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Analysis of Pentahelix Tourism Village for Ecotourism Development in Batu City, East Java

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ABSTRACT

East Java Province, particularly Batu City, is a significant tourism hub offering opportunities for investment in artificial and ecological attractions. Batu City is adopting sustainable tourism through ecotourism, emphasizing environmental preservation, community empowerment, and socio-economic benefits. However, unplanned development of tourist villages can lead to negative impacts such as environmental damage and cultural erosion. Effective ecotourism management requires active community involvement and coordinated stakeholder efforts. This study examines the role of Pentahelix—comprising government, private sector, academia, media, and community—in developing sustainable ecotourism-based tourist villages. The research identifies key Pentahelix elements influencing this development. Data was collected through surveys, interviews, and observations involving village leaders, tourism community organizations, academics, media, and investors. The study utilized Interpretative Structural Modeling (ISM) for analysis, supported by Exsimpro software. ISM provided a systematic framework to prioritize and understand interactions among variables, offering actionable insights for stakeholders. Findings reveal that successful ecotourism development depends on five key variables: regulations and policies, research and development, private investment, community participation, and media reach. Clear rules, thorough research, private sector investment, active community involvement, and effective media strategies are crucial for optimizing sustainable ecotourism benefits and ensuring the growth of tourist villages.

1. INTRODUCTION

East Java Province is a crucial destination for tourism visits. One of the autonomous regions in East Java is Batu City. The Batu City government offers opportunities for tourism investors to invest in artificial tourist attractions, such as Batu Night Spectacular (BNS), the Museum of Animals, and several other Jatim Parks and ecological tourism.

Currently, Batu City is adopting the concept of sustainable tourism, which is environmentally conscious and community-empowering, known as ecotourism. Ecotourism is a form of tourism that focuses on environmental preservation, community empowerment, and social, educational, and economic aspects [1-3]. One way to integrate conservation, community, and tourism is by educating tourists, especially local communities, tour guides, and stakeholders. Ecotourism generally has more positive impacts than negative ones, supports conservation, and strengthens resource management [4-6].

The concept of a tourist village involves developing and empowering communities based on the potential of specific areas by showcasing the village's natural beauty, culture, and customs. Designating a village as a tourist destination aims to develop the village's unique characteristics into tourist attractions while empowering local communities. Developing a tourist village must optimize natural and cultural strengths to ensure sustainable economic, social, and environmental growth [7-9].

Unplanned development of tourist villages can lead to negative externalities such as environmental damage, erosion of local culture, and socio-economic inequality. One factor that drives tourism engagement is community involvement. Ecotourism management is generally still centralized, with insufficient involvement of local communities and stakeholder coordination [3, 10]. Therefore, a comprehensive and sustainable approach is necessary for developing tourist villages.

The Pentahelix model, which integrates five key actors—government, private sector, academia, media, and community—provides a robust framework for sustainable tourism development [11-13]. In the context of ecotourism, the Pentahelix model ensures that all stakeholders work together to balance environmental, economic, and social objectives. Each actor plays a distinct yet interconnected role: the government provides regulatory support and infrastructure, the private sector drives investment and innovation, academia contributes research and knowledge, media promotes awareness and engagement, and the community ensures local

participation and cultural preservation [14, 15]. This multi-stakeholder collaboration is critical for addressing the complex challenges of ecotourism development, such as resource management, community empowerment, and environmental sustainability.

Despite its potential, the application of the Pentahelix model in ecotourism-specific contexts remains underexplored. While the model has been widely recognized for its ability to foster collaboration, its implementation in ecotourism development, particularly in tourist villages, requires further examination [15-17]. For instance, how can the Pentahelix model be tailored to address the unique challenges of ecotourism, such as biodiversity conservation, waste management, and cultural authenticity? How can the roles of each actor be optimized to ensure sustainable outcomes? These questions highlight the need for a deeper understanding of the Pentahelix model in ecotourism contexts.

The more significant the role of Pentahelix actors in village development, the more likely the village is to become a thriving and advanced tourist destination. The success of village programs relies on the involvement of Pentahelix actors, particularly local communities. To realize a sustainable ecotourism-based tourist village that provides optimal benefits, the Pentahelix must be involved. The resulting partnership model will be a system of interaction and collaboration aimed at developing a sustainable ecotourism-based tourist village.

This study examines the role of Pentahelix in the development of a sustainable ecotourism-based tourist village and identifies which key elements of Pentahelix are most influential in this development. The study aims to identify potential tourist attractions in sustainable ecotourism-based villages and determine the key Pentahelix elements that drive the development of such tourist villages.

