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From Traditional to Thriving: Predicting Rural Tourism Sustainability in Water Based Tourism of Kedung Ombo, Indonesia Using Bayesian Networks

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Abstract: *Rural tourism is growing in Indonesia as an engine of rural development, offering a mix of nature, culture, and authentic experiences. The Kedung Ombo reservoir area in Central Java Province is one of the rural areas with great tourism potential, providing a variety of attractions like water tourism, culinary experiences, nature exploration, and agro-tourism. Despite its potential for rural development, rural tourism in Kedung Ombo faces challenges due to complex interactions among nature, stakeholders, and institutional aspects. This study aims to identify key factors for effective management of the tourist village in this area, exploring the relationships between tourism management components, external and internal conditions, and their impact on the environment to promote sustainable village tourism. Using the Bayesian Network as a tool, the research reveals that the sustainability of rural water-based tourism in Kedung Ombo relies on factors such as financial incentives, stakeholder engagement, business scale, supporting infrastructure, and the environmental aspect of the reservoir. Valuable insights from this research can improve rural tourism management not only in this area but also in similar destinations.*

Keywords: *Rural Tourism, Rural Development, Sustainability, Effective Management, Bayesian Network.*
JEL Classification: R58, P25, L83

1. Introduction

Indonesia is renowned as a premier rural tourism destination, showcasing breathtaking and pristine rural scenery, vibrant traditions, and a distinctive rural lifestyle. The expansion of rural tourism in Indonesia is significant, as the number of tourist villages is projected to reach 4,732 by 2023. These villages, provide avenues for sustainable local economic growth [6]; [7]. They play a role in generating employment, empowering communities, and fostering an entrepreneurial mindset among local inhabitants [8].

One area with significant rural tourism potential is the Kedung Ombo reservoir area in Central Java Province. This vast reservoir, the largest in Southeast Asia, presents opportunities for water tourism, culinary tourism, nature tourism, and agro-tourism. Various community groups have established tourist attractions within and around the reservoir, offering a range of experiences. While some attractions are easily accessible, others pose more of a challenge. Despite its development since 2010, tourism in this area has not progressed significantly in terms of visitor numbers, infrastructure completeness, and management income [9].

The lack of strategic planning has hindered the growth of tourist attractions in the Kedung Ombo area. Achieving advanced and sustainable rural tourism development, therefore, is a complex process that cannot be accomplished overnight. It requires careful coordination between various institutions, program activities, policies, and an understanding of future changes [10]. Effective management of advanced and sustainable rural tourism necessitates a structured governance approach [3] that considers all stages and processes systematically [11].

This study aims to identify the key factors that support the management of the tourist village in Kedung Ombo through a participatory approach. Specifically, it seeks to uncover the causal relationships between tourism

management elements, internal and external conditions, and their impact on the environment to promote sustainable village tourism. The integration of uncertainties arising from interactions between human systems and the environment is crucial in the management of tourist villages. To address this, the research will utilize the Bayesian Belief Network or Bayesian Network for short, as a suitable tool. Given the complexity and uncertainty inherent in the tourism system [12];[13];[14], particularly concerning tourist preferences, loyalty, arrivals, and behavior [3], a Bayesian network model (Bayesian Belief Network-BBN) will be employed for analysis. Bayesian methods excel in handling uncertainty and aiding decision-making processes. The use of BBN in this study will help identify governance drivers and their interactions visually, facilitating the creation of comprehensive scenarios that capture the intricacies of the process.

2. Method

2.2. Location and Analysis Method

This research was conducted at the Kedung Ombo reservoir area in Central Java Privonce (Fig.1). This study utilizes Bayesian networks (BN), also known as Bayes Belief Network (BBN) or causal probabilistic networks, to assess the sustainability level of rural-based tourism in water-based tourism at Kedung Ombo

