InJAST
Volume 4, Number 2, October 2023
Pages: 85-92

P - ISSN: 2722 - 0133
E - ISSN: 2722 - 0141
DOI: 10.33751/injast.v4i2.8976

Analysis of the sustainability status of community-based drinking water supply in Kapongan District, East Java

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Submitted 29 September 2023 ; Accepted 27 November 2023

ABSTRACT

Ensuring the availability and sustainability of clean water is a key focus of the United Nations Sustainable Development Goals (SDGs) and has emerged as a significant concern for both central and local governments in Indonesia. In the Kapongan District of Situbondo Regency, the government's PAMSIMAS Programme is a proactive initiative designed to secure safe access to drinking water for the community. Within this district, two villages, Landangan and Pokaan, have successfully implemented community-based drinking water provision. The ongoing sustainability of these water supply systems in these villages is pivotal for meeting the continuous drinking water needs of the community, necessitating a comprehensive investigation into its sustainability. The primary objective of this study is to assess the sustainability status of community-based drinking water provision within the ongoing PAMSIMAS program in Kapongan District. The dimensions under consideration encompass environmental, social, economic, technological, and institutional aspects. Employing a quantitative approach, the research utilizes the Rap-SPAM analysis method, a modification of Rapfish, with primary data collected through surveys, observations, and interviews. Additionally, secondary data is acquired through an extensive literature review and consultation with various related agencies. The assessment results reveal a sustainability index of 58.92, classifying it as reasonably sustainable. The Multi-Dimensional Scaling (MDS) model produced Stress values ranging from 0.15 to 0.18 and R2 values between 0.93 to 0.94. The variance between the MDS index and Monte Carlo analysis is less than 5%. In conclusion, this study finds that the community-based water supply facilitated by the PAMSIMAS program in Kapongan District demonstrates a reasonably sustainable status. To enhance its sustainability, there is a need to prioritize and improve dimensions with lower sustainability index values in a holistic manner.

ABSTRAK

Memastikan ketersediaan dan keberlanjutan air bersih merupakan fokus utama Tujuan Pembangunan Berkelanjutan (SDGs) PBB dan menjadi perhatian besar bagi pemerintah pusat dan daerah di Indonesia. Di Kecamatan Kapongan Kabupaten Situbondo, Program PAMSIMAS yang dicanangkan pemerintah merupakan inisiatif proaktif yang dirancang untuk menjamin akses yang aman terhadap air minum bagi masyarakat. Di kabupaten ini, Desa Landangan dan Pokaan telah berhasil menerapkan penyediaan air minum berbasis masyarakat. Keberlanjutan sistem pasokan air di desa-desa ini sangat penting untuk memenuhi kebutuhan air minum masyarakat secara berkelanjutan, sehingga memerlukan kajian komprehensif. Tujuan dari penelitian ini untuk menilai status keberlanjutan penyediaan air minum berbasis masyarakat dalam program PAMSIMAS yang sedang berjalan di Kecamatan Kapongan. Dimensi yang dipertimbangkan meliputi aspek lingkungan, sosial, ekonomi, teknologi, dan kelembagaan. Dengan menggunakan pendekatan kuantitatif, penelitian ini menggunakan metode analisis Rap-SPAM, modifikasi dari Rapfish, dengan data primer yang dikumpulkan melalui survei, observasi, dan wawancara. Selain itu, data sekunder diperoleh melalui penelusuran literatur yang ekstensif dan konsultasi dengan berbagai lembaga terkait. Hasil kajian menunjukkan indeks keberlanjutan sebesar 58,92 yang tergolong cukup berkelanjutan. Model Multi-Dimensional Scaling (MDS) menghasilkan nilai Stress yang berkisar antara 0,15 hingga 0,18 dan nilai R2 antara 0,93 hingga 0,94. Perbedaan antara indeks MDS dan analisis Monte Carlo kurang dari 5%. Kesimpulannya, penelitian ini menemukan bahwa pasokan air berbasis masyarakat yang difasilitasi oleh program PAMSIMAS di Kabupaten Kapongan menunjukkan status yang cukup berkelanjutan. Untuk meningkatkan keberlanjutannya, terdapat kebutuhan untuk memprioritaskan dan memperbaiki dimensi dengan nilai indeks keberlanjutan yang lebih rendah secara holistik.

