_atole (accessed on 24 June 2025).
76. Nochixtlan Bonito. Masita y Taco de Barbacoa de Tlaxiaco, Oaxaca. Facebook. Available online: <https://www.facebook.com/share/p/15sV8oaMMz/> (accessed on 11 July 2025).
77. Fonteyne, S.; Castillo Caamal, J.B.; Lopez-Ridaura, S.; Van Loon, J.; Espidio Balbuena, J.; Osorio Alcalá, L.; Martínez Hernández, F.; Odjo, S.; Verhulst, N. Review of agronomic research on the milpa, the traditional polyculture system of Mesoamerica. *Front. Agron.* **2023**, *5*, 1115490. [CrossRef]
78. Aguilar Avila, H. La Milpa una Forma de Vida en Ñuu Kene Ndute (Ojo de Agua). Master's Thesis, Universidad Autónoma Metropolitana, Unidad Xochimilco, Ciudad de México, Mexico, 2017. Available online: <https://repositorio.xoc.uam.mx/jspui/bitstream/123456789/936/1/190035.pdf> (accessed on 11 July 2025).
79. Méndez Hernández, Á.; Hernández Hernández, A.A.; López Santiago, M.C.; Morales López, J. *Herbolaria Oaxaqueña para la Salud*; Instituto Nacional de las Mujeres (INMUJERES): Mexico City, Mexico, 2009. Available online: http://cedoc.inmujeres.gob.mx/documentos_download/101102.pdf (accessed on 25 May 2025).
80. París Pombo, M.D. Youth identities and the migratory culture among Triqui and Mixtec boys and girls. *Migr. Int.* **2010**, *5*, 139–164.
81. Tong, J.; Li, Y.; Yang, Y. System Construction, Tourism Empowerment, and Community Participation: The Sustainable Way of Rural Tourism Development. *Sustainability* **2024**, *16*, 422. [CrossRef]
82. Gingell, J. Viva Zapotec! A Thriving Ecotourism Project in Mexico's Oaxaca State. *The Guardian*, 28 April 2025. Available online: <https://www.theguardian.com/travel/2025/apr/28/viva-zapotec-a-thriving-ecotourism-project-in-mexicos-oaxaca-state> (accessed on 11 July 2025).
83. Oropeza-Tosca, D.; Jiménez-Márquez, O.; Martínez-Gutiérrez, R.; Lucas-Bravo, G.; Rincón-Molina, C. Experiential and sustainable tourism: Teaching with artificial intelligence to native corn producers in Tlaxiaco, Oaxaca. In *Training, Education, and Learning Sciences*; Nazir, S., Ed.; AHFE Open Access: New York, NY, USA, 2025; Volume 193. [CrossRef]
84. Martínez-Martínez, D.A.; Matías-Pérez, D.; Varapizuela-Sánchez, C.F.; Hernández-Bautista, E.; Sánchez-Medina, M.A.; García-Montalvo, I.A. Quesillo: A cultural and economic legacy in Oaxaca through the social and solidarity economy. *Front. Sustain. Food Syst.* **2024**, *8*, 1496193. [CrossRef]
85. Novotny, I.P.; Tittone, P.; Fuentes-Ponce, M.H.; López-Ridaura, S.; Rossing, W.A.H. The importance of the traditional milpa in food security and nutritional self-sufficiency in the highlands of Oaxaca, Mexico. *PLoS ONE* **2021**, *16*, e0246281. [CrossRef] [PubMed]
86. Peterson, C.A.; McCarthy, C. Cultural tourism: The Oaxaca, Mexico approach. *Tour. Rev.* **1992**, *47*, 19–26. [CrossRef]
87. Sosa, M.; Aulet, S.; Mundet, L. Community-based tourism through food: A proposal of sustainable tourism indicators for isolated and rural destinations in Mexico. *Sustainability* **2021**, *13*, 6693. [CrossRef]
