

RESEARCH ARTICLE

Sustainable Tourism Village Development in Sidoarjo through the Pentahelix Model and Geospatial Planning

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ABSTRACT

This paper analyses the application of the Pentahelix approach in Sidoarjo's tourism village development, highlighting the importance of joint actions among key stakeholders to realise SDG 8, SDG 11, and SDG 17. The research adopted a descriptive qualitative strategy that integrated document analysis, field interviews, and group discussions, targeting stakeholders selected through purposive sampling. Data analysis was conducted using thematic coding to identify patterns in stakeholder participation, challenges, and best practices. Findings indicate that Pentahelix collaboration has positively impacted infrastructure improvements, marketing strategies, and tourism management practices, creating opportunities for local economic growth and cultural preservation. However, the study also identifies gaps, particularly in the involvement of academic institutions in research and innovation, and limited community participation in decision making processes. Strengthening the participatory capacity of local communities and enhancing cross sector cooperation can lead to more equitable benefits, foster a stronger sense of ownership, and support long term sustainability. The research provides practical implications for policymakers and tourism practitioners seeking to implement integrated, community based development models, suggesting that sustained dialogue, capacity building programs, and monitoring mechanisms are essential to maximize the potential of Pentahelix partnerships. Overall, this study contributes to the literature on collaborative governance in rural tourism and highlights the importance of multi stakeholder engagement for sustainable and inclusive village development.

Keywords: Sustainable tourism; Pentahelix collaboration; Community based tourism; Lapindo geotourism; SDGs (Sustainable Development Goals)

1. Introduction

Sustainable tourism seeks to balance economic, social, and environmental goals while ensuring local communities benefit and natural cultural resources are preserved [1], [2]. In practice, this approach emphasises responsible resource management, reduced environmental impacts, and increased social and economic inclusion of local communities [1], [3]. Sustainability in tourism rests on three interconnected dimensions (economic development, environmental protection, and social equity) that must coexist in balance. At its core,

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the concept seeks to support present tourism progress without compromising the opportunities and resources available to future generations ^[1]. The essence of this idea is the involvement of local residents. Through a community-based tourism (CBT) approach, communities not only benefit from tourism, but also play an active role in managing it. This involvement strengthens empowerment, fosters ownership, and contributes to improved local livelihoods ^{[4], [5]}.

Beyond community participation, sustainable tourism also relies heavily on collaboration among multiple actors. The Pentahelix framework serves as a holistic strategy to promote integrated and adaptive tourism governance ^{[6], [7]}. Each stakeholder plays a unique but complementary role in order to increase innovation and resource optimization. This synergy is expected to create policy harmony in the development of tourism villages ^{[8], [9]}. Although the adoption of this synergy is widely used, the implementation of sustainable tourism within the SDGs framework remains a challenge ^{[10], [11]}. High implementation costs, limited incentives for businesses, and the difficulty of measuring sustainability indicators continue to impede progress ^{[1], [3]}. Experiences from diverse regions such as the Danube Delta in Romania ^[2], Sikkim in India, and Basse Casamance in Senegal ^[12] illustrate that lasting success depends primarily on strong community engagement and effective inter stakeholder collaboration.

Despite various global challenges, Sidoarjo Regency in Indonesia still shows strong prospects for advancing community based tourism through village development . The region is rich in cultural heritage, history and ecotourism ^[7]. Official data shows that although Sidoarjo has 353 villages, only seven villages are registered as tourist villages in Jadesta. Of the seven registered villages, most still lack strong institutions and effective tourism management. For example, Kebaron and Candipari villages, although they have developed agro edutourism and heritage tourism concepts, still need support in digital marketing, human resource capacity building and sustainable infrastructure access. Economically, Sidoarjo’s tourism and creative sectors have grown steadily, with the broader tourism industry increasing from IDR 13.1 trillion in 2020 to IDR 18.1 trillion in 2024, and its GRDP share rising from 9.3% to 10.1% ^[13].

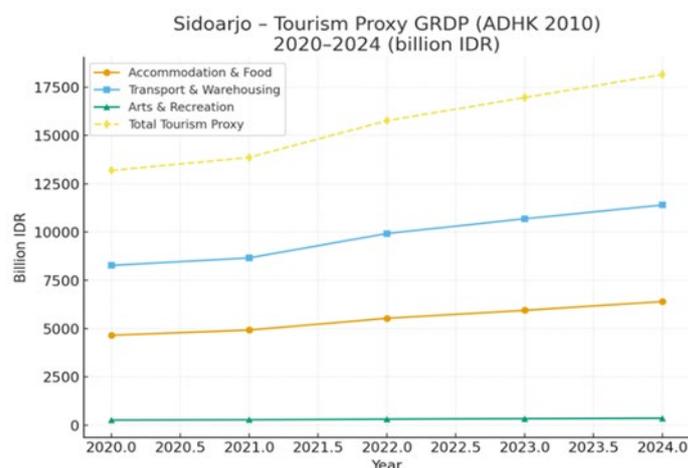


Figure 1. Sidoarjo – Tourism Proxy GRDP (ADHK 2010), 2020–2024

Figure 1 shows a consistent increase in the tourism is related GRDP sectors (accommodation, transport, and recreation). This upward trend illustrates the resilience of Sidoarjo’s tourism economy, even after the pandemic shock in 2020, and highlights its role as a growing driver of regional development.

This progress aligns with SDG-8 on decent work and economic growth, particularly target 8.9, which promotes sustainable tourism that creates jobs and showcases local culture and products. Despite some progress, engagement from businesses and academic actors remains minimal, preventing the establishment of

a strong and integrated collaboration system in tourism development. Sidoarjo also has strong human resource potential, with around 176,000 active MSMEs and a labour force participation rate of 69.62% in 2023 (BPS, 2023). When developed through the Pentahelix framework, this potential has the capacity to drive the growth of community based tourism villages in a more integrated and sustainable way. Despite Sidoarjo's strong tourism potential, major challenges remain, including weak stakeholder coordination, limited funding, low technology adoption, and the absence of adaptive management strategies. Few tourism villages use digital media for promotion, revealing a digitalisation gap. This study explores how the Pentahelix model is applied in Sidoarjo to propose local solutions that enhance coordination, digitalisation, and community involvement, while advancing SDG-8, SDG-11, and SDG-17.