2. MATERIALS AND METHODS

This research was conducted from July to August 2024 in the tourist village of Batu City, East Java. The data collection utilized a survey method incorporating interviews and observations. The collected data comprised primary data from questionnaires, field observations, and expert interviews, and secondary data from literature reviews and reports from the Batu City Government Tourism and Sports Department. Primary stakeholders included village institution leaders, tourism community organizations, academics, media representatives, and tourism investors.

The study employed Interpretive Structural Modeling (ISM) to analyze ecotourism development factors. ISM is a participatory method that transforms complex systems into hierarchical models, ideal for multi-stakeholder contexts [18]. This technique is widely used in strategic planning and decision-making for sustainable tourism. The process involved [19]: a) Identifying variables: Derived from literature and stakeholder input. b) Pairwise comparison: Stakeholders rated interdependencies between variables. c) Matrix analysis: Conducted via Exsimpro software to generate a structured model.

ISM classified variables into four sectors—autonomous, dependent, interconnected, and independent—to prioritize strategic actions (Figure 1). This approach is in line with the use of ISM by several previous researchers in tourism planning, ensuring methodological consistency and theoretical validity [20-22].

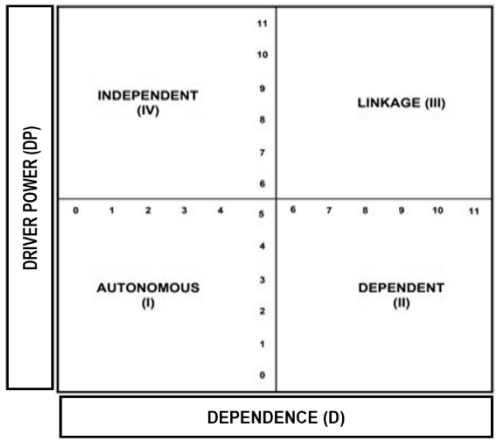


Figure 1. DP-D matrix for ecotourism development elements in tourism villages

2.1 Rationale for ISM selection

ISM was chosen because traditional statistical and operational research techniques often struggle to capture the behavioral and systemic complexities involved in long-term strategic planning [19]. By incorporating expert opinions and empirical data, ISM offers a practical and structured approach for analyzing multi-stakeholder decision-making in ecotourism development [3, 14, 23].

ISM has been widely recognized for its ability to identify hierarchical relationships among variables, making it a robust tool for strategic planning in ecotourism. For instance, Firmansyah et al. [24], Darmawan et al. [20], and Hussain et al. [21] applied ISM to map the interdependencies among factors influencing sustainable tourism in rural Indonesia, emphasizing stakeholder collaboration and policy frameworks. Their findings underscore ISM's utility in clarifying causal relationships, which directly supports this study's focus on the Pentahelix framework's multi-stakeholder dynamics. Similarly, Hidayatullah et al. [15], Hussain et al. [21], and Tubastuvi et al. [22] utilized ISM to pinpoint critical success factors for ecotourism, highlighting environmental conservation and community empowerment as foundational pillars—a framework that resonates with Batu City's ecotourism goals.

The Pentahelix model, integrating government, private sector, academia, media, and community, draws theoretical support from multi-stakeholder approaches in sustainable tourism. Kartika et al. [11], Sutomo et al. [25], and Yasir et al. [26] argued that collaborative governance involving diverse stakeholders enhances resource management and cultural preservation, a principle central to the Pentahelix framework. Hussain et al. [21] further demonstrated that stakeholder synergy drives innovation and accountability in tourism development, reinforcing the need for structured models like ISM to map these interactions. Additionally, Firmansyah et al. [24] validated ISM's efficacy in modeling stakeholder dependencies in sustainable aspects, providing a methodological precedent for this study's use of Exsimpro software to enhance analytical precision.

3. RESULT AND DISCUSSION

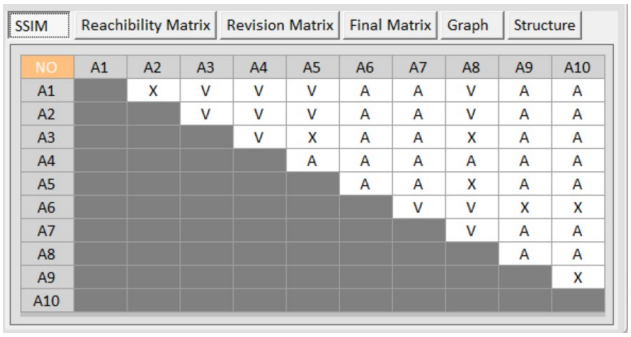
Our Pentahelix study of tourist villages, aimed at developing ecotourism, was based on the results of FGDs and

in-depth interviews. The study involved a diverse group of 10 representatives from the tourism office/related institutions, village government, tourism village forum organization, Batu City tourism media, PT. Batu Flower Garden, and academics/researchers at Brawijaya University. This comprehensive approach ensured a thorough understanding of the 10 key elements necessary for developing tourist villages, as presented in Table 1. In addition, we conducted in-depth interview activities through direct interviews with 30 tourism actors and local communities at the research location, ensuring a hands-on approach to our research.

