

TRANSFORMING ENVIRONMENTAL LIABILITY TO SOCIAL ASSET: COMMUNITY-BASED WATER UTILIZATION OF POST-MINING VOIDS

TRANSFORMANDO O PASSO AMBIENTAL EM RECURSO SOCIAL: UTILIZAÇÃO COMUNITÁRIA DA ÁGUA EM VAZIOS PÓS-MINERADORES

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Abstract

A strategic method to promoting sustainable development, especially in areas impacted by intense coal mining, is the conversion of post-mining voids into alternate supplies of clean water. This study investigates the use of the Andaru Void, a PT Borneo Indobara-owned post-mining site in Tanah Bumbu Regency, South Kalimantan, Indonesia, as a clean water source for local communities. Stratified random sampling was used to pick 300 respondents for the descriptive quantitative design. Descriptive statistics and correlation analysis were used to examine the data, and Cronbach's Alpha was used to test the instrument's reliability. The findings show that clean water management

Resumo

Um método estratégico para promover o desenvolvimento sustentável, especialmente em áreas afetadas pela intensa exploração de carvão, é a conversão de cavidades pós-mineração em fontes alternativas de água potável. Este estudo investiga o uso da Cavidade de Andaru, um local pós-mineração de propriedade da PT Borneo Indobara na Regência de Tanah Bumbu, Kalimantan do Sul, Indonésia, como fonte de água potável para as comunidades locais. Utilizou-se amostragem aleatória estratificada para selecionar 300 entrevistados para o desenho quantitativo descritivo. Estatísticas descritivas e análise de correlação foram utilizadas para examinar os



through Village-Owned Enterprises (Badan Usaha Milik Desa/BUMDes) significantly improved household access to water, reduced monthly water expenditures from up to IDR 100,000 to approximately IDR 25,000–30,000, and strengthened village economic capacity through locally generated revenue. Approximately 82% of households adopted void water as their primary source, while 70% expressed satisfaction with service quality. In addition, community participation and institutional trust were found to be key drivers of system sustainability. This study adds to the body of post-mining literature by incorporating institutional and socioeconomic viewpoints into the management of water resources. Additionally, it offers a reproducible model for community-based governance of water resources left over from mining in poor nations.

Keywords: Post-Mining Voids. Community-Based Water Management. Clean Water Access. Bumdes. Sustainable Development.

dados, e o Coeficiente Alfa de Cronbach foi utilizado para testar a confiabilidade do instrumento. Os resultados mostram que a gestão da água potável por meio de Empresas de Propriedade da Aldeia (Badan Usaha Milik Desa/BUMDes) melhorou significativamente o acesso das famílias à água, reduziu os gastos mensais com água de até 100.000 IDR para aproximadamente 25.000–30.000 IDR e fortaleceu a capacidade econômica da aldeia por meio de receitas geradas localmente. Aproximadamente 82% das famílias adotaram a água de cavidades como fonte primária, enquanto 70% expressaram satisfação com a qualidade do serviço. Além disso, constatou-se que a participação comunitária e a confiança institucional são fatores-chave para a sustentabilidade do sistema. Este estudo contribui para a literatura sobre o pós-mineração ao incorporar perspectivas institucionais e socioeconômicas na gestão dos recursos hídricos. Adicionalmente, oferece um modelo reproduzível para a governança comunitária dos recursos hídricos remanescentes da mineração em nações pobres.

Palavras-chave: Vazios pós-mineração. Gestão comunitária da água. Acesso à água potável. Bumdes. Desenvolvimento sustentável.

1 INTRODUCTION

Access to clean water remains a critical global challenge within the sustainable development agenda. The United Nations, through the Sustainable Development Goals (SDGs), emphasizes Clean Water and Sanitation (SDG 6), recognizing access to safe water as a fundamental human right and a prerequisite for improvements in public health, education, and economic productivity. Despite this commitment, more than two billion people worldwide still lack access to safely managed drinking water, particularly in developing countries vulnerable to climate change and environmental degradation. In Indonesia, similar challenges persist, especially in rural and coastal areas where clean water infrastructure remains limited. These challenges are further exacerbated by population growth, climate variability, and environmental degradation caused by intensive natural resource extraction, including coal mining activities [1]. Consequently,

innovative and locally grounded approaches to water resource management are urgently required.

One prominent feature of mining landscapes is the presence of post-mining voids—large excavation pits left after extractive operations. Conventionally, these voids are perceived as environmental liabilities due to associated risks such as water contamination, hydrological disruption, and safety hazards [2]. However, recent studies challenge this perception by highlighting the potential of mining voids to function as water reservoirs that support clean water supply, ecological restoration, and drought mitigation. When properly managed, post-mining voids can transition from environmental burdens into productive infrastructure that provides ecological services with tangible social and economic value.

