Water Sowing and Harvesting Tourism: An Educational and Water Conservation Experience in Manglaralto, Ecuador

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Abstract

The commune of Manglaralto, Santa Elena (Ecuador), is a coastal town that relies exclusively on the Manglaralto aquifer for its local water supply and tourist flow. Faced with the risks of overexploitation and saline intrusion, the community has implemented an artificial recharge system using a technical-artisanal dam (tape), generating water benefits as well as spontaneous educational and recreational uses. The site is considered a site of geological interest due to its hydrogeological characteristics and has been designated an Ecohydrology Demonstration Site by UNESCO. However, this experience has not yet been systematized for inclusion in the area's tourism agenda. The objective of this research is to propose tourism strategies integrating elements of geodiversity, environmental education, and community conservation of the aquifer to strengthen local sustainable tourism. The methodological design included: i) baseline diagnosis, ii) SWOT analysis with community and technicians, and iii) a tourism proposal for the site (route and guidelines for education-culture-environment-society-economy-governance). As a result, a guided experience based on the Manglaralto river-aquifer system is proposed, the "Water Route", which includes visits to five points of interest: a) Manglaralto Water Board headquarters, 2) historic wells 1 and 2, c) technical-artisanal dam site, e) water reservoirs and natural viewpoint, and f) Manglaralto river mouth, where technical and historical information on community water management, its benefits, and local significance can be obtained. This research allows for the revaluation of the underground resource and the infrastructure for rescuing ancestral knowledge with Water Sowing and Harvesting (WS&H) systems, integrating its educational (social-cultural-environmental) and tourist (administration-operation) use as a social innovation project.

Keywords

WS&H, Community tourism, Educational tourism, Groundwater tourism

1. Introduction

Water is an indispensable resource for life and community development. Its role is key to sustainable development, serving as the basis for the economy, energy, food production, ecosystems, and human survival [1]. In the tourism sector, water is an essential resource, as it is consumed in accommodations, contributes to landscaping, and is the medium for various aquatic activities [2]. Water and its importance require greater reflection on its management, value, and roles for both humans and nature [3], which is especially crucial in coastal areas where water resources tend to be scarce and fragile.

Coastal areas are characterized by being places of great tourist attraction, commonly linked to their environmental characteristics (e.g., sun, beaches, cliffs, mangroves) and recreational activities such as water sports and tours. Coastal and marine tourism represents at least 50% of total global tourism. It is estimated that this type of tourism contributes around 4.6 trillion US dollars (5.2%) to the global gross domestic product (GDP) [4]. It is also an important source of employment, generating 52 million jobs worldwide by 2023 [5]. However, the increase in tourism and tourism infrastructure, such as hotels, resorts, bars, and restaurants, has also increased the water demand [6]. In this sense, tourism, despite being an essential economic sector in these areas, can also exert significant pressure on local water resources.

Many coastal areas are located in arid and semi-arid regions where surface water resources are

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limited and groundwater is the only available water resource [7, 8]. In these regions, tourism growth has placed stress on coastal aquifers already facing pressures from urbanization, climate variability, and overexploitation [9]. Traditional beach tourism consumes large amounts of water and can contribute to declining groundwater levels, saline intrusion, and water quality degradation [10]. This situation has generated the need for a more conscious tourism that offers opportunities to raise awareness of water issues and strengthen sustainable tourism.

Beyond leisure and contemplation, tourism has become a strategic tool for environmental education, resource conservation, and the promotion of sustainable development models [11, 12]. In territories such as coastal areas, tourism can be an opportunity to highlight community practices that contribute to water resilience and ecosystem balance. Furthermore, it can be an opportunity to raise awareness of groundwater, a fundamental water resource in semi-arid areas.

The parish of Manglaralto (Santa Elena Province), on the southern coast of Ecuador, relies exclusively on groundwater for its water supply. The area is widely known as a popular tourist destination due to its many beaches and cliff landscapes, as well as its diverse recreational, cultural, ecological, and gastronomic offerings. In the parish, groundwater resources are managed by communities through Community Water Boards. These communities possess valuable ancestral water management knowledge and practices that, in addition to being hydrologically effective, have high educational and cultural value [13].