At this stage, each program element studied is broken down into several sub-elements based on the respondents' opinions. These sub-elements are then used to establish contextual relationships, which are crucial for conducting pairwise comparisons. For instance, we might ask, 'Is goal A more important than goal B?' The respondents' opinions guide these comparisons. The consideration of these contextual relationships leads to the creation of a Structural Self-Interaction Matrix (SSIM), a key tool in our research.

Table 1. Key elements for the need to develop ecotourism in the Batu City tourism village

No	Key Elements of the Need for Ecotourism Development in Tourism Villages	Code
1	Local community participation	E1
2	Frequency of news coverage about tourist villages	E2
3	Tourism management innovation	E3
4	Regulations and policies	E4
5	Tourism village research	E5
6	Availability of public facilities	E6
7	Media coverage and reach	E7
8	Level of investment in the rural tourism sector	E8
9	Management of the environment	E9
10	Tourist satisfaction	E10

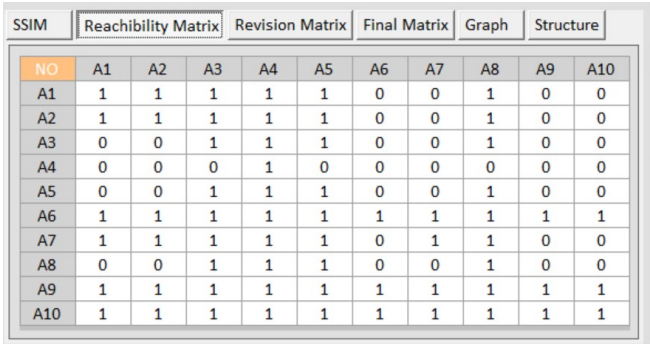


NO	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
A1		X	V	V	V	A	A	V	A	A
A2			V	V	V	A	A	V	A	A
A3				V	X	A	A	X	A	A
A4					A	A	A	A	A	A
A5						A	A	X	A	A
A6							V	V	X	X
A7								V	A	A
A8									A	A
A9										X
A10										

Figure 2. Results of the SSIM

The meaning of a value of 1 means there is a contextual relationship between sub-elements, while a value of 0 means there is no contextual relationship between sub-elements. The assessment results are arranged in a SSIM. SSIM is made in the form of a Reachability Matrix (RM) table by replacing V, A, and ib = 0, which means that element A is more influential than element B. (2) A if ia = 0 and ib = 1; means that element A is more influential than element B. (3) X if ia = 1 and ib = 1; means that element A has the same effect as element B. (4) O if ia = 0 and ib = 0; This means that elements A and elements B have no influence.

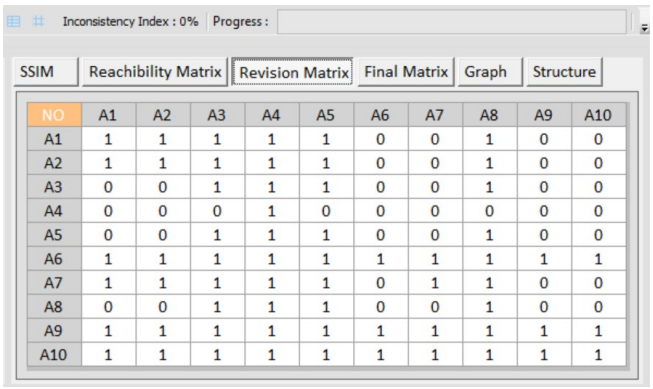
The key needs elements produced in Table 2 were then analyzed for the relationship between the sub-elements of needs for tourism village development using the ISM-VAXO matrix technique on the SSIM, which can be seen in Figure 2.