88. Avalos-Rangel, M.A.; Campbell, D.E.; Reyes-López, D.; Rueda-Luna, R.; Munguía-Pérez, R.; Huerta-Lara, M. The environmental-economic performance of a poblano family milpa system: An emergy evaluation. *Sustainability* **2021**, *13*, 9425. [CrossRef]
89. Acevedo-Ortiz, M.A.; Lugo-Espinosa, G.; Ortiz-Hernández, Y.D.; Pérez-Pacheco, R.; Ortiz-Hernández, F.E.; Martínez-Tomás, S.H.; Tavera-Cortés, M.E. Nature-based solutions for conservation and food sovereignty in indigenous communities of Oaxaca. *Sustainability* **2024**, *16*, 8151. [CrossRef]
90. Hiram, N.; Hidalgo Morales, M.R. Sustainable community-based ecotourism development mechanism: Oaxaca and Puebla cases in Mexico. *Cienc. Lat. Rev. Cient. Multidiscip.* **2024**, *8*, 11684–11702. [CrossRef]
91. Elo, S.; Kyngäs, H. The qualitative content analysis process. *J. Adv. Nurs.* **2008**, *62*, 107–115. [CrossRef] [PubMed]
92. Hsieh, H.-F.; Shannon, S.E. Three approaches to qualitative content analysis. *Qual. Health Res.* **2005**, *15*, 1277–1288. [CrossRef] [PubMed]
93. Carr, W.; Kemmis, S. *Becoming Critical: Education, Knowledge and Action Research*; Falmer Press: London, UK, 1986. [CrossRef]
94. McNiff, J. *Action Research: Principles and Practice*, 3rd ed.; Routledge: Abingdon, UK, 2013. [CrossRef]
95. Lane, B.; Kastenholz, E. Rural tourism: The evolution of practice and research approaches—Towards a new generation concept? *J. Sustain. Tour.* **2015**, *23*, 1133–1156. [CrossRef]
96. Buckley, R. Sustainable tourism: Research and reality. *Ann. Tour. Res.* **2012**, *39*, 528–546. [CrossRef]
97. Everett, S.; Aitchison, C. The role of food tourism in sustaining regional identity: A case study of Cornwall, South West England. *J. Sustain. Tour.* **2008**, *16*, 150–167. [CrossRef]

98. Pine, B.J.; Gilmore, J.H. *The Experience Economy: Work Is Theatre & Every Business a Stage*; Harvard Business School Press: Boston, MA, USA, 1999.
99. Jiménez-Márquez, O.; Oropeza-Tosca, D.R.; González-Izquierdo, K.; Manzano-Gómez, L.A.; Ortiz-Espejel, B. Saberes del cultivo de la milpa: Estrategia de sustentabilidad desde la agricultura tradicional. In Proceedings of the FORO 2025 Ciencias Sociales, Economía Social y Solidaria: Confluencias, Diálogos de Economía y Ciencias Sociales, Chetumal, Quintana Roo, Mexico, 4 November 2025. [\[CrossRef\]](#)
100. Falconi, S.I.; González-Izquierdo, K.; Oropeza-Tosca, D.R. Methodology for the design of a sustainable tourism model in rural destinations: Case of Ismate and Chilapilla Primera Sección, Tabasco. In *Turismo Circular y Sustentable en Destinos Rurales*; Ortiz Martínez, F.I., Mazó Quevedo, M.L., Eds.; Universidad Juárez Autónoma de Tabasco: Villahermosa, Mexico, 2023; pp. 135–151. [\[CrossRef\]](#)
101. Reason, P.; Bradbury, H. *Action Research: Participative Inquiry and Practice*, 2nd ed.; SAGE Publications: London, UK, 2008.
102. Kemmis, S.; McTaggart, R.; Nixon, R. *The Action Research Planner: Doing Critical Participatory Action Research*; Springer: Singapore, 2014.