Keywords: *Drinking water supply system, Multi-Dimensional Scaling, PAMSIMAS Programme, Rapfish, sustainability*

INTRODUCTION

Ensuring availability and sustainability of clean water has been targeted in the United Nations Sustainable Development Goals (SDGs) and has become an important issue of both central and local governments in Indonesia (Pambudi, 2023), as climate change has created major social and economic, as well as environmental problems in the country, especially in Sumatra and Java (Monk & Priatna, 2022). Provision of drinking water is a crucial activity to fulfill the needs of a productive, clean, and healthy society, as regulated in Presidential Regulation Number 122 of 2015. The government strives to achieve 100% access to safe and adequate drinking water, with a target of 15% in the 2020-2024 National Medium-Term Development Plan (RPJMN), in accordance with Presidential Regulation Number 18 of 2020. This initiative aims to improve the quality of life for the community and support sustainable development. The 2005-2025 Medium-Term Regional Development Plan (RPJP) emphasizes the development of adequate drinking water and sanitation facilities as a priority to drive economic growth and overall societal well-being, as stipulated in Law Number 17 of 2007. Additionally, the government has set a target to achieve Sustainable Development Goal (SDG) number 6, which is universal, safe, and affordable access to drinking water by 2030, considering it a fundamental human right and a key promoter of health and well-being, in line with Bappenas (2020) and the United Nations 2015 sustainable development agenda.

In its pursuit of the mission, every ministry has tasks and responsibilities to improve the social, economic, environmental, and cultural well-being of communities, both in the present and for the future (Widiyono, 2020). The PAMSIMAS programme is a government initiative organized by the Ministry of Public Works and Housing (*Kementerian PUPR*) to enhance community access to safe water and proper sanitation (Pamsimas, 2022). The programme focuses on the development of community-based drinking water systems. Government programmes that prioritize empowerment have provided valuable experiences in cost reduction for a given task while maintaining the quality equivalent to non-empowerment programmes (Soesanta, 2013). In its implementation, PAMSIMAS involves community groups in all stages, from planning to maintenance of the water supply systems. The goal is to ensure that communities can access improved drinking water and sanitation (source: https://pamsimas.pu.go.id). The implementation of the PAMSIMAS Programme holds significant importance as a source of raw water to address the current and potential future challenges of clean water scarcity (Suheri et al., 2020).

Situbondo Regency, located in East Java Province, is a target area for the PAMSIMAS programme aimed at improving access to proper drinking water through a community-based approach. As of 2022, a total of 94 villages in Kabupaten Situbondo have benefited from this programme between 2014 and 2022 (DPUPP Kab. Situbondo, 2023). According to Swastomo and Iskandar (2021), the sustainability of water supply in these villages is crucial to ensure the continual fulfillment of the community's drinking water needs. Mukherjee and van Wijk (2003) highlight five interconnected and interdependent aspects in the context of sustainable water and sanitation development: technical, social, financial, environmental, and institutional aspects. The sustainability of water and sanitation development depends on the interaction and support among these five aspects. Therefore, it is essential to conduct a study on the sustainability of the provision of drinking water through the PAMSIMAS programme in functioning villages.