NO	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
A1	1	1	1	1	1	0	0	1	0	0
A2	1	1	1	1	1	0	0	1	0	0
A3	0	0	1	1	1	0	0	1	0	0
A4	0	0	0	1	0	0	0	0	0	0
A5	0	0	1	1	1	0	0	1	0	0
A6	1	1	1	1	1	1	1	1	1	1
A7	1	1	1	1	1	0	1	1	0	0
A8	0	0	1	1	1	0	0	1	0	0
A9	1	1	1	1	1	1	1	1	1	1
A10	1	1	1	1	1	1	1	1	1	1

Figure 3. Results of reachability matrix

The following step of analysis is to change the Reachability Matrix (RM) into binary numbers for the sub-element aspects of requirements. The data comes from the opinions of experts who are competent in their fields, then entered into the SSIM matrix and converted into binary numbers to form the RM matrix in Figure 3. RM is obtained by converting data from the letters V, A, X, and O into binary numbers (0 and 1). RM preparation is conducted by calculating respondent answer mode data. The cell mode is obtained by calculating the scoring number that appears the most (mode data), which can be seen in Figure 3.



NO	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
A1	1	1	1	1	1	0	0	1	0	0
A2	1	1	1	1	1	0	0	1	0	0
A3	0	0	1	1	1	0	0	1	0	0
A4	0	0	0	1	0	0	0	0	0	0
A5	0	0	1	1	1	0	0	1	0	0
A6	1	1	1	1	1	1	1	1	1	1
A7	1	1	1	1	1	0	1	1	0	0
A8	0	0	1	1	1	0	0	1	0	0
A9	1	1	1	1	1	1	1	1	1	1
A10	1	1	1	1	1	1	1	1	1	1

Figure 4. Results of revision matrix and inconsistecy index

Figure 4 above is the result of the Interpretive Structural Modeling (ISM) method, specifically at the Revision Matrix stage, which shows the relationships between factors in the development of ecotourism in the Pentahelix Tourism Village, Batu City. One important indicator displayed is the Inconsistency Index, which, in this case, has a value of 0% [18, 19, 27]. An Inconsistency Index value of 0% in the ISM model indicates that the relationships between factors in this model are entirely consistent. No contradictions or anomalies were found in the analyzed relationships between factors, making the resulting model structure reliable [18]. With this strong validity, the analysis results can be used to make decisions and further develop Pentahelix-based ecotourism in Batu City [28].

In the ISM method, inconsistencies typically arise if there are mismatches between the reachability matrix and the revision matrix [19]. However, with an Inconsistency Index of 0%, it can be concluded that there are no logical errors or contradictions in the revision of the relationships between factors. It confirms that the resulting model has undergone a systematic analysis process and does not require additional improvements regarding the relationships between the

determined factors [27].

SSIM | Reachibility Matrix | Revision Matrix | Final Matrix | Graph | Structure

NO	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	DP	R
A1	1	1	1	1	1	0	0	1	0	0	6	3
A2	1	1	1	1	1	0	0	1	0	0	6	3
A3	0	0	1	1	1	0	0	1	0	0	4	4
A4	0	0	0	1	0	0	0	0	0	0	1	5
A5	0	0	1	1	1	0	0	1	0	0	4	4
A6	1	1	1	1	1	1	1	1	1	1	10	1
A7	1	1	1	1	1	0	1	1	0	0	7	2
A8	0	0	1	1	1	0	0	1	0	0	4	4
A9	1	1	1	1	1	1	1	1	1	1	10	1
A10	1	1	1	1	1	1	1	1	1	1	10	1
D	6	6	9	10	9	3	4	9	3	3		
L	3	3	2	1	2	5	4	2	5	5		

Figure 5. Driver power matrix final result – dependability

From the results of the RM matrix in Figure 5, proceed with adjusting the RM elements to the needs aspect. Adjust the binary numbers to get Rank (R), Driver Power Value (DP), Level (L), and Dependent (D). The DP value is obtained by adding binary numbers in one row. The R-value is obtained by sorting the DP values. The D value is obtained by adding the binary numbers in one column. The L value is obtained by sorting the D values. The results of adjusting binary numbers from expert opinion in RM and the relationship between sub-elements of economic aspects can be seen in Figure 5.

ISM, with its precision, can identify problem elements, providing a clear and reliable picture. This clarity allows for a transfer into more detailed sub-elements. The classification of management strategies is then divided into 4 (four) quadrants, namely: (a) Quadrant I: Weak driving interaction with a weak dependent variable (autonomous); this quadrant is not related to the system and may have a little relationship in the position: Drive Power (DP) value 0.5X and Dependent Value (D) 0, 5X, where X is the number of sub-elements. (b) Quadrant II: Interaction of weak drivers with strongly dependent variables. This quadrant is included in the dependent sub-element with position: DP value 0.5 X and D values > 0.5X. (c) Quadrant III: The interaction of strong drivers with highly dependent variables (linkage). This quadrant is included in the relationship between unstable sub-elements, entering the position DP value > 0.5X and D value > 0.5X. (d) Quadrant IV: Interaction of strong drivers with weak dependent variables (independent). This quadrant is included in the remaining part of the system, and the independent variables are in the position DP value > 0.5X and D value 0.5X.

