Analysis of The Sustainability Green Hospital Implementation in Tampan Psychiatric Hospital

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Abstract. Tampan Psychiatric Hospital is a leading center for mental health treatment in Riau Province. It offers a comprehensive package of medical and psychological treatments to individuals. Quality health care plus striving efforts towards minimizing environmental impacts by introducing the Green Hospital concept have not been properly implemented, i.e., effective or efficient at Tampan Psychiatric Hospital up till now, hence sustainability analysis is required to gauge the level of sustainability and its leverage factors. This study adopts a mixed-method design with an embedded correlational model. Data are collected using a modified version of IPMGH and analyzed using MDS (Multi-dimensional Scaling) assisted by Rapfish (Rapid Appraisal for Fisheries) software. The results of the MDS Rap Green Hospital assessment indicate that the sustainability level falls into the less sustainable category, with a score of 45.90% and nine identified leverage factors. The low level of sustainability underscores the need for a collective commitment to develop appropriate strategies that will support Tampan Psychiatric Hospital in realizing its transformation into a Green Hospital, particularly in addressing the growing challenges of global environmental issues.

1 Introduction

Psychiatric hospitals are healthcare facilities that provide medical and psychological care to individuals with mental disorders or mental health problems requiring intensive care [1]. Compared to conventional hospitals, psychiatric hospitals have slightly different service specializations [2]. According to Kepmenkes (Regulation of the Minister of Health) No. 1204, the operation of hospitals must take into account elements of harmony in terms of ecology, social factors, and aesthetics as a reference point in every decision-making process by optimizing environmental management and empowerment [3]. The operation of psychiatric hospitals significantly affects various aspects of people's lives, both positively and negatively [4]. Hospitals that do not care for the environment may contribute to poor air quality, the emission of harmful pollutants, and the spread of microparticles that can facilitate the spread of infections, thus affecting the health of patients and medical staff [5].

The Green Hospital concept arose in response to the need for healthcare services that focus not only on patient care but also on environmental impact [6]. A Green Hospital is

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designed, built/renovated, and operated in accordance with the principles of health and environmental sustainability [7]. Implementation of the Green Hospital concept focuses not only on environmental aspects but also on improving the well-being of patients and hospital staff, thereby creating a healthier, more sustainable environment [8]. This implementation encompasses various technologies and policies promoting energy efficiency, waste management, and environmentally friendly building design [9]. Many countries around the world have developed research-based and insight-driven criteria for green hospitals, tailored to their specific contexts. Among the various criteria, three guidelines are widely adopted worldwide: BREEAM, LEED with Green Guide for Healthcare, and Green Star [10].

In recent years, attention to the implementation of the Green Hospital concept has increased in line with global commitments to the Sustainable Development Goals (SDGs). Pham Thi Thu Hien (2021) emphasized the importance of integrating sustainability principles into Vietnam's hospital system through energy efficiency, waste management, and environmentally friendly design that supports the SDGs. A similar study by Thanh et al. (2020) showed that implementing green practices in healthcare facilities can improve operational efficiency while reducing carbon footprints [11]. Meanwhile, Zhang et al. (2022) highlighted that the success of Green Hospitals is strongly influenced by governance factors, healthcare worker awareness, and government policy support for sustainable resource management [12].

Findings from other Asian countries reinforce this view. In China, Lee et al. (2022) found that implementing green policies in public hospitals positively impacted energy efficiency and patient satisfaction when supported by an integrated environmental management system [13]. In South Korea, Kim and Lee (2023) emphasized that green leadership and organizational culture play a crucial role in the successful transformation of hospitals toward sustainable practices [14]. In Sweden, Silva et al. (2024) concluded that the implementation of green, sustainable, and smart hospital concepts should integrate passive design strategies, energy-efficient technologies, and comprehensive operational management. At the same time, user comfort must remain a priority alongside energy-reduction efforts, underscoring the need for a multi-dimensional approach to create efficient, comfortable, and sustainable healthcare facilities [15].

In line with these findings, Marshal et al. (2021) revealed that in Indonesia, the implementation of Green Hospitals is still in its early stages and tends to focus on medical waste management and energy efficiency, but has not yet fully encompassed the social, institutional, and cultural aspects of the organization [16]. This comparison suggests that Asian countries are beginning to adopt a multi-dimensional approach to implementing green hospitals, whereas in Indonesia, a more comprehensive, context-specific implementation model is still needed, particularly in psychiatric hospitals such as Tampan Psychiatric Hospital.

The implementation of the green hospital concept at Tampan Psychiatric Hospital is not merely an option but an urgent necessity. A clean, green environment can enhance air quality and cleanliness, thereby positively impacting the health of patients, staff, and visitors at Tampan Psychiatric Hospital. The adoption of the Green Hospital model can certainly lower long-term operational costs through energy efficiency and improved waste management [17]. Furthermore, the implementation of the Green Hospital can assist Tampan Psychiatric Hospital in complying with increasingly stringent environmental regulations and international health and environmental standards. However, the implementation of the Green Hospital at Tampan Psychiatric Hospital faces various challenges from multiple dimensions, including ecological, economic, social, institutional, technological, and environmental health. Therefore, identifying and analyzing the sustainability of the Green Hospital implementation at Tampan Psychiatric Hospital is essential to address existing issues, with the hope that Tampan Psychiatric Hospital can devise effective strategies to overcome obstacles and support the sustainable implementation of green hospitals.

