Success Factors in Managing Wastewater Infrastructure through Community Participation (Case Study: Wastewater Infrastructure in Residential Areas of Medan Deli Subdistrict, Medan)

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Abstract

Both central and local governments strive to implement sanitation programs, especially in the management of wastewater infrastructure, with a focus on community involvement from planning to maintenance. The Medan Deli Subdistrict, engaged in wastewater infrastructure management through community participation, faces challenges, including a decline in users and dysfunctional management groups. The limited community involvement also impacts the failure of management. The research was conducted in the Medan Deli Subdistrict using survey and exploration methods. The analysis of survey questionnaire data with the Relative Importance Index (RII) method identified five key success factors, used as research indicators to identify obstacles through structured interviews. The research results show that these factors involve the choice of technology, organization, and leadership, which have proven to have a significant impact. Additionally, service convenience, operator performance, and clean and healthy living habits also prove to be drivers of success in this management. In this context, it can be concluded that technical factors, especially the selection of technology and organization, dominate the success of wastewater management. The success of wastewater infrastructure development through community participation also heavily depends on institutional elements and social approaches. However, after identifying success elements, some analyzed obstacles include the process of selecting technology means that are not in line with the needs and preferences of the community, managers responsible for wastewater infrastructure management often relocating without replacement, hindering the administrative process of management, infrastructure maintenance requiring operators to routinely perform operational functions, and a community that is not fully committed to implementing clean water infrastructure management.

Keywords: Success Factors, Management, Infrastructure, Wastewater, Medan Deli

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Introduction

Liquid industrial waste is not the only source of water pollution; household waste, market waste, waste from plantations and rice fields, as well as hospital waste are some other sources (Azhari, 2022). Physical and chemical factors in water can be disrupted by daily waste such as

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detergent waste, feces, and food residues disposed of in drainage channels. Water can become non-renewable under certain conditions, requiring thousands of years to pass through the soil, and excessive water intake can lead to groundwater depletion.

If waste is found to contain pollutants that can cause environmental damage or pollution, the waste must be treated (Ginting, 2007). If fecal sludge waste is not managed properly, it can produce contaminants that can pollute water bodies because they do not meet established water quality standards. The quality of waste is represented by waste specifications measured by the amount of pollutant content with several parameters. Environmental pollution is less if parameters and concentrations are reduced (Kristanto, 2004; Sugiarto & Ramadania, 2023).

People's access to settlement wastewater infrastructure is closely related to health, environment, education, social, cultural, and poverty aspects. Several studies have shown that the greater the population's access to settlement wastewater infrastructure, waste disposal, drainage, and understanding of cleanliness, the lower the likelihood of disease spread through water media (waterborne diseases). The Local Wastewater Grant Program requires the participation of the local community from the beginning of the process. Maximum participation is expected in every phase of the activity.

Many internal and external factors impact health. According to Bloom (1974) in Soekidjo (2005, p. 19; Milanie et all, 2014), components influencing individual, group, and community health can be divided into four based on the magnitude of influence: 1) Environment, which includes physical, social, cultural, economic, and so on; 2) Behavior (behavior); and 3) Health Services (health services). Of these four factors, the environmental factor has the greatest influence. The environment is several main accesses directly related to humans, according to Blum (1974). This includes access to clean water, garbage, house floors, pollution, public sanitation, hazardous toxic materials, and the cleanliness of Public Service Places (TPU).

Clean water, wastewater, and basic sanitation management are some examples of environmental factors mentioned earlier. Some examples focus on access to basic sanitation, which is the first health access directly related to each household. As a result, the Ministry of Health of the Republic of Indonesia stated in public health education in Jakarta in 2002 that building family toilets that meet health standards is one way to make the environment healthier. The quality of work, operational success, and maintenance of infrastructure, the community's ability to build partnerships, and the community's ability to facilitate activities independently in its area are some factors that will be influenced by the evaluation of environmental sanitation factors, especially in terms of improving the Local Wastewater Grant Program.

Community involvement in development can be achieved through infrastructure development, economic empowerment, poverty alleviation, education, health, and efforts to improve the quality of community health and the environment. Some examples show that environmental infrastructure development does not work without maintenance, so community involvement in development is essential. A community has its own way of realizing residential facilities in its environment (Nuraini et al, 2023)

To encourage community participation in development, they must be given responsibility for planning and implementing activities. Focusing on human development is a development strategy that requires direct involvement from the communities receiving the program to ensure that the results meet their desires and needs (Adisasmita, 2006). If the actors or implementers of development programs in the area are considered honest, and the program is relevant to the community's main problems and benefits them, community participation will increase (Nuraini, and Suprayitno,2019; Nurani, 2019)

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The main focus of wastewater treatment is to improve water quality by reducing biological oxygen demand (BOD), chemical oxygen demand (COD), and mixed particles—helping to eliminate nutrients and toxic substances. Currently, wastewater treatment goals also include sustainability and aesthetics. Wastewater Treatment Plants (WWTPs) allow treatment processes to be done naturally through stabilization ponds or with the help of installations such as septic tanks, control tanks, settling tanks, anaerobic baffled tanks (ABRs), and anaerobic filter or biofilter tanks. Before the treatment process begins, large suspended particles are filtered, and floating materials are separated.