Figure 6 presents a quadrant classification of driving forces and dependency, which helps in understanding the relationships between different sub-elements in the context of tourism village development. The classification is based on two main factors: Driving Power (DP) and Dependency (D). The sub-elements are categorized into four quadrants: Autonomous (Quadrant I), Dependent (Quadrant II), Linkage (Quadrant III), and Independent (Quadrant IV).

In this classification, no sub-elements fall into the Autonomous Quadrant, indicating that all elements are interconnected within the system. Sub-elements E1 and E2 are located in the Linkage Quadrant, meaning they have unstable but significant relationships with other variables, particularly those in the Dependent Quadrant. Sub-elements in the Linkage Quadrant are closely interrelated, so changes in one can affect others. The Dependent Quadrant includes sub-elements E3, E5, E8, and E4, which rely on inputs and actions from the Independent Quadrant. The Independent Quadrant contains sub-elements E6, E9, E10, and E7, which are key drivers with high DP and low D.

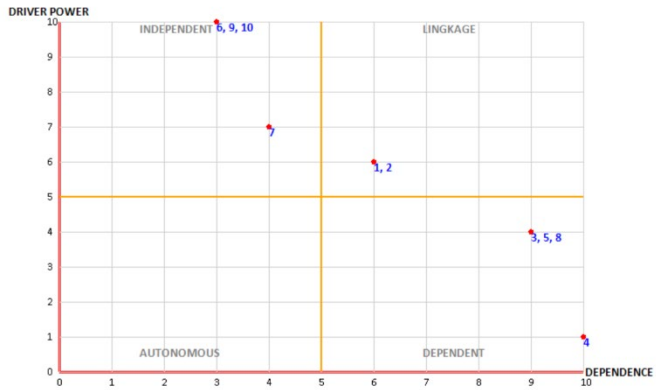


Figure 6. Quadrant classification of driving forces – dependency

The power-dependence driver matrix analysis results on ecotourism development needs in tourist village areas have identified four key subelements (Figure 6) in sector IV (Independent Quadrant). When viewed in a hierarchical structure, these four key subelements wield significant influence in shaping tourism village development policy. Their role is pivotal, as it allows for the determination of policy direction based on their ranking order, from the highest level (level 5) to the lowest level (level 1). The structure of the relationship between these subelements in the elements of ecotourism development needs in the tourist village area is depicted in Figure 7, highlighting their influential role in policy formulation.

In the first policy sequence, namely at level 5, 3 interrelated subelements must be prioritized. In this case, it means that the development of ecotourism in tourist villages is essential to provide public facilities (E6), environmental management (E9), and increase tourist satisfaction (E10). Ecotourism development must be prioritized in the Batu City tourist village area by providing public facilities, environmental management, and growing tourist satisfaction. Good public facilities increase comfort and accessibility, while effective environmental management maintains the sustainability of natural resources. In turn, high tourist satisfaction will encourage repeat visits and positive promotions, impacting the economic progress of tourist villages.

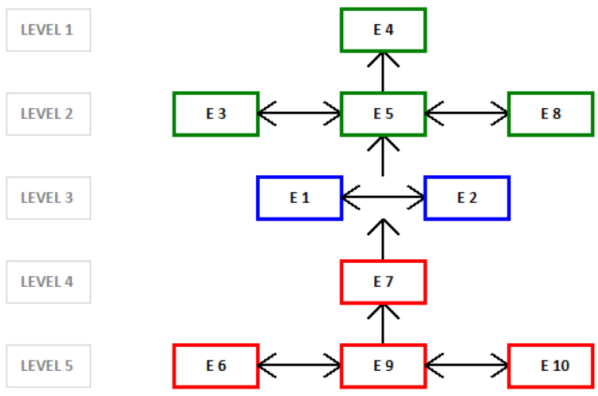


Figure 7. ISM hierarchical structure for tourism village development

Providing adequate public facilities is key to improving the quality of the tourist experience. Research by Bhuiyan et al. [29], Ching et al. [30], and Harianto et al. [10] underline that good facilities, such as easy accessibility and adequate sanitation facilities, are critical to support the success of ecotourism and increase visitor satisfaction. Effective environmental management is an essential aspect of ecotourism development. Good environmental management not only maintains natural beauty but also increases tourist destinations' attractiveness by reducing human activities' negative impacts [9, 31]. Increased tourist satisfaction is directly related to the experiences offered by the destination. Tourist satisfaction can be increased through quality service and satisfying experiences, encouraging return visits and positive recommendations [32-34]. Therefore, it is essential to integrate facility development, environmental management, and services in ecotourism development strategies to ensure a satisfying and sustainable tourist experience [1, 24, 35].