Practically, this study aims to strengthen the implementation of tourism village development in Sidoarjo through better coordinated Pentahelix collaboration. It also seeks to enhance community and MSME participation in the tourism value chain, offer a reference model for similar regions, and foster stronger connections between education, technology, and culture to drive local tourism innovation. Thus, this research is not only important as an academic foundation, but also has a direct impact on improving community welfare, preserving local culture and strengthening the competitiveness of Sidoarjo tourism destinations in the regional and national context.

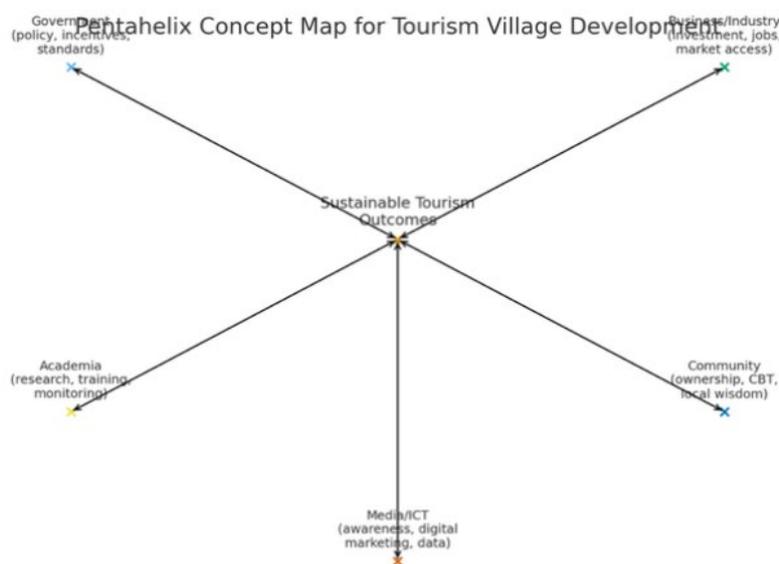


Figure 2. Pentahelix Concept Map for Tourism Village Development

Figure 2 illustrates the Pentahelix model in the context of sustainable tourism village development. Government contributes through policy, incentives, and standards; business/industry provides investment, jobs, and market access; communities ensure ownership, apply the CBT model, and preserve local wisdom; academia strengthens research, training, and monitoring; while media and ICT raise awareness and enable digital marketing. Together, these five elements interact to produce sustainable tourism outcomes.

The concept map above underscores the fact that no single actor can independently drive sustainable tourism. The synergy between all five elements is what determines whether tourism villages in Sidoarjo can evolve from pilot initiatives into self-sustaining models of economic growth, cultural preservation, and environmental protection. For example, without government incentives and infrastructure policies, village based initiatives may lack funding and legal legitimacy. Similarly, without business and industry participation, local tourism products may never reach wider markets. Communities, while at the center of sustainable tourism,

require ongoing capacity building, which is best supported through academia. Finally, digital platforms and media engagement are essential to reduce the visibility gap, considering that many tourist villages in Sidoarjo still struggle with online presence and promotion. In this sense, the Pentahelix model provides not only a theoretical but also a practical roadmap for overcoming the main challenges previously discussed. By strengthening interlinkages between these five actors, Sidoarjo can not only improve its tourism village governance but also better align local initiatives with the broader SDGs (8, 11, and 17).

2. Materials and methods

This study employs a qualitative approach to develop a comprehensive yet flexible understanding of the phenomenon. It began with topic selection and conceptualisation to identify relevant issues and formulate focused research questions. A literature review was then conducted to examine previous studies and highlight research gaps addressed in this study [14]. The next phase involved methodological planning, including the selection of epistemological approaches, theoretical foundations, and suitable data collection techniques. Primary data were obtained through in depth interviews and Focus Group Discussions (FGDs). Ethical approval was secured, and participants provided informed consent, with confidentiality maintained throughout the research process [15], [16].

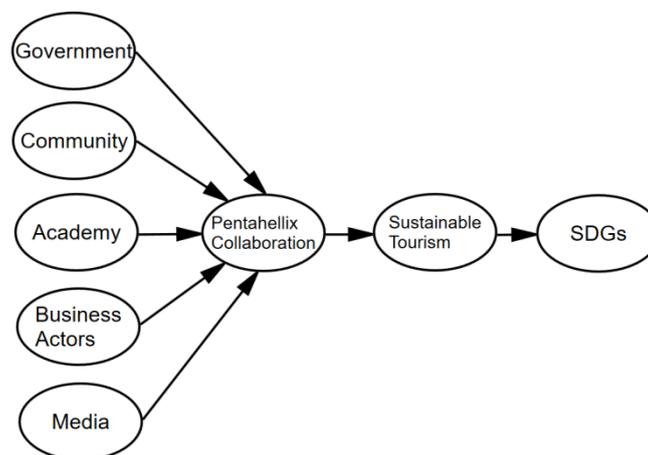


Figure 3. Research concept

The informants selected were those who had direct involvement and practical experience in developing village tourism initiatives in Sidoarjo Regency. Respondents represented various stakeholders: the Department of Youth, Sports, and Tourism (Disporapar), the Regional Development Planning Agency (Bappeda), and the Public Works Agency, as well as village governments, women's groups (PKK), tourism enthusiast organizations (Pokdarwis), news media, and academics from Surabaya State University. To gain broad insights, in-depth discussions with stakeholders were conducted for 40-60 minutes. The four main frameworks explored in the discussions were:

1. Perceptions of the effectiveness of Pentahelix collaboration,
2. Coordination barriers among stakeholders,
3. Identifying potential initiatives for community empowerment and digital marketing in tourism villages.
4. Developing strategic measures to support sustainable tourism growth in Sidoarjo.

Data collection was conducted through structured interviews and observations, with the support of trained enumerators to maintain consistency in the data collection process. Data were analyzed using thematic analysis, which included the stages of data familiarization, coding, theme development, and validation to identify key patterns. The research findings were then reflected in a relevant theoretical framework. Data credibility was maintained through inter-researcher discussions, audit trail compilation, and critical validation [17]. The research results were synthesized with the findings of previous studies [18] and carried out in accordance with research ethics standards [19]. Although this study faced limitations, such as field access and funding constraints, the researchers made methodological adjustments to maintain the reliability and robustness of the research findings [20].