2 Materials and Methods

2.1 Research Design

The research design of this study uses a mixed-methods approach, where the quantitative method serves as the foundational data and supports and enhances the information gathered through the qualitative approach [18]. The mixed-method approach in this study utilizes an embedded design, specifically the embedded correlational model. This design choice was made because the qualitative approach will be used to explore and address aspects that remain unexplored in the quantitative analysis results [19].

2.2 Participants

Participants in this study encompassed all components involved in the operational activities of Tampan Psychiatric Hospital. These included biological components such as the entire Hospitalia community (443 individuals), patients and their families, green plant populations, animals, and infection-causing microorganisms; physical components such as buildings and land; and socio-economic components including the surrounding community, researchers, and academics. Quantitative measurement sampling was conducted using a purposive sampling technique, and the sample size was determined using the Slovin formula, yielding 210 respondents. The qualitative sample in this study consisted of seven experts, including representatives from the Ministry of Health, Riau Provincial Health and Environment Services, the Tampan Psychiatric Hospital Supervisory Board, the hospital's Director and Deputy Director, and one university lecturer.

2.3 Data Collection

Data collection methods in this study include a literature review and survey techniques, using a self-assessment questionnaire designed to meet the study's requirements. The research instrument is a modified questionnaire tailored to the researcher's needs, having undergone validation testing and adapted from the Green Hospital Implementation Self-Assessment Instrument (IPMGH) based on the Green Hospital International Guidelines.

2.4 Data Analysis

Data analysis in this study used Multi-dimensional Scaling (MDS) with RAPFISH software. MDS analysis, aided by Rapfish software (Rapid Appraisal for Fisheries), is a method and tool used to assess the sustainability of the management of a study object, including the hospital environment in this case. The use of the RAPFISH method provides a new perspective for evaluating the sustainability of Green Hospital implementation at Tampan Mental Hospital, as it can assess sustainability multidimensionally and identify the main levers that influence it, producing a more comprehensive and contextual analysis than conventional evaluation methods.

In this study, weighting and scoring in the MDS–Rapfish analysis used a Likert scale (1–5) to assess sustainability indicators across six dimensions: ecological, economic, social, technological, institutional, and environmental health, ranging from very poor (1) to very good (5). The results were analyzed using multi-dimensional scaling to determine the sustainability index and status. Meanwhile, the AHP method applied expert-based pairwise comparisons to assign priority weights, identifying the most influential dimensions and factors in the Green Hospital implementation at Tampan Psychiatric Hospital.

3 Result and Discussion

3.1 Ecological Dimension

Ecological sustainability in the context of hospital environmental management emphasizes efforts to maintain ecosystem balance through effective management. This dimension encompasses six attributes: a) Location and landscape, b) Hospital building, c) Management of hazardous and toxic waste, d) Management of non-medical waste, e) Use of non-medical materials, f) Use of medical materials. Evaluating these six attributes forms the basis for understanding the extent to which Tampan Psychiatric Hospital has adopted the principles of ecological sustainability, as illustrated in the following ordination graph **(Fig. 1)**.

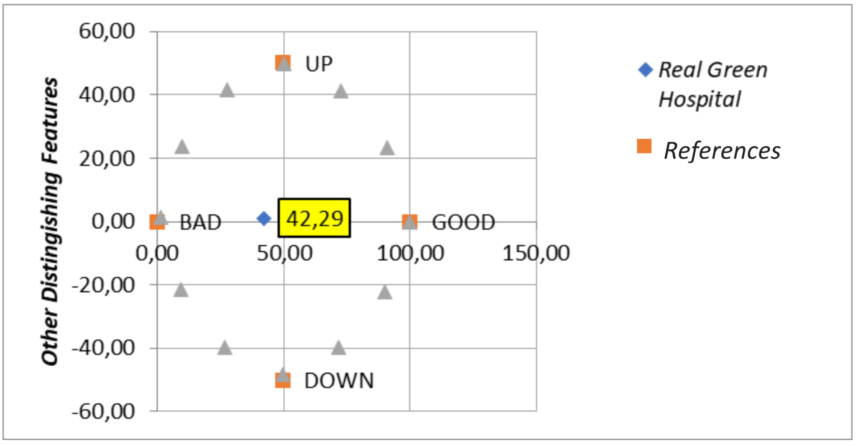

Fig. 1. Ecological sustainability ordination chart

Based on Rap Green Hospital results, Tampan Psychiatric Hospital has an ecological sustainability index of 42.29%, which is classified as "less sustainable". This figure reflects the state of environmental management at Tampan Psychiatric Hospital, particularly concerning B3 waste management, energy efficiency, and the use of eco-friendly materials.

The results, indicating an error of less than 5%, demonstrate that the sustainability index estimation model is both accurate and feasible [20]. In the Monte Carlo test, the analysis of the Rap-Green Hospital model for the ecological dimension produced an error value of less than 5%, indicating that the model is feasible and demonstrates good predictive accuracy. The results of the leverage attribute analysis are presented in **Fig. 2**, **Fig. 3**, and **Table 1**.