A notable case occurs in the Manglaralto commune. Here, the Manglaralto coastal aquifer is managed through the application of Water Sowing and Harvesting (WS&H) systems, which include artificial recharge of the aquifer through a structure known as a tape (dam) and exploitation through water Wells [14]. This system allows rainwater to be stored underground to guarantee supply during dry seasons, but it also acts as an important barrier to saline intrusion, making it an example of nature-based solutions as part of integrated water resources management [15]. This system is key to ensuring water for the local population and tourists.

The Manglaralto river-aquifer system has been inventoried among the sites of geological interest of the Santa Elena Peninsula Geopark project, and was recently designated a UNESCO Ecohydrology Demonstration Site [16, 17]. The site represents a natural laboratory where the general community, students, and researchers can learn firsthand about the hydrogeological resource and its community management. Making river-aquifer system management visible through tourism can strengthen local identity and promote more responsible water use, especially among visitors. However, these activities have not yet been included in the area's tourism offering.

In this context, the following research question arises: Could tourism based on water sowing and harvesting be applied as a tool to raise awareness and strengthen local water management while promoting the first steps toward a culture of sustainable tourism? The objective of this work is to propose tourism strategies based on community-based water management by integrating elements of geodiversity, environmental education, community conservation, and participatory aquifer monitoring for the sustainable use of water resources and the promotion of local sustainable tourism.

2. Materials and Methods

This study employs a qualitative-descriptive approach to design an educational-hydrogeological tourism proposal, leveraging elements of the Manglaralto river-aquifer system, recognized by UNESCO as an Ecohydrology Demonstration Site. The socio-environmental context is reviewed (with surface-ground hydrological analysis), and a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis is established using participatory methods to generate a tourism promotion proposal with an educational-cultural focus. The methodological design included: i) baseline diagnosis, ii) SWOT analysis with community and technicians, and iii) tourism proposal for the site (route and guidelines for education, culture, environment, society, economy, and governance) (Figure 1).

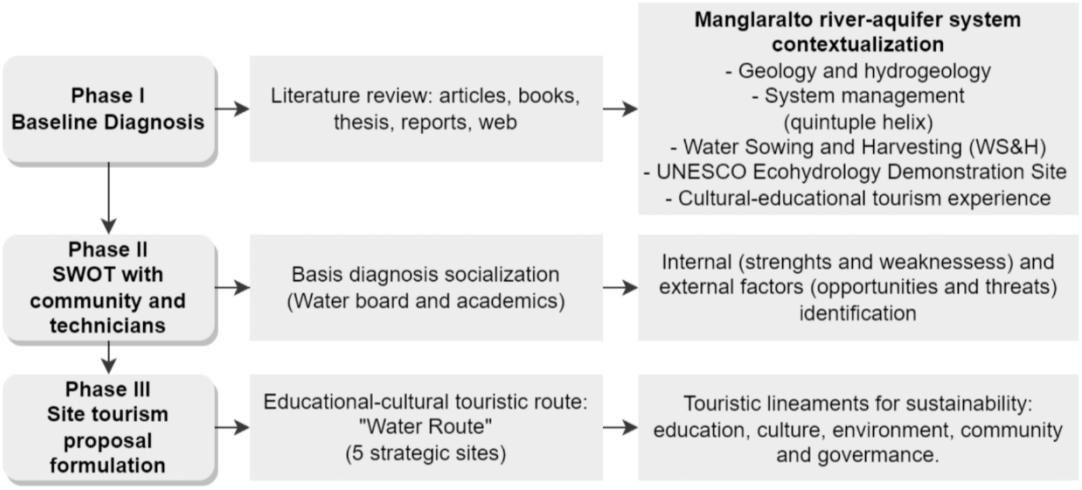

Figure 1: Methodological scheme of study.

2.1. Phase I: Baseline diagnosis

This phase consisted of contextualizing the study area based on the compilation and review of existing literature related to the Manglaralto hydrogeological system. Scientific publications, institutional technical reports, and other literature on community-based water management and experiences related to tourism and environmental education in the area were compiled and analyzed. In addition to characterizing the physical and socio-hydrological context, this phase allowed for the identification of the territorial elements with the most significant potential for integration into an educational tourism offering, especially regarding the valorization of groundwater, geodiversity, and the use of the communities' ancestral knowledge.