3. Results and discussion

Tourism village development serves as a key strategy for economic diversification and the preservation of local identity in Indonesian regions, including Sidoarjo. This study highlights the Pentahelix model as a central framework guiding collaborative tourism development. However, its application in Sidoarjo remains limited, pointing to the need for greater integration and more active participation from all stakeholders.

3.1. The pentahelix model as a synergistic force in tourism village development

Empirical evidence demonstrates that the Pentahelix framework has been instrumental in fostering synergy among stakeholders in Sidoarjo's tourism landscape. The synergy among government agencies, academic institutions, business actors, media representatives, and local communities has brought meaningful advancements in infrastructure provision, tourism promotion, and the efficiency of destination management [21], [22]. Through this structured and cross sector collaboration, roles become clearer, responsibilities are shared more equitably, and resources are mobilised more effectively. Such synergy has served as an accelerator for developing sustainable, competitive, and community based tourism destinations [6], [7]. These efforts directly align with SDG 17, particularly target 17.17, which encourages the strengthening of multi stakeholder partnerships.

Sustainable tourism development inherently requires the active participation of diverse actors, each contributing complementary expertise to achieve common goals [21], [23]. The academic sector plays a crucial role in generating data driven insights, policy recommendations, and innovative tourism management models that are environmentally responsible and socially inclusive [24], [25]. This contribution not only promotes evidence based decision making but also nurtures innovation and capacity building within local tourism communities [26]. Academic participation also aligns with and strengthens global commitments under the SDGs, notably SDG 4, SDG 9, and SDG 11, which emphasise education quality, innovation driven development, and sustainable urban growth [23], [24]. Government institutions hold a key position in shaping policies and regulatory frameworks that guide tourism area management and in supplying the fundamental infrastructure needed for its development [25]. Additionally, the government acts as a facilitator of collaboration between various stakeholders to ensure inclusive and sustainable development. Effective policies and strong multi stakeholder synergy are essential to achieving SDG-16 and SDG-17 [23]. The government also supports SDG-6 through initiatives that improve access to basic services [27].

Local communities, as the primary actors in the preservation of culture and the environment, have a significant role in maintaining local wisdom and developing tourism based businesses that support the local economy [27]. Active government participation is vital to advancing several Sustainable Development Goals, especially SDG-1, SDG-8, and SDG-15 [11], [28], [29]. Businesses support sustainable tourism by developing environmentally responsible facilities, providing employment opportunities, and engaging in CSR programs.

Through such initiatives, the private sector contributes to SDG-7, SDG-12, and SDG-13 ^{[11], [24]}. The scale of destruction caused by the Lapindo mudflow eruption since 2006 is categorized as a catastrophic industrial disaster, with its material impacts still felt to this day ^[30]. Calculations from government agencies and academics estimate that the total economic loss has exceeded Rp 45 trillion, a staggering figure that reflects the loss of productive assets and recovery costs. Physically, more than 700 hectares of productive land, including thousands of homes, dozens of factories, and crucial infrastructure such as the Surabaya-Gempol toll road, have been permanently buried, completely altering the geographical and economic landscape of three sub districts in Sidoarjo.

Geographically, Sidoarjo has a landscape rich in tourism potential, ranging from the maritime richness of the east coast, the dense urban areas with history and culture, to unique areas such as the Lapindo mud site that can be transformed into educational geotourism objects ^{[31], [32], [33]}. Such tourism provides a great opportunity for the development of thematic tourism based on education and environmental preservation ^{[34], [35]}. The area can be developed with facilities such as geotourism galleries, rest areas, sports and educational spaces, culinary and souvenir centers, urban forests, retention ponds, and urban farming. These initiatives align with SDG-11, particularly target 11.4 on preserving cultural and natural heritage, and contribute to SDG-13 (Climate Action) through urban forest and water retention development. Challenges in the implementation of Pentahelix are still evident. It was found that the synergy between parties has not been fully optimised, mainly due to the lack of maximum involvement from academia and environmental institutions. The results correspond with prior investigations suggesting that the practical execution of collaboration often falls short of its theoretical ideals ^[36]. Social network analysis (SNA) of stakeholders in Sidoarjo likely reveals low academic centrality in decision making on tourism villages ^[37]. This indicates that their roles as knowledge sources, innovators, and independent evaluators remain underutilised, limiting progress toward SDG-4 (Quality Education) through research based learning and knowledge application.

An important observation reveals that community participation remains constrained, with residents having minimal influence in shaping tourism initiatives ^{[22], [38]}. This condition creates inequality in decision making and weakens community ownership of tourism village development ^[39]. Evidence from global and local cases shows that active community involvement in planning and management enhances responsibility and supports the long term sustainability of tourism initiatives ^{[21], [40]}. This is crucial for achieving SDG-10 and SDG-8 through inclusive local economic empowerment. To deepen this analysis, integration of village demographic data (age, education level, main livelihood) with socio-economic data (income levels, asset ownership) in tourist villages in Sidoarjo would be particularly relevant ^[41]. Where the majority of villagers have low levels of education and depend on the traditional agricultural sector. Tourism village development programmes should be accompanied by intensive vocational training and the establishment of strong local institutions to ensure meaningful participation ^[42]. This supports SDG-4 and SDG-8. A visual map of community participation can illustrate how engaged residents are at various stages of developing a tourism village (such as planning, implementation, monitoring, and evaluation) and help pinpoint areas with lower involvement ^{[40], [43]}. This allows for more targeted interventions, such as participatory workshops, skills training, or the establishment of more inclusive community forums.

Hence, enhancing community participation through capacity building, providing cross sector training, and fostering transparent, collaborative communication are key strategies to address these challenges ^{[25], [39]}. By equally empowering all elements of the Pentahelix, tourism village development in Sidoarjo can boost local and community income (contributing to SDG-8) while also reinforcing a sense of local ownership and pride ^[22]. This strategy offers Sidoarjo a valuable opportunity to establish itself as an educational and environmentally responsible tourism destination capable of competing at regional and national levels. This

approach reflects the principles of inclusive and sustainable development by placing communities at the core of village progress ^[7] directly contributing to SDG-11.