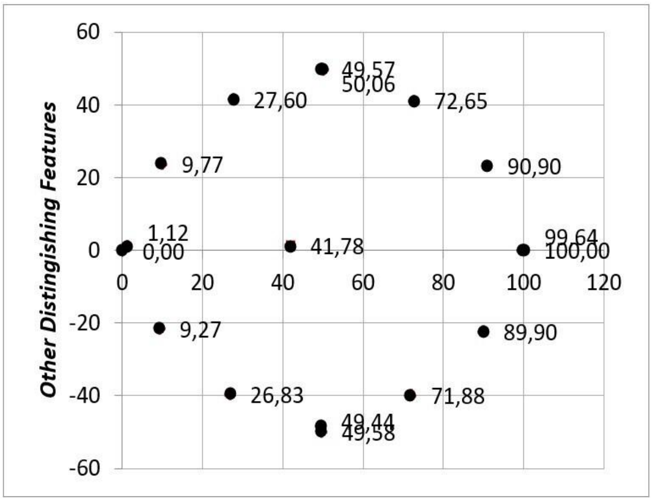

Fig. 2. Monte Carlo test of ecological dimensions

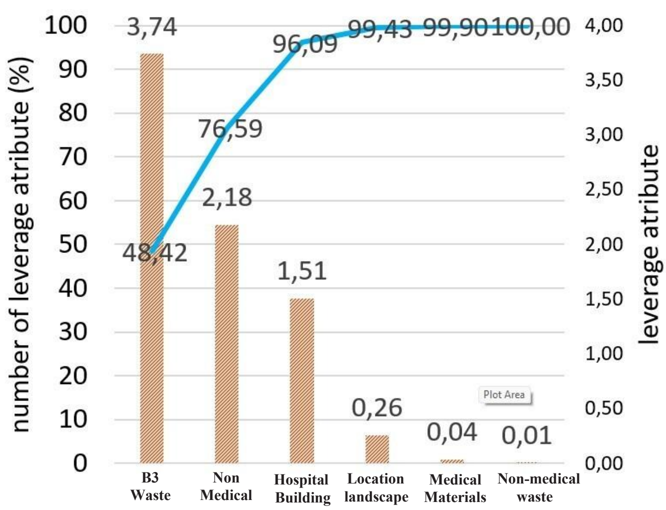

Fig. 3. Ecological leverage attribute graph

Table 1. Sustainability Levers for Ecological Dimension

Leverage Attribute	RMS(%)
B3 waste management	3.74

Through the analysis of leverage attributes using the Pareto Optimum principle, one primary attribute was identified as a level of sustainability in the ecological dimension of Tampan Psychiatric Hospital: the management of Hazardous and Toxic Materials (B3) waste. This attribute has a Root Mean Square (RMS) value of 3.74%, underscoring the significance of B3 waste management in promoting environmental sustainability at Tampan

Psychiatric Hospital. The Root Mean Square (RMS) value indicates the contribution of each attribute to sustainability sensitivity [21].

3.2 Economic Dimension

Economic sustainability in the management of the hospital environment, based on the Green Hospital model at Tampan Psychiatric Hospital, reflects the hospital's performance regarding resource use efficiency and budget management. This dimension encompasses five main attributes: water efficiency, energy efficiency, budget management, budget performance, and marketing. Evaluating these five attributes provides a foundation for understanding the extent to which Tampan Psychiatric Hospital has implemented the principles of economic sustainability, as illustrated in the ordination graph **(Fig. 4)**.

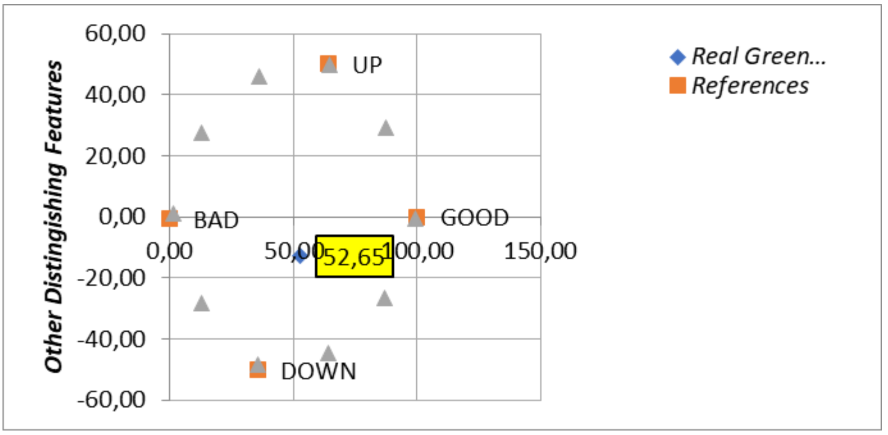

Fig. 4. Economic sustainability ordination chart

Based on Rap Green Hospital's results, Tampan Psychiatric Hospital's economic sustainability index value was 52.65%, placing it in the "quite sustainable" category. This figure indicates that while Tampan Psychiatric Hospital has implemented initiatives to enhance operational efficiency, there remains potential for further improvement. In the Monte Carlo test, the results from the Rap Green Hospital analysis regarding the economic dimension indicated an error value of less than 5%, suggesting that the model employed was quite feasible and demonstrated good accuracy (**Fig. 5, 6,** and **Table 2**).

Table 2. Sustainability Levers for Economic Dimension

Leverage Attribute	RMS(%)
Performance and Budget	5.31
Energy Efficiency	5.34

According to the analysis of leverage attributes using the Pareto Optimum Principle approach, the two primary attributes that serve as levers for sustainability in the economic dimension of managing the hospital environment at Tampan Psychiatric Hospital are performance and budget (with an RMS value of 5.31) and energy efficiency (with an RMS value of 5.24).

