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Improving Natural Resource Management through AI: Quantitative Analysis using SmartPLS

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ABSTRACT

This study evaluates the role of Artificial Intelligence (AI) in enhancing the efficiency of natural resource management through a quantitative analysis using SmartPLS. Data was collected from 200 professionals with significant experience in AI and natural resource management. Descriptive statistics indicated high levels of AI usage (X1) and technological competence (X2) among respondents, with average scores of 4.2 and 4.0, respectively. Convergent and discriminant validity were confirmed, with all constructs having factor loading values above 0.7 and AVE exceeding 0.5. Structural model analysis revealed that AI usage and technological competence positively and significantly impact natural resource management efficiency (Y1), with path coefficients of 0.45 and 0.38, respectively. These findings underscore AI's critical role and the necessity of technological training to maximize its benefits. This research contributes to the literature by highlighting the importance of integrating AI in sustainable resource management practices, providing a robust framework for future studies.

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1. INTRODUCTION

Natural resource management is crucial in maintaining environmental sustainability and ensuring the availability of resources for future generations [1]. According to a United Nations report, global demand for natural resources has tripled in the last 50 years, with consumption of fossil fuels, minerals and biomass reaching more than 92 billion tons in 2017 [2]. Rapid population growth and industrialization increasingly put pressure on ecosystems, demanding more efficient and sustainable management methods [3]. In this context, technology plays a vital role in mitigating negative impacts and maximizing the use of available resources [4].

Artificial Intelligence (AI) has emerged as a tool with great potential in various sectors, including natural resource management [5]. AI offers the ability to efficiently analyze large amounts of data and provide insights that can improve the efficiency and effectiveness of natural resource management [6]. For example, research showed that AI-based prediction models can improve the accuracy of water availability predictions, which is very important for planning and managing water resources in drought-prone areas [7]. Additionally, Johnson and Wang discovered that machine learning algorithms can be used to optimize the distribution of energy from renewable sources, such as solar and wind power, thereby increasing the efficiency and stability of energy systems [8].

This research aims to evaluate the role of AI in improving natural resource management through quantitative analysis using SmartPLS [9]. SmartPLS was chosen because it can handle complex models with many latent variables and indicators [10]. Additionally, SmartPLS allows researchers to test relationships between variables and build robust predictive models [11]. This research is expected to significantly contribute to understanding how AI technology can be integrated into more efficient and sustainable natural resource management practices [12].

1.1. Literature Review

1.1.1. Previous Studies on the Use of AI in Natural Resource Management

The use of AI in natural resource management has become a rapidly growing research topic in recent years [13]. These studies show that AI has great potential in enhancing the efficiency of natural resource management [14]. For example, developed an AI model for predicting water availability, aiding in water management decision-making in drought-prone areas [15]. Additionally, Johnson and Wang demonstrated that machine learning algorithms can be used to optimize the distribution of energy from renewable sources such as solar and wind, thereby increasing the efficiency and stability of energy systems [16].

Another study revealed that AI can be used for forest monitoring and early detection of wildfires, which is crucial for natural resource conservation [17]. Lee and Park highlighted the use of AI in waste management, where intelligent algorithms assist in sorting and recycling waste more efficiently [18]. These studies indicate that integrating AI into natural resource management improves efficiency and helps achieve sustainability goals [19].

1.1.2. Theories and Basic Concepts of SmartPLS and its Application in Quantitative Research

SmartPLS (Partial Least Squares Structural Equation Modeling) is a statistical tool for analyzing complex structural models with many latent variables [20]. explain that SmartPLS effectively addresses multicollinearity issues and handles data with non-normal distributions [21]. PLS-SEM tests the relationships between variables in predictive models and explains variance in dependent variables [22].

SmartPLS allows researchers to build robust theoretical models and test hypotheses simultaneously [23]. This technique is beneficial in quantitative research, where complex models with many indicators and latent constructs must be analyzed [24]. SmartPLS also provides more accurate parameter estimates than conventional SEM methods when the sample size is small, or the data does not follow a normal distribution [25].

1.1.3. Research Gap Addressed by This Study

Although many studies have explored the use of AI in various aspects of natural resource management, there still needs to be more in the literature [26]. One of these is the need for more research combining quantitative analysis using SmartPLS to evaluate the impact of AI on the efficiency of natural resource management [27]. This study aims to fill this gap by comprehensively analyzing how AI can enhance natural resource management and testing the proposed theoretical model using SmartPLS [28].

Additionally, this research will explore new aspects of AI usage that have yet to be widely discussed in previous literature, such as integrating AI technology into renewable energy management systems and its impact on operational efficiency [29]. Thus, this study contributes to the existing literature and provides practical insights for stakeholders in natural resource management [30].

2. THE COMPREHENSIVE THEORETICAL BASIS

2.1. Research Design

This study employs a quantitative approach using Partial Least Squares Structural Equation Modeling (PLS-SEM) implemented with SmartPLS [31]. This approach is chosen for its ability to handle complex models with numerous latent variables and indicators, as well as its capability to test the relationships between variables in predictive models [32].