3.2. Examining the implementation of the pentahelix model in Sidoarjo

Beyond the material losses, the social and humanitarian impacts are far deeper. This disaster has forced over 60,000 people to lose their homes, with tens of thousands of them being relocated, severing their social and cultural roots. The prolonged compensation process and uncertainty about the future have caused long term trauma for the victims. The loss of communities, social interaction spaces, and traditional livelihoods represents a social wound that cannot be measured by numbers, yet its impact continues to be felt by the affected generations. As a form of resilience, some of the victims have creatively transformed the disaster area into a "disaster tourism" destination, an irony that has become their livelihood. Residents offer services as guides or tour operators to visitors who want to witness the eruption site firsthand, creating a microeconomic ecosystem out of the tragedy. However, it must be acknowledged that the economic turnover from this tourism activity does not compare to the scale of destruction that occurred. This initiative is more a symbol of survival than a comprehensive solution for economic recovery.



Figure 4. Field surveys in the Lapindo Mud tourism area were conducted as part of the Pentahelix collaboration. This partnership identifies potentials and challenges while formulating strategies for sustainable tourism development. Through this integrated approach, stakeholders aim to ensure the long-term environmental and socio-economic sustainability of the destination.

The figure illustrates the application of the Pentahelix model in the Lapindo Mud tourism area, highlighting collaboration among academics, government, communities, businesses, and media. This joint effort enhances data collection, incorporates multiple perspectives, and informs evidencebased planning for sustainable tourism. Through such cooperation, stakeholders support ecological balance, boost local income, promote disaster education, and demonstrate how resilient tourism can emerge from local collaboration. The Pentahelix model consists of five main actors: government, academia, the private sector, media, and local community. This collaborative model helps combine different interests and skills to achieve shared goals in tourism development. In Sidoarjo Regency, this approach has been used to promote villagebased tourism that reflects local culture and natural potential. The following part presents how the Pentahelix elements are related to the SDGs.

Academic institutions play a vital role in advancing geotourism development in the Lapindo Mud area. Research activities help to identify tourism potential, assess environmental impact, and design sustainable management plans. However, in Sidoarjo, the role of universities and researchers has not yet been fully developed. Strengthening academic involvement will improve innovation, provide accurate data, and ensure that tourism development in the region is inclusive and adaptive. Collaboration among universities, the government, and the tourism sector in the Lapindo area remains limited, resulting in researchbased training

programs that could improve tourism management not being fully optimized. academic involvement in designing sustainable tourism programs based on more in depth research will significantly support the achievement of SDG-4 and SDG-17.

The private sector, especially local investors, plays a key role in developing the Lapindo tourism area. Investments in facilities such as homestays, local culinary centers, and souvenir shops around the area have begun to emerge, providing a positive impact on the local economy. However, the development of these facilities has mostly concentrated in areas with better access, while more remote potential areas in the Lapindo region have not received adequate attention. Therefore, it is crucial for the private sector to further develop facilities in less accessible areas to create more balanced development and support SDG-8. Enhancing community involvement in tourism management, both as service providers and as guardians of cultural values, can generate sustainable economic benefits and strengthen local ownership in the development of the Lapindo tourism area.



Figure 5. Diagram of Pentahelix Concept Analysis in Sidoarjo Tourism Supporting the SDGs. This section provides a brief overview of the analysis as an initial step in exploring the Pentahelix implementation in Sidoarjo’s tourism sector.

3.2.1. Government: regulator and facilitator

The Sidoarjo district government has introduced various policies and programs to promote tourism village development [31], including budget allocations for public facilities such as geopark galleries in the Lapindo Mud area, rest areas, educational centers, and urban farming sites [27]. Infrastructure map shows good connectivity between the city centre and several potential tourism villages, but there are still gaps in remote areas. The government's role as a provider of regulations and permits has facilitated the legalisation of several tourism awareness groups (pokdarwis), although bureaucracy remains a challenge for less educated communities. According to data from the Sidoarjo Tourism Office, the number of villages applying to become tourism villages has increased, reflecting strong policy support consistent with decentralization and good governance initiatives (contributing to SDG-16).

3.2.2. Private sector/business: investors and business practitioners

The private sector plays an important role in financing, service provision, and the development of tourism facilities [38], [44]. In Sidoarjo, investments in homestays, local culinary centres, transport services and tour package management are beginning to emerge. Data from the Sidoarjo Cooperatives and MSMEs Office

indicate a rise in the number of MSMEs involved in the tourism sector, positively impacting the local economy and creating new job opportunities. For example, around the Lapindo mudflow area, several local investors have opened food stalls and souvenir shops, creating a significant economic cluster. This effort directly contributes to SDG 8, particularly target 8.3, which promotes development oriented policies that encourage productive activities, decent employment, entrepreneurship, creativity, and innovation, while fostering the formalisation and growth of micro, small, and medium enterprises. The investment distribution map shows that these economic clusters tend to be concentrated in areas with high accessibility, leaving potential in more remote areas ^[45], ^[46].

3.2.3. Academia: source of knowledge and innovation

Theoretically, academia's role in the Pentahelix model is to provide the scientific basis and innovation to support sustainable tourism development, including mapping tourism potential, training human resources and databased programme evaluation. However, in the Sidoarjo context, this role has not been maximised. Interviews with tourism village managers and government representatives show that synergies between universities, local government and tourism actors are weak ^[47], ^[48]. Internal data from several tourist villages show that researchbased training programmes from academics are minimal. This gap suggests that the potential for research and innovation from universities has not been fully utilized. In fact, the involvement of academics is crucial to achieving SDG-4 through the provision of expertise and research, and SDG-17 in knowledge exchange. The map of higher education institutions in Sidoarjo shows available academic resources, yet specific policies and forums are needed to enhance their involvement in local tourism planning and implementation.

3.2.4. Community: drivers of participation and guardians of local culture

Local communities are key to maintaining tourism sustainability. They are the direct implementers of tourism management and the custodians of local cultural values ^[49]. In Sidoarjo, the community has become active in providing homestay services, culinary specialities, handicraft products and as tour guides. This involvement fosters a sense of ownership and creates an authentic tourism experience. However, capacity building and training are still needed to enable communities to compete in providing quality and professional services. Data from government organised training programmes show that the level of community participation in management and hospitality training still needs to be improved. Limited engagement from academia and environmental organizations has also reduced opportunities for local communities to participate ^[50], ^[51], resulting in unequal decision making and a diminished sense of ownership. Empowering these communities directly contributes to SDG-1 through increased income, SDG-5 when women are involved in management, and SDG-10 by promoting local inclusion. The lack of maximum involvement from academia and environmental organisations has also resulted in limited space for local communities to participate ^[50], ^[51], leading to inequalities in decision making processes and a decreased sense of ownership. This community empowerment fundamentally supports SDG-1 through increased income, SDG-5 if it involves women in management, and SDG-10 by ensuring local inclusion.