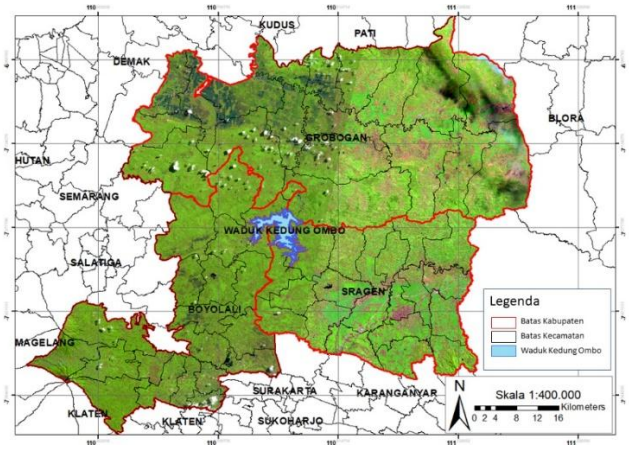

Fig.1: Research Location.

A Bayesian Network comprises two components: a qualitative component represented by a directed acyclic graph (DAG) showing the relationships among variables, and a quantitative component consisting of probabilities of the variables in the form of conditional probabilistic tables (CPT) [15]. The basic structure of the BN, involving three variables, is illustrated in Figure 2.

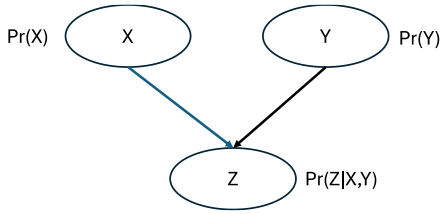

Fig. 2: Simple Structure of DAG.

In Figure 2, variable X and Variable Y are known as Parents variable variable Z is known as child variable. Therefore, in Figure 1, both variable x and y are parents to variable z, so variable z is dependent node. Mathematically, DAG of Figure 2 is written as:

$$Pr(Z) = Pr(Z|X,Y)*Pr(X)*Pr(Y) \quad (1)$$

For a network containing *n* variables, the probability of full BN structure is calculated by joint probability distribution as written:

$$Pr(X_1, X_2, \dots X_n) = \prod_{i=1}^{n} (Pr(X_i|\psi_i) \quad (2)$$

Where $\Pr(X_1, X_2, \dots X_n)$ is the full joint probability distribution, and ψ_i is the parents of node i.

One of the key advantages of BN is its ability to model changes in input variables based on the output level [16], known as "what-if" or scenario analysis [17]. For instance, policymakers can easily test policy interventions by adjusting inputs and observing the resulting impact within the network structure. Moreover, the causal relationships in BBN are straightforward to comprehend, and additional variables can be seamlessly incorporated as needed [18];[19]. The network structure is not only intuitively appealing but also convenient for illustrating intervention theories and evaluating them against real-world data [17]. In addition to above advantages, BN can handle uncertainty in probabilistic terms rigorously, hence it is suitable for analysis of management context and especially relevant in poor data context [20].

2.1. Data Collection

2.1.1 Identifying Variables

To determine factors related to sustainability of water-based rural tourism in Kedung Ombo Central java, first we have to identify key variables related to the sustainability. We follow [21] to identify of variables using BN framework. [21] explain that in BN framework identification variables can be carried out using the following interaction of variables namely, objectives, intervention, intermediate factors, controlling factors, implementation factors and additional impacts variables. The interaction of these variables can be described by the following diagram.

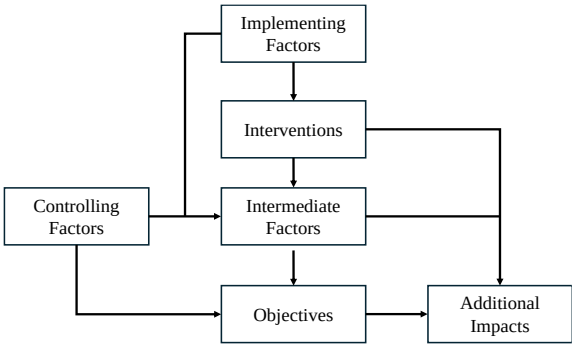

Fig. 3: Interaction of BN Variables [21].

Based on those variables, we conducted focus group discussion to determine the variables that becomes the nodes in BN structure. Focus Group Discussion was carried out with relevant stakeholders in Kedung Ombo Water-based tourist sites in August 2023. The following variables were agreed as variables related to sustainability of Kedung Ombo water-based tourism.