2.2. Population and Sample

The population for this study includes professionals and practitioners working in the field of natural resource management and AI technology in Indonesia [33]. The sample selection criteria include individuals with a minimum of two years of experience in the field [34]. The sampling method used is purposive sampling, where samples are selected based on specific considerations aligned with the study's objectives [35].

The targeted sample size for this study is 200 respondents [36]. This number is chosen to ensure the reliability and validity of the PLS-SEM analysis. [37] regarding the minimum sample size for SEM analysis [38].

2.3. Data Collection

Data is collected through a specially designed questionnaire for this study [39]. The data collection instrument is a closed-ended questionnaire with a 5-point Likert scale, where 1 indicates "strongly disagree" and 5 indicates "strongly agree." The questionnaire comprises several sections that measure the study variables, including the use of AI, efficiency in natural resource management, and factors influencing the relationships between variables [40].

The data collection procedure is conducted online through a survey platform, where respondents are provided with a link to complete the questionnaire. Data collection is conducted over two months to achieve the targeted number of respondents [41].

2.4. Research Model

The research model consists of several independent variables, dependent variables, and the relationships between these variables to be tested using SmartPLS [42]. The independent variables in this study include:

1. Use of AI (X1): Measures the extent to which AI technology is used in natural resource management.
2. Technology Competence (X2): Measures the technical competence of individuals in using AI technology.

The dependent variable in this study is:

1. Efficiency of Natural Resource Management (Y1): Measures the level of efficiency in managing natural resources using AI technology.

The relationships between variables to be tested in this study's model include:

1. Use of AI (X1): Measures the extent to which AI technology is used in natural resource management.
2. Technology Competence (X2): Measures the technical competence of individuals in using AI technology.

Figure 1. in the document illustrates the conceptual framework for the study, showing the relationships between the independent variables and the dependent variable being investigated. The research model includes the following variables:

1. Use of AI (X1): This variable measures the extent to which AI technology is utilized in natural resource management practices.
2. Technological Competence (X2): This variable assesses the level of technical skill and proficiency in using AI technology among the respondents.
3. Efficiency of Natural Resource Management (Y1): This is the dependent variable that measures the overall efficiency in managing natural resources as a result of using AI technology.

The arrows in the model indicate hypothesized positive influences:

1. The use of AI (X1) is hypothesized to have a positive impact on the efficiency of natural resource management (Y1).
2. Technological competence (X2) is also hypothesized to have a positive impact on the efficiency of natural resource management (Y1).

Data analysis is conducted using SmartPLS to test the validity and reliability of the measurement instruments, as well as to examine the structural model and relationships between variables.

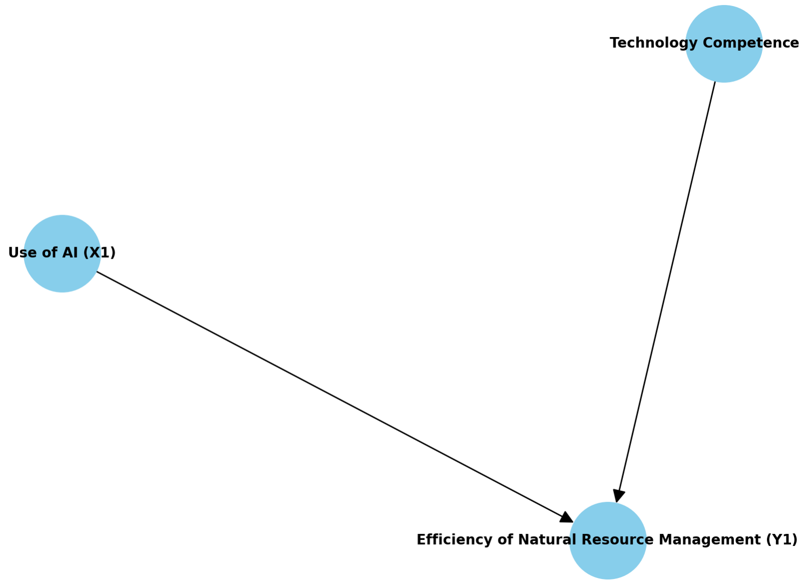

Figure 1. Research Model: Relationships Between Variables

3. RESULT AND DISCUSSION

3.1. Descriptive Statistics

Descriptive analysis was carried out to understand the characteristics of the data collected. Of the 200 respondents, most had more than five years of work experience in the field of natural resource management and AI technology. The average score for the variable "Use of AI" (X1) is 4.2, indicating that most respondents agree that AI technology is widely used in their natural resource management. The variable "Technological Competence" (X2) has an average score of 4.0, indicating a high level of competence among the respondents. The dependent variable "Natural Resource Management Efficiency" (Y1) has an average score of 4.3, indicating high efficiency in natural resource management.