The "Transforming Our World" declaration, adopted by 193 United Nations member countries at a meeting in New York, USA, on August 2, 2015, became the main inspiration for sustainable development efforts. The Millennium Development Goals—which lasted from September 2000 to 2015—were continued with Agenda 2030, also known as the Sustainable Development Goals (SDGs). The goal is to ensure that everyone has sustainable access to drinking water and sanitation. Indonesia has set a target of 100-0-100, which means one hundred percent access to clean drinking water, one hundred percent slum areas, and one hundred percent access to adequate sanitation. Through various programs, the Indonesian government is assisting in sanitation development, especially domestic wastewater management.

However, adequate sanitation coverage is still below 60%, especially in North Medan. To improve sanitation conditions, small-scale peripheral systems and community systems such as Deli WWTP and Belawan WWTP are built. One of the wastewater infrastructure development projects in Indonesia is the Local Wastewater Grant Program, supported by the Special Allocation Fund (DAK). One of the various components of the aforementioned issues is the problem of wastewater management. This is a complex, clearly overlooked, and even not considered a priority by many parties, both the general public and the government. Although this does not indicate that no effort or attention is made to address this issue, its management can still be considered not achieving a sufficient level of accomplishment (Bappenas, 2006). The condition of household waste management in North Sumatra Province is highly diverse. However, a recent survey shows that the level of sanitation in North Sumatra province has declined (BPS, 2020). The decent sanitation coverage rate in North Sumatra is 56.47% of the total population, slightly higher than the national figure of 55.60% (KemenPU, 2018, in Hidayati, 2021). Community and small-scale peripheral systems were developed in Region III, especially in North Medan. There are two subsystems, namely the Deli WWTP and Belawan WWTP (Hidayati, 2021).

Studies on sanitation infrastructure management have been conducted extensively. Choiriyyah (2010) first investigated how the Community-Led Total Sanitation (CLTS) program was implemented in Kampung Pulo, Tangerang. Choiriyyah (2010) conducted an analysis of how effective the CLTS program is based on four factors: planning, institutional, facility utilization, and environmental health. Second, Afandi et al. (2013) conducted an analysis of the strategic sustainability of the waste treatment system in Probolinggo City using five dimensions. The analysis includes institutional, community participation, environmental quality, technical, and financial aspects.

Third, Febriyanti (2014) looked at the reasons for the success of the CLTS program in Mojokerto City from a social, institutional, technical, and environmental perspective. According to Febriyanti (2014), social and women's aspects in the operation and maintenance of the program, as well as social interactions in the community, are key to the program's

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success. Nevertheless, there are still issues in managing wastewater infrastructure. One of the main challenges is low community.

Literature Review

Previous studies or research have examined various publications on aspects influencing the success and sustainability of wastewater management. According to research conducted by Brikke and Bredero (2003), Choiriyyah (2010), Afandi et al. (2013), and Oktiawan (2012), four factors influence the operational continuity and maintenance of community water supply and sanitation infrastructure: technical mechanisms, societal aspects, environmental factors, and physical legal aspects.

Additionally, a study referred to as "Determination of the Implementation of the Community-Based Sanitation Program (SANIMAS) Case Study: Sanimas Program in Kampung Pulo, Gintung Village, Sukadiri District, Tangerang Regency" analyzed the effectiveness of sanitation programs, considering four factors: planning, institutional, facility utilization, and environmental health. Additional research examined ways to ensure the sustainability of the wastewater management system in Probolinggo City over the years, considering factors such as technical, financial, institutional, community participation, and environmental quality. In this case, the research found that current payment conditions significantly impact environmental quality.

In her study on the success of the Sanimas program in Mojokerto City, Febriyanti (2014) used a combination of quantitative and qualitative methods. Social aspects of the community, institutional factors, technical aspects, and the environment were the primary subjects of the research. The hierarchy method was used to determine aspects and indicators. The results showed that the success of the Sanimas program in Mojokerto city was related to social aspects through PHBS: women's roles in operation and maintenance, social relations within the community, and the success of institutional fee management in maintenance.

Freddy Nelwan et al. outlined elements to consider when evaluating the success of wastewater management infrastructure in their 2003 study. Performance of wastewater management and the community's perception of services are the two main components of this evaluation. These factors are divided into various criteria, each evaluated with specific indicators. In 2011, Doni Arief Kurniawan et al. stated that the evaluation of domestic wastewater services considers institutional, infrastructure, fee collection, and collaboration with other organizations.

In 2017, Muji Siswati et al. defined six components for wastewater service assessment: institutional, technical, regulatory, financial, community roles, and performance. Service coverage, capacity, technology, ease of operation and management, and adaptive capacity are metrics used to assess technical aspects. System services, institutional capacity, and human resources form the organization. Legal devices and law enforcement are part of regulations. Financing includes investment costs, operational and management costs, tariff fees, and recovery costs. Social roles consist of knowledge, interest, needs, involvement, responsibility, and the ability to pay. Factors such as efficiency, reliability, sustainability, affordability, and public perception of performance are ways to assess performance. Katz and Sara (1998) and Apriatman (2010) state that sanitation monitoring and evaluation involve institutional, technical, social, financial, and environmental aspects. In conclusion, several critical elements with significant influence on determining the success of the development and management of public sanitation facilities in Tangerang include the presence of local institutions, the presence of external parties, community involvement, and the ability to maintain sustainability.