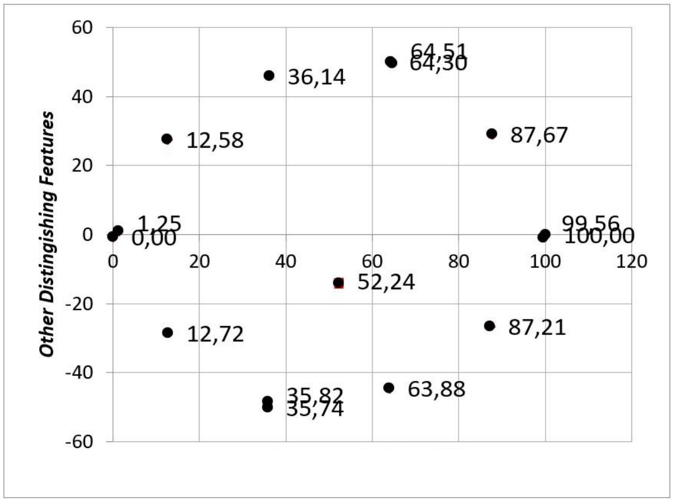

Fig. 5. Monte Carlo test of economic dimensions

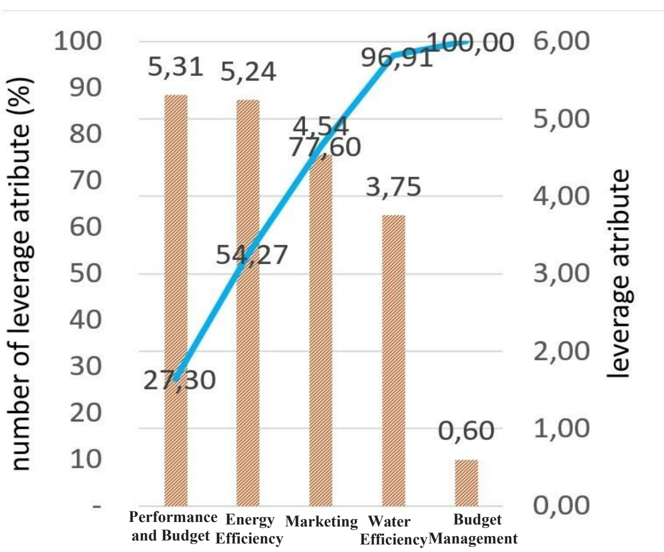

Fig. 6. Economic leverage attribute graph

3.3 Social Dimension

The social dimension encompasses five key attributes: environmentally friendly education, transportation and parking management, satisfaction levels with environmental services, accessibility, and green culture. Evaluating these five attributes provides a foundation for understanding the extent to which Tampan Psychiatric Hospital has implemented the principles of social sustainability, as illustrated in the ordination graph (**Fig. 7**).

Based on the Rap Green Hospital analysis, the social dimension of sustainability in environmental management has an index of 50.72%, which is categorized as quite sustainable. This index shows that Tampan Psychiatric Hospital has taken significant steps to implement the Green Hospital concept from a social perspective, though there is still room for improvement.

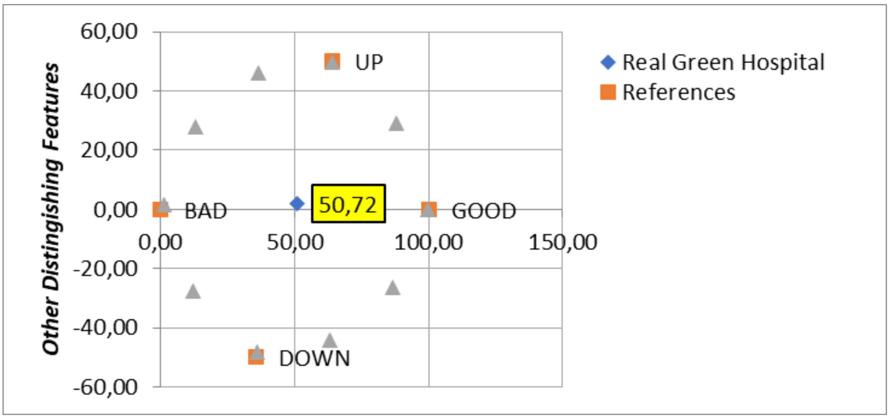

Fig. 7. Social Dimension Sustainability Ordination Chart

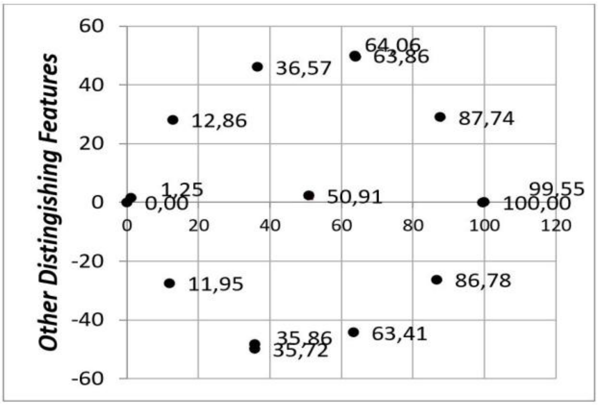

Fig. 8. Monte Carlo test of Social Dimensions

Monte Carlo analysis indicates a difference of less than 5%. This small difference suggests that the impact of errors or mistakes in scoring is relatively minor. Such errors can arise from variations in scoring or missing data [16].

Table 3. Sustainability levers for Social Dimension

Leverage Attribute	RMS(%)
Level of environmental service satisfaction	3.57

Based on an analysis of leverage attributes using the Pareto Optimum principle, the level of satisfaction with environmental services is the primary lever attribute in the social dimension of hospital sustainability. This attribute has a Root Mean Square (RMS) value of 3.57, indicating a significant influence on hospital environmental sustainability (**Fig. 8**, **Fig. 9**, and **Table 3**).