2.2. Phase II: SWOT with community and technicians

This phase involved a collective analysis of the possibilities for developing a tourism offering based on community-based water management. A SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis [18], was applied, through a focus group with the participation of the authors, academics/researchers in the areas of hydrogeology and tourism, and the community, represented by the Manglaralto Regional Drinking Water Management Board (JAAPMAN), including system directors and operators. The process was carried out in two steps: i) dissemination of the baseline diagnosis obtained in phase I, and ii) a SWOT analysis workshop.

The activity allowed for the identification of internal factors (strengths and weaknesses) and external factors (opportunities and threats) that influence the development of a tourism offering focused on water management, and the generation of initial ideas about possible activities, routes, stakeholders, and the conditions necessary for their implementation.

2.3. Phase III: Site tourism proposal formulation

Based on the results obtained in the previous phases, a preliminary proposal for educational-cultural tourism was developed, focusing on the river-aquifer system. The proposal primarily considers local water management through water sowing and harvesting as the central axis for tourism. A tour was established at five key points: 1) JAAPMAN Headquarters, 2) Historic Wells 1 and 2, 3) Technical-Artisanal Dam, 4) Water Reservoirs and Natural Viewpoint, and 5) Manglaralto River Mouth. In addition, tourism guidelines were established along six axes: education, culture, environment, community, economy, and governance.

The tourism proposal includes educational explanations of the system, participatory monitoring activities, spaces for dialogue with the community, and the use of existing infrastructure for artificial

aquifer recharge, all within the framework of raising awareness about water resources and territorial empowerment.

3. Results

3.1. Contextualization of the Manglaralto river-aquifer system

3.1.1. Geology and hydrogeology

The Manglaralto river-aquifer system is located within the Manglaralto hydrological basin, Santa Elena (Figure 2a). The oldest geological unit in the basin corresponds to the Cayo Formation of the Upper Cretaceous, which comprises volcano-sedimentary rocks. The impermeable layer that favors water trapping corresponds to the lithological units of the Ancón group of the Eocene, which include limestones, carbonate sandstones, conglomerates, sandstones, mudstones, and shales. Meanwhile, the aquifer layer corresponds to alluvial deposits of the Quaternary [19] (Figure 2b). The aquifer covers an area of 508 H and an estimated volume of 13.6 Hm^3. Due to its proximity to the sea, the aquifer is affected by saline intrusion [20, 21].