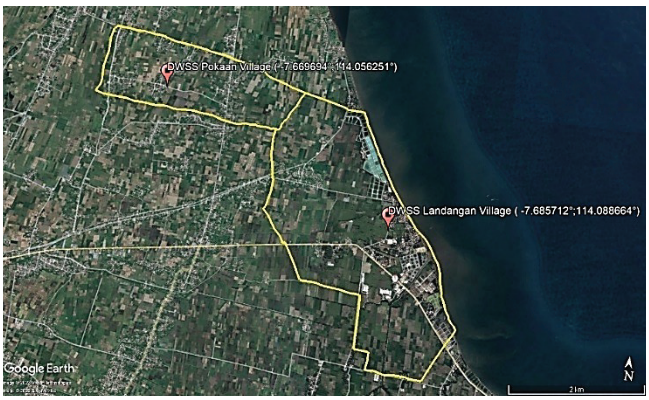
One of the districts in the Situbondo Regency is Kapongan, which has implemented community-involved water supply through the PAMSIMAS programme in five villages within its area. These villages received the programme in the years 2017, 2018, 2021, and 2023. Currently, in Kapongan District, two villages, Landangan and Pokaan, still have functioning drinking water supply systems (DWSS), while in the villages of Peleyan, Seletreng, and Wonokoyo, the systems are non-functional (DPUPP Kab. Situbondo, 2023). This situation has resulted in a lack of access to drinking water for the communities in these villages where the SPAM systems are not functional.

Given this background, research is required to assess the sustainability status of the functioning The Community-based Water Supply Programme (PAMSIMAS). This research aims to ensure the continuity of continuous drinking water access in villages where the DWSS (Drinking Water Supply System) is still operational. Through this study, it is hoped that the sustainability status of the community-based water supply programme under PAMSIMAS can be determined, enabling further improvements and development.

METHODS

Research Location

The research was conducted in the villages of Landangan and Pokaan, Kapongan District, Situbondo Regency, East Java Province. The village of Landangan implemented a community-based water supply system through the PAMSIMAS programme in 2018, managed



(Source: Google Earth, 2023)

Figure 1. Research location at Pokaan and Landangan Villages

by the group named "Samudra Mandiri". On the other hand, the village of Pokaan implemented a community-based water supply system through the PAMSIMAS programme in 2022, managed by the group named "Tirta Jaya". The village locations are depicted in Figure 1.

Materials and Tools

The author directly conducted fieldwork to gather the necessary information, having prepared guidelines to serve as data collection tools. The equipment used for the survey, particularly for interviews, included: questionnaire forms for data collection, writing tools such as pens, pencils, and notepads, and a pocket camera for documentation during the research activities. Data processing was carried out using computer software.

Sampling Method

This research utilized a method of primary data collection through surveys, observations, and interviews with questionnaire completion by relevant respondents. Primary data was obtained directly from users and operators of the Drinking Water Supply System (DWSS). The selection of respondents in each village for DWSS users was done randomly using the simple random sampling technique, meaning the selection of respondents without considering the strata present in the use of drinking water. As for the members of the management group, three members were chosen from the entire DWSS management group, consisting of the chairman, treasurer, and technician. The sample size for drinking water users in each village was determined using the Slovin's formula, as follows (Priyono, 2016):

$$n = \frac{N}{1 + N(e)^2}$$

Note:
n= Sample size / number of respondents
N= Population size
e= Percentage of desired sampling error; e=0.1

Based on the formula above, the sample sizes for the PAMSIMAS users in Pokaan village (Tirta Jaya DWSS) and Landangan village (Samudra Mandiri DWSS) were determined to be 50 and 75 respondents, respectively. In addition to primary data, this research also utilized secondary data to support analysis and draw conclusions. Secondary data was obtained through literature reviews from various relevant sources, such as government agencies, universities, textbooks, reports/papers, and other sources relevant to this research.

Research Procedure

This research used the Rap-SPAM method, which is a modification of the Rapfish (Rapid Appraisal for Fisheries) method. The Rapfish method is a statistical technique for the rapid assessment of the relative status of entities (in this case, the fisheries sector), quantitatively assessed against a set of pre-determined attributes grouped into 'evaluation domains' or disciplines (Kavanagh and Pitcher, 2004). Although Rapfish was initially designed for sustainability analysis in the fisheries sector, the fundamental principles of sustainability it developed can be applied to other sectors as well (Fauzi, 2022). The research process with the Rap-SPAM method consists of three main steps: attribute review and sustainability identification, scoring each attribute, and data analysis with Rap-SPAM, as shown in Figure 2.