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Some determining factors are still less significant, such as community involvement in management and development processes. Other studies emphasize that communities should be more interested in participating in wastewater management through behavioral changes and a better understanding of the importance of wastewater management at both the regional and national levels. According to research conducted by Hosain and colleagues (1999), Putra et al. (2015), and Manullang (2014), sustainable management of rural water supply and sanitation systems is crucial. A study in Tulen Village, Malang Regency, found that post-program physical changes, such as the construction of toilets and wastewater treatment plants, and community participation in decision-making, have significant positive effects. After the program, economic and social impacts become indicators of its success, with other studies confirming that community self-reliance varies through satisfactory responsiveness and efficiency. According to Mukherjee (1999), Indonesia's sanitation program involves sustainability elements such as organizational, social, technical, environmental, and financial aspects. Kaliba's study (2002) in southern Tanzania found a strong relationship between community participation and the success of water supply and sanitation programs.

Gressiadi and Suhaeniti (2009), Subandiyah (2013), Fajar et al. (2015), Respati (2003), and Ifrah (2014) have conducted studies indicating that three main components—community social, institutional, and technical—can ensure the success of sanitation programs with community participation. Although understanding of operational and management procedures is lacking, communities are highly interested in wastewater management. An evaluation study of the impact of community-participatory sanitation programs in Ogan Ilir Regency found that, although behavior change takes time, there is improvement and better effects on open defecation everywhere. Despite the relatively low level of community participation in sanitation management in Makassar City, the impact of this sanitation management remains positive for environmental health.

Research on the Impact of the Community-Based Total Sanitation Program (STBM) First Pillar in Gucialit Village, Gucialit District, Lumajang Regency (Nugraha, 2015) found that the Community-Based Total Sanitation Program (STBM) produced many benefits for the targeted community, especially in terms of environmental, social, health, and cultural aspects. Overall, STBM assists people in various ways, especially in the use of healthy toilet facilities. To understand the changes that occur, programs or policies must be continuously evaluated. Rossi and Freeman (1999) define impact assessment as follows: "Impact assessment is to estimate whether an intervention produces the expected effects or not." The main purpose of impact assessment is to show how a program estimates the "net effect" of an intervention—that is, the estimated impact of an intervention unaffected by external influences. Such estimates do not yield definite answers but only possibilities that make sense.

The results of efforts or achievements of an action are considered initial successes, with success defined in the Indonesian Big Dictionary (KBBI) as conditions that must be fulfilled. Management, according to Sudjana (2000) and Hersey and Blanchard, is the specific ability to perform tasks with or on behalf of others to achieve organizational goals. In this context, management is interpreted as activities carried out together and through individuals and groups to achieve organizational goals. Successful management processes involve planning, organizing, moving, controlling, and developing innovation. Wastewater treatment infrastructure through community participation in the Medan Deli Subdistrict is the focus of this research. Sustainability, defined as the ability to maintain facilities and benefits achieved without sacrificing the environment, is a key factor in management success.

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Sustainable development, with a focus on equality, improved living standards, and community well-being, is the primary goal. The three pillars of sustainable development involve the economy, society, and the environment, working together to manage assets such as natural resources, infrastructure, and human resources. Five key indicators, both at the community and program planner levels, are considerations in assessing the sustainability of water supply and sanitation facilities. System quality, human capacity development, local institutional capacity, unit price distribution, and organizational collaboration all play a crucial role.

Mukherjee (2022) identifies five critical components in the sustainability of water supply and sanitation facilities, including technology, finance, institutions, social factors, and environmental sustainability. Evaluating the success of a program requires attention to these factors. Apriatman (2010) adds that success indicators for the implementation of wastewater treatment infrastructure involve institutional, technical, social, financial, and environmental aspects. According to him, the Comprehensive Sanitation Program (Sanimas) should consider social factors such as increased interaction, cooperation, healthy living habits, and community access to sanitation services.

Organizational aspects involve a complete legal system and organizational management, regular wastewater treatment plant supervision, and accountable financial reporting. From a technical standpoint, it is essential to ensure that facilities function well and meet standards, as well as have standard operating procedures (SOP). Economic aspects include fundraising from users for facility development, consistent support for operation and maintenance, and financial self-reliance without reliance on external funds. Environmental factors should also be assessed, including environmental condition improvements, water pollution reduction, and decreased diarrhea cases.

By considering these indicators, the evaluation of the success of wastewater treatment infrastructure programs through community participation in the Medan Deli Subdistrict can be comprehensive and holistic. The results of this evaluation are expected to help design strategies and solutions to support the sustainability of these programs in the future.

Research Methods

This research aims to identify and analyze the factors influencing the success of wastewater infrastructure management through community participation in the Medan Deli Subdistrict, Medan, as well as to identify and analyze the obstacles hindering the success of such management.

The research approach used in this study is qualitative descriptive, employing an inquiry and discovery approach. Preliminary surveys were conducted to evaluate the relationships between variables found in previous research, especially the 24 factorial indicators, and the opinions of experts. Out of these 24 indicators, 22 were chosen as research variables, using a questionnaire as the data collection tool. The main data collection method involved surveys with questionnaires and structured interviews.