TABLE I. Variables Category and Their Associated Nodes

Variables Category	Variable Nodes	Measurement
Objectives	Sustainability of water-based tourism	Low, Medium, High
Interventions	Financial incentive Stakeholder engagement	Yes, No
Intermediate factors	Profitability Number of visitors	Low, Medium, High
Controlling factors	Water level of dam Location of the business (geographic)	Low, Medium, High
Implementation factors	Village Enterprises Economic Scale	Yes, No Low, Medium, High
Additional impacts	Water pollution Potential conflict	Low, Medium, High

2.2.2 BN Structure and CPT

Based on those agreed variables, an initial of DAG BN structure was constructed with the stakeholder as depicted in Figure 4. As can be seen from Figure 4, the sustainability of water-based village tourism is product of three main aspects namely environment (pollution) that depends on state of reservoir, economic scale and geographical location, followed the second aspect which is economic component (profitability), and social aspect (stakeholder engagement and potential conflict).

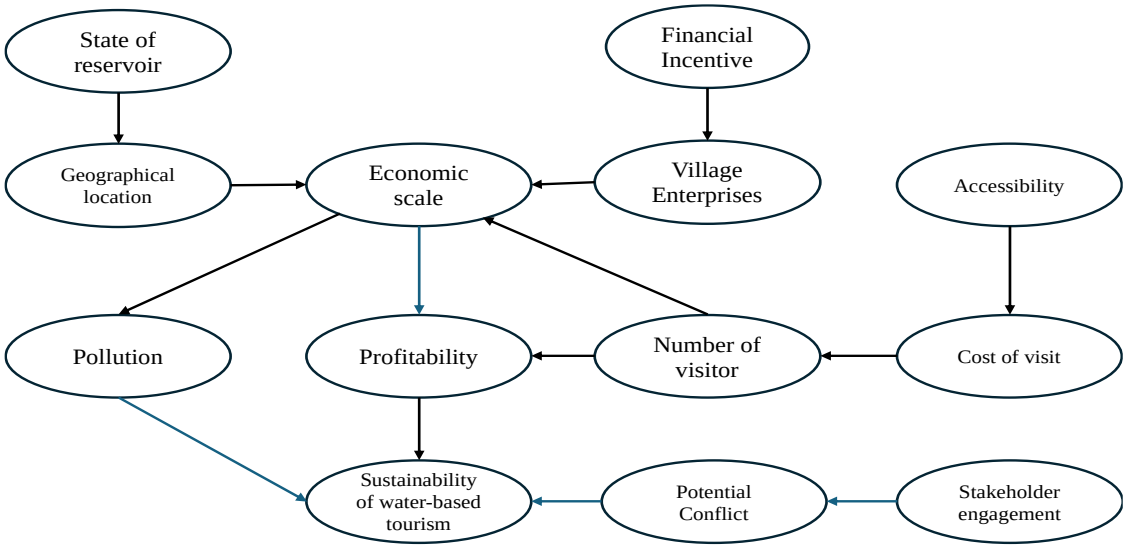

Fig. 4: DAG of BN Structure of Sustainable Water-based Tourism in Kedung Ombo.

Once the BN structure has been constructed, the stakeholders were asked to elicit the probability of each node based on measurement described in Table 1. The probabilities were put in CPT to fill out prior probabilities for BN structure using GeNie Academic Edition software (https://www.bayesfusion.com/genie/).

3. Results and Discussions

3.1. Strength Analysis

The structure of BN of prior probabilities for sustainability of water-based village tourism can be seen in Figure 5. As can be seen from Figure 5, with current value of CPT obtained from stakeholder's elicitation, using 50:50 change of financial incentive and 50:50 chance of stakeholder engagement as implementing nodes, the level of sustainability of water-based tourism is approximately 36% high.