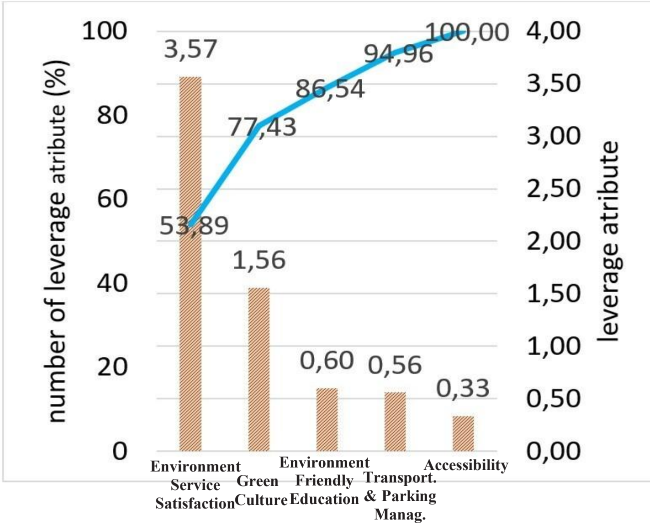

Fig. 9. Social Leverage Attribute Graph

3.4 Technological Dimension

Sustainability in the technological dimension reflects the hospital's effectiveness in adopting technological innovations that support the Green Hospital concept. This dimension comprises four management attributes: a) Waste processing technology, b) Energy conservation technology, c) Water conservation technology, and d) Clean air management technology. Evaluating these four attributes provides a foundation for understanding the extent to which Tampan Psychiatric Hospital has implemented the principles of technological sustainability, as illustrated in the ordination graph (**Fig. 10**).

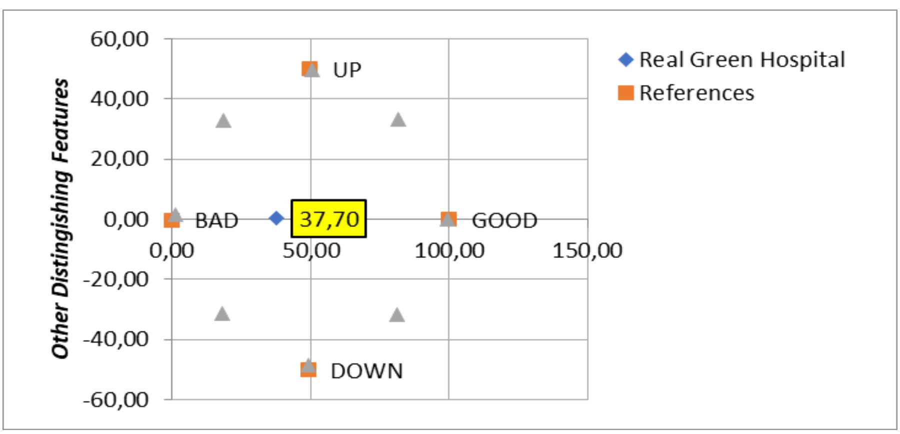

Fig. 10. Technological Dimension Sustainability Ordination Chart

Based on Rap Green Hospital's results, the sustainability index for the technology dimension is 37.70%, placing it in the less sustainable category. This figure indicates ongoing pressure and highlights the need for attention and substantial improvement efforts in the technology dimension of hospital management.

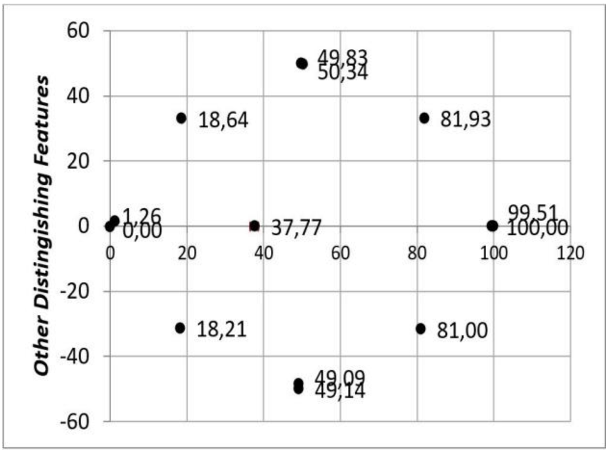

Fig. 11. Monte Carlo test of technological dmension

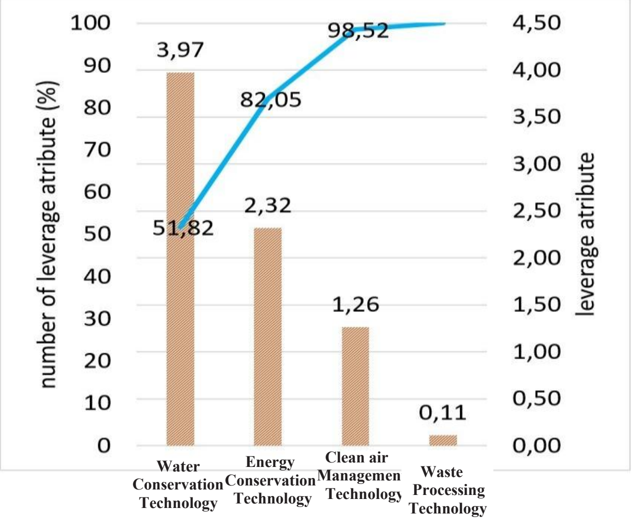

Fig. 12. Technological Leverage Attribute Graph

Monte Carlo analysis yielded relatively small values, well below the 5% threshold. This indicates that the influence of errors, or the impact of scoring errors, is minimal, allowing the Rap Green Hospital model for the technology dimension to be considered a reliable prediction tool.