103. Chatkaewnapanon, Y.; Lee, T.J. Planning Sustainable Community-Based Tourism in the Context of Thailand: Community, Development, and the Foresight Tools. *Sustainability* **2022**, *14*, 7413. [\[CrossRef\]](#)
104. Manzano-Gómez, L.A.; Rincón-Molina, C.I.; Martínez-Romero, E.; Stopol-Martínez, S.S.; Santos-Santiago, A.; Villalobos-Maldonado, J.J.; Ruíz-Valdiviezo, V.M.; Rincón-Rosales, R. Native rhizobial inoculation improves tomato yield and nutrient uptake while mitigating heavy metal accumulation in a conventional farming system. *Microorganisms* **2025**, *13*, 1904. [\[CrossRef\]](#) [\[PubMed\]](#)
105. Sammauria, R.; Kumawat, S.; Kumawat, P.; Tiwari, S.; Verma, V.; Sharma, B. Microbial inoculants: Potential tool for sustainability of agricultural production systems. *Arch. Microbiol.* **2020**, *202*, 677–693. [\[CrossRef\]](#) [\[PubMed\]](#)
106. Yan, L.; Echeverria, V.; Fernandez Nieto, G.; Jin, Y.; Swiecki, Z.; Zhao, L.; Gašević, D.; Martinez-Maldonado, R. Human-AI collaboration in thematic analysis using ChatGPT: A user study and design recommendations. *arXiv* **2023**, arXiv:2311.03999. [\[CrossRef\]](#)
107. Johnson, L.; Adams Becker, S.; Estrada, V.; Freeman, A. *The NMC Horizon Report: 2015 Higher Education Edition*; New Media Consortium: Austin, TX, USA, 2015. Available online: <https://eric.ed.gov/?id=ED559357> (accessed on 18 February 2026).
108. Prell, C. Unpacking “participation” in the adaptive management of social-ecological systems: A critical review. *Ecol. Soc.* **2006**, *11*, 39. [\[CrossRef\]](#)
109. Krug, C.B.; Sterling, E.; Cadman, T.; Geschke, J.; Drummond de Castro, P.F.; Schliep, R.; Osemwegie, I.; Muller-Karger, F.E.; Maraseni, T. Stakeholder participation in IPBES: Connecting local environmental work with global decision making. *Ecosyst. People* **2020**, *16*, 197–211. [\[CrossRef\]](#) [\[PubMed\]](#)
110. Oropeza-Tosca, D.R.; Ramón-Santiago, P.; Martínez-Gutiérrez, R. Evaluación del desarrollo de habilidades investigativas a través de estrategias de aprendizaje activo, aplicando inteligencia artificial. In *Estrategias de Formación Para el Desarrollo de Competencias en Ambientes Académicos*; Universidad Autónoma de Querétaro: Querétaro, Mexico, 2021; pp. 153–178. Available online: https://www.uaq.mx/facultad/psi/images/investigacion/publicaciones/documentos/Estrategias_formacion.pdf (accessed on 19 February 2026).
111. Zhang, H.; Wu, C.; Xie, J.; Lyu, Y.; Cai, J.; Carroll, J.M. Harnessing the power of AI in qualitative research: Exploring, using, and redesigning ChatGPT for thematic analysis. *Comput. Hum. Behav. Rep.* **2025**, *6*, 100144. [\[CrossRef\]](#)
112. Utami, L.A.; Lechner, A.M.; Permanasari, E.; Purwandaru, P.; Ardianto, D.T. Participatory learning and co-design for sustainable rural living, supporting the revival of indigenous values and community resiliency in Sabrang Village, Indonesia. *Land* **2022**, *11*, 1597. [\[CrossRef\]](#)
113. Kindon, S.; Pain, R.; Kesby, M. *Participatory Action Research Approaches and Methods: Connecting People, Participation and Place*; Routledge: London, UK, 2007.