This perspective is particularly relevant in South Kalimantan Province, one of Indonesia's largest coal-producing regions, where extensive mining activities have resulted in numerous large-scale voids. Paradoxically, communities located near mining areas often experience limited access to clean water due to the depletion of natural springs and declining river water quality. These conditions underscore the importance of reimagining post-mining voids as alternative local water resources capable of meeting household needs, provided that water quality, safety, and supply continuity are ensured [1].

Nevertheless, the utilization of post-mining voids cannot be assessed solely from a technical perspective, such as water quality parameters, pumping systems, or distribution networks. The long-term sustainability of such initiatives depends heavily on social, institutional, and economic dimensions. Evidence from international studies indicates that community-based water management systems are more likely to succeed when supported by active participation, institutional legitimacy, and adaptive technical capacity [3,4]. In the absence of accountable governance mechanisms, such systems often become fragile and unsustainable.

Despite growing recognition of these issues, the literature on post-mining land use remains dominated by technical and environmental studies focusing on geotechnical stability, hydrogeochemical characteristics, and water remediation strategies [2,5]. In contrast, research examining socio-economic and institutional dimensions remains limited. This imbalance is problematic because sustainable development requires the

integration of social, economic, and environmental dimensions as inseparable components [6]. Therefore, there is a need for empirical studies that explore how local institutions, particularly community-based organizations, can govern post-mining resources in an inclusive and sustainable manner.

The Andaru Void, owned by PT Borneo Indobara in Tanah Bumbu Regency, provides a compelling case for such investigation. The site has been integrated into village-level public service systems through management by Village-Owned Enterprises (BUMDes). Initially supported by Corporate Social Responsibility (CSR) programs, the system has evolved into a self-sustaining water service supplying nearly all households in Banjarsari and Mekar Jaya villages through a participatory tariff mechanism. This arrangement represents a hybrid governance model involving collaboration among the private sector, local government, and community institutions.

Theoretically, this study draws upon five frameworks: sustainable development theory [6,7], socio-economic theories including the capability approach and social capital theory [8–10], Green Theory [11], community-based water management [12], and contemporary mine reclamation theory [13]. Together, these frameworks provide a comprehensive lens for understanding the transformation of post-mining landscapes into socio-economic assets.

Against this background, this study aims to examine the utilization of the Andaru Void as a community-based clean water source and to articulate its contributions to sustainable post-mining governance. Academically, it addresses a gap in the literature by emphasizing socio-economic and institutional dimensions. Practically, it offers a replicable governance model for similar post-mining regions. More broadly, it contributes to global discussions on post-extractive development by demonstrating how local communities can play a central role in shaping sustainable futures.

2 METHODS

2.1 Study area and research period

This research was carried out in villages surrounding the Andaru Void, a post-mining site owned by PT Borneo Indobara and located in Banjarsari and Mekar Jaya

villages, Angsana District, Tanah Bumbu Regency, South Kalimantan Province, Indonesia. The study region was purposefully chosen because the Andaru Void is a post-mining site that has been actively used as a community-based clean water supply by a Village-Owned Enterprise (Badan Usaha Milik Desa/BUMDes).

Between March and May 2025, the research was conducted in three stages: research planning, data collecting, and analysis.

2.2 Research design

This study employed a descriptive quantitative design to provide a comprehensive overview of post-mining void utilization as a community-based clean water source. The analysis focused on socio-economic characteristics, household water consumption patterns, community perceptions and participation, and the institutional capacity of BUMDes in managing water services.

The study did not aim to establish causal relationships but rather to examine the social, economic, and institutional mechanisms influencing sustainability.

2.3 Population and sampling

The study population consisted of approximately 1,800 households receiving water services sourced from the Andaru Void. A stratified random sampling technique was applied based on proximity to the water distribution network.

Using Slovin's formula with a 5% margin of error, a sample size of 300 respondents was obtained, which was considered adequate to capture variability across households.

2.4 Research variables and instruments

The research variables were obtained from theoretical frameworks and study objectives. Socioeconomic variables (age, education, occupation, and income) served as control variables. Water access variables were principal water source, consumption volume, cost, and service satisfaction.

Community participation variables included involvement in decision-making, payment consistency, and participation in maintenance tasks. Institutional variables included transparency, accountability, service quality, and public trust in BUMDes.

Data were collected using a structured questionnaire. A pilot test involving 30 respondents was conducted to ensure clarity and reliability. Instrument reliability was confirmed using Cronbach's Alpha ($\alpha \geq 0.7$).

2.5 Data collection techniques

2.5.1 Data collection employed multiple methods

Data were collected using multiple complementary techniques to ensure comprehensive and reliable findings. Primary data collection involved household surveys administered through structured questionnaires to obtain quantitative information from respondents. In addition, in-depth interviews were conducted with BUMDes managers, community leaders, and relevant stakeholders to gather detailed qualitative insights regarding program implementation and community participation.