Table 4. Sustainability levers for Technological Dimension

Leverage Attribute	RMS(%)
Water conservation technology	3.97

Based on the analysis of leverage attributes using the Pareto Optimum principle, one key attribute was identified as a lever for the sustainability of the technology dimension in environmental management at Tampan Psychiatric Hospital: water conservation technology, with a Root Mean Square (RMS) value of 3.97. This attribute demonstrates the highest sensitivity to the sustainability of the technology dimension, highlighting the importance of efficient and effective water management in supporting the transition to the Green Hospital concept (**Figs. 11**, **Fig. 12** and **Table 4**).

3.5 Environmental Health Dimension

The sustainability of the environmental health dimension is an important part of the hospital's efforts towards a Green Hospital, which focuses on managing factors that affect the health of patients, employees, and the surrounding environment. This dimension consists of six management attributes, namely: a) health promotion; b) nosocomial infections; c) food and beverages; d) vector control; e) radiation; and f) public sanitation facilities. Evaluating these six attributes provides a foundation for understanding the extent to which Tampan Psychiatric Hospital has implemented the principles of environmental health sustainability, as illustrated in the ordination graph (**Fig. 13)**.

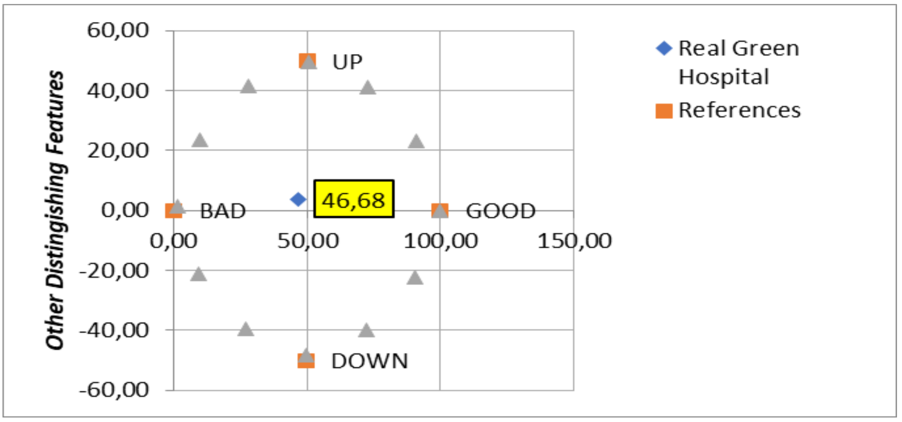

Fig. 13. Environmental Health Dimension Sustainability Ordination Chart

Based on Rap Green Hospital's results, the sustainability index for the Environmental Health Dimension is 46.68%, which is classified as less sustainable. This figure indicates that the management of environmental health aspects in hospitals continues to encounter significant challenges. One of the primary obstacles is the inadequate implementation of policies and practices that promote a clean, healthy, and environmentally friendly hospital.

The difference value obtained from the Monte Carlo analysis is minimal, well below the 5% threshold. This indicates that the impact of scoring errors or inaccuracies is quite low.

Table 5. Sustainability levers for Environmental Health Dimension

Leverage Attribute	RMS(%)
Health promotion	1.45
Vector eradication	1.39
Radiation	1.29

Based on the analysis of leverage attributes using the Pareto Optimum principle approach, it was determined that the three primary attributes serving as levers for the sustainability of the environmental health dimension at Tampan Psychiatric Hospital are health promotion, with a Root Mean Square (RMS) value of 1.45; vector control, with a Root Mean Square (RMS) value of 1.39; and radiation management, with a Root Mean Square (RMS) value of 1.29 (**Figs. 14 and 15** and **Table 5**).

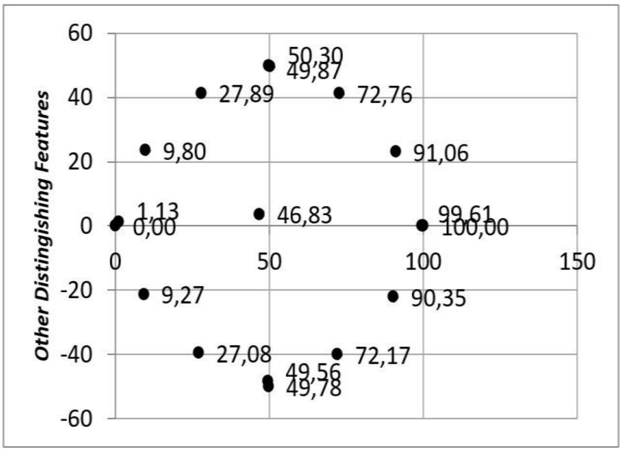

Fig. 14. Monte Carlo test of environmental health dimensions

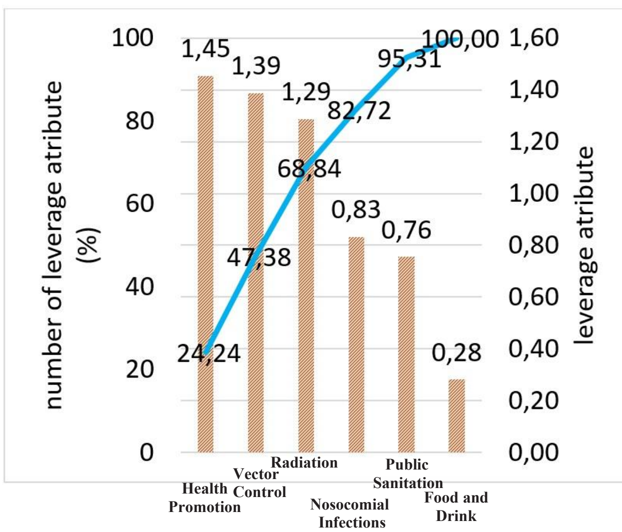

Fig. 15. Environmental Health Leverage Attribute Graph

3.6 Institutional Dimension

Sustainability of the institutional dimension at Tampan Psychiatric Hospital is a crucial aspect of the effort towards becoming a Green Hospital. This dimension comprises four management attributes: a) leadership, b) organization, c) environmental documentation, and d) collegial relationships. Evaluating these four attributes forms the basis for understanding the extent to which Tampan Psychiatric Hospital has adopted the principles of institutional sustainability, as depicted in the ordination graph (**Fig. 16**).