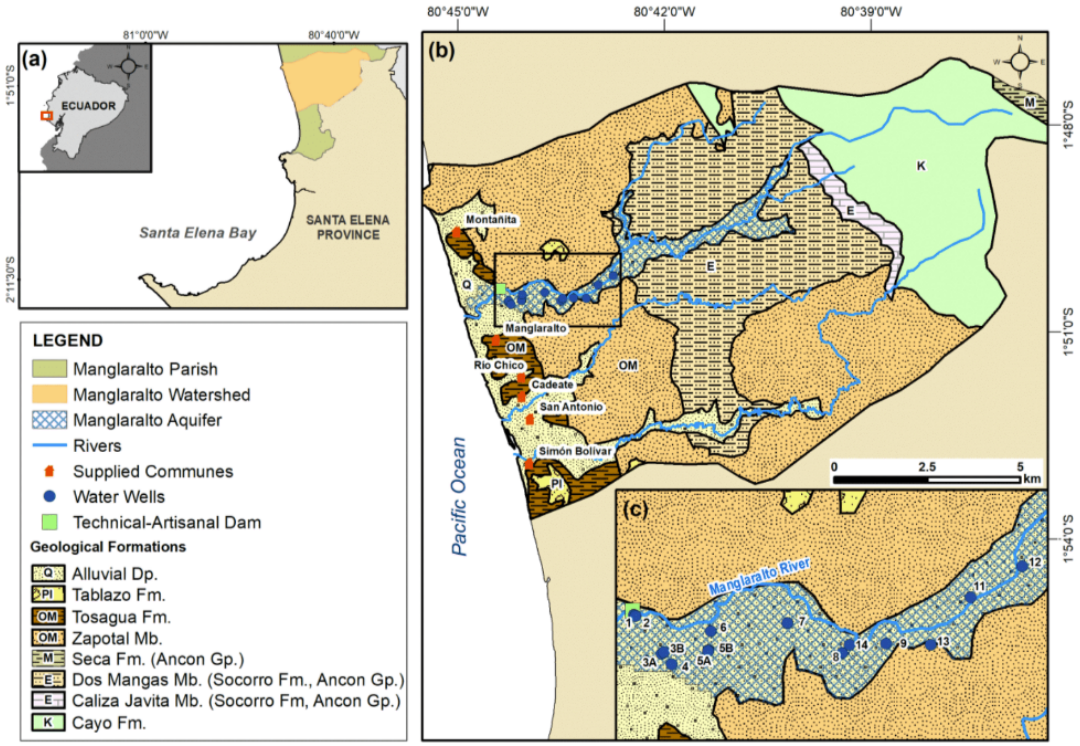

Figure 2: Geological and hydrological context of the Manglaralto river-aquifer system. **(a)** General location, **(b)** Geology of the Manglaralto hydrological basin, **(c)** System of wells and dams managed by JAAPMAN

3.1.2. System management

The management of the Manglaralto river-aquifer system has historically been the responsibility of the local community. Since 1979, the Manglaralto Regional Drinking Water Management Board has been responsible for groundwater collection, storage, treatment, and distribution. Currently, the system is managed under a quintuple helix model [22, 23], combining community, academic, environmental, governmental, and industrial management, in a sustainability approach (Figure 3). The system supplies water to six communes: Libertador Bolívar, San Antonio, Cadeate, Río Chico, Manglaralto, and Montañita, benefiting around 20,000 local users daily. This population can double during holiday or vacation periods (February-April) due to the arrival of tourists [24].

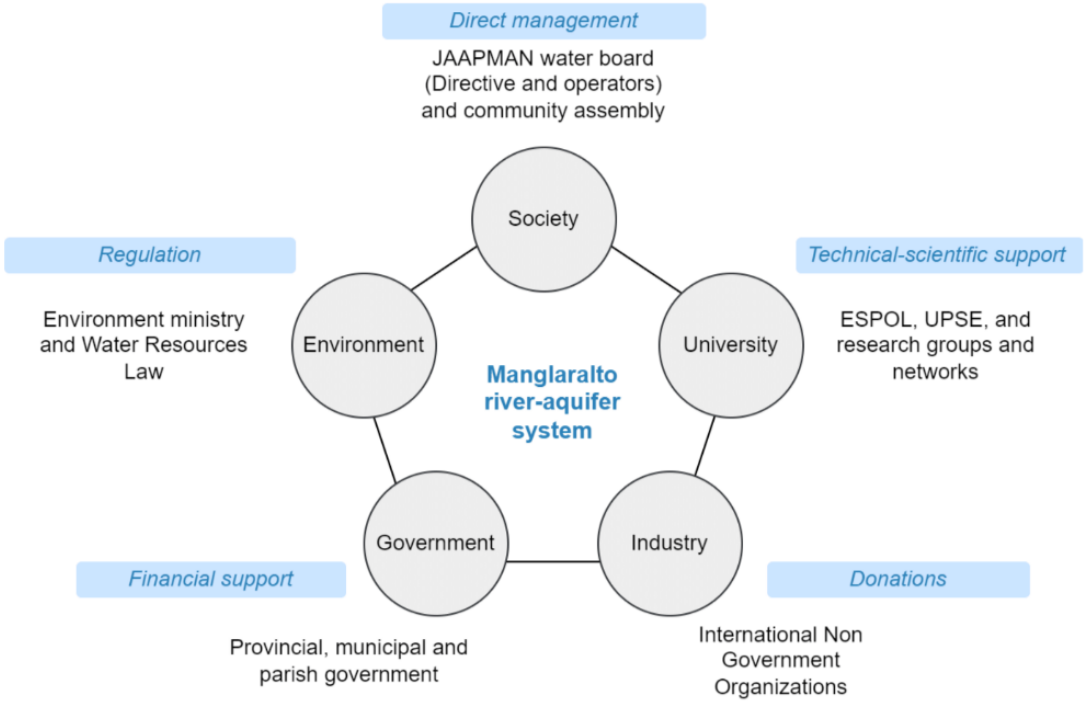

Figure 3: Management model of the Manglaralto river-aquifer system following the quintuple helix approach.