Focus Group Discussions (FGDs) were also organized to capture collective perspectives, experiences, and perceptions of community members. Furthermore, direct field observations were carried out to assess on-site conditions and verify information obtained from respondents. Secondary data were obtained through the review of relevant documents, including Corporate Social Responsibility (CSR) reports, village records, financial reports, and other institutional publications.

The use of these multiple data collection methods enabled methodological triangulation, thereby enhancing the credibility, validity, and reliability of the study findings.

2.6 Data analysis

Quantitative data were analyzed using descriptive and inferential statistical techniques. Descriptive statistics, was used to summarize the socio-economic characteristics of respondents and their levels of participation. In addition, Chi-square

tests were employed to examine the relationships between selected socio-economic variables and participation levels. All statistical analyses were conducted using standard statistical software, and results were presented in tables and charts where appropriate.

2.7 Research ethics

All respondents voluntarily participated in the study and provided informed consent prior to data collection. Confidentiality and privacy were maintained through the anonymization of respondents' identities and the secure handling of collected information. Ethical clearance and necessary permissions for conducting the research were obtained from relevant authorities, including village governments and PT Borneo Indobara.

2.8 Methodological limitations

This study is subject to certain limitations. First, the descriptive research design limits the ability to establish causal relationships between variables. In addition, the findings are context-specific to the study area and may not be fully generalizable to other regions or settings with different socio-economic and institutional conditions. Nevertheless, the study employed methodological triangulation and representative sampling techniques to enhance the credibility, reliability, and overall robustness of the findings.

3 RESULTS

3.1 Socio-economic profile of the community

According to the 2024 Community Development Profile (PPM Ring 1) of PT Borneo Indobara, the total population in the surrounding mining area reaches approximately 25,700 inhabitants distributed across 12 villages. The majority of residents are engaged in agriculture, plantation activities, and small-scale mining-related occupations. Educational attainment is relatively heterogeneous, with most residents

having completed junior and senior secondary education, while only a small proportion have attained higher education. Average household income ranges between IDR 2,000,000 and IDR 3,000,000 per month, reflecting the characteristics of rural, resource-based communities.

Based on the household survey involving 300 respondents from Banjarsari and Mekar Jaya villages, the age distribution of household heads is relatively balanced. Approximately 35% fall within the productive age group of 31–45 years, 28% are aged 46–55 years, 20% are above 55 years, and the remainder are below 30 years. Formal education levels are dominated by senior high school graduates (45%), followed by junior high school graduates (32%), primary school graduates (15%), and those with tertiary education (8%).

In terms of occupation, the majority of respondents work as farmers or plantation workers (52%), followed by mining laborers or extractive-sector workers (18%), small traders (15%), and other occupations (15%), including teachers, village officials, and informal workers. Household income distribution indicates that 40% of respondents earn between IDR 2,000,000 and IDR 3,000,000 per month, 30% earn less than IDR 2,000,000, 20% earn between IDR 3,000,000 and IDR 4,000,000, and only 10% earn more than IDR 4,000,000 per month.

These findings highlight the limited purchasing power of households and underscore the importance of affordable clean water services. Similar studies conducted in rural India and Nepal [13] indicate that tariff affordability is a critical determinant of sustainability in community-based water supply systems.

3.2 Water sources and household consumption patterns

Before the utilization of water from the Andaru Void through BUMDes management, most households relied on rivers, shallow wells, and rainwater as their primary sources of water. River water was mainly used for bathing and washing, while rainwater was collected for drinking purposes during the rainy season. During the dry season, however, communities frequently experienced clean water shortages and were forced to purchase water delivered by tanker trucks at relatively high prices.

Following the introduction of clean water services sourced from the Andaru Void, household water consumption patterns underwent significant change. Approximately 82% of respondents reported using BUMDes-managed void water as their primary source for daily household needs, while the remainder continued to use a combination of river and rainwater. Average household water consumption ranged between 80 and 100 liters per day.

In terms of cost, the average monthly household expenditure for BUMDes' water services ranged from IDR 25,000 to IDR 30,000, which is substantially lower than the cost of purchasing tanker-delivered water, which can reach up to IDR 100,000 per month. These results demonstrate a significant reduction in household water expenditure following access to water services based on voids.

Community satisfaction with the water service is relatively high. Approximately 70% of respondents reported being satisfied, 20% moderately happy, and only 10% dissatisfied. The most positively perceived aspects include continuity of supply, water clarity, and affordable pricing. Nevertheless, a small proportion of respondents reported concerns related to limited distribution coverage in certain hamlets and occasional technical issues such as pipeline leakage. These findings are consistent with the study by Hope et al. (2020) in East Africa, which emphasizes the importance of service reliability and quality in building trust in community-based water systems [3].