Table 6. Sustainability levers for Institutional Dimension

Leverage Attribute	RMS(%)
Environmental documents	5.6

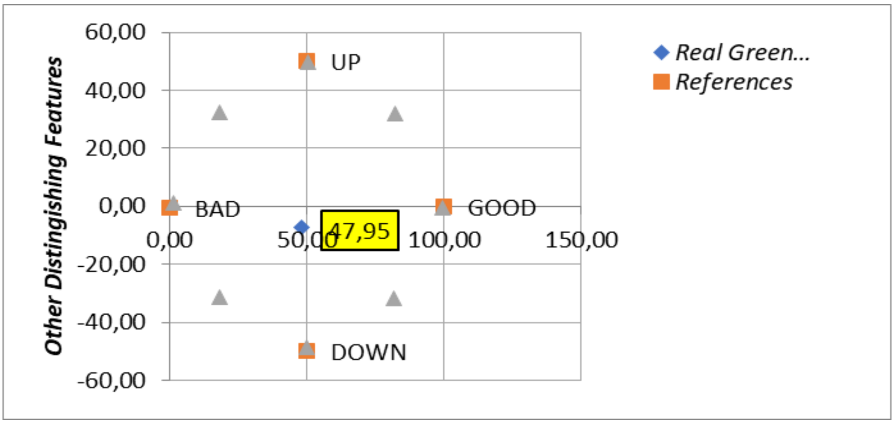

Fig. 16. Institutional Dimension Sustainability Ordination Chart

The Institutional Dimension scored 47.95%, placing Tampan Psychiatric Hospital in the "less sustainable" category, indicating weaknesses in leadership, inter-unit coordination, and environmental policy implementation.

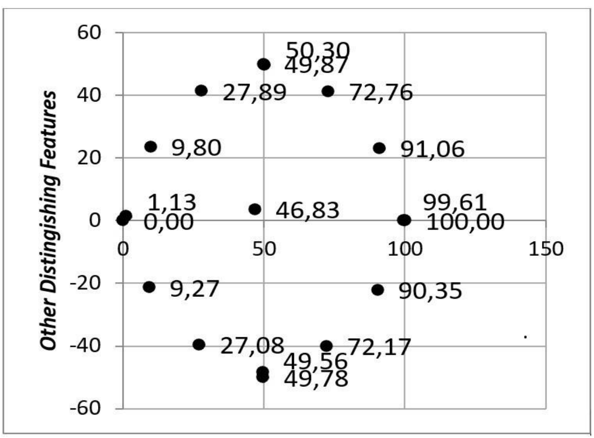

Fig. 17. Monte Carlo test of institutional dimensions

Monte Carlo analysis shows a very small difference, below 5%, indicating that the influence of errors in the model is very minimal. This indicates that this model is able to evaluate sustainability with a high level of accuracy.

Based on the Pareto optimum principle, the analysis shows that the sustainability lever attribute of the institutional dimension at Tampan Psychiatric Hospital is focused on "Environmental Documents," with an RMS value of 5.60. This value indicates that environmental documents have a significant contribution to the sustainability of hospital environmental management. The evaluation of the sustainability level of green hospital-based environmental management at Tampan Psychiatric Hospital involves a thorough analysis that considers the weight of each dimension, organized hierarchically to establish priorities for implementing sustainable work programs. The findings from the recapitulation of the sustainability status assessment of green hospital-based environmental management are detailed in **Table 7**.

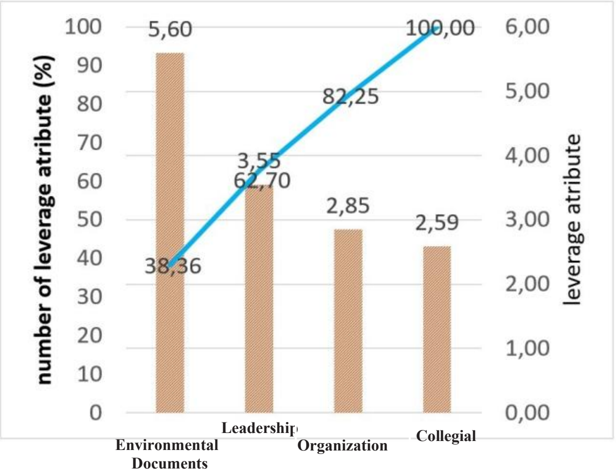

Fig. 18. Institutional Leverage Attribute Graph

Table 7. Recapitulation Results from the Assessment of Sustainability Status in the Hospital Environmental Management

Ecology	Economy	Social	Technology	Environmental Health	Institutional
42.29	52.65	50.72	37.70	46.68	47.95

The Analytic Hierarchy Process (AHP) method was utilized to identify the dimensions that contribute most significantly to sustainability. The findings of the AHP analysis are summarized in (**Fig. 19**), which displays the priority weights for each dimension and highlights the areas of environmental management strategies that require enhancement at Tampan Psychiatric Hospital. After scoring, the AHP results were multiplied by the sustainability status score obtained through the Multi-Dimensional Scaling (MDS) approach with the Rap Green Hospital tool as shown in **Table 8**.