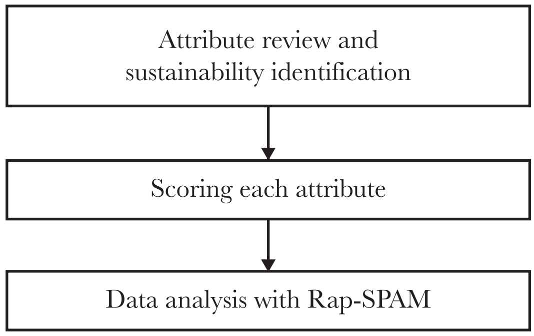


Figure 2. The Rap-SPAM method process.

The first steps, the review of attributes and sustainability identification, involves the determination of attributes based on the five dimensions of sustainability: technical, social, financial, environmental, and institutional. The determination of these attributes is based on various literature studies related to the discussion to assess the sustainability of community-based water supply. The results from the questionnaires and interviews will serve as the fundamental data for the scoring process. The expected attributes that are anticipated to influence the sustainability level of the five reviewed dimensions are presented in Table 1.

Table 1. Determination of dimension attributes.

No	6 Environmental Dimension Attributes
1	Quantity of raw water
2	Protection of water sources
3	Continuity of raw water
4	Pollution potential
5	Surrounding land conditions
6	Rainfall & rainy days
	6 Social Dimension Attributes
7	Practices of using the water supply system
8	Concern for the water supply system
9	Necessity of the water supply system
10	Desire for sustainability

11	Community meetings
12	Community trust
	6 Economic Dimension Attributes
13	Existence of user fees
14	Affordability of user fees
15	Regularity of fee payments
16	Fee adequacy with Operations & Maintenance
17	Existence of fees for the development of the water supply system network
18	Availability of funds for the development of the water supply system
	6 Technological Dimension Attributes
19	Quality of received water
20	Availability of water at all times
21	Ease of technology application
22	Efficiency of water use
23	Quantity of obtained water
24	Network leakages
	6 Institutional Dimension Attributes
25	Regulations for water supply management
26	Clear organizational structure
27	Activity of the management
28	User satisfaction
29	Implementation of rules in water supply system management
30	Performance and financial reporting by the management to the users of the water supply system

The second step is scoring each attribute, which involves converting primary and secondary data obtained into a Likert scale based on the indicators for each attribute that has been prepared. The Likert scale used is 0=poor, 1=moderate, 2=good, 3=very good. The scoring results for each attribute are then analyzed using the Rapfish application, which is an add-in within Microsoft Excel.

The third step is the Rap-SPAM analysis, where the scoring results for each attribute are then analyzed using the Rapfish application, which is an add-in in the MS Excel application. Rap-SPAM ordination is the output of the Rap-SPAM software, depicting the sustainability index. This sustainability index has a range of values between 0-100% and is plotted on two orthogonal axes (x-axis and y-axis). The best scale (good) is reflected by a 100% index value, while the worst scale (bad) is reflected by a 0% index value. Therefore, if the index indicates a value less than 50%, it is categorized as unsustainable. Conversely, if the index shows a value greater than or equal to 50%, it is categorized as sustainable. The description of the resulting ordination index can be provided in four categories of sustainability status, as shown in Table 2.

Table 2. Sustainability criteria.

Index Value	Category	Description
75.01 - 100	Good	Sustainable
50.01 - 75	Fair	Fairluy Sustainable
25.01 - 50	Poor	Less Sustainable
0 - 25	Bad	Not Sustainable

(Source: Yusuf et al. (2021))

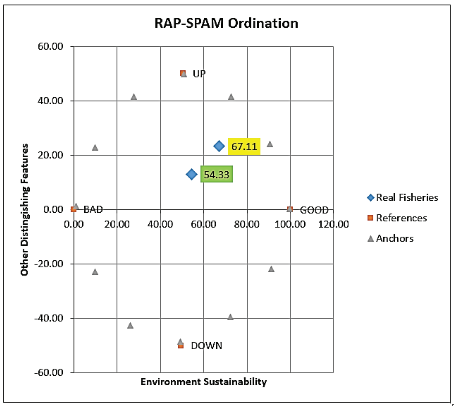
In addition to generating the sustainability index, MDS ordination results along with stress and R^2 values, the automatically scored data is also utilized for Monte Carlo ordination and sensitivity analysis. The Monte Carlo analysis is employed to estimate the influence of errors in the analysis process with a 95% confidence level. Evaluation of stress and coefficient of determination (R^2) values is used to determine whether additional attributes are needed to accurately reflect the evaluated dimensions. According to Kavanagh and Pitcher (2004) as cited in Cocon (2016), a good model is characterized by a stress value below 0.25 and an R^2 value approaching 1, indicating that the MDS analysis is qualitatively reliable.