114. Liang, A.R.-D.; Tung, W.; Wang, T.-S.; Hui, V.W.-S. The use of co-creation within community-based tourism experiences: Service-dominant logic and design implications. *Tour. Manag. Perspect.* **2023**, *48*, 101157. [\[CrossRef\]](#)
115. Turčinović, M.; Vukonić, A.; Vukonić, B. Community-led sustainable tourism in rural areas: Local empowerment, cultural heritage, and destination competitiveness. *Sustainability* **2025**, *17*, 2878. [\[CrossRef\]](#)
116. Rocandio-Rodríguez, M.; Santacruz-Varela, A.; Córdova-Téllez, L.; López-Sánchez, H.; Hernández-Bautista, A.; Castillo-González, F.; Lobato-Ortiz, R.; García-Zavala, J.J.; Antonio López, P. Estimation of genetic diversity in seven races of native maize from the highlands of Mexico. *Agronomy* **2020**, *10*, 309. [\[CrossRef\]](#)
117. Aragón-Martínez, M.; Serrato-Díaz, A.; Rocha-Munive, M.G.; Martínez-Castillo, J.; Perales, H.; Álvarez-Buylla, E.R. Traditional management of maize in the Sierra Sur, Oaxaca, maintains moderate levels of genetic diversity and low population differentiation among landraces. *Econ. Bot.* **2023**, *77*, 282–304. [\[CrossRef\]](#)

118. Maranto-Gómez, V.M.; Rincón-Molina, C.I.; Manzano-Gómez, L.A.; Gen-Jiménez, A.; Maldonado-Gómez, J.C.; Villalobos-Maldonado, J.J.; Ruiz-Valdiviezo, V.M.; Rincón-Rosales, R.; Rincón-Molina, F.A. Plant probiotic potential of native rhizobia to enhance growth and sugar content in *Agave tequilana* Weber var. Blue. *Horticulturae* **2025**, *11*, 137. [CrossRef]
119. Pskowski, M. Indigenous Maize: Who Owns the Rights to Mexico's "Wonder" Plant? *Yale Environment* **360**, 16 July 2019. Available online: <https://e360.yale.edu/features/indigenous-maize-who-owns-the-rights-to-mexicos-wonder-plant> (accessed on 11 July 2025).
120. Velasco-Murguía, A.; del Castillo, R.F.; Rös, M.; Rivera-García, R. Successional pathways of post-milpa fallows in Oaxaca, Mexico. *For. Ecol. Manag.* **2021**, *500*, 119644. [CrossRef]
121. Rogé, P.; Friedman, A.R.; Astier, M.; Altieri, M.A. Farmer strategies for dealing with climatic variability: A case study from the Mixteca Alta region of Oaxaca, Mexico. *Agroecol. Sustain. Food Syst.* **2014**, *38*, 786–811. [CrossRef]
122. Orozco-Ramírez, Q.; Bocco, G.; Solís-Castillo, B. Cajete maize in the Mixteca Alta region of Oaxaca, Mexico: Adaptation, transformation, and permanence. *Agroecol. Sustain. Food Syst.* **2019**, *44*, 1162–1184. [CrossRef]
123. Nixtamal99. Poetic Language of the Maguey. *Masa Americana*, 28 May 2021. Available online: <https://masaamerica.com/2021/05/28/poetic-language-of-the-maguey/> (accessed on 11 July 2025).
124. Martínez-Cruz, T.; Camacho-Villa, T.C.; Adelman, L. Indigenous peoples and the making of resilient life: Hybridizing the culture of maize to achieve food sovereignty. In *Food and Humanitarian Crises: Science and Policies for Prevention and Mitigation*; Pontificia Academia Scientiarum: Vatican City, Italy, 2023. Available online: https://www.pas.va/en/publications/scripta-varia/sv154pas/martinez_cruz.html (accessed on 29 July 2025).
125. Ramírez, C.A. Descubra el Singular Agave Cupreata (Agave Papalome). Del Maguey Blog, 2024. Available online: <https://delmaguey.com/es/agave-cupreata/> (accessed on 29 July 2025).