3.1.3. Application of Water Sowing and Harvesting (WS&H) techniques

Manglaralto preserves ancestral methods used by indigenous peoples in Santa Elena to sow water during the rainy season (infiltration into the subsoil), in response to the region's water shortage. Water sowing employs a technical-artisanal technique in the riverbed, which retains water and favors its infiltration into the aquifer. Water harvesting is carried out using groundwater extraction wells (15 in total) located along the banks of the Manglaralto river, for the benefit of the community (Figure 4) [15]. Water sowing makes the local aquifer sustainable, ensuring water supply and promoting the retreat of the saline intrusion wedge affecting the coastal aquifer.

3.1.4. Ecohydrology Demonstration Site

Ecohydrology is an interdisciplinary approach that combines hydrological and ecological processes to promote water sustainability and ecosystem conservation. In contexts of water scarcity, such as semi-arid coastal areas, ecohydrology offers nature-based solutions that optimize water availability, restore habitats, and strengthen community resilience to climate change [25, 26]. In 2025, the Manglaralto river-aquifer system was designated a UNESCO Ecohydrology Demonstration Site [17], for the implementation of principles and techniques for sustainable water management and biodiversity preservation, such as:

- Use of ancestral knowledge to build artisanal dams ("tapes"), improving artificial aquifer recharge and increasing water supply.
- Use of riparian vegetation and green filters with Guadua angustifolia to improve infiltration and treat water pollutants.
- Water-biota regulation: The technical-artisanal tape helps maintain essential water resources for coastal communities, associated ecosystems (estuaries, mangroves, and tropical dry forests), and the diversity of aquatic and aerial fauna.
- Biota-water regulation: Reforestation with Guadua angustifolia on the banks reduces erosion, improves infiltration, and filters sediments and nutrients, improving the quality of the water available to the community.

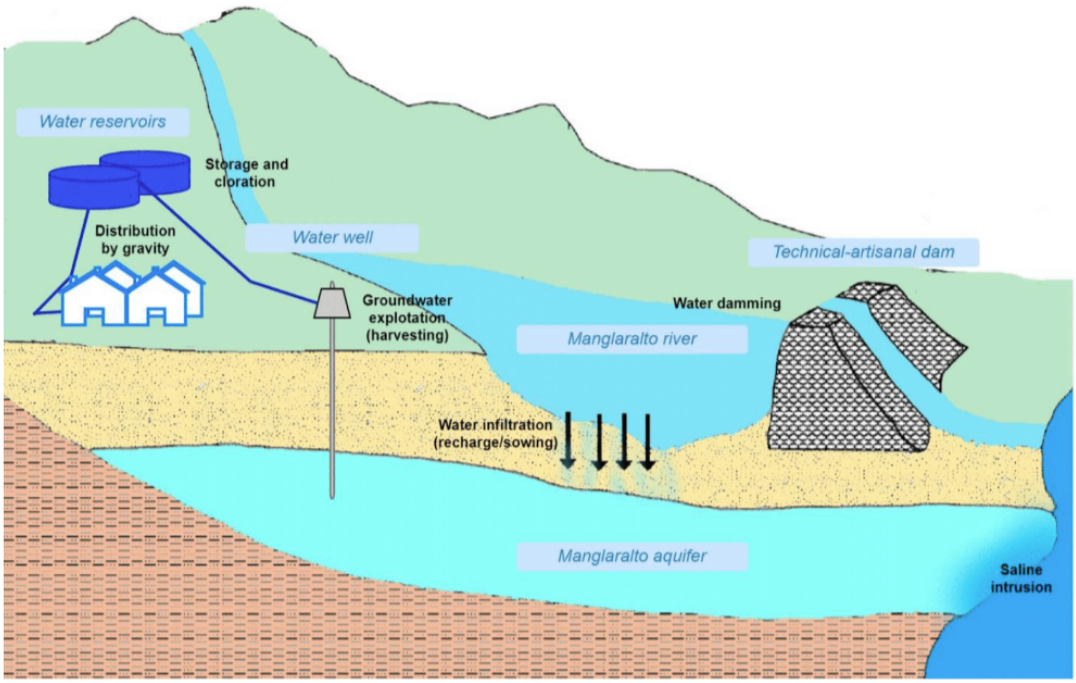

Figure 4: Graphic scheme of the application of SyCA techniques in the Manglaralto river-aquifer system.