Data analysis utilized the Relative Importance Index (RII) to assess the importance level of factors affecting the success of wastewater infrastructure management. Confidence Intervals (CI) were used to measure the accuracy level of sample estimates. Descriptive analysis was employed to explain the condition of the problem and its causal factors. The results provide insights supporting an understanding of elements that either support or hinder community participation in wastewater infrastructure management in the Medan Deli Subdistrict. The research findings are expected to serve as a foundation for designing strategies and solutions

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in the field of sanitation in the future, particularly in wastewater infrastructure management through community participation in the Medan Deli Subdistrict, Medan.

Results and Discussion

The results of this research are referenced through data collected in two (2) survey stages, namely interviews and questionnaire distribution. The first stage of this survey consists of 26 (twenty-six) indicators for 3 (three) variables, as shown in Table 1 below:

Table 1. Variable dan Indicators

No	Variables	Indicators
1	X1 (Institutional)	Selection Mechanism of Management, Operator Performance, Institutional Management Capacity Level, Schedule of Regular Meetings for Management and Users, Operator Performance
2	X2 (Technical)	Determination of Technology, Physical Infrastructure Model, Raw Material Supply, Wastewater Treatment Plant (IPAL), SOP Determination, System Development, Operational Ease
3	X3 (Community Roles)	Community Participation, Community Movements, Clean and Healthy Living Behavior, Responsiveness to Needs, Women's Participation, Community Understanding Level, Payment Management Ability

Source: Author's Analysis, (2023)

In the preliminary survey (survey 1), respondents consisted of experts or professionals involved in the wastewater infrastructure program through community participation at the Public Works Agency of Medan Deli Subdistrict. The detailed profile of the participants can be found in Table 2 below:

Table 2. Profile of Survey Stage 1 Respondents

No	Type of Respondent	Education Level	Estimated Experience
1	Respondent Level-1	Master's Degree (S2)	5 Years
2	Respondent Level-2	Bachelor's Degree (S1)	4 Years
3	Respondent Level-3	Bachelor's Degree (S1)	5 Years
4	Respondent Level-4	Master's Degree (S2)	8 Years
5	Respondent Level-5	Bachelor's Degree (S1)	8 Years

Source: Author's Analysis, (2023)

The survey results indicate the locations of the infrastructure renewal that has been carried out:

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Figure 1. Infrastructure Condition in Medan Deli Subdistrict, Medan

Environment I (Source: Author's Documentation, 2022)

Figure 2. Infrastructure Condition in Medan Deli Subdistrict, Medan

Environment II and III (Source: Author's Documentation, 2022) In this study, phase 2 survey consists of a questionnaire structured based on three main variables: technical, institutional, and community participation. A Likert scale is employed to evaluate the responses from the questionnaire. A score of one indicates very insignificant, two indicates insignificant, three indicates neutral, four indicates significant, and five indicates very significant. The perception of each respondent is represented by the score on the scale. This survey involves 20 respondents who are administrators of groups managing wastewater infrastructure through public participation in the Medan Deli Subdistrict from 2019 to 2022. The following image depicts the profile of phase 2 respondents:

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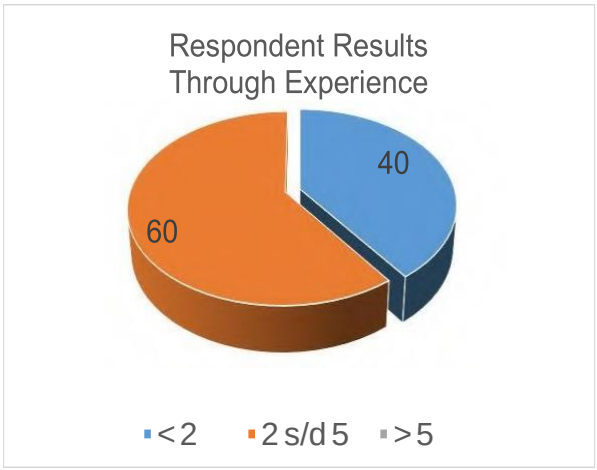

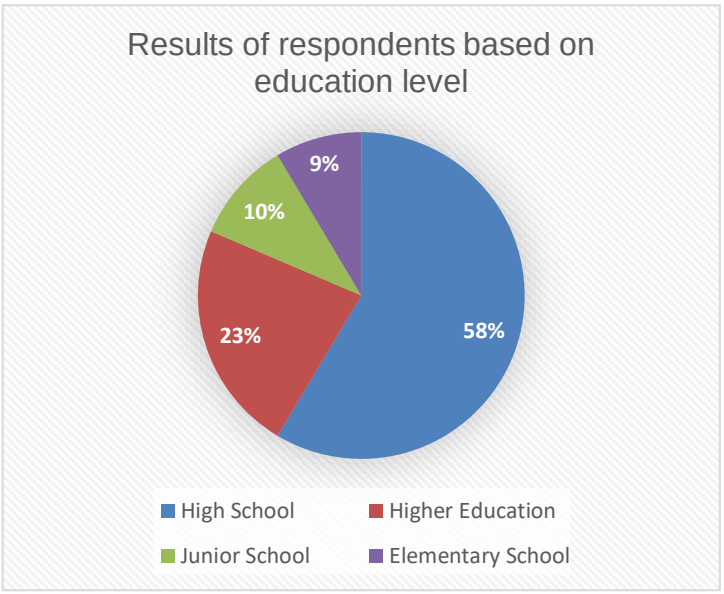

Figure 3. Results of Respondents Based on Experience as Managers of Infrastructure Management Groups and Educational Level