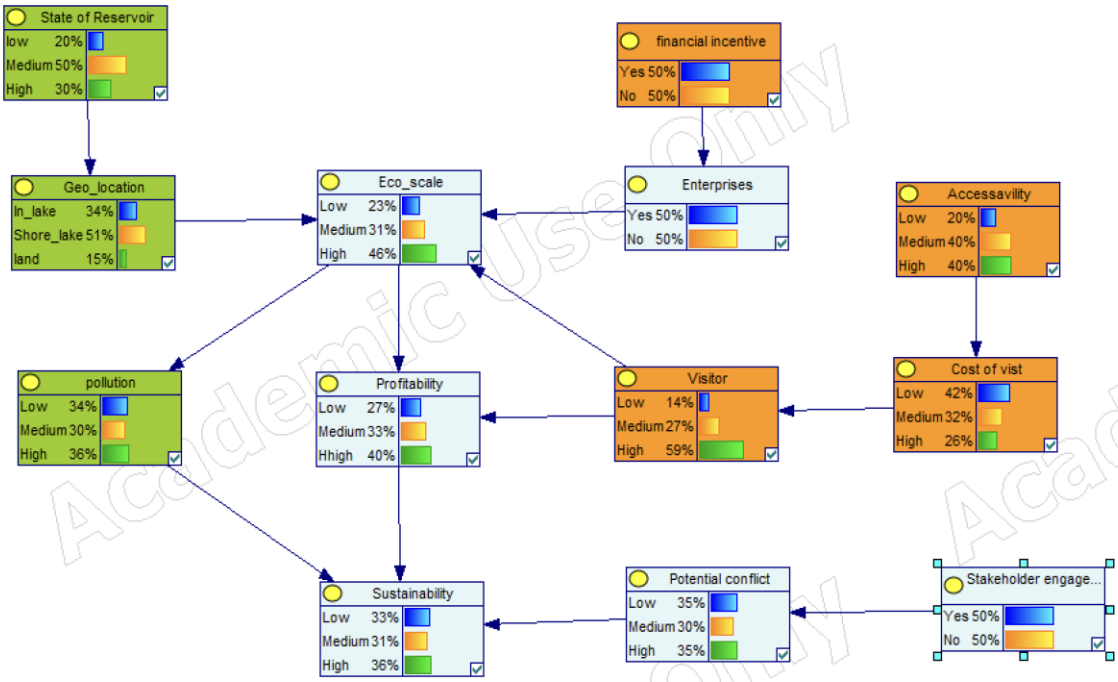

Fig 5: Structure BN with Prior Probabilities.

In Bayesian Network analysis, the next stage involves identifying the relationships between variables within the network structure. This is achieved in Genie through strength analysis using Influence diagrams. Strength analysis allows us to comprehend the potential cause-and-effect relationships among variables, with the width of the arc representing the strength of each connection between parent and child nodes [22]. The score of the strength influence is presented in Table 2.

TABLE II. Score of Strength Influence between Parent and Child Node in the BN Structure

Parent	Child	Average	Maximum
Financial incentive	Enterprises	0.800	0.800
Stakeholder engagement	Potential conflict	0.500	0.500
Accessibility	Cost of visit	0.389	0.557
Eco_scale	Pollution	0.333	0.500
Cost of visit	Visitor	0.242	0.361
Pollution	Sustainability	0.198	0.500
Visitor	Profitability	0.189	0.346
Enterprises	Eco_scale	0.174	0.265
Visitor	Eco_scale	0.165	0.300
State of Reservoir	Geo_location	0.158	0.200
Potential conflict	Sustainability	0.149	0.300
Profitability	Sustainability	0.147	0.300
Geo_location	Eco_scale	0.139	0.200
Eco_scale	Profitability	0.099	0.173

In Table 2, the most significant impact is observed from financial incentives on enterprises, with an average score of 0.8 and a maximum of 0.8. This is followed by stakeholder engagement leading to potential conflicts, with an average of 0.5 and a maximum of 0.5. Additionally, there is an influence from accessibility to the cost of visit, with an average of 0.389 and a maximum of 0.557, as well as an influence from economic scale to pollution, with an average of 0.33 and a maximum of 0.5.

Understanding the key factors that impact the sustainability of water-based village tourism, we analyzed how these variables influence sustainability within the BN structure. This analysis involved setting five main arcs as target nodes with a probability value of 100% or marking them as "evidence" in GeNie software as shown in Figure 6. By indicating "yes" for financial incentives, "high" for accessibility, "low" for economic scale, and "yes" for stakeholder engagement, the sustainability level rose from 36% in initial probability to 50% in subsequent probability. The selection of these factors was based on stakeholders' commitment to the future management of water-based tourism. Stakeholders emphasize the importance of financial incentives and engagement, while advocating for a low economic scale (suited for small and medium enterprises) to preserve the reservoir's ecosystem, especially considering the businesses' proximity to the lake's shore. Maintaining a small business scale leads to lower pollution levels (60% probability) and a slight increase in profitability.