3.1.5. Site educational-cultural tourist experience

For several years, the Manglaralto river-aquifer system has been used as a natural laboratory, where visitors of all kinds come to engage in activities related to the natural sciences. The sites of wells 1 and 2, as well as the location of the technical-artisanal tape, have been central venues for events related to the dissemination of hydrogeology, such as "Hydrogeoday" workshops in 2023 and 2025, visits from experts in Water Sowing and Harvesting, and technical visits from undergraduate students (e.g., geology, civil engineering, graphic design), and graduate students in Environmental Sciences and Earth Sciences (Figure **??**). In addition, this site has become a tourist attraction for visitors who admire the natural basin of the Manglaralto River in the area.

All this is complemented by the existence of graphic and audiovisual resources (books, brochures, videos) produced by the academy, which make visible the rescue of ancestral knowledge (WS&H) [27], as well as the role of the community, with emphasis on the participation of women [28].

3.2. SWOT analysis

Error: Reference source not found summarizes the results of the SWOT analysis conducted from the focus group with experts and members of the water board.

3.3. Tourism proposal based on water sowing and harvesting

As a result of the baseline diagnosis concerning the Manglaralto river-aquifer system and community water management, as well as the SWOT analysis, a proposal for educational-cultural tourism based on local Water Sowing and Harvesting was developed to promote the sustainable use of water resources and boost sustainable tourism in this coastal area. A tourist route called "Water Route" is proposed, which includes visits to five important sites related to community water management in Manglaralto, essential for the integration of knowledge on the subject: 1) JAAPMAN Headquarters, 2) Historic Wells 1 and 2, and 3) Technical-artisanal dam, 4) Water reservoirs and natural viewpoint, and 5) Manglaralto river mouth (Figure 5).

Table 1
Matrix for identifying internal factors (strengths and weaknesses) and external factors (opportunities and threats).

Strengths (S)	Weaknesses (W)
• Existence of a community management with infrastructure related to local water management (water board headquarters, wells, technical-artisanal dam). • Participation of JAAPMAN, with ancestral knowledge. • Proximity to strategic tourist areas such as Manglaralto beach and Montañita (surf city). • Rich local cuisine and culture. • Links with universities, non-governmental organizations (NGOs), parish and municipal decentralized autonomous governments (GADs), and sustainable development programs. • Presence of basic infrastructure for guided tours (trails and initial signage) and availability of educational materials (leaflets, books, videos).	• Lack of interpretive infrastructure (panels, signage, and visitor centers). • Lack of specific tourism strategies (guidelines, packages). • Limited capacity for tourism promotion and marketing experiences. • Need to improve connectivity or physical access from the main road during the rainy season.
Opportunities (O)	**Threats (T)**
• Possibility of incorporating the site into educational, scientific, and community tourism routes in the province. • Possibility of capitalizing on tourism demand for educational experiences related to the environment and culture. • Growing interest in sustainable and community-based tourism nationwide. • Potential for accessing funding for conservation, education, and climate change adaptation projects.	• Extreme events (droughts or floods) can affect the functioning or perception of the site. • Political or institutional changes that weaken support for the site as an example of community sustainability. • Risk of losing the demonstration purpose if tourism is prioritized over community function. • Risk of degradation of the demonstration site.

For effective promotion of the tourism proposal, it is essential to consider the tourism management aspects set out in Table 2:

In addition, tourism guidelines are proposed, framed within six strategic axes: education, culture, environment, community, economy, and governance, focused on the sustainable development of the proposed tourism offering.