Source: Data Processed by the Author, 2023

From the diagram, it can be seen that 60% of stage 2 respondents have experience as managers of community-participated wastewater infrastructure management groups for 2 to 5 years. As for their educational level, 58% completed high school (SMA), while the rest came from a college and junior high school background. The next stage involves interviews. These interviews were conducted after obtaining the results from the data analysis, where the dominant aspects influencing the success of wastewater infrastructure management through community participation in the Medan Deli Subdistrict were identified from the analysis. Respondents in this interview stage are managers of Community Self-Help Groups (KSM) involved in managing wastewater infrastructure through community participation, categorized as moderate in the Medan Deli Subdistrict. The profile of interview respondents can be further explained in Table 3 below:

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Table 3. Interview Respondent Profile

Type of Respondent	Education Level	Position
Respondent Level-1	Senior High School (SMA)	Chairman
Respondent Level-2	Bachelor's Degree (S1)	Chairman
Respondent Level-3	Senior High School (SMA)	Chairman
Respondent Level-4	Senior High School (SMA)	Chairman

Source: Author's Data Processing Results, 2023

The interview was conducted to gather data and information about the existing conditions and potential of the Community-Based Organizations (KSM). This identification aims to uncover constraints and potentials that can either hinder or support the program. The constraint review includes the selection of technology, organization, management, service facilities, operator performance, and Clean and Healthy Behavior (PHBS). Through the identification and analysis of these constraints, it is expected to reveal the core issues that lead to the less successful management by KSM or fall within the 'moderate' category. These findings serve as a reference to determine optimal problem-solving steps.

The main constraints faced by KSM include changes in residents' habits, transitioning from using communal facilities to private facilities in their own homes. Other constraints involve suboptimal KSM management, changes in management structure, lack of complaint and payment services, and suboptimal operator performance. The non-application of PHBS in the practice of disposing of feces is also a constraint, as there is still a perception that does not align with environmental health standards. From the results of data collection and analysis in the previous section, the findings of the Validity Test are as follows:

Table 4. Validity Test Results

Number	Variables	r-Counted	r-Table	Result
X1.1	Technology Selection	0.895	0.476	Valid
X1.2	Available Materials	0.689	0.476	Valid
X1.3	Physical Infrastructure Condition	0.810	0.476	Valid
X1.4	WWTP Performance	0.490	0.476	Valid
X1.5	SOP Model	0.664	0.476	Valid
X1.6	Operational Convenience	0.588	0.476	Valid
X1.7	Service Convenience	0.874	0.476	Valid
X1.8	System Development Level	-0.108	0.476	Not Valid
X2.1	Organization and Decision	0.890	0.476	Valid
X2.2	Board Selection Mechanism	0.076	0.476	Not Valid
X2.3	Institution Management	0.749	0.476	Valid
X2.4	Financial Management	0.520	0.476	Valid
X2.5	Operator Performance	0.870	0.476	Valid
X2.6	Regular Meetings	0.824	0.476	Valid
X2.7	External Support	0.648	0.476	Valid
X2.8	Policies and Regulations	0.520	0.476	Valid
X3.1	Responsiveness to Needs	0.849	0.476	Valid
X3.2	Community Participation	0.520	0.476	Valid
X3.3	PHBS (Clean & Healthy Living Behavior)	0.870	0.476	Valid
X3.4	Women's Participation	0.724	0.476	Valid
X3.5	User Ability to Pay	0.014	0.476	Not Valid

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X3.6	Social Level	0.690	0.476	Valid
X3.7	Understanding Level	0.924	0.476	Valid
X3.8	Need Level	0.010	0.476	Not Valid

Source: Author's Data Processing Results, 2023

Out of 24 indicator variables, 4 indicators were found to be invalid. The remaining 20 indicator variables are deemed valid and reliable, and will be used in further analysis.

Table 5. Results of Reliability Test

Cronbach's	Cronbach's Alpha Based on Standardized Items	N of Items
,905	,938	24

Source: Author's Data Processing Results, 2023

The results of the Relative Importance Index (RII) test indicate that the technical variable, particularly the selection of technology, is the most dominant factor, followed by the institutional variable, namely organization and management, in the second rank. In the third rank, there is another technical variable, namely ease of service. Meanwhile, the institutional variable of operator performance and the community participation variable, namely Clean and Healthy Living Behavior (PHBS), are ranked fourth and fifth, respectively.

Tabel 6. The Rank of RII

Number	Variable	RII	Rank
X1.1	Technology Selection	0.89	1
X2.1	Organization and Manajement	0.89	2
X1.7	Service Convenience	0.87	3
X2.5	Operator Performance	0.87	4
X3.3	PHBS (Clean & Healthy Living Behavior)	0.87	5