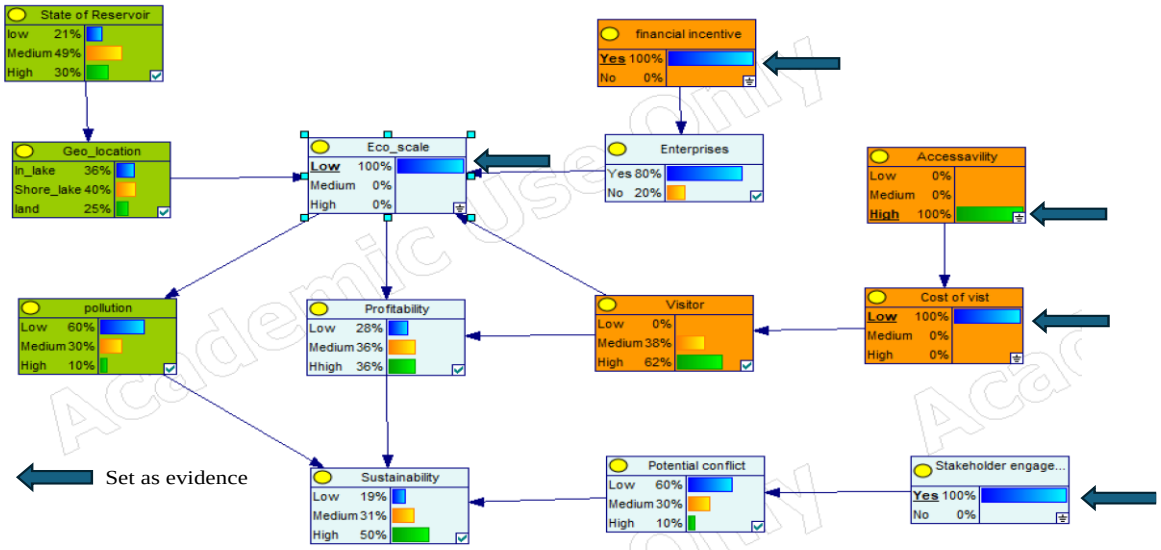

Fig. 7: BN Structure with Evidence Variables.

The significance of financial incentives for rural development is underscored by the reliance of most rural tourism activities in Indonesia on self-financing and small loans from local banks. However, these loans come with relatively high interest rates, posing challenges for small-scale businesses to thrive. Utilizing village funds, which are distributed to every village in Indonesia, could enhance business opportunities for rural entrepreneurship. Currently, village funds are primarily used for infrastructure development, such as roads and sanitation, with minimal allocation towards enhancing local business capacity. Reallocation of village funds may not yield desired results without stakeholder engagement, potentially leading to conflicts with other user groups of the Kedung Ombo Dam. Therefore, both financial incentives and stakeholder engagement are crucial in transitioning the traditional management of water-based rural tourism in Kedung Ombo towards a more effective and sustainable approach, ultimately aiming to improve the welfare of rural communities.

3.2. Sensitivity Analysis

One of the key benefits of Bayesian Networks is their ability to conduct sensitivity analyses on target nodes in response to changes in evidence [23]. In this particular study, a sensitivity analysis was performed to identify which nodes or variables are most affected by changes in the probability of sustainability in water-based tourism. Sustainability is considered the target node, while other variables serve as evidence nodes. GeNie utilizes color-coded and tornado diagrams to assess the sensitivity of these variables.

Figure 8 presents the tornado diagram illustrating the sensitivity analysis for the sustainability of water-based rural tourism in Kedung Ombo, Central Java. The horizontal axis of the diagram shows the absolute change in posterior probability of sustainability, while the length of the bars indicates the impact intensity of specific nodes on the target nodes, which in this case is the sustainability of water-based tourism. The color changes in the diagram indicate the direction of change in the target node, with green representing positive change and red representing negative change.