1. Educational Guidelines
    - Develop interpretive materials with an educational focus (panels, guides, brochures, audiovisual materials).
    - Train community guides in water and environmental education, with an approach adapted to different target audiences (children, students, national and international tourists).
    - Incorporate participatory learning experiences such as on-site monitoring of water well levels and measurement of physical and chemical water quality parameters.
    - Establish partnerships with educational institutions at different levels (schools, colleges, universities, technical institutes) for technical visits, practices, or internships.
    - Create a water interpretation center with educational and scientific materials available to visitors.
2. Cultural Guidelines

Figure 5: Proposed tourist route "Water Route".

- Highlight ancestral water management techniques (tapes, albarradas), in conjunction with modern science.
- Integrate local cultural narratives into guided tours (stories, legends, water use customs).
- Promote themed cultural events, such as water festivals, local product fairs, or community art activities.
- Encourage the production of handicrafts that reflect local cultural identity and are associated with water themes (ceramics, weaving, recycled art).

3. Environmental Guidelines
   - Apply green infrastructure and ecological design criteria in all tourist areas.
   - Ensure proper management of solid and liquid waste during tourist activities.
   - Establish visitor numbers based on the site's tourist carrying capacity analysis.
   - Analyze potential environmental impacts related to tourist activities on the site and propose mitigation measures (erosion, biodiversity).
   - Engage locals and tourists in direct conservation activities such as planting native species and community cleanups.
4. Community Guidelines
   - Ensure that the community, represented by JAAPMAN, leads the tourism project, its implementation, and oversight.
   - Promote the inclusion of vulnerable community members (women, youth, and older people).
   - Provide fair employment opportunities (guides, artisans, cooks, lodging).
5. Economic Guidelines
   - Establish a differentiated fare model based on visitor profiles (domestic and international tourists, students, and researchers).
   - Promote the economy related to tourism (e.g., handicrafts based on the river-aquifer system, commemorative T-shirts).
   - Create a reinvestment fund for the use of tourism revenues in community projects.

Table 2
Considerations for the tourism promotion of the "Water Route" proposal.

Aspects of tourism promotion	Considerations/requirements
Identification of strategic actors and allies	Coordination between local and regional stakeholders, with the Manglaralto Regional Drinking Water Management Board (JAAPMAN) as the main player, in collaboration with entities such as the Parish and Municipal Government for logistical support and promotion, community organizations (neighborhood committees, women's and youth associations), and academic and technical institutions (ESPOL, UPSE) specializing in water resources, education, and sustainable tourism.
Route approach	The tour covers a distance of 4.7 km, starting at the JAAPMAN headquarters and ending with a visit to the mouth of the Manglaralto River and its boardwalk. This route can be completed by car and lasts approximately two hours, allowing 20-25 minutes for explanations and appreciation at each point.
Experience plannin	Inclusion of trained guides who provide expert and illustrative explanations at each stop of the tour. This experience will allow visitors to gain a deeper understanding of the history of water management in the local community, the sustainable methods used (such as the WS&H method), the benefits achieved, and the area's international recognition as a UNESCO Ecohydrology Demonstration Site. Narrations can occasionally be complemented by on-site interactions, such as measuring water levels in wells and monitoring the physical and chemical properties of water, which will further enrich the experience.
Identification of associated tourism resources	The tourist experience is complemented by existing local resources such as vehicle access from the Spondylus Route, coastal cuisine with an emphasis on seafood, accommodation options, the sale of community-made handicrafts (ceramics, textiles, carvings) that highlight the local culture, and recreational activities such as hiking and birdwatching.
Local adaptation	Adapt and improve the infrastructure at visitor points, including roads, parking, restrooms, and shaded areas; and information panels with scientific and educational content related to groundwater, community management, WS&H, ecohydrology, and associated biodiversity, among others.
Promotion and dissemination	A comprehensive communications strategy involving training local people as community guides, designing interpretive materials (brochures, leaflets, infographics, maps, videos) in Spanish and English that integrate scientific, cultural, and tourism aspects, and disseminating them on social media and in local and institutional media.

- Establish institutional partnerships to diversify revenues, focusing on training activities and specialized courses, among others.

6. Governance Guidelines
    - Create inter-institutional cooperation alliances involving parish and municipal GADs, higher education institutions, NGOs, and regional tourism networks.

4. Discussion

This study highlighted the potential for educational tourism based on community-based water management around the Manglaralto river-aquifer system, considering the application of Water Sowing and Harvesting techniques as a basis for the experience and the tourism potential associated with the site.