3.3 Community perceptions of void-based water services

Survey results indicate that the majority of respondents perceive void water as suitable for household use. Approximately 75% believed that the quality of well water is superior to river or shallow well water, particularly in terms of clarity and taste. However, around 10% of respondents expressed concerns regarding potential heavy metal contamination associated with mining voids, despite laboratory water quality tests conducted by the Tanah Bumbu Environmental Agency confirming the suitability of the water for consumption.

Secondary data from laboratory analyses conducted by PT Borneo Indobara between 2020 and 2022 as shown in Table 1, it shows that key water quality parameters, including pH, total suspended solids (TSS), iron (Fe), manganese (Mn), and cadmium

(Cd), consistently met national water quality standards. These findings reinforce the perception that Andaru Void water is safe for domestic use.

Table 1

Results of Water Quality Analysis of the Andaru Void

No.	Parameter	Unit	Analytical Result	Quality Standard	Specification
Laboratory Analysis, 11 February 2022					
1	Laboratory pH	-	7,6	-	SNI 6989.11.2004
2	Total Suspended Solids (TSS)	mg/L	6	≤ 200	SNI 6989.3-2004
3	Total Iron (Fe)	mg/L	< 0,023	≤ 7	SNI 6989.84.2019
4	Total Manganese (Mn)	mg/L	0,09	≤ 4	SNI 6989.84.2019
5	Total Cadmium (Cd)	mg/L	< 0,014	≤ 0,05	SNI 6989.84.2019
Laboratory Analysis, 25 October 2021					
1	Laboratory pH	-	7,8	-	SNI 6989.11.2004
2	Total Suspended Solids (TSS)	mg/L	21	≤ 200	SNI 6989.3-2004
3	Total Iron (Fe)	mg/L	0,10	≤ 7	SNI 6989.84.2019
4	Total Manganese (Mn)	mg/L	0,16	≤ 4	SNI 6989.84.2019
5	Total Cadmium (Cd)	mg/L	< 0,014	≤ 0,05	SNI 6989.84.2019
Laboratory Analysis, 14 October 2020					
1	Laboratory pH	-	7,5	-	SNI 06-6989.11.2004
2	Total Suspended Solids (TSS)	mg/L	7	≤ 200	SNI 06-6989.3-2004
3	Total Iron (Fe)	mg/L	< 0,023	≤ 7	SNI 6989.4:2009
4	Total Manganese (Mn)	mg/L	< 2,023	≤ 4	SNI 6989.5:2009
5	Total Cadmium (Cd)	mg/L	< 0,014	≤ 0,05	SNI 6989.16:2009
Laboratory Analysis, 6 January 2020					
1	Laboratory pH	-	7,0	-	SNI 06-6989.11.2004
2	Total Suspended Solids (TSS)	mg/L	60	≤ 200	SNI 06-6989.3-2004
3	Total Iron (Fe)	mg/L	< 0,033	≤ 7	SNI 6989.4:2009
4	Total Manganese (Mn)	mg/L	0,03	≤ 4	SNI 6989.5:2009
5	Total Cadmium (Cd)	mg/L	< 0,015	≤ 0,05	SNI 6989.16:2009

Notably, higher levels of satisfaction with water services are positively associated with timely payment of user fees. Respondents who reported higher satisfaction were more likely to comply with monthly payment obligations, indicating a positive relationship between service quality and financial sustainability. This finding aligns with Wong and van der Heijden (2023), who emphasize the linkage between institutional legitimacy, service quality, and community participation in water governance in Southeast Asia.

3.4 Community participation

Community participation in the management of water services based on voids is relatively high. Approximately 60% of respondents reported having participated in village deliberation meetings related to water governance. Additionally, 75% reported making regular and timely payments of monthly water fees, while approximately 40% actively participated in collective maintenance activities, such as repairing pipelines or maintaining storage tanks.

This high level of participation is influenced by community trust in BUMDes management, tangible benefits derived from the service, and the persistence of strong collective action norms (*gotong royong*). These findings are consistent with Putnam's (2000) social capital framework, which posits that participation is strengthened when social trust and perceived collective benefits are present [9].

3.5 Institutional capacity of BUMDes

BUMDes, as the primary institution responsible for managing void-based water services, demonstrates relatively strong institutional capacity. Transparency is maintained through the public disclosure of financial reports every three months during village forums, while accountability is ensured through participatory decision-making processes, particularly in the determination of water tariffs.

Survey results indicate that 85% of respondents perceive BUMDes as a credible and trustworthy institution in managing clean water services. This level of trust constitutes an essential form of social capital that underpins the system's sustainability. Nevertheless, several challenges remain, including limited technical personnel for infrastructure maintenance, initial dependence on corporate CSR support, and the need for reserve funds to support long-term maintenance.