3.2.5. Media: information and promotion channel

Media plays a vital role in promoting and disseminating information about tourist destinations ^[52]. With the help of digital and social media, tourism promotion in Sidoarjo has reached a wider market quickly and efficiently. Social media content analysis shows an increase in the number of local influencers promoting Sidoarjo tourism villages. The media has also helped shape the image and brand of tourist destinations, and become a link between tourism managers and tourists. However, communication strategies still need to be strengthened so that the messages conveyed truly illustrate local uniqueness and excellence ^[53]. Social media

engagement data shows that visual and interactive content has greater reach and impact, but not all tourist villages have an optimal content strategy^[54]. The role of this media is very supportive of SDG-17 (Partnerships for Purpose) in disseminating information and raising awareness.

3.3. Optimising spatial potential through a geospatial approach

Sidoarjo Regency in East Java possesses diverse tourism potential that can be strategically developed through the Pentahelix model^[33]. These include culinary education based on local products such as petis and smoked milkfish, mangrove and fishing village tours, batik centers, cultural festivals, agritourism, and historical attractions. Among these assets, the Lapindo mud area stands out as a unique geotourism and educational site with strong geological and socio-economic narratives^[30]. By integrating a geospatial approach and spatial mapping, these tourism resources can be systematically planned, interconnected, and developed to support sustainable destination management and regional competitiveness^[32].

Within this spatial framework, the Lapindo mud area can be positioned as a core geotourism zone that highlights its geological uniqueness while also conveying its long-term social and economic impacts^[30],^[31]. The planned development may include visitor centers, observation decks, educational trails, and eco-friendly transportation routes designed to provide meaningful learning experiences with minimal environmental disturbance. To strengthen local economic inclusion, complementary facilities such as community-based homestays, culinary hubs, cultural performance spaces, and MSME clusters can be integrated into the surrounding area, creating value chains that directly involve local communities^[2],^[32],^[38].

Several supporting functions further reinforce this integrated model. An interactive geotourism gallery can present geological processes, historical context, and social impacts of the Lapindo mudflow through educational displays, with the district government managing licensing, academics contributing scientific content, businesses investing in installations, media promoting the attraction, and local communities serving as guides^[2],^[32]. In parallel, an integrated rest area and culinary center can provide visitor convenience while showcasing local cuisine, supported by government land provision, academic market studies, business-led facility management, MSME product supply, and media promotion^[38].

In addition, multifunctional education and sports facilities, urban forests, and urban farming areas can be developed as green spaces that support environmental education, recreation, and food security^[25],^[55]. These initiatives rely on coordinated roles among stakeholders, including government land allocation and regulation, academic expertise in program design and ecological practices, business participation through operations and corporate social responsibility, media engagement to raise public awareness, and active community involvement in implementation and maintenance^[24],^[26],^[40]. Together, these facilities enhance environmental resilience while offering experiential tourism opportunities^[55].

The application of geospatial data across these initiatives directly supports SDG 11, particularly Target 11.3 on participatory, integrated, and sustainable urban planning, and also contributes to SDG 15 through conservation and urban farming efforts^[7],^[48]. Additional spatial analyses, such as accessibility maps, local human resource distribution maps, and disaster risk maps, can further strengthen planning effectiveness^[30]. Through the use of GIS, the government can formulate a more integrated and sustainable tourism village master plan, identify priority development zones, and allocate resources more efficiently, especially in areas with high geotourism potential but limited supporting infrastructure .

4. Recommendation

Based on the assessment of spatial gaps and opportunities, strategic recommendations can be proposed to overcome challenges and enhance the Pentahelix model, supporting the achievement of multiple SDGs.

4.1. Increasing community participatory capacity

Strengthening the capacity of communities to participate is essential. This can be achieved through ongoing training in tourism management, hospitality, digital marketing, financial skills, and destination storytelling, involving both academics and industry professionals. Such initiatives support SDG-4 and SDG-8. Additionally, it is important to create formal and informal platforms for communities to express their aspirations, ideas, and concerns in the planning and management of tourist villages, such as special village tourism planning meetings or the formation of representative community task forces, supporting SDG-10 and SDG-16. Strengthening the role of Tourism Awareness Groups (Pokdarwis) as the frontline of village management through financial, technical, and training support is also essential, in line with SDG-16.

4.2. Enhancing the involvement of academics and environmental organizations

Local governments can provide research funding for tourism village development projects, involving local universities to evaluate potential, impacts, and innovative approaches in sustainable tourism. This approach promotes research and innovation in line with SDG-9 and SDG-17. Additionally, integrating ecotourism and environmental conservation into school and university curricula in Sidoarjo, using tourism villages as case studies, will support the achievement of SDG-4. The establishment of a special unit at higher education institutions focused on research, training, and advocacy for sustainable tourism in Sidoarjo is also necessary to act as a strategic advisor to the government and community, strengthening the knowledge ecosystem.

4.3. Enhancing transparent and collaborative communication across sectors

Creating a shared digital platform, such as a web portal or application, allows all Pentahelix stakeholders to exchange information, track progress, and address challenges in real time, enhancing transparency and supporting SDG-16. Regular coordination meetings help evaluate progress, resolve issues, and develop new strategies, strengthening partnerships in line with SDG-17. Developing a master plan for tourism village development, agreed upon by all Pentahelix actors with clear targets and measurable indicators, improves policy effectiveness and further supports SDG-16.