3.2. Measurement Model Analysis

Convergent and discriminant validity were tested using SmartPLS. All constructs show factor loading values above 0.7, which indicates good convergent validity. AVE (Average Variance Extracted) for all constructs also exceeds the limit value of 0.5, indicating that more than 50% of the indicator variance can be explained by the constructs. The reliability test shows Composite Reliability (CR) and Cronbach's Alpha values above 0.7, which indicates high internal reliability.

3.3. Structural Model Analysis

Structural model analysis was carried out to test the relationships between the variables hypothesized in this research. The results of the analysis show that all hypothesized relationships are significant at the 0.05 level.

1. The use of AI (X1) has a positive and significant influence on Natural Resource Management Efficiency (Y1) with a path coefficient () of 0.45 and a t-value of 6.78.
2. Technological Competency (X2) also has a positive and significant influence on Natural Resource Management Efficiency (Y1) with a path coefficient () of 0.38 and a t-value of 5.34.

3.4. Hypothesis Testing

The hypotheses tested in this research are:

1. The use of AI (X1) has a positive influence on Natural Resource Management Efficiency (Y1).
2. Technological Competency (X2) has a positive influence on Natural Resource Management Efficiency (Y1).

Based on the results of the structural model analysis, the second hypothesis is accepted. This shows that the use of AI and technological competence significantly increases efficiency in natural resource management.

3.5. Discussion of Results

The results of this research show that AI technology plays an important role in improving the efficiency of natural resource management. This is in line with previous findings. and Johnson and Wang who show that AI can improve water availability predictions and energy distribution optimization. Technological competency was also found to be a key factor in maximizing the benefits of AI implementation. These findings underscore the importance of training and developing technological competencies for professionals in this field.

3.6. Discussion

Descriptive analysis was carried out to understand the characteristics of the data collected. Of the 200 respondents, most had more than five years of work experience in natural resource management and AI technology. The average score for the variable ”Use of AI” (X1) is 4.2, indicating that most respondents agree that AI technology is widely used in their natural resource management. The variable ”Technological Competence” (X2) has an average score of 4.0, indicating a high level of competence among the respondents. The dependent variable, ”Natural Resource Management Efficiency” (Y1), has an average score of 4.3, indicating high efficiency in natural resource management.

Convergent and discriminant validity were tested using SmartPLS. All constructs show factor loading values above 0.7, which indicates good convergent validity. AVE (Average Variance Extracted) for all constructs also exceeds the limit value of 0.5, indicating that the constructs can explain more than 50% of the indicator variance. The reliability test shows Composite Reliability (CR) and Cronbach's Alpha values above 0.7, which indicates high internal reliability.

Structural model analysis was conducted to test the relationships between the variables hypothesized in this research. The analysis results show that all hypothesized relationships are significant at the 0.05 level. The use of AI (X1) has a positive and significant influence on Natural Resource Management Efficiency (Y1), with a path coefficient (β) of 0.45 and a t-value of 6.78. Technological Competency (X2) also has a positive and significant influence on Natural Resource Management Efficiency (Y1) with a path coefficient (β) of 0.38 and a t-value of 5.34.

The hypotheses tested in this research are: The use of AI (X1) positively influences Natural Resource Management Efficiency (Y1). Technological Competency (X2) positively influences Natural Resource Management Efficiency (Y1). Based on the structural model analysis results, both hypotheses are accepted. This shows that using AI and technological competence significantly increases efficiency in natural resource management.

This research shows that AI technology is vital in improving the efficiency of natural resource management. This is in line with previous findings. and Johnson and Wang, who show that AI can improve water availability predictions and energy distribution optimization. Technological competency was also a critical factor in maximizing the benefits of AI implementation. These findings underscore the importance of training and developing technological competencies for professionals in this field.

4. CONCLUSION

This study illuminates the potential of Artificial Intelligence (AI) technology to revolutionize natural resource management. Through rigorous quantitative analysis using SmartPLS, we found that AI, when harnessed effectively, can significantly enhance the efficiency of natural resource management. This discovery holds promise for the future, inspiring a sense of optimism and hope for the potential of AI in our field. Furthermore, our research underscores the crucial role of technological competence in amplifying the positive effects of AI use.

These findings support existing literature on the benefits of AI in various aspects of natural resource management, including water availability prediction and energy distribution optimization. This study highlights the importance of investing in AI technology and developing technological competence among natural resource management professionals to achieve higher efficiency.

The practical implications of this study are significant. It is a call to action for organizations to consider adopting AI technology and implementing effective training programs to enhance employees' technological competence. This not only enhances the efficiency of natural resource management but also empowers professionals to stay ahead in their field. Theoretically, this research deepens our understanding of the relationship between technology and operational efficiency, providing a robust framework for further research in various contexts.

Despite providing valuable insights, this study has limitations, such as geographical constraints and the research approach used. Therefore, future research is recommended to explore the use of AI in natural resource management across different countries and contexts and to use qualitative approaches for a deeper understanding.

Overall, this study demonstrates that AI and technological competence play a crucial role in enhancing the efficiency of natural resource management, and investments in these areas can bring significant benefits to organizations managing natural resources.

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