Although BUMDes' performance is generally viewed positively, these challenges indicate the need for continued institutional strengthening through technical training and regulatory support from local governments to ensure long-term resilience.

3.6 Key findings

Based on the empirical results, several key findings can be identified:

- a. The Andaru Void has been successfully transformed into an alternative clean water source for communities in Banjarsari and Mekar Jaya villages, significantly reducing dependence on river water and rainwater.
- b. Access to void-based clean water has improved household welfare by lowering water-related expenditures and enhancing overall quality of life.
- c. High levels of community participation are closely linked to trust in BUMDes as the managing institution.
- d. BUMDes exhibits relatively strong institutional capacity, although further technical and financial strengthening is required.
- e. The community-based water management model implemented at the Andaru Void demonstrates strong potential for replication in other post-mining areas with similar characteristics, provided that local contextual adaptation is considered.

Overall, these findings confirm that transforming post-mining voids into community-based clean water sources is not only feasible but also contributes significantly to achieving the Sustainable Development Goals, particularly SDG 6 on clean water and sanitation.

4 DISCUSSION

The utilization of the Andaru Void in Tanah Bumbu Regency represents a concrete example of how post-mining landscapes traditionally regarded as environmental liabilities can be transformed into productive resources that support community welfare. This transformation can be comprehensively understood through the lenses of sustainable development theory, socio-economic development theory, Green Theory, community-based water management, and contemporary mine reclamation literature. More importantly, the Andaru case demonstrates how village-level institutions, particularly Village-Owned Enterprises (BUMDes), can serve as key governance actors when supported by formal regulations and active community participation.

4.1 Post-mining voids within the sustainable development framework

The utilization of the Andaru Void demonstrates the practical application of sustainable development principles at the local level. According to Purvis et al. (2019), sustainability emerges at the intersection of economic, social, and environmental dimensions, all of which are clearly evident in the Andaru case [6].

From an economic perspective, households in Banjarsari and Mekar Jaya villages previously spent up to IDR 350,000 per month on clean water, equivalent to approximately 20–25% of monthly household income due to repeated purchases of tanker-delivered water. The introduction of void-based water services reduced household water expenditure by approximately 60%, thereby releasing household income for other essential needs. This finding is consistent with Chatterjee et al. (2021), who reported that access to affordable clean water significantly enhances the economic resilience of low-income households in rural India [13].

From the perspective of society, better water access alleviated the physical and time strain experienced especially by women and children, who had previously had to go up to 2-3 kilometers to collect water from rivers or shallow wells. This is consistent with Wong and van der Heijden's (2023) results, which emphasize that increased water access promotes gender parity and allows women to participate more fully in productive economic activities [4].

Figure 1*Location of the Andaru Void*

From an environmental perspective, hydrological analysis indicates a positive annual water balance surplus of approximately $+121,711 \text{ m}^3$, suggesting that water extraction from the Andaru Void does not exceed ecological carrying capacity. Instead, the void functions as an environmental buffer during seasonal droughts. This supports Zhang et al. (2022), who highlight the strategic role of mining voids as long-term water reserves in tropical regions [2].

Figure 1 shows the location of the Andaru Void, taken together, the Void exemplifies the operationalization of sustainable development in a post-mining context by integrating economic benefits, social empowerment, and environmental sustainability. Consequently, the initiative contributes directly to SDG 6 (Clean Water and Sanitation) and indirectly to SDG 11 (Sustainable Cities and Communities).

4.2 Socio-economic impacts: household and village-level dynamics

4.2.1 Household-level impacts

Data from Banjarsari Village indicate that the average household consists of four to five members. With an estimated water requirement of approximately 120 liters per person per day, a household requires around 15 m^3 of water per month. When met through

tanker-delivered water, monthly costs could reach IDR 875,000. Under the BUMDes-managed system, monthly tariffs range from IDR 75,000 to IDR 100,000, resulting in household savings exceeding IDR 700,000 per month.

Beyond financial savings, improved proximity and continuity of water supply significantly reduced the time and physical effort previously required to secure water. Survey results indicate that women who traditionally bear responsibility for household water management previously spent up to two to three hours per day collecting water. Reduced water-fetching burdens create opportunities for increased participation in income-generating and social activities. This finding aligns with Fischer and Qaim (2021), who argue that access to basic infrastructure strengthens women's roles in rural development [14].

These empirical findings suggest that access to clean water contributes not only to financial efficiency but also to broader social transformation at the household level.

4.2.2 Village-level economic impacts

The study demonstrates that BUMDes-managed water services generate regular revenue contributing between IDR 25,000,000 and IDR 35,000,000 per month to Village Original Revenue (Pendapatan Asli Desa—PADes). This finding confirms that post-mining void utilization is not merely consumptive but also institutionally productive.