RESULTS AND DISCUSSIONS

According to the National Urban Water Supply Project (NUWSP, 2020), to support a sustainable and beneficial Community-Based Drinking Water Supply System for the community, there are four important aspects that need attention. The first aspect is the technical-technological aspect, which includes meeting the quality and quantity of drinking water according to standards, as well as ease of application of water technology. The second aspect is the socio-economic cultural aspect, emphasizing the importance of considering the community's ability to subscribe and setting appropriate tariffs. The third aspect is the institutional aspect, which includes a clear organizational structure, regular funding, and attention to operation and maintenance to maintain the sustainability of the system. The fourth aspect is the environmental aspect, which includes strategies to improve the quantity and quality of clean water and environmental capacity to conserve natural resources and the environment. Various factors that directly or indirectly affect the sustainability of water supply are influenced by the participation of the community, institutions, financing, and technical aspects (Krisdhianto and Sembiring, 2016). Moreover, social, environmental, and economic factors also play a significant role in the sustainability of water supply (Djono, 2011).

Sustainability Status of the Environmental Dimension

The analysis using Rap-SPAM on the 6 attributes yielded sustainability index values for the environmental dimension in the community-based drinking water supply system in Landangan Village at 67.11%, categorizing it as moderately sustainable (index falls between 50.01-75.00). Meanwhile, in Pokaan Village, the sustainability index is at 54.33%, also classified as moderately sustainable, as shown in Figure 3.

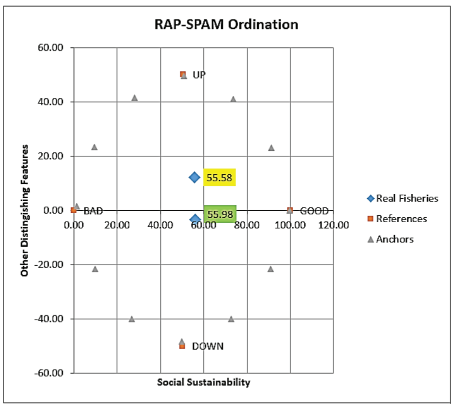


(Source: Analysis, 2023)

Figure 3. Ordination graph of the environmental dimension

Sustainability Status of Social Dimension

The analysis using Rap-SPAM on 6 attributes yielded sustainability index values for the social dimension in the community-based drinking water supply system in the Landangan village of 55.58%, categorizing it as moderately sustainable (index falls between 50.01-75.00). Meanwhile, in the Pokaan village, the index was 55.98%, also classified as moderately sustainable, as shown in Figure 4.

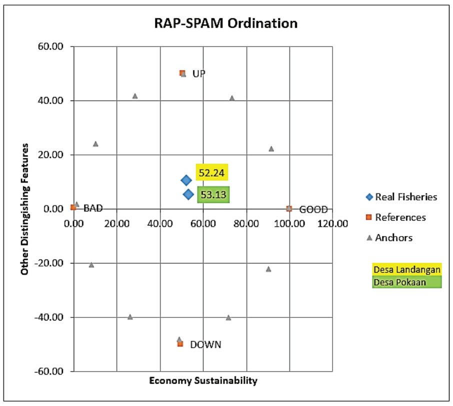


(Source: Analysis, 2023)

Figure 4. Ordination graph of the social dimension

Sustainability Status of Economic Dimension

The analysis using Rap-SPAM on 6 attributes resulted in sustainability index values for the economic dimension in the community-based drinking water supply system Landangan Village at 52.24%, categorizing it as moderately sustainable (index falls between 50.01-75.00). Meanwhile, in the Pokaan village, the sustainability index was 53.13%, also classifying it as moderately sustainable, as shown in Figure 5.