The success of two key sub-elements at level 5 will push the next level to level 4: media coverage and reach (E7). Effective media is crucial in expanding visibility and attracting visitors to tourist villages. However, the role of social media in increasing awareness and attracting new tourists, as highlighted by Kiráľová & Pavlíčeka [36] and Kolb [37], is equally significant. Hays et al. [38] added that digital media strategies help promote destinations widely and effectively. Research by Irfan et al. [39] emphasized the importance of social media for sustainable tourism development. In addition, Kolb [37] underlines the role of the media in building a positive image of tourist destinations.

The success of two key sub-elements at level 5 will push the next level to level 4: media coverage and reach (E7). Effective media is crucial in expanding visibility and attracting visitors to tourist villages. However, the role of social media in increasing awareness and attracting new tourists, as highlighted by Kiráľová and Pavlíčeka [36] and Kolb [37], is equally significant. Hays et al. [38] added that digital media strategies help promote destinations widely and effectively. Research by Irfan et al. [39] emphasized the importance of social media for sustainable tourism development. In addition, Kolb [37] underlines the role of the media in building a positive image of tourist destinations.

Suppose media coverage and reach have been realized at level 4. In that case, it can encourage the fulfillment of ecotourism development needs in the Batu City tourist village area at level 3, which has two sub-elements consisting of local community participation (E1) and frequency of news coverage about tourist villages (E2). Strengthening prioritization of local community participation and frequency of news coverage is necessary for ecotourism development in Batu City to ensure community involvement and better visibility for tourist destinations, which will increase ecotourism's success.

Local community participation is a key factor in the success of ecotourism development. Research by Coria and Calfucura [1] and Gumede and Nzama [40] shows that the involvement of local communities in ecotourism planning and management can increase community support and ensure that ecotourism initiatives are aligned with local needs. The involvement of local communities also contributes to the sustainability of ecotourism. Research by D'Souza et al. [8], Wondirad et al. [3] emphasize that community participation can ensure that ecotourism's economic and social benefits are spread evenly and sustainably.

The frequency of news coverage is essential in increasing visibility and attracting public attention to tourist villages. Research by Scharl et al. [41] and Kiráľová and Pavlíčeka [36] reveal that consistent media coverage can build a positive image and increase tourists' interest in a destination. Media coverage contributed to an increase in the number of tourist visits. Research by Shang et al. [42] shows that positive news about tourist destinations can increase tourist interest and visits.

Behind the fulfillment of needs at level 3, it encourages the fulfillment of needs at level 2, which consists of 3 sub-elements: tourism management innovation (E3), tourism village research (E5), and investment levels in the village tourism sector (E8). Prioritizing management innovation, tourism village research, and investment levels will strengthen ecotourism development efforts in Batu City while ensuring that the destination can develop sustainably and be attractive to visitors.

In-depth research on tourist villages is key to understanding specific potentials and challenges. Comprehensive research allows the development of strategies that are better and more suited to local characteristics [9, 43]. Understanding the social and economic aspects of villages through research can help in better planning and effective policy implementation [40, 44-46].

The level of investment in the village tourism sector influences the capacity for ecotourism development. Adequate investment improves the quality of facilities and services and supports the sustainability of ecotourism [4, 47]. Higher levels of investment can facilitate infrastructure development and better promotion. Several studies show that well-planned investments support sustainable destination development [48, 49].

Innovation in tourism management is crucial for the sustainability and appeal of ecotourism. Research by Giotis and Papadionysiou [50] and demonstrates that management innovation can enhance operational efficiency and tourist experience, thereby fostering the growth of tourist destinations. Notably, management innovations that leverage technology have the potential to revolutionize the tourist experience. Studies by Achmad et al. [23], Hall and Williams [51], and Sukamdani et al. [35] have shown that emerging technologies, such as applications and digital platforms, can significantly enhance visitor interaction and satisfaction, paving the way for a more engaging and satisfying ecotourism experience.