Revenue from the clean water business unit enhances the village fiscal capacity, enabling the financing of operational costs and other development programs. As such, BUMDes functions as a village-level economic instrument that reduces dependence on external assistance. These results indicate that post-mining spaces can generate new sources of economic value when managed effectively through local institutions.

4.2.3 Social dynamics and collective action

High compliance rates, exceeding 85%, for regular fee payment and active participation in village meetings and collective maintenance activities, reflect strong community trust in BUMDes as the water service provider. Importantly, residents

perceive the water system not as an externally imposed project but as a shared community asset.

High participation levels also serve as an informal social control mechanism. When tangible benefits are experienced collectively, compliance with local rules increases without the need for strict enforcement mechanisms. This finding reinforces the arguments of Putnam (2000) and Woolcock (2001) that social capital manifested through trust, norms, and social networks is a critical determinant of successful community governance [9][10].

4.3 Community participation and social capital in void-based water management

Community participation in the Andaru Void water system operates across three interrelated dimensions:

- a. Financial participation, through regular payment of user fees;
- b. Formal participation, through attendance at village deliberations on tariff setting, service evaluation, and network expansion;
- c. Informal participation, through collective action (*gotong royong*) in infrastructure maintenance and water source protection.

Survey results indicate that positive perceptions of water quality and BUMDes performance (with over 70–80% of respondents expressing satisfaction across key indicators) are closely associated with higher levels of participation. This suggests that participation is driven not merely by obligation but by satisfaction and institutional trust.

In line with Ostrom's (1990) theory of common-pool resource governance, locally developed rules enforced through social legitimacy are more effective than externally imposed regulations. The Andaru case demonstrates that village deliberations and village regulations function as both socially binding and legally recognized governance instruments [12]. This sense of ownership among users strengthens system resilience and sustainability, consistent with Wong and van der Heijden's (2023) findings on community-based water governance in Southeast Asia [4].

4.4 Institutional capacity and governance of BUMDes

The success of Andaru Void utilization is closely tied to the strength of local institutional arrangements. A combination of legal legitimacy, participatory organizational structures, accountability mechanisms, and multi-actor collaboration supports water governance in Banjarsari and Mekar Jaya villages

4.4.1 Formal legitimacy: village regulations as legal instruments

Village Regulation No. 3 of 2024 in Banjarsari Village and Village Regulation No. 10 of 2020 in Mekar Jaya Village provide a clear legal foundation for clean water governance. These regulations define user obligations, BUMDes authority, tariff mechanisms, and community oversight procedures, ensuring that water services are institutionalized beyond temporary CSR programs. Formal legitimacy strengthens BUMDes' role as a recognized public service provider at the village level.

4.4.2 Institutional structure: integration of BUMDes and PAMSIMAS

Institutional arrangements integrate BUMDes with the Community-Based Water Supply and Sanitation Program (PAMSIMAS). Core management units handle administration and financial reporting, while technical teams manage operations and maintenance. Community involvement in the selection of management personnel enhances social legitimacy.

This institutional integration allows BUMDes to focus on economic and legal dimensions while PAMSIMAS strengthens technical capacity and community participation. The clear division of roles improves operational efficiency and minimizes governance conflicts.

4.4.3 Participation and accountability mechanisms

Village deliberation forums serve as the primary arena for setting tariffs, evaluating services, and making network expansion decisions. Regular public disclosure

of financial reports reinforces transparency and public accountability. High levels of trust in BUMDes management are closely linked to these transparency practices, which in turn support financial compliance and system sustainability.

4.4.4 Village–company–community collaboration

Governance of the Andaru Void reflects a hybrid governance model involving:

- a. PT Borneo Indobara, providing initial infrastructure through CSR programs;
- b. Village governments, offering legal legitimacy and oversight;
- c. Community institutions (BUMDes–PAMSIMAS) act as primary operators with financial and social participation from residents.

Long-term sustainability is currently driven by village regulations and community engagement as shown in Figure 2 and 3, while CSR sponsorship was a catalyst in its initial stages. This result emphasizes that corporate engagement works best as an enabling mechanism rather than a long-term management solution.

Figure 2

Clean Water Storage Facility Managed by the Community



Figure 3

Community Utilization of Clean Water at a Public Facility (Mosque)



4.4.5 Challenges and governance implications

Despite generally positive institutional performance, challenges remain, including limited technical human resources, insufficient reserve funds, and increasing management complexity as services expand. These challenges highlight the need for continuous capacity building to ensure institutional adaptability and resilience. Adaptive, transparent, participatory, and accountable local institutions are essential for sustaining post-mining transitions.