The Manglaralto river-aquifer system represents an ideal space for the development of cultural-educational tourism, supported by training initiatives linked to community-based water management and the recovery of ancestral knowledge. This site has been the setting for events, programs, workshops,

and guided tours recognizing community action. Furthermore, the audiovisual resources and interpretive materials, as well as international recognition (UNESCO Demonstration Site), reinforce its importance as a place that integrates environmental education, cultural identity, and awareness-raising for aquifer conservation as the central axis of the tourism proposal. Added to this is the role of women, comparable to other references (e.g., [29, 30]) where their participation and leadership have been key in community management and inclusive water governance in rural communities.

The SWOT analysis revealed a strategic alignment of strengths and opportunities, highlighting the existence of functional infrastructure for planting and harvesting water (wells and a technical-artisanal dam), the commitment of organized community stakeholders (JAAPMAN), and the growing demand for tourism experiences linked to environmental stewardship (Error: Reference source not found). However, significant weaknesses were also identified, linked to operational limitations for tourism (e.g., lack of basic and informative signage) and the limited promotion of the site as an attraction. Likewise, threats related to extreme event scenarios, institutional changes, or site degradation represent risks that can negatively impact the creation of a tourism experience and must be managed in advance. Therefore, the potential for a tourism proposal in Manglaralto will depend on the ability to leverage both strengths and opportunities and manage weaknesses and threats without compromising ecological functionality or community autonomy over water.

The tourism proposal based on the "Water Route" (Figure 5), is aligned with international trends in responsible environmental tourism. An example of this is Madirda Lake (Berjo village, Ngargoyoso, Central Java), a natural spring that integrates water education into the lake's tourism activities. In this case, guided interpretation of the natural and anthropogenic water management system (water treatment) has contributed to the diversification of the tourism offer, but also to raising visitor awareness about the vulnerability of water resources, their role in the ecosystem, the processes involved in their conservation and collective management [31]. In this sense, the Manglaralto proposal can become a replicable model of resilience for environmental education in areas of water stress, emphasizing the role of communities as guardians of water [32].

Tourism guidelines based on six pillars (education, culture, environment, community, economy, and governance) allow for balanced tourism management, which is essential to avoid negative impacts (e.g., tourist overload, loss of control over resources). Furthermore, this proposal is part of the construction of a comprehensive tourism offering, the design of which seeks to directly benefit the community through new opportunities for local employment generation, strengthening the economy, and encouraging productivity through activities such as crafts, gastronomy, and tourism services [33]. This approach is in line with community-based tourism studies, which show that projects with a comprehensive approach are more resilient, inclusive, and long-lasting [34, 35, 36].

The contribution of this research is related to the field of sustainable tourism, linking community water management with the design of an educational and cultural tourist route for water conservation. This work proposes a synergy between functional water infrastructure, local water governance practices, and sustainability, which are at the center of the tourist experience, positioning Manglaralto as a natural and social laboratory for territorial innovation. In the future, this research can be complemented with studies of tourist carrying capacity at the proposed tourist route sites. It would also be valuable to consider analyzing the perceptions of visitors and local stakeholders, as well as assessing the economic profitability and benefit distribution of the proposal.

5. Conclusion

A comprehensive analysis of the Manglaralto river-aquifer system reveals its potential for developing educational and sustainable tourism, based on the territory's hydrogeological richness, community participation in water management, ancestral knowledge, and previous experiences in scientific outreach. The "Water Route" tourism proposal, complemented by guidelines based on six strategic axes (education, culture, environment, community, economy, and governance), constitutes a tool for integrating tourism with the conservation of sensitive ecosystems and community-based water management. Its implemen-

tation can be inspired by similar experiences developed in other international contexts, where tourism has contributed both to the appreciation of natural heritage and the consolidation of local capacities, paving the way for a conscious, inclusive, and resilient tourism model. This research allows for the revaluation of groundwater resources and the infrastructure for rescuing ancestral knowledge through water sowing and harvesting systems, integrating their educational (social-cultural-environmental) and tourism (administration-operation) uses as a social innovation project.

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Declaration on Generative AI

The authors have not employed any Generative AI tools.

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