126. Mardero, S.; Schmook, B.; Calmé, S.; White, R.M.; Joo Chang, J.C.; Casanova, G.; Castelar, J. Traditional knowledge for climate change adaptation in Mesoamerica: A systematic review. *Soc. Sci. Humanit. Open* **2023**, *7*, 100473. [CrossRef]
127. Sandoval-Copado, J.; Orozco-Villafuerte, J.; Pedrero-Fuehrer, D.; Colín-Cruz, M.A. Sensory profile development of Oaxaca cheese and relationship with physicochemical parameters. *J. Dairy Sci.* **2016**, *99*, 7075–7084. [CrossRef] [PubMed]
128. Carrillo-López, L.M.; Huerta-Jiménez, M.; Morales-Rodríguez, S.; Gámez-Piñón, J.R.; Carballo-Carballo, D.E.; Gutiérrez-Méndez, N.; Alarcón-Rojo, A.D. Textural, rheological, and sensory modifications in Oaxaca cheese made with ultrasonicated raw milk. *Processes* **2023**, *11*, 1122. [CrossRef]
129. Gutiérrez-Méndez, N.; Rodríguez-Figueroa, J.C.; González-Córdova, A.F.; Nevárez-Moorillón, G.V.; Rivera-Chavira, B.; Vallejo-Cordoba, B. Phenotypic and genotypic characteristics of *Lactococcus lactis* strains isolated from different ecosystems. *Can. J. Microbiol.* **2010**, *56*, 432–439. [CrossRef] [PubMed]
130. Warinner, C.; Robles Garcia, N.; Tuross, N. Maize, beans and the floral isotopic diversity of Highland Oaxaca, Mexico. *J. Archaeol. Sci.* **2013**, *40*, 868–873. [CrossRef]
131. Dots on a Map. 15 Traditional Oaxacan Foods You Have to Try. Available online: <https://www.dotsonamap.net/traditional-oaxacan-foods/> (accessed on 25 August 2025).
132. Secretaría de Agricultura y Desarrollo Rural (SADER). Los orígenes del mixiote. *Gobierno de México*, 22 August 2025. Available online: <https://www.gob.mx/agricultura/articulos/los-origenes-del-mixiote> (accessed on 25 August 2025).
133. Wezel, A.; Bellon, S.; Doré, T.; Francis, C.; Vallod, D.; David, C. Agroecology as a science, a movement and a practice. *Agron. Sustain. Dev.* **2009**, *29*, 503–515. [CrossRef]
134. Siles, P. *Fertilidad de los Suelos en Sistemas de Pastos, café y Cacao en el TeSAC Nicaragua*; CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS): Managua, Nicaragua, 2019. Available online: <https://hdl.handle.net/10568/107227> (accessed on 15 June 2026).
135. Severiano-Pérez, P.; Cristians, S.; Bye, R.; Lucas-Florentino, B.; Ramírez-Orejón, J.C.; Linares, E.; Mera-Ovando, L.M.; Castro-Lara, D.; Enríquez-Maldonado, D.; Rodríguez-Servín, J.; et al. Quelites pasados of the Sierra Tarahumara, Chihuahua, Mexico: An interdisciplinary ethnobotanical study of leafy green vegetables. *Econ. Bot.* **2023**, *77*, 433–454. [CrossRef]
136. Slotten, V.; Lentz, D.; Sheets, P. Landscape management and polyculture in the ancient gardens and fields at Joya de Cerén, El Salvador. *J. Anthropol. Archaeol.* **2020**, *59*, 101191. [CrossRef]
137. Arnés, E.; Astier, M. Handmade comal tortillas in Michoacán: Traditional practices along the rural-urban gradient. *Int. J. Environ. Res. Public Health* **2019**, *16*, 3211. [CrossRef] [PubMed]
138. Pope, V. The Communal Table: Communal Meal Traditions in Milpa Alta, Mexico. National Geographic, 2025. Available online: <https://www.nationalgeographic.com/foodfeatures/communal-table/> (accessed on 25 August 2025).