4.5 Green theory and socio-ecological reclamation

Hydrological data and community perceptions indicate that utilization of the Andaru Void does not impose significant ecological pressure-Instead, the void functions as ecological infrastructure providing clean water while supporting environmental recovery. From a Green Theory perspective, the Andaru Void illustrates how ecological degradation can be reconfigured into productive socio-ecological systems. The emergence of new habitats, including riparian vegetation and freshwater fish, reflects the potential for biodiversity.

This aligns with Dobson's (2007) concept of ecological citizenship, wherein communities act not only as resource users but also as stewards of restored ecosystems [11].

4.6 Mine reclamation: from technical remediation to socio-economic transformation

While mine reclamation literature has traditionally focused on technical stability and water quality [5; 2], the Andaru case expands this perspective by demonstrating the importance of socio-economic integration. What was once considered a mining risk has been transformed into a strategic resource supporting village welfare. These findings reinforce Chatterjee et al.'s (2021) argument that community involvement is essential for successful water-related reclamation projects [13].

4.7 International comparison and lessons learned

Internationally, the Andaru Void shares similarities with community-based water initiatives in India and Nepal that emphasize the formation of social capital [13]. However, Andaru's distinguishing features include strong legal legitimacy through village regulations and a hybrid governance arrangement supported by CSR.

Compared to post-mining practices in countries such as Australia, Germany, and Canada, where voids are primarily conserved as passive landscapes, the Andaru approach reflects a more context-sensitive model suitable for rural communities in developing countries. Legal legitimacy and community participation emerge as key differentiators of success.

4.8 Theoretical and practical implications

Theoretically, this study reinforces the argument that social and institutional dimensions are central to post-mining reclamation and water governance literature. Practically, the Andaru model offers a replicable framework for community-based void utilization, provided that local contextual adaptations are carefully considered.

4.9 Limitations and future research directions

The primary limitation of this study lies in its descriptive design, which restricts causal inference. Future research should employ longitudinal approaches to assess the long-term dynamics of water quality, public health outcomes, and institutional resilience. Comparative studies across multiple post-mining voids in South Kalimantan would further enhance understanding of governance variation and outcomes.

5 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This study shows that community-based governance structures can turn post-mining landscapes into sustainable socio-economic assets. The Andaru Void in Banjarsari and Mekar Jaya villages, Angsana District, Tanah Bumbu Regency, offers empirical proof that, when managed by inclusive and responsible local institutions, post-mining voids can function as productive infrastructure rather than just being environmental remnants. This research leads to several important findings.

First, using post-mining voids as sources of clean water directly supports the goals of sustainable development. In addition to meeting basic household needs, water from the Andaru Void increases household economic capacity by lowering water-related expenses, enhancing general quality of life, and assisting in the accomplishment of the Sustainable Development Goals, especially SDGs 6 (Clean Water and Sanitation) and 11 (Sustainable Cities and Communities).

Also, the socio-economic impacts of void-based water utilization are substantial. At the household level, reduced water expenditures enable families to reallocate financial resources toward productive sectors such as education, health, and micro-enterprises. At the village level, revenue generated from BUMDes-managed water services contributes to Village Original Revenue (Pendapatan Asli Desa/PADes), strengthening local fiscal capacity and reducing dependence on external assistance. This dual impact illustrates how post-mining resource utilization can simultaneously enhance individual welfare and collective economic resilience.

Third, community participation emerges as a critical determinant of success. High levels of community involvement in fee payment, village deliberations, and collective maintenance activities underpin the sustainability of the Andaru Void water system. Strong public trust in BUMDes reflects the presence of robust social capital, which serves as a foundational element for the long-term viability of the system.

Fourth, adaptive institutional capacity supported by formal legal legitimacy plays a central role in governance effectiveness. Village Regulation No. 3 of 2024 in Banjarsari Village, along with complementary regulatory instruments in Mekar Jaya Village, provides a clear legal framework for water management. The integration of BUMDes and PAMSIMAS demonstrates an inclusive organizational structure that balances technical and administrative functions. Village deliberation forums serve as mechanisms for transparency, accountability, and public oversight. This governance configuration highlights the importance of combining formal regulation, participatory decision-making, and public accountability.

Fifth, the Andaru Void exemplifies the application of Green Theory and socio-ecological reclamation principles. A site previously regarded as mining waste has been transformed into ecological infrastructure that simultaneously provides clean water and supports emerging ecosystems. This reflects a broader reclamation paradigm in which environmental restoration is integrated with social and economic objectives rather than treated as a purely technical exercise.

Finally, in comparison with international post-mining practices, the Andaru case presents a distinctive model of community-based reclamation, characterized by strong legal legitimacy at the village level and hybrid governance involving communities, local governments, and the private sector. This model enriches the global literature on post-mining land use, which has historically emphasized technical and environmental dimensions while underrepresenting socio-institutional dynamics.