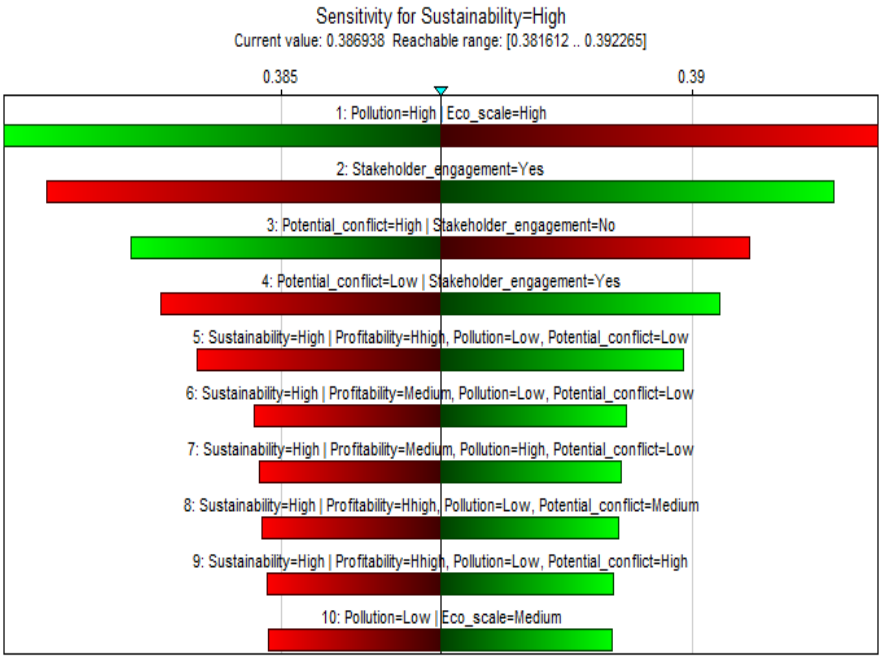

Fig.9: Tornado Diagram for Sensitivity Analysis of Sustainability Level as Target.

As shown in Figure 9, pollution and economic scale have a significant impact on the sustainability level. An increase in economic scale may lead to lower sustainability (indicated by red color), while reducing pollution levels has the opposite effect (shown by green colour). For instance, expanding a business, such as increasing the size of a restaurant from 4 x 4 meters to 8 x 8 meters, could boost profits temporarily. However, in nature-based tourism, especially water-based tourism, this may not be ideal as the business location is influenced by the reservoir water level. Moreover, scaling up the business could result in increased pollution discharge into the lake, diminishing its capacity and ultimately harming sustainability.

In Figure 9, it is evident that stakeholder engagement and potential conflicts are the second most influential variables impacting sustainability. When stakeholders are more involved in decision-making for water-based tourism, it can enhance sustainability (indicated by green color), whereas an increase in conflicts has the opposite effect. In rural tourism, stakeholder engagement is vital as it fosters a sense of ownership over the lake, which is technically under government jurisdiction and managed as a common property resource. As discussed by Garrett Hardin over half a century ago, resources managed as common property can lead to the tragedy of the commons. Therefore, boosting stakeholder involvement is a strategy to prevent this tragedy by reducing conflicts and enhancing ownership sentiments. The remaining bars in the tornado diagram depicted in Figure 9 illustrate the interplay of potential conflict, pollution, and profitability. These factors are also responsive to altering the sustainability level, as previously outlined in the influence diagram.

4. Conclusion

Utilizing a Bayesian network, the research demonstrates that intervention variables like financial incentives and community engagement, along with impact variables such as pollution resulting from business activities, are crucial factors that, along with other variables like business size and type, should inform tourism management decisions. Financial incentives play a pivotal role in driving the growth of village tourism, while stakeholder

engagement acts as the guiding force in village tourism management, shaping the future direction of tourist development. It is imperative for the government to consider reallocating village financial resources towards more productive activities like rural tourism, beyond mere infrastructure development. Additionally, efforts should be made to enhance community capacity through training and capacity-building initiatives to promote sustainable village businesses, including water-based tourism.

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