4.4. Leveraging geospatial and GIS data for strategic planning

Compiling all data on tourism potential, infrastructure, demographics, and the environment into an integrated GIS database accessible to all stakeholders will promote data driven decision making, supporting SDG-17. Detailed remapping of tourism potential using GIS, including analysis of infrastructure gaps and potential for new area development, will ensure optimal planning, in line with SDG-9 and SDG-11. Finally, employing GIS to monitor the environmental and socio economic impacts of tourism development, as well as to assess program effectiveness, can ensure sustainability and support SDG-12 and SDG-13. By equally enhancing the roles of all Pentahelix actors and using geospatial data for precise, targeted planning, the development of tourism villages in Sidoarjo can increase local and community income while fostering stronger ownership and pride among residents. This strategy offers Sidoarjo the opportunity to establish itself as an educational and environmentally sustainable tourist destination capable of competing at regional and national levels. This approach also supports inclusive and sustainable development by positioning local communities as the main drivers of village progress. If implemented effectively, these recommendations can position Sidoarjo as a model of Pentahelix collaboration in developing tourism grounded in local potential. This approach will also contribute to the integrated and holistic achievement of multiple SDGs.

5. Conclusion

This study confirms that the Pentahelix model, when integrated with geospatial planning, provides an effective framework for promoting sustainable tourism village development in Sidoarjo Regency and contributes directly to the achievement of SDG 8, SDG 11, and SDG 17. Collaboration among government, academia, the private sector, communities, and media has supported improvements in infrastructure provision, destination promotion, and tourism governance, while geospatial planning enables more data-driven, integrated, and spatially balanced development, particularly in complex areas such as the Lapindo mud geotourism zone. In the long term, the sustainability of tourism village development depends on the continuity of stakeholder collaboration and the strengthening of local capacity building. Institutionalising Pentahelix partnerships, enhancing community participation, and reinforcing the role of academia in research-based planning are essential to maintain innovation, local ownership, and adaptive governance. This study is subject to several limitations. The findings are based on a qualitative approach and a limited study area, which may restrict their generalisability. In addition, the geospatial analysis remains largely descriptive and has not yet incorporated advanced quantitative spatial modelling. Future research is therefore encouraged to adopt comparative studies across regions, apply more quantitative and spatially explicit GIS methods, and use longitudinal designs to assess the long-term sustainability of tourism villages and stakeholder collaboration. Overall, this study demonstrates that the integration of Pentahelix collaboration and geospatial planning can serve as a replicable and inclusive model for sustainable tourism development in other regions.

Author contributions

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Conflict of interest

The authors declare no conflict of interest

References

1. K. Fuchs, "Navigating the Fine Line of Sustainable Tourism: A Critical Analysis with Implications for Tourism Planning," *J. Environ. Manag. Tour.*, vol. 14, no. 4, pp. 1908–1914, 2023, doi: 10.14505/jemt.v14.4(68).02.
2. I. Tulbure and E. M. Eduard, "Opportunities And Challenges In Achieving Sustainable Tourism On Regional Level," in *International Multidisciplinary Scientific GeoConference Surveying Geology and Mining Ecology Management, SGEM*, 2024, pp. 165–172. doi: 10.5593/sgem2024/5.1/s20.23.
3. H. Özgüt, "How should small island developing states approach long-term sustainable development solutions? A thematic literature review," *Worldw. Hosp. Tour. Themes*, vol. 14, no. 4, pp. 323–328, 2022, doi: 10.1108/WHATT-03-2022-0039.
4. A. Safari, L. Afriza, and A. Riyanti, "Tourism Village Assistance in Purwakarta Regency (Case Study of Indonesian Wanayasa Village)," *Asian J. Bus. Res.*, vol. 13, no. 2, pp. 1–24, 2023, doi: 10.14707/ajbr.230147.