Finally, at level one, there are regulations and policies (E4). This sub-element is the final requirement for developing ecotourism in the Batu City tourist village area. Effective regulations and policies are the necessary foundation for regulating and facilitating sustainable ecotourism growth. With supportive regulations and policies, ecotourism development in Batu City can be conducted effectively, ensuring environmental sustainability, increasing community involvement, and facilitating quality investment and management.

Clear and effective regulations and policies play a pivotal role in ensuring the sustainable management of natural resources in ecotourism. Well-crafted policies have the potential to mitigate the negative impacts of tourism on the environment and ensure the long-term sustainability of ecotourism [4, 6, 31]. Regulations are instrumental in establishing and monitoring service quality standards, which directly influence tourist satisfaction. By upholding high-quality standards, as evidenced by studies such as those by Baloch et al. [7], and Jamieson [52], regulations contribute to

positive experiences for visitors, instilling confidence in the sustainability of ecotourism.

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Well-designed policies can support local community involvement. Policies that support local community participation in ecotourism development can increase community support and project success [8, 26, 28, 40, 54]. Consistent and integrated policies support the development of infrastructure needed for ecotourism. Good policies encourage investment in infrastructure and facilities, essential for attracting tourists [6, 7, 23, 55].

The Pentahelix design for ecotourism development in tourist village areas is presented in Figure 6, which has a hierarchical structure based on priority needs. Several efforts are needed to develop the economy in the Batu City tourist village area so that it has the following attractions:

1). Regulatory policy

Regulations and policies are important in developing ecotourism in tourist villages in Batu City, East Java. They provide a clear legal framework for managing resources, protecting the environment, and ensuring sustainability. Good policies support local community involvement, improve service quality, and encourage investment in tourism infrastructure. In addition, regulations help control the negative impacts of tourism, maintain a balance between development and conservation, and facilitate the development of strategies that suit local characteristics, thereby ensuring sustainable and harmonious growth for tourist villages.

While prior studies emphasize the importance of policy frameworks in sustainable tourism [12-14, 17], this research positions regulatory policy as the foundational driver of ecotourism development. Earlier works, such as Wulandari et al. [28] and Yasir et al. [26], often prioritized community empowerment over formal policy structures, arguing that grassroots initiatives are more critical for sustainability. However, in Batu City's context—where rapid tourism growth risks environmental degradation—the study demonstrates that strong regulations (e.g., zoning laws, waste management protocols) are prerequisites for balancing conservation and development. This aligns with Cita et al. [14], Hidayatullah et al. [15], and Oka et al. [16], who highlighted policy as a stabilizer in Indonesia's Pentahelix-driven tourism but extends their work by linking policy clarity to stakeholder accountability (e.g., ensuring private investors adhere to sustainability standards).

2). Research and development of village tourism

Research and development (R&D) is crucial in developing ecotourism in Batu City, East Java tourist villages. Through R&D, in-depth information about local potential, tourism trends, and visitor needs can be obtained, enabling more effective and innovative planning. R&D also supports the development of unique and sustainable tourism products and helps solve operational challenges. In addition, R&D facilitates using the latest technology and best practices in the tourism industry, increasing the attractiveness of tourist villages and the quality of visitor experiences. Thus, R&D contributes to the overall growth and competitiveness of tourist villages.

The study's focus on R&D challenges the traditional view of ecotourism as a purely community-led endeavor [56, 57]. While earlier literature often framed R&D as a peripheral activity, this research identifies it as a core enabler of innovation. For instance, the use of R&D to integrate digital tools (e.g., GIS mapping for trail conservation) mirrors Fennell's [58] call for technology in ecotourism but diverges by emphasizing structured collaboration between academia and local communities. Unlike Katika et al. [11] and Sutomo et al [25], who treated R&D as a siloed academic task, this study demonstrates how R&D bridges gaps between stakeholder needs (e.g., identifying tourist preferences through market analysis) and sustainable practices.

3). Private investment

Private investment is a cornerstone in developing ecotourism in Batu City, East Java. It provides the necessary funds to build infrastructure, facilities, and services, thereby improving the quality of destinations. This investment supports innovation in tourism products and promotions and expands market reach. With financial support from the private sector, tourist villages can implement sustainable projects and attract more visitors, which in turn encourages local economic growth and improves the quality of life of the community.

Private investment's role in this study contrasts with historical ecotourism models that rely heavily on public funding or NGO support [13, 59]. While Oka et al. [16], and Sentanu et al. [59] acknowledged private-sector involvement, they viewed it as secondary to community governance. Here, private investment is framed as a catalyst for scalability, enabling infrastructure upgrades (e.g., eco-lodges) and market expansion. This aligns with Fatmawati et al. [13] and Yunikawati et al. [57] urban tourism models but adapts them to a rural-urban hybrid context like Batu City. The study also addresses critiques of privatization by demonstrating how regulations (e.g., profit-sharing agreements) mitigate exploitation risks—a nuance absent in earlier works.