Source: Author's Data Processing Results, 2023

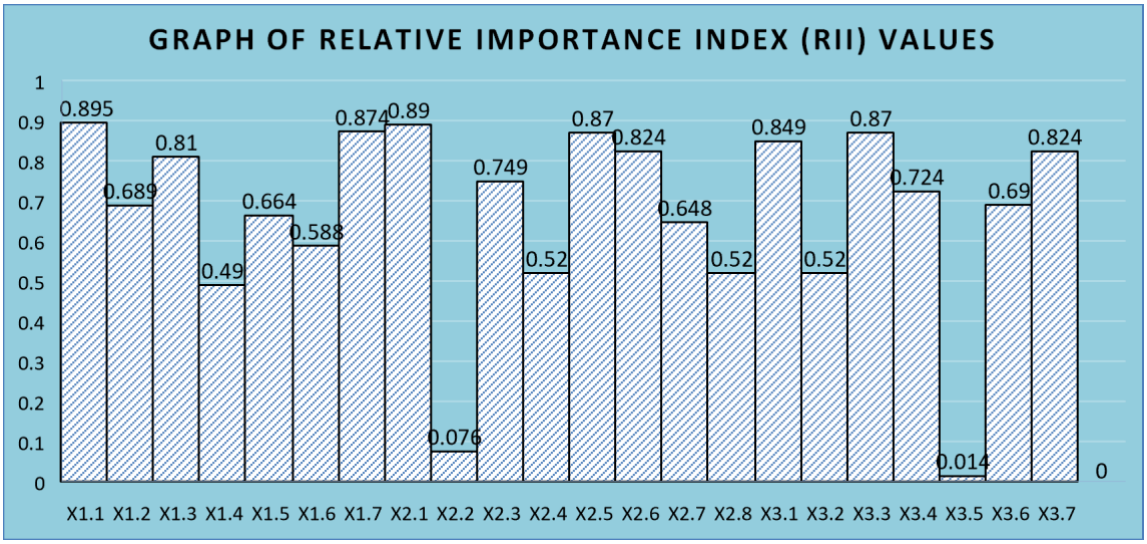

Figure 4. Graph of Relative Importance Index (RII) Values

Source: Author's Data Processing Results, 2023

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Table 7. CI Ranking

No	Number of variable	Variabel	RII	Rank
1	X1.1	Technology Selection	0.89	1
2	X2.1	Organization and Management	0.89	1
3	X1.7	Service Convenience	0.87	1
4	X2.5	Operator Performance	0.87	1
5	X3.3	PHBS (Clean and Healthy Living Behavior)	0.87	1

Source: Author's Data Processing Results, 2023

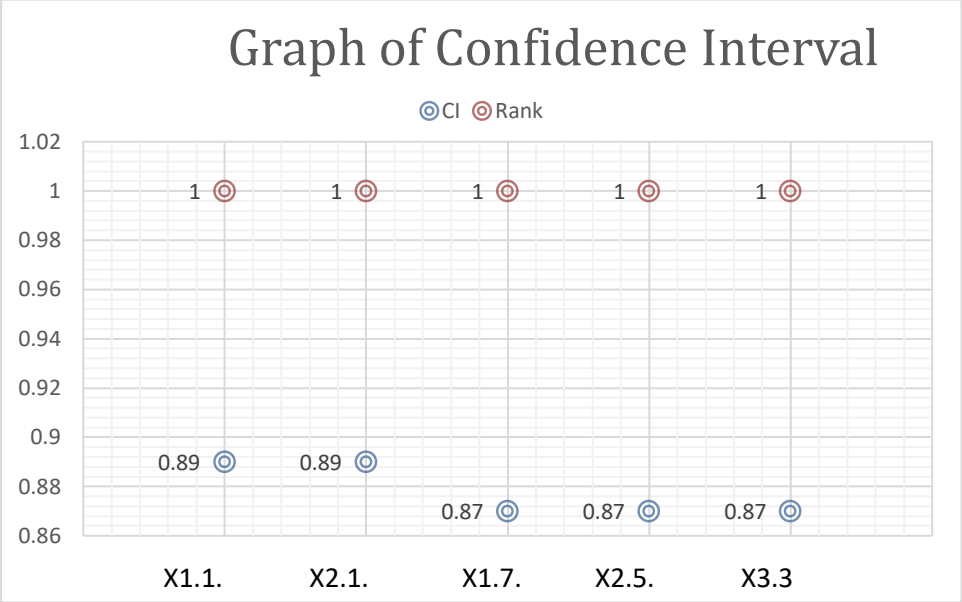

Figure 5. Graph of Confidence Interval

Source: Author's Data Processing Results, 2023

The results of the Confidence Interval (CI) test indicate that the technical variable has a dominant impact on success, with organizational and community participation variables contributing to ranks 2, 4, and 5. By comparing the results of the RII and CI tests, it can be concluded that the CI test validates the findings from the RII or strengthens the ranking of responses.

Descriptive analysis of the interview results with respondents who are managers of the Community Self-Help Groups categorized as 'moderate' indicates that the location faces constraints in aspects influencing success. These aspects include the technology selection process that is not in line with conditions and needs, suboptimal managerial functions such as complaint services, payment facilities, and operator performance in operation and maintenance. Constraints are also evident in the less-than-optimal implementation of PHBS in daily life, becoming a hindering factor in achieving successful management.

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Success Aspects in Managing Wastewater Infrastructure through Community Participation

Technology

One of the crucial factors influencing the success of wastewater infrastructure management through community participation is the selection of appropriate technology. In this study, the technology selection factor dominates the first rank in the confidence interval, with a Relative Importance Index (RII) value reaching 0.8. The research findings also reflect the consensus of 20 respondents out of a total of 22 respondents who strongly agree or agree that this factor has a significant impact on the success of management. The process of selecting technology in the community-based wastewater program begins by presenting information and discussing technology options based on the Informed Choice Catalogue (ICC) during community meetings. The community then chooses a sanitation system that suits their preferences and local environmental conditions. The selected facility components form the basis for planning documents such as Detailed Engineering Design (DED), budget plans, and Community Work Plans (RKM). The chosen technology components involve toilets, piping systems, waste treatment, as well as operational and maintenance components. The selected technological system can be a communal piped network or a Bath, Laundry, Toilet (MCK) plus system (Ditjen Cipta Karya, 2013).