5. A. Sulistyono and I. Fatmawati, "Community-Based Village Management Independence in Efforts to Create Sustainable Tourism (Panglipuran Tourism Village Phenomena)," in *E3S Web of Conferences*, 2023. doi: 10.1051/e3sconf/202344401013.
6. G. N. Ikhtiangung and M. R. Radyanto, "New Model for Development of Tourism Based on Sustainable Development," in *IOP Conference Series: Earth and Environmental Science*, 2020. doi: 10.1088/1755-1315/448/1/012072.
7. L. Noviana, M. T. N. Situmorang, B. Cahyaputri, F. Farida, and T. Sukwika, "Analysis of Pentahelix Tourism Village for Ecotourism Development in Batu City, East Java," *Int. J. Sustain. Dev. Plan.*, vol. 20, no. 3, pp. 1273–1282, 2025, doi: 10.18280/ijstdp.200332.
8. Ilyana Janis, "Strategies for Establishing Dependability between Two Qualitative Intrinsic Case Studies: A Reflexive Thematic Analysis," *Field methods*, vol. 34, no. 3, pp. 240–255, Feb. 2022, doi: 10.1177/1525822X211069636.
9. M. Xiao, S. Luo, and S. Yang, "Synergizing Technology and Tradition: A Pathway to Intelligent Village Governance and Sustainable Rural Development," *J. Knowl. Econ.*, vol. 16, no. 1, pp. 1768–1823, 2025, doi: 10.1007/s13132-024-01937-6.
10. C. M. Hall, "Constructing sustainable tourism development: The 2030 agenda and the managerial ecology of sustainable tourism," *J. Sustain. Tour.*, vol. 27, no. 7, pp. 1044–1060, Jul. 2019, doi: 10.1080/09669582.2018.1560456.
11. M. A. Fauzi, "Sustainable tourism and sustainable development goals (SDGs): a state-of-the-art review of past, present, and future trends," *Environ. Dev. Sustain.*, vol. 27, no. 2, pp. 2841–2862, 2025, doi: 10.1007/s10668-023-04077-0.
12. A. Ouellet, "Integrated rural tourism in Basse-Casamance (Senegal). Survival of a community-based tourism project in a crisis context?," *BELGEO*, vol. 1, 2024, doi: 10.4000/127hj.
13. B. P. S. K. Sidoarjo, "Statistik Pariwisata Kabupaten Sidoarjo 2024," 205AD, *Badan Pusat Statistik Kabupaten Sidoarjo, Sidoarjo*.
14. E. Barroga and G. J. Matanguihan, "A Practical Guide to Writing Quantitative and Qualitative Research Questions and Hypotheses in Scholarly Articles," *J. Korean Med. Sci.*, vol. 37, no. 16, pp. 1–18, 2022, doi: 10.3346/jkms.2022.37.e121.
15. M. Hosseini and Å. Haukås, "Beyond Macroethics: Developing an Ethical Framework for Interview Data Collection and Analysis to Acknowledge Participant Rights," *J. Acad. Ethics*, 2025, doi: 10.1007/s10805-024-09594-9.
16. M. Nordtug and M. Haldar, "Ethics Beyond the Checklist: Fruitful Dilemmas Before, During, and After Data Collection," *Qual. Inq.*, vol. 30, no. 6, pp. 474–483, 2024, doi: 10.1177/10778004231176088.
17. M. ÖZDEN, "Content and Thematic Analysis Techniques in Qualitative Research: Purpose, Process and Features," *Qual. Inq. Educ. Theory Pract.*, vol. 2, no. 1, pp. 64–81, 2024, doi: 10.59455/qietp.20.
18. A. Zhaksylyk, O. Zimba, M. Yessirkepov, and B. F. Kocyigit, "Research Integrity: Where We Are and Where We Are Heading," *J. Korean Med. Sci.*, vol. 38, no. 47, pp. 1–11, 2023, doi: 10.3346/jkms.2023.38.e405.
19. J. Matas, "Publication and Dissemination of Research Results," pp. 93–105, 2023, doi: 10.1007/978-3-031-22412-6_7.
20. M. Kessler, F. Marino, and D. Liska, "Netnographic research ethics in applied linguistics: A systematic review of data collection and reporting practices," *Res. Methods Appl. Linguist.*, vol. 2, no. 3, p. 100082, 2023, doi: <https://doi.org/10.1016/j.rmal.2023.100082>.
21. N. Chamidah, B. Guntoro, and E. Sulastri, "Marketing communication and synergy of pentahelix strategy on satisfaction and sustainable tourism," *J. Asian Financ. Econ. Bus.*, vol. 7, no. 3, pp. 177–190, 2020, doi: 10.13106/jafeb.2020.vol7.no3.177.
22. R. M. W. A. Pradhipta and F. Nofiyanti, "Penta Helix Strategy in Rural Tourism (Case Study of Tugu Utara Bogor)," in *E3S Web of Conferences*, J. Prof., S. P., T. M.M., and R. Z., Eds., Hospitality and Tourism, Stp Trisakti, IKPN Bintaro, Jakarta Selatan, 12330, Indonesia: EDP Sciences, 2021. doi: 10.1051/e3sconf/202123204010.
23. S. S. Iriani *et al.*, "Sustainable tourism village development through pentahelix collaboration: A pathway to achieving SDGs," in *E3S Web of Conferences*, 2025. doi: 10.1051/e3sconf/202564001004.
24. D. F. Eprilianto *et al.*, "Pentahelix collaborative analysis through stakeholder engagement in realizing sustainable environmentally based tourism village governance to support the achievements of the Village SDGs," in *E3S Web of Conferences*, S. N., P. B.K., S. M., L. L., A. G. M., and A. S., Eds., Department of Public Administration, Faculty of Social and Political Sciences, State University of Surabaya, Surabaya, 60231, Indonesia: EDP Sciences, 2024. doi: 10.1051/e3sconf/202456804002.
25. W. T. Hardianto, M. R. K. Muluk, and F. Wijaya, "PentaHelix synergy on tourism development in Batu, East Java," *Int. J. Innov. Creat. Chang.*, vol. 10, no. 6, pp. 137–149, 2019, [Online]. Available:

<https://www.scopus.com/inward/record.uri?eid=2-s2.0-85079657746&partnerID=40&md5=fbbc1f2424d5fb4700e2113a1b7e4adf>