Table 8. The Results of Calculation the Multi-dimensional Sustainability Index by Considering The Weighting Among Dimensions

Ecology	Economy	Social	Technology	Environmental Health	Institutional	Sustainability Index
6.78	2.29	3.32	3.86	17.71	11.93	45.90

This analysis shows that the overall index value is 45.90, placing Tampan Psychiatric Hospital in the less sustainable category. This indicates that although some aspects of environmental management have been implemented, major challenges remain to achieve a fully environmentally friendly hospital and Green Hospital standards.

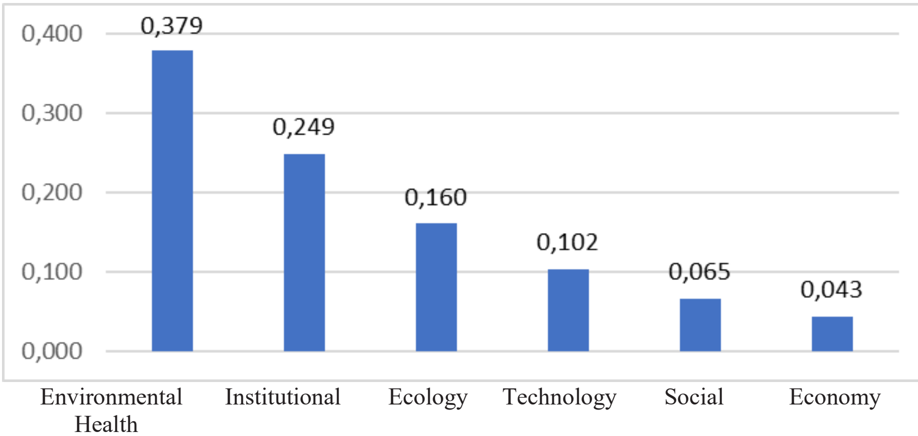

Fig. 19. Results of The Analysis of Priority Dimensions in The Environmental Management Towards Green Hospitals

Based on the results of the leverage attributes analysis, nine main attributes were identified as levers for the sustainability of hospital environmental management in green hospitals. These attributes, which are divided into various dimensions, include one in the ecological dimension, two in the economic dimension, one in the social dimension, one in the technological dimension, three in the environmental health dimension, and one in the institutional dimension, as summarized in **Table 9**.

Table 9. Environmental Management Leverage Attributes of a Green Hospital at Tampan Psychiatric Hospital

Dimensi	**Atribut**	**RMS(%)**
Ecology	B3 waste management	3.74
Economy	Performance and Budget Energy Efficiency	5.31 5.24
Social	Level of environmental service satisfaction	3.57
Technology	Water conservation technology	3.97
Environmental Health	Health promotion Vector eradication Radiation	1.45 1.39 1.29
Institutional	Environmental Documents	5.60

The nine leverage attributes identified across the sustainability dimensions can be strengthened through targeted strategic interventions to improve the implementation of the Green Hospital model at Tampan Psychiatric Hospital. In the ecological dimension, improving B3 waste management (RMS 3.74%) can be achieved by adopting ISO 14001–based environmental management systems and enhancing waste segregation and treatment facilities. In the economic dimension, strengthening performance and budgeting (RMS 5.31%) can be done through green budgeting and cost-efficiency audits, while energy efficiency (RMS 5.24%) can be enhanced by implementing renewable energy sources and digital energy monitoring systems. The social dimension, represented by environmental service satisfaction (RMS 3.57%), can be improved through staff training and patient-centered environmental awareness programs.

In the technological dimension, advancing water conservation technology (RMS 3.97%) can involve digital water-use monitoring, rainwater harvesting, and recycling systems. Within the environmental health dimension, interventions such as eco-health education programs for health promotion (RMS 1.45%), integrated pest management for vector eradication (RMS 1.39%), and regular radiation safety audits for radiation control (RMS 1.29%) are recommended. Lastly, in the institutional dimension, improving environmental documentation (RMS 5.60%) can be achieved by developing a digital documentation system aligned with ISO 14001 standards, ensuring better monitoring, transparency, and continuous improvement in sustainable hospital governance.

4 Conclusion

Based on the study's results, six main dimensions underlie the development of green hospital criteria at Tampan Psychiatric Hospital: ecology, economy, social, technology, environmental health, and institutions. The results of the sustainability status assessment for the MDS Rap Green Hospital at the Tampan Psychiatric Hospital indicate that the sustainability level is in the less sustainable category, with a score of 45.90%. The leverage attributes for the sustainability of environmental management of hospitals based on the Green Hospital at Tampan Psychiatric Hospital include: a) B3 waste management, b) performance and budget optimization, c) energy efficiency, d) increasing satisfaction with environmental services, e) application of water conservation technology, f) health promotion, g) vector control, h) radiation control, and i) environmental document management. The assessment of the sustainability status of environmental management is the main indicator for measuring the extent of success in implementing the Green Hospital program at the Tampan Psychiatric Hospital. This study not only provides a detailed picture of sustainable environmental management practices but also directly contributes to achieving SDG 3 (Good Health and Well-being) and SDG 13 (Climate Action). By identifying key leverage attributes such as waste management, energy efficiency, and health promotion, the findings support improved hospital environments that enhance patient and staff well-being (SDG 3) while simultaneously reducing carbon emissions and promoting resource conservation (SDG 13). Thus, this research offers both practical and strategic insights for advancing sustainable healthcare systems aligned with global development goals.

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