In the Medan Deli Subdistrict, especially in several rural areas, there are still cultural practices of using shared facilities for bathing, washing, and defecation. Additionally, in some urban settlements, residents do not have private toilets in their homes. Therefore, in the case of wastewater infrastructure development in these areas, the appropriate system to implement is the MCK plus, which includes bathroom/toilet cubicles and washing facilities, along with wastewater treatment installations. Meanwhile, for urban residential areas that already have toilets in each house but inadequate septic tank systems, the suitable solution is a piped system, where wastewater from houses is conveyed through a piped network to a communal Wastewater Treatment Plant (WWTP).

Organization and Management

The presence of an institution with structured management and legal status is a crucial factor that plays a role in determining the success of wastewater infrastructure management through community participation. In the context of community-based activities, the importance of an organization managing operations and maintenance is emphasized as a vital aspect that should originate from the beneficiary group (Ditjen Cipta Karya, 2013). The research results show that all respondents, a total of 100%, consistently state that they strongly agree or agree that organization and management have a significant impact on the success of wastewater infrastructure management through community participation in the Medan Deli Subdistrict. The organization and management factor occupies the first rank in the confidence interval with a Relative Importance Index (RII) value reaching 0.9. This finding indicates that this factor has a strong influence on achieving success in management.

Principles of implementation, including consultation, transparency, as well as public accountability and social control, are key aspects in the stages of infrastructure development and utilization. At the community level, the organizing entity involved is the Community Self-Help Group (KSM). The organizational structure of KSM is designed to involve direct community participation, with legality manifested through a Decree (SK) as a legitimizing tool. The existence of this legality is considered essential and has a significant impact on the organization's flexibility in interacting with various parties, both government and non-

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governmental institutions (Pamungkas, 2010). Additionally, KSM is expected to have organizational rules and operational guidelines formulated through consultations with KSM members. These rules should cover aspects such as beneficiaries, finance, duties of KSM officials, and Standard Operating Procedures (SOP) for the use and maintenance of facilities. KSM is also expected to have Standard Operating Procedures (SOP) related to the use and maintenance of facilities, which must be followed with discipline by operators appointed by KSM.

Service Convenience

The research results indicate that 85% of the respondents agree that service convenience, including the availability of supporting facilities to facilitate complaints and payments, has a significant impact on the success of wastewater infrastructure management through community participation. The service convenience factor consistently ranks first in the interval with a Relative Importance Index (RII) value of 0.87. In this context, the quality of services to beneficiaries is directly related to the satisfaction level of wastewater infrastructure users (Alamsyah, 2009). Service quality can be assessed based on the handling of complaints, both technical and non-technical, responsiveness to violations, and handling of complaints outside working hours. The Community Self-Help Group (KSM), as an extension of the beneficiaries, is expected to maximize all efforts related to the smooth operation and maintenance of facilities, including the procurement of support facilities to handle complaints and payments.

KSM has the responsibility to respond to every user complaint effectively, considering that non-responsiveness can lead to dissatisfaction and disrupt the performance of existing infrastructure. KSM administrators implement various strategies to improve service convenience for users, such as providing suggestion boxes, setting working hours, providing contactable telephone numbers, specifying payment schedule, and providing payment boxes. These measures are aimed at ensuring optimal response to every complaint and minimizing the potential negative impact on infrastructure performance.

Operator Performance

The operator is an individual responsible for checking Wastewater Treatment Infrastructure (WWTP), bathrooms, toilets, pipes, and other supporting facilities such as lights/illumination, water faucets, and other elements. The operator's duties also include cleaning the components of wastewater infrastructure. The findings from this research indicate that operator performance has a Relative Importance Index (RII) value of 0.87 and consistently ranks first in the confidence interval. Nineteen out of 20 respondents agree that operator performance affects the success of wastewater infrastructure management. Each Community Self-Help Group (KSM) has an operator, although in some cases, the operator's responsibilities may be delegated to other administrators. The failure of the operator's function or the absence of an operator in a wastewater infrastructure can lead to a decline in the function of a specific part of the facility and may even render that part non-functional. An example of a part that requires special attention from an operator is the control basin.To achieve successful management, operators need to undertake several steps, including (1) conducting routine monitoring to periodically check the condition of the facility, (2) detecting damages as early as possible to plan maintenance and repairs effectively, (3) timely rehabilitation to fix components that have been damaged, (4) periodically evaluating service performance, and (5) implementing management in accordance with established operational standards and procedures.