26. N. Chamidah, B. Guntoro, and E. Sulastri, "Marketing communication and synergy of pentahelix strategy on satisfaction and sustainable tourism," *J. Asian Financ. Econ. Bus.*, vol. 7, no. 3, pp. 177–190, 2020, doi: 10.13106/jafeb.2020.vol7.no3.177.
27. S. Latifah *et al.*, "Pemetaan Dan Pengembangan Data Desa Presisi Untuk Jalur Wisata Berbasis Mobile Webgis Di Lingkar Geopark Rinjani," *JMM (Jurnal Masy. Mandiri)*, vol. 7, no. 2, p. 1271, 2023, doi: 10.31764/jmm.v7i2.13487.
28. S. S. Iriani, D. A. Nuswantara, D. Nugrohoseno, P. S. Sukardani, F. Pribadi, and R. D. Junianta, "Enhancing Tourism Villages Through VRIN Resources and Local Endorsement: A Resource-Based View on Achieving Sdgs in Rural Development," *J. Lifestyle SDGs Rev.*, vol. 5, no. 2 SE-, p. e02740, Nov. 2024, doi: 10.47172/2965-730X.SDGsReview.v5.n02.pe02740.
29. A. Gantait, R. Mathew, P. Chatterjee, and K. Singh, "Community-based tourism as a sustainable direction for the tourism industry: Evidence from the Indian sundarbans," in *Interlinking SDGs and the Bottom-of-the-Pyramid Through Tourism*, 2024, pp. 197–217. doi: 10.4018/979-8-3693-3166-8.ch009.
30. R. Maulana and I. Bagus, "Strategi Pengembangan Lumpur Lapindo Sebagai Wisata Edukasi Di Kabupaten Sidoarjo Jawa Timur," vol. 7, no. 2, pp. 281–287, 2019.
31. F. Mutia, A. Avenzoar, and F. Zahroh, "The Effect of Urban Spatial Configuration on Sustainable Tourism Development in Jabon District, Sidoarjo," *EMARA Indones. J. Archit.*, vol. 7, no. 2, pp. 68–74, 2022, doi: 10.29080/eija.v.
32. L. R. R. U. Tampubolon, S. Marwiyah, and E. Haryati, "Integrating CBT and SWOT models for marine ecotourism management in Tlocor Indonesia," *Cogent Soc. Sci.*, vol. 11, no. 1, 2025, doi: 10.1080/23311886.2025.2494713.
33. A. R. U. Balahmar, E. Rustianingsih, I. U. Choiriyah, H. Sukmana, and T. W. Abadi, "Geopark lumpur investment development Sidoarjo East Java Indonesia," *J. Leg. Ethical Regul. Issues*, vol. 24, no. Special Issue 1, pp. 1–7, 2021, [Online]. Available: <https://www.scopus.com/inward/record.uri?eid=2-s2.0-85112862855&partnerID=40&md5=f6800d78571049e4a0a80e47aa6c059d>
34. N. Karimov *et al.*, "The Ecotourism Industry's Role in Environmental Stewardship," *Nat. Eng. Sci.*, vol. 9, no. 2, pp. 293–308, 2024, doi: 10.28978/nesciences.1574450.
35. L. Živković, J. Jovanović, I. Đorđević, and T. Janković, "Educational tourism in the function of the environmental protection," *Zb. Rad. - Geogr. Fak. Univ. u Beogradu*, no. 70, pp. 73–81, 2022, doi: 10.5937/zrgfub2270073z.
36. M. Grafström, A. Jonsson, and M. Klintman, "Embracing the academic–practice gap: Knowledge collaboration and the role of institutional knotting," *Manag. Learn.*, 2023, doi: 10.1177/13505076231213056.
37. S. Kang, W. G. Kim, and D. Park, "Understanding tourist information search behaviour: the power and insight of social network analysis," *Curr. Issues Tour.*, vol. 24, no. 3, pp. 403–423, 2021, doi: 10.1080/13683500.2020.1771290.
38. A. Sahabudin, "Local Culinary Entrepreneurship As The Development Of Regional Gastronomy And Urban Tourism," *J. Khazanah Intelekt.*, vol. 5, no. 3, pp. 1229–1250, 2022, doi: 10.37250/newkiki.v5i3.123.
39. Y. Yasir, Y. Firzal, A. Sulistyani, and C. Yesicha, "Penta helix communication model through community based tourism (CBT) for tourism village development in Koto Sentajo, Riau, Indonesia," *Geoj. Tour. Geosites*, vol. 37, no. 3, pp. 851–860, 2021, doi: 10.30892/GTG.37316-718.
40. R. Pratiwi *et al.*, "The Collaboration of Penta Helix to Develop Halal Tourism Villages in Batang, Cental Java," *Int. J. Sustain. Dev. Plan.*, vol. 19, no. 7, pp. 2753–2761, 2024, doi: 10.18280/ijdp.190732.
41. A. Choi and I. E. Schneider, "Acculturation and tourist stress among US Korean immigrant leisure travelers," *J. Int. Migr. Integr.*, vol. 24, no. 3, pp. 1159–1174, 2023, doi: 10.1007/s12134-022-00997-4.
42. R. B. Mathafena and A. Grobler, "The effectiveness of human resources practices in driving proactive experimentation and risk-taking work behaviours in organisations," *SA J. Hum. Resour. Manag.*, vol. 18, pp. 1–11, 2020, doi: 10.4102/sajhrm.v18i0.1259.
43. S. A. Hazaimah, S. Elbanna, and T. Fatima, "Education and employment reforms toward developing human capital: the case of Qatar," *CASE J.*, vol. 19, no. 2, pp. 252–272, 2023, doi: 10.1108/TMJ-09-2021-0153.
44. R. Scuderi, "Special Focus: Local resources for tourism – from impact to growth," *Tour. Econ.*, vol. 24, no. 3, pp. 294–296, 2018, doi: 10.1177/1354816618758728.
45. H. Liu and R. Li, "The Impact of Spatial Layout of Emerging Industry Clusters Development on Economic Structural Adjustment," *J. World Econ.*, vol. 3, no. 1, pp. 49–54, 2024, doi: 10.56397/jwe.2024.03.07.
46. G. Wei, P. Sun, Z. Zhang, and X. Ouyang, "The Coordinated Relationship between Investment Potential and Economic Development and Its Driving Mechanism: A Case Study of the African Region," *Sustainability*, vol. 12, p. 442, Jan. 2020, doi: 10.3390/su12010442.

47. T. Arrahman and I. L. Suwaryono, "The Penta Helix Model In The Development Efforts Of Agro-Tourism Village Kubu Gadang, Padang Panjang City," *J. Adm. Dan Kebijak. Kesehat.*, vol. 5, no. 2, pp. 238–247, 2024, [Online]. Available: <http://jakp.fisip.unand.ac.id/index.php/jakp/article/view/139>
48. R. Febrianto, Gatot Adi Susilo, B. Teguh Ujjianto, and Sudiro, "Kajian Kontribusi Pentahelix Pada Desa Wisata Berdasarkan Sustainable Tourism Development," *Pros. SEMSINA*, vol. 4, no. 2, pp. 147–152, 2024, doi: 10.36040/semsina.v4i2.8069.
49. D. Cahyaningrum, T. D. Hasani, N. Wayan, A. Mutiara, and D. Safitri, "The Role of Community Participation Toward Economic Empowerment in the Tourism Sector," vol. 2, no. 04, pp. 1150–1158, 2024.
50. A. D. Amelia and Ety Dwi Susanti, "Peran Komunitas Lokal Dalam Membangun Pariwisata Berkelanjutan (Studi Kasus Lumbung Stroberi)," *J. Publicuho*, vol. 7, no. 2, pp. 874–883, 2024, doi: 10.35817/publicuho.v7i2.443.
51. J. Mabbott, "The Role of Community Involvement," *Policy Stud.*, vol. 14, no. 2, pp. 27–35, 1993, doi: 10.1080/01442879308423637.
52. Y. Bachtiar and B. Bernanthos, "The Role of Social Media in Promoting Tourism Villages : A Case Study in Semarang Regency," pp. 1–8, 2024.
53. H. Prasetyo, N. Irawati, and Z. Satriawati, "Pemanfaatan Media Sosial sebagai Sarana Pemasaran Desa Wisata," *Ideas J. Pendidikan, Sos. dan Budaya*, vol. 9, no. 2, p. 515, 2023, doi: 10.32884/ideas.v9i2.1281.
54. D. Andzani, D. Virgin, and N. Setijadi, "Peran Media Sosial Dalam Membangun Citra Destinasi Pariwisata Yang Menarik," *JMBI UNSRAT (Jurnal Ilm. Manaj. Bisnis dan Inov. Univ. Sam Ratulangi)*, vol. 11, no. 1, pp. 188–195, 2024, doi: 10.35794/jmbi.v11i1.53212.
55. E. Tadung, "Opportunities and Challenges of Pentahelix Collaboration for Poverty Alleviation in Indonesia: A Systematic Literature Review," *KnE Soc. Sci.*, vol. 2023, pp. 289–303, 2023, doi: 10.18502/kss.v8i17.14122.