Overall, the findings confirm that the success of post-mining resource management is determined not solely by technical feasibility, but also by the strength of local institutions, community participation, and legal legitimacy.

5.2 Recommendations

Based on the findings of this study, several recommendations are proposed for both practical implementation and future research.

- a. Strengthening Technical and Human Resource Capacity
- b. BUMDes and PAMSIMAS should enhance the technical capacity of management personnel through regular training in water system management, pump maintenance, and troubleshooting the distribution network. Strengthening local technical expertise is crucial for reducing reliance on external technicians and ensuring uninterrupted service.
- c. Diversification of Financing Mechanisms
- d. To enhance financial sustainability, BUMDes should establish a reserve fund derived from surplus user fees to cover major repairs and long-term infrastructure maintenance. In addition, partnerships with local governments and donor agencies may be explored to support network expansion and system upgrades.
- e. Integration with Environmental and Climate Resilience Programs
- f. The Andaru Void has the potential to function as part of broader climate adaptation strategies, particularly as a water reserve during prolonged dry seasons. Local governments are encouraged to integrate void-based water systems into Regional Action Plans related to water security and drought risk mitigation.
- g. Enhancing Transparency and Governance Innovation
- h. Although village deliberation mechanisms are functioning effectively, governance practices can be further strengthened by adopting digital financial reporting and billing systems. Such innovations would improve efficiency, expand public access to information, and reinforce accountability.
- i. Replication and Contextual Adaptation
- j. The Andaru Void model can be replicated in other post-mining areas with similar characteristics, provided that implementation is adapted to local socio-economic, institutional, and environmental contexts. Legal legitimacy, community participation, and institutional capacity should be prioritized as foundational elements.

5.2.1 Directions for future research

From an academic perspective, future studies are recommended to:

- a. Conduct longitudinal water quality monitoring to assess long-term safety and sustainability;
- b. Examine social dynamics in greater depth, including potential conflicts among user groups or differential access within communities;
- c. Undertake comparative analyses across multiple post-mining voids in South Kalimantan to identify variations in governance arrangements and outcomes.

6 CLOSING REMARKS

The Andaru Void case illustrates that post-mining reclamation can evolve beyond a technical compliance exercise into a community-centered development pathway. Rather than reiterating empirical findings, this study highlights the broader insight that sustainable post-mining transitions depend on the alignment between institutional legitimacy, participatory governance, and socio-ecological integration.

By positioning local communities as active stewards rather than passive beneficiaries, the Andaru experience highlights the importance of governance arrangements that integrate post-mining resources into everyday social and economic systems. In this regard, the case contributes to ongoing international debates on post-extractive development by demonstrating how locally grounded institutions can transform environmental legacies into long-term development assets.

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REFERENCES

- [1] Rahmawati, A. and Suherman, E., 2022. *Journal of Water and Climate Change*, 13(4), pp.1505–1517.
- [2] Zhang, L., Wu, Q., Zhao, Y. , and Liu, Y., 2022. *Hydrological Processes*, 36(5), Article e14567.
- [3] Hope, R., Thomson, P. and Koehler, J., 2020. *Oxford Review of Economic Policy*, 36(1), pp.171–190.
- [4] Wong, T. and van der Heijden, J., 2023. *Water International*, 48(2), pp.217–235.
- [5] Li, J., Zhang, J., & Wang, Y. (2018). *International Journal of Mining Science and Technology*, 28(6), pp.933–945.
- [6] Purvis, B., Mao, Y. , and Robinson, D., 2019. *Sustainability Science*, 14(3), pp.681–695.
- [7] World Commission on Environment and Development (WCED), 1987. *Sustainable development. Our Common Future*. Oxford: Oxford University Press, pp.1–400.
- [8] Sen, A., 1999. *Development and freedom. Development as Freedom*. New York: Oxford University Press, pp.1–366.
- [9] Putnam, R.D., 2000. *Social capital and civic engagement. Bowling Alone: The Collapse and Revival of American Community*. New York: Simon & Schuster, pp.1–541.
- [10] Woolcock, M., 2001. *Canadian Journal of Policy Research*, 2(1), pp.11–17.
- [11] Dobson, A., 2007. *Environmental citizenship. Environmental Citizenship: Towards Sustainable Development*. London: Routledge, pp.1–285.

[12] Ostrom, E., 1990. *Governing the Commons. Governing the Commons: The Evolution of Institutions for Collective Action*. Cambridge: Cambridge University Press, pp.1–280.

[13] Chatterjee, S., Singh, R., and Saha, S., 2021. *Water Policy*, 23(6), pp.1475–1491.

[14] Fischer, E. and Qaim, M., 2021. *World Development*, 146, Article 105568.