139. Capra, F.; Luisi, P.L. *The Systems View of Life: A Unifying Vision*; Cambridge University Press: Cambridge, UK, 2014. [CrossRef]
140. Manzanero-Medina, G.I.; Vásquez-Dávila, M.A.; Lustre-Sánchez, H.; Pérez-Herrera, A. Ethnobotany of food plants (quelites) sold in two traditional markets of Oaxaca, Mexico. *S. Afr. J. Bot.* **2020**, *130*, 215–223. [CrossRef]

141. Peinado-Guevara, V.M.; Peinado-Guevara, H.J.; Sánchez-Alcalde, M.C.; González-Félix, G.K.; Herrera-Barrientos, J.; Ladrón de Guevara-Torres, M.d.l.Á.; Cuadras-Berrelleza, A.A. Backyard activities as sources of social and personal well-being: A study of the Mexican population (Guasave, Sinaloa). *Soc. Sci.* **2024**, *13*, 462. [\[CrossRef\]](#)
142. Avilez-López, T.; van der Wal, H.; Aldasoro-Maya, E.; Rodríguez-Robles, U. Home gardens' agrobiodiversity and owners' knowledge of their ecological, economic and socio-cultural multifunctionality: A case study in the lowlands of Tabasco, México. *J. Ethnobiol. Ethnomed.* **2020**, *16*, 42. [\[CrossRef\]](#) [\[PubMed\]](#)
143. Medina, F.-X.; Vázquez-Medina, J.A.; Covarrubias, M.; Jiménez-Serna, A. Gastronomic sustainable tourism and social change in World Heritage Sites: The enhancement of local agroecological products in the chinampas of Xochimilco (Mexico City). *Sustainability* **2023**, *15*, 16078. [\[CrossRef\]](#)
144. Oteros-Rozas, E.; Ravera, F.; García-Llorente, M. How Does Agroecology Contribute to the Transitions towards Social-Ecological Sustainability? *Sustainability* **2019**, *11*, 4372. [\[CrossRef\]](#)
145. Gen-Jiménez, A.; Flores-Félix, J.D.; Rincón-Molina, C.I.; Manzano-Gómez, L.A.; Villalobos-Maldonado, J.J.; Ruiz-Lau, N.; Roca-Couso, R.; Ruiz-Valdiviezo, V.M.; Rincón-Rosales, R. Native *Rhizobium* biofertilization enhances yield and quality in *Solanum lycopersicum* under field conditions. *World J. Microbiol. Biotechnol.* **2025**, *41*, 126. [\[CrossRef\]](#) [\[PubMed\]](#)
146. Oropeza-Tosca, D.R.; Rincón-Molina, C.I.; Baptista, A.; Notario-Priego, R. Perspective chapter: Development of business in rural southeastern Mexican communities and environmental awareness. In *Degrowth and Green Growth—Sustainable Innovation*; Martínez-Gutiérrez, R., Ed.; IntechOpen: London, UK, 2024; pp. 1–24. [\[CrossRef\]](#)
147. Rincón-Rosales, R.; Villalobos-Escobedo, J.M.; Rogel, M.A.; Martínez, J.; Ormeño-Orrillo, E.; Martínez-Romero, E. *Rhizobium calliandrae* sp. nov., *Rhizobium mayense* sp. nov. and *Rhizobium jaguaris* sp. nov., Rhizobial Species Nodulating the Medicinal Legume *Calliandra grandiflora*. *Int. J. Syst. Evol. Microbiol.* **2013**, *63*, 3423–3429. [\[CrossRef\]](#) [\[PubMed\]](#)
148. Jiménez Márquez, O.; Soria Saavedra, R.; Pesce Gomez, A. Una Opción de Turismo Alternativo y Vivencial, Caso la Microcuenca Río Delgado. In *La Producción de Conocimiento en las Ciencias Sociales Aplicadas*; Atena Editora: Ponta Grossa, Brazil, 2023; Chapter 6; pp. 58–76. Available online: <https://atenaeditora.com.br/catalogo/download-post/77104> (accessed on 25 August 2025).