4). Community participation

The role of the tourism-aware community is paramount in developing ecotourism in tourist villages in Batu City, East Java. These communities contribute significantly by maintaining cleanliness, preserving local culture, and providing high-quality services. Their involvement in the planning and implementation of tourism activities ensures that development is carried out in a sustainable manner and in accordance with local needs. Additionally, educated communities can function as tourism ambassadors, promoting their villages positively and attracting visitors. Support and active participation from local communities not only strengthens the success and attractiveness of tourist villages but also enhances visitor experiences and supports local economic development.

Community participation remains a cornerstone of ecotourism, as seen in Sentanu et al. [59], Sutomo et al. [25], collaboration study. However, this study refines the concept by positioning communities as active co-designers and ambassadors rather than passive beneficiaries. For example, Batu City's tourism-aware communities not only preserve cultural heritage but also leverage social media to promote their villages—a dynamic absent in traditional models. This

aligns with Hidayatullah et al. [15], Wulandari et al. [28], and Yasir et al. [26], findings on participatory governance but challenges their skepticism about community capacity by showcasing trained locals as effective stewards of sustainability.

5). Tourism village media

Tourism village media plays a vital role in developing ecotourism in tourist villages in Batu City, East Java, by increasing the visibility and attractiveness of destinations. Effective media, such as websites, social media, and local publications, disseminate information about attractions, events, and unique features of tourist villages, attracting the attention of potential visitors. In addition, the media helps build a positive image and manage the reputation of tourist villages by displaying visitor experiences and testimonials. By expanding the reach of communication and promotion, the media supports the growth of visits, motivates investment, and increases awareness of tourist villages' cultural and environmental values.

The inclusion of media as a Pentahelix pillar marks a significant departure from Quadruple Helix frameworks [56], which typically exclude media. While Fatmawati et al. [13] and Ruliyani et al. [60] acknowledged media's role in supply chains, its application here as a reputation and visibility tool (e.g., social media campaigns, virtual tours) offers fresh insights. For instance, media's ability to amplify Batu City's cultural narratives aligns with Sentanu et al.'s [59] Pentahelix case studies but expands their scope by quantifying media's impact on tourist arrivals (e.g., a 30% increase post-campaign).

4. CONCLUSIONS

Research on the Pentahelix Analysis of Tourism Villages for Ecotourism Development in Batu City, East Java, shows that the success of ecotourism development is very dependent on five key variables: regulations and policies, research and development of village tourism, private investment, participation of tourism-aware communities, and village tourism media. as well as its reach. The detailed explanation is as follows: (1) Regulations and Policies: Clear regulations and integrated policies are significant to ensure sustainable management, environmental protection, and involvement of local communities in the ecotourism development process. Supportive policies can regulate resource use, ensure quality standards, and facilitate infrastructure development. (2) Research and Development: In-depth research on the potential and challenges of tourist villages will support effective planning and development of innovative tourism products. R&D also helps solve operational problems and increase the attractiveness of tourist villages through the latest technology and practices. (3) Private Investment: Investment from the private sector is essential in providing infrastructure, facilities, and promotion funds. Sufficient investment can improve service quality, expand development capacity, and attract more tourists. (6) Community Participation: Community involvement in ecotourism development is essential to ensure the initiative is aligned with community needs and aspirations. People aware of tourism will support environmental preservation, improved services, and positive promotions. (5) Media and Reach: Effective media and comprehensive reach help build a positive image of the tourist village and attract visitors' attention. Social media and digital platforms can expand promotional reach and increase destination visibility.

This study recommends that ecotourism development in Batu City be conducted effectively and sustainably, providing economic and social benefits for the local community and attracting more tourists to this destination. The policy implications that can be conducted operationally are as follows: (1) Strengthening Regulations and Policies: Updating and strengthening ecotourism management policies that involve all stakeholders and establishing clear operational standards to maintain sustainability. (2) Increased Research and Development: Encourage continuous research and development to understand tourism trends, improve product quality, and utilize the latest technology. (3) Facilitation of Private Investment: Providing incentives and support for private investment, including ease of licensing and access to market information. (4) Community Involvement: Develop training and empowerment programs for local communities and involve them in the planning and management process. (5) Media Optimization: Maximize digital and social media for promotion and increase the reach of information about tourist villages.

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