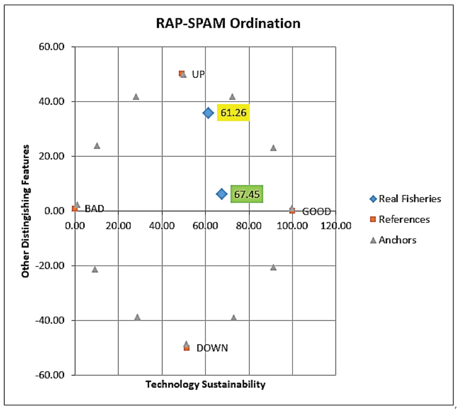


(Source: Analysis, 2023)

Figure 5. Ordination graph of the economic dimension

Sustainability Status of Technology Dimension

The analysis using Rap-SPAM on 6 attributes yielded sustainability index value for the technological dimension in the community-based drinking water supply system in Landangan village of 61.26%, classified as moderately sustainable (the index falls between 50.01-75.00), while in Pokaan village, it was 67.45%, also classified as moderately sustainable, as shown in Figure 6.

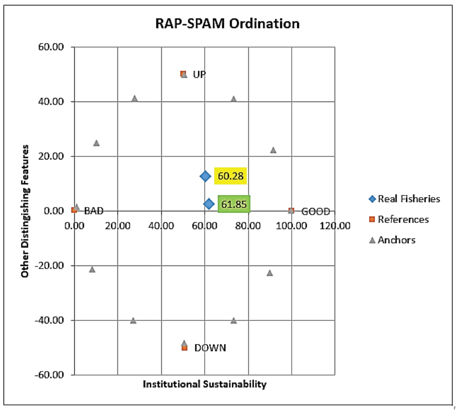


(Source: Analysis, 2023)

Figure 6. Ordination graph of the technological dimension

Sustainability Status of Institutional Dimension

The analysis using Rap-SPAM on the 6 attributes resulted in a sustainability index value for the institutional dimension in the community-based drinking water supply system in the Landangan Village of 60.28%, which falls into the category of fairly sustainable (the index is within the range of 50.01-75.00). Meanwhile, in the Pokaan Village, the sustainability index is 61.85%, which also falls into the category of fairly sustainable, as shown in Figure 7.



(Source: Analysis, 2023)

Figure 7. Ordination graph of the institutional dimension

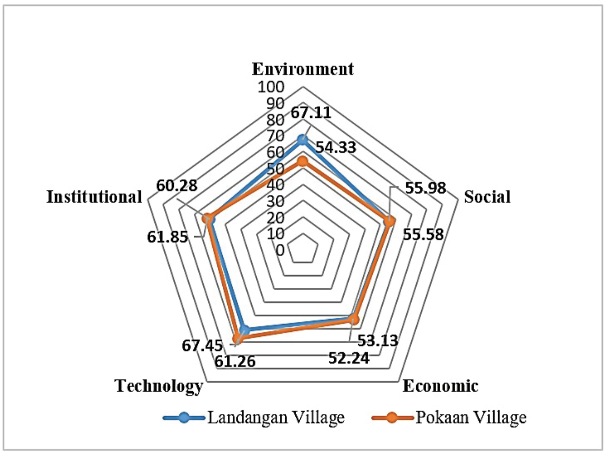
Sustainability Status of Community-Based Drinking Water Supply in Kapongan District

The results of the Rap-SPAM analysis on the five dimensions of community-based drinking water supply in the PAMSIMAS in two villages in the Kapongan District are presented by the sustainability index values and statuses as shown in Table 3 below:

Table 3. Multidimensional Sustainability Index.