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Clean and Healthy Behavior (CHB)

Clean and Healthy Behavior (CHB) can be defined as a series of health actions consciously taken by family members or individuals with the aim of maintaining their health. CHB involves the awareness and active participation of family members in health activities within the environment and community, as well as the ability to self-care in various health aspects. Conscious empowerment, willingness, and the ability to implement CHB are essential aspects of this concept (Astuti et al., 2013). In this research, 95% of respondents agreed that CHB has a significant impact on the success of wastewater infrastructure management. This factor obtained a Relative Importance Index (RII) value of 0.87 and consistently ranks first in the confidence interval. Several parameters related to CHB include (1) Understanding the risks of open defecation, (2) Practice of Handwashing with Soap (HWWS), (3) Treatment of infant feces, and (4) Implementation of CHB. If CHB is not applied in daily life, health disorders related to waterborne diseases such as diarrhea, itching, dengue fever, helminthiasis, and polio may arise. These diseases remain significant issues in Indonesia (Apratman, 2010). The implementation of CHB becomes crucial with the presence of built wastewater infrastructure, allowing every family member to use these facilities and avoid open defecation practices.

Challenges Faced in Managing Wastewater Infrastructure Through Community Participation

Technology

In the implementation of the Environmental Sanitation Program Through Community Participation (SLBM) in the Medan Deli District, there are planning stages that require adjustments to the principles of technology selection involved in Community Participation. The research findings indicate the existence of Mandi Cuci Kakus Plus (MCK plus) locations that no longer provide maximum benefits due to the need for adjustments to wastewater infrastructure technology. The research results show that several MCK plus locations have lost their utility because residents in the vicinity no longer use the facilities routinely. Some reasons include the presence of toilets in their homes and the supply of clean water that has been piped into their houses. Therefore, bathing and washing activities no longer use the MCK plus that has been built. In both villages, MCK plus is not in line with the wastewater planning stages of the Medan Deli District. Planning for the development of wastewater infrastructure in both areas includes the use of individual local systems, such as individual or communal septic tanks. Meanwhile, the infrastructure locations that were initially planned for development using the MCK plus system turned out to be realized using a piped system in accordance with the technology choice in the sanitation program.

Organization and Management

Community institutions in the post-construction stage seem to receive less serious attention from relevant parties, leading to the neglect of minor-scale damages. The organization of the Community Self-Help Group (KSM), which is the backbone of the institution, appears to be merely a prerequisite for activities. This is indicated by some executives who are only active during the planning and construction of infrastructure but are less active after construction. Therefore, it is necessary to provide post-construction training for managers, especially in management and maintenance, to make institutional management more dynamic and independent.

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Alternative follow-up actions may include involving discussions, restructuring executives, and improving management commitment. Reactivating institutional executives can be done through executive restructuring and increased commitment, taking into account the potential of beneficiary residents and awareness of institutional responsibility for all users. Additionally, attention should be paid to adjusting KSM personnel to the type of technology used in wastewater infrastructure locations, where a piped system will require more operator/maintenance personnel compared to the MCK plus system.

Service Convenience

Users of wastewater infrastructure face difficulties in complaint services after the Chair of KSM relocated. Other executives refer questions and complaints related to wastewater facilities to the Chair of KSM. Although the payment box is still available on-site, there is no update of the revenue data from the box.

There is a need for immediate follow-up in complaint and payment services by assigning specific tasks to one of the executives to handle complaints and assigning another executive to handle payments according to the existing agreement.

Operator Performance

Regarding operator performance, KSM does not have an active operator to carry out operational and maintenance tasks. Tasks that should be performed by an operator are carried out incidentally by various individuals, leading to frequent facility damage, clogged pipes, and burnt-out light bulbs that need replacement not being promptly addressed. Although there is an operations and maintenance section within the KSM organizational structure that acts as an operator, after construction is completed, the members of this section lack adequate information about their tasks and responsibilities and are not provided with orientation and technical training related to operator duties.

Clean and Healthy Living Behavior (PHBS)

In the Medan Deli District, KSM locations still face the issue of residents defecating in inappropriate places despite the provided facilities. Some residents still choose to defecate in the nearby river. Efforts are needed for education and motivation, using a persuasive approach, and possibly increasing the number of household connections, such as adding toilets to homes with relatively large families. Relevant authorities, such as the nearest community health center (Puskesmas), need to enhance education and conduct awareness campaigns so that residents can clearly understand the impact of improper defecation practices. Around the locations of wastewater infrastructure managed by KSM, some residents still use water channels as a place for defecation, believing that they are not familiar with toilets and assuming that the waste they dispose.

Conclusion

In this study, after analysis and discussion, several key factors influencing the success of wastewater management in the Medan Deli District have been identified. These factors involve the choice of technology, organization, and leadership, which have proven to have a significant impact. Additionally, the ease of service, operator performance, and clean and healthy living habits also prove to be drivers of success in this management. In this context, it can be concluded that technical factors, especially the choice of technology and organization, dominate the success of wastewater management. The success of wastewater infrastructure development through community participation also heavily depends on institutional elements and social approaches.

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However, after identifying success elements, several obstacles have also been revealed, including (1) The process of selecting technological facilities that do not align with the needs and preferences of the community, (2) Managers responsible for wastewater infrastructure management often change their residence without a replacement, hindering administrative management processes, (3) Infrastructure maintenance requires operators who regularly perform their operational functions, and (4) The community is not fully committed to implementing clean water infrastructure management. Considering these findings, there is a need for strategies that address both technical and institutional aspects in wastewater management in the Medan Deli District. Solutions to obstacles such as appropriate technology selection, effective infrastructure maintenance, and increased community commitment can strengthen the long-term success of this program.

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