149. Martínez-Gutiérrez, R.; Barreto-Canales, I.G.; Lucas-Bravo, G.; Moreno-Cabral, S. SDG Voluntary Local Reports (VLRs): Analysis of Glocal Sustainable Innovation. In *Degrowth and Green Growth—Sustainable Innovation*; IntechOpen: London, UK, 2025. [\[CrossRef\]](#)
150. Cornish, F.; Breton, N.; Moreno-Tabarez, U.; Delgado, J.; Rua, M.; de-Graft Aikins, A.; Hodgetts, D. Participatory action research. *Nat. Rev. Methods Prim.* **2023**, *3*, 34. [\[CrossRef\]](#)
151. Aguilera, C.A.; Castro, A.; Scheihing, E.; Paredes, J.M.; Aguilera, C. Offline Technology for Rural AI Literacy: Steps Towards a Holistic Educational Solution. *Sustainability* **2026**, *18*, 5105. [\[CrossRef\]](#)
152. Oropeza-Tosca, D.R.; Escalante-Fernández, J.J.; Camargo-Santos, O.C.; Aguiar-Sierra, R.; López-Cardoza, M.I. Desarrollo sostenible y empoderamiento comunitario a través del uso de *Atractosteus tropicus*. *Eur. Public Soc. Innov. Rev.* **2025**, *11*, 1–14. [\[CrossRef\]](#)
153. Gaudio, N.; Escobar-Gutiérrez, A.J.; Casadebaig, P.; Evers, J.B.; Gérard, F.; Louarn, G.; Colbach, N.; Munz, S.; Launay, M.; Marrou, H.; et al. Current knowledge and future research opportunities for modeling annual crop mixtures: A review. *Agron. Sustain. Dev.* **2019**, *39*, 20. [\[CrossRef\]](#)
154. Castro-De La Cruz, J.; Reyes-Chab, E.J.; De León-De Los Santos, B.R.; Galindo-Sánchez, E.E.; Esqueda-Elizondo, J.J. Propuesta de un modelo logístico de comercialización para los productores de chile habanero en la comunidad de Acachapan Buenavista 5ta sección del municipio del Centro del estado de Tabasco. *Rev. Aristas Cienc. Bás. Apl.* **2023**, *10*, 300–305. [\[CrossRef\]](#)
155. Battiston, R.; Di Pietro, W.; Amerini, R.; Sciberras, A. The praying mantids (*Insecta: Mantodea*) as indicators for biodiversity and environmental conservation: A case study from the Maltese and Balearic archipelagos. *Biodiversity* **2020**, *21*, 142–149. [\[CrossRef\]](#)
156. Cortés, J.D.; Guix, M.; Bohle-Carbonell, K. Innovation for sustainability in the Global South: Bibliometric findings from management and business and STEM fields in developing countries. *Heliyon* **2021**, *7*, e07809. [\[CrossRef\]](#) [\[PubMed\]](#)
157. Ortiz Espejel, B.; Duval, G. *Sistemas Complejos, Medio Ambiente y Desarrollo*; Universidad Iberoamericana Puebla: Puebla, Mexico, 2008. Available online: <https://elementos.buap.mx/directus/storage/uploads/00000003984.pdf> (accessed on 12 October 2025).
158. Aloo, B.N.; Tripathi, V.; Makumba, B.A.; Mbega, E.R. Plant growth-promoting rhizobacterial biofertilizers for crop production: The past, present, and future. *Front. Plant Sci.* **2022**, *13*, 1002448. [\[CrossRef\]](#) [\[PubMed\]](#)

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.