Dimension	Index			Status
	DWSS in Landangan Village	DWSS in Pokaan Village	Average	
Environment	67.11	54.33	60.72	Fairly Sustainable
Social	55.58	55.98	55.78	Fairly Sustainable
Economic	52.24	53.13	52.68	Fairly Sustainable
Technology	61.26	67.45	64.35	Fairly Sustainable
Institutional	60.28	61.85	61.07	Fairly Sustainable
Multidimensional	59.29	58.55	**58.92**	**Fairly Sustainable**

(Source: Analysis, 2023)



(Source: Analysis, 2023)

Figure 8. Kite diagram of the sustainability of community-based drinking water supply in Kapongan District.

Overall, the sustainability index score for the community-based drinking water supply programme PAMSIMAS in Kapongan District is 58.92, categorizing it as fairly sustainable. The community-based drinking water supply programme PAMSIMAS in Landangan Village has the highest level of sustainability index with a score of 59.29 (fairly sustainable), while in Pokaan Village, it has the lowest level of sustainability index with a score of 58.55 (fairly sustainable). The sustainability index scores for each dimension are visualized in a kite diagram in Figure 8.

Validity of Analysis Results

The calculation results using the Rap-SPAM approach for all dimensions yielded stress values between 0.15 to 0.18 and R2 values between 0.93 to 0.94, as presented in Table 4. Based on the S and R^2 values, according to the statistical model analysis criteria, a good model is indicated by an S value less than 0.25 and R^2 approaching 1 (Kavanagh and Pitcher, 2004). Therefore, it can be concluded that the model examined in this study is good (good fit) across all dimensions. This demonstrates that all attributes for each dimension have accurately depicted the conditions in the community-based PAMSIMAS programme water supply areas in Kapongan District, making it unnecessary to add or reduce the number of attributes.

Table 4. The Stress and R^2 values for all dimensions.

Parameter	Dimensions				
	Environment	Social	Economic	Technology	Institutional
Stress	0.15	0.17	0.18	0.15	0.17
R^2	0.94	0.93	0.93	0.94	0.94

(Source: Analysis, 2023)

Monte Carlo Analysis in Rap-SPAM is used to examine the influence of errors in the scoring process on attributes due to limitations in information, the variability of scoring due to differences in opinions or assessments of attributes by each respondent, the stability of the MDS ordination process, and errors in data entry (Kavanagh, 2001). Conclusions of the analysis are drawn by comparing the difference between the ordination results in the Monte Carlo sustainability index and the MDS sustainability index, as shown in Table 5 below.

In this study, the Monte Carlo analysis was performed 25 times with a 95% confidence interval, showing that the difference between the MDS index values and the Monte Carlo analysis values was not more than 5%. This indicates that the sustainability index values for each dimension have relatively small random errors (Hardjomidjojo et al., 2016 as cited in Munawir et al., 2022). Therefore, the results of the Monte Carlo analysis support the accuracy of determining the ordination of the sustainability status of community-based drinking water provision examined.

Table 5. Comparison between MDS index and Monte Carlo.

Dimensions	DWSS Location	Index MDS	Monte Carlo	Deviation
Environment	Landangan Village	67.11	65.53	1.59
	Pokaan Village	54.33	54.17	0.16
Social	Landangan Village	55.58	55.33	0.25
	Pokaan Village	55.98	56.04	0.07
Economic	Landangan Village	52.14	52.24	0.10
	Pokaan Village	53.35	53.13	0.22
Technology	Landangan Village	61.26	60.08	1.18
	Pokaan Village	67.45	66.31	1.14
Institutional	Landangan Village	59.71	60.28	0.57
	Pokaan Village	61.82	61.85	0.04

(Source: Analysis, 2023)

CONCLUSION

From the results of this research, it can be concluded that the status of community-based drinking water provision through the PAMSIMAS programme in Kecamatan Kapongan falls under the category of fairly sustainability with an index value of 58.92. Efforts are needed to improve the sustainability index by prioritizing dimensions with lower sustainability values. Improvements in these sustainability dimensions need to be made holistically. Hence, the involvement and commitment of local government and stakeholders are crucial in enhancing sensitive attributes to support the enhancement of the sustainability index for community-based drinking water provision through the PAMSIMAS programme in Kapongan District.

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