Jurnal Presipitasi
Media Komunikasi dan Pengembangan Teknik Lingkungan
e-ISSN: 2550-0023

Vol 23, No 1, 2026, 130-142
Article available at [homepage presipitasi]()

Original Research Article

River Quality Analysis and Integration of Community Participation in the Development of the PROKASIH Program

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Abstract

River water pollution from domestic and industrial waste remains a major challenge in Indonesia's environmental governance. The Clean River Program (PROKASIH) was established as a national initiative to control water pollution through collaboration among government agencies, industries, and local communities. However, local implementation often faces constraints, particularly limited community participation and insufficient integration of environmentally friendly infrastructure. This study evaluates the implementation of the Clean River Program in Sukoharjo Regency, examines community participation, identifies influencing factors, and develops an improvement strategy based on social cohesion and sustainable technology. A mixed-methods approach was applied, combining river water quality analysis, dissolved oxygen, biochemical oxygen demand, chemical oxygen demand, total suspended solids, nitrate, and phosphate, with a survey of 100 respondents and in-depth interviews. Reliability testing produced a Cronbach's alpha value of 0.86, while Spearman 'scorrelation analysis showed a significant relationship between education level and participation. The results indicate a program success rate of 58.7%, with community participation classified as moderate. This study proposes the Green–Community River Management (G-CRM) framework, integrating participatory governance and eco-friendly infrastructure to strengthen PROKASIH implementation in line with the 2023–2030 KLHK Clean River Program Roadmap and support Sustainable Development Goal 6.3.

Keywords: Community-based river management; green infrastructure; PROKASIH; public participation; water quality assessment

1. Introduction

Indonesia is grappling with a severe ecological crisis, characterized by a profound disruption in environmental equilibrium that diminishes the carrying capacity of ecosystems at both global and local scales (Suriadi et al., 2024). The escalation of industrial, agricultural, and household activities has led to substantial pollution burdens on rivers across numerous regions, with repercussions including the destabilization of aquatic ecosystems, deterioration of raw water sources, and heightened risks of waterborne illnesses (Kilic, 2021; Pratiwi, 2020). According to data from the Central Statistics Agency (2021), Indonesia hosts 10,683 villages or sub-districts with contaminated waters, with 1,130 located in

Central Java Province. In Sukoharjo Regency, 29 villages or sub-districts are affected by water pollution, surpassing figures in neighboring urban zones (Sukoharjo Regency Environmental Agency, 2022).

In recent years, water quality in key rivers such as Samin, Langsur, and Premulung has deteriorated markedly because of untreated industrial effluents (Environmental Agency, 2022). The Samin River suffers from ethanol waste from small-scale alcohol production (Pramuaji et al., 2020), the Langsur River is burdened by heavy metals from textile operations (Zahra, 2023), and the Premulung River receives liquid waste from small- to medium-scale batik enterprises (Mumpuni et al., 2020). This underscores that water contamination in Sukoharjo stems not only from large-scale industries but also from localized economic endeavors.

To address this, the Indonesian government initiated the Clean River Program (PROKASIH), a nationwide effort to uphold river water quality through partnerships among authorities, businesses, and communities, grounded in the principle of safeguarding water functions for sustainable progress. Despite its administrative efficacy, the program's execution is constrained by inadequate community involvement and the superficial nature of on-site technical efforts. Prior research on the program's effectiveness has predominantly centered on institutional frameworks, regulatory measures, and industrial monitoring (Sari, 2019), with scant attention to social dimensions and environmental technology integration. Contemporary studies, however, reveal that successful river management hinges not only on governmental policies but also on public engagement and the adoption of eco-friendly technologies, including green infrastructure such as vegetative buffers, artificial wetlands, or natural biofiltration systems (Riyanto et al., 2023). The shortcomings of existing literature highlight a research void concerning the evolution of the Clean River Program into a more adaptable, cooperative, and enduring initiative via the fusion of social participation and environmental engineering strategies.

This study bridges the gap by introducing a novel conceptual framework termed green community-based river management (G-CRM), which merges a socially oriented approach centered on community empowerment with green infrastructure technologies as a superior method for controlling water pollution. The scientific innovation here resides in synthesizing two previously disparate elements in clean river program analyses: social participation and environmental engineering techniques. Under the G-CRM paradigm, community involvement transcends mere campaigns or outreach and becomes a core component of a green technology-driven river management system. This is anticipated to evolve the clean river program from a bureaucratic endeavor into a synergistic framework that curtails pollution while fostering greater ecological consciousness among residents. Against this backdrop, the research appraises the clean river program 's implementation in Sukoharjo Regency, evaluates community participation levels, identifies influencing variables, and devises a development strategy anchored in social cohesion and sustainable technologies.

2. Methods

2.1 Study Area and Research Duration

This study focused on three key rivers in Sukoharjo Regency, Central Java. Specifically, the Samin, Langsur, and Premulung Rivers were chosen because of their high susceptibility to wastewater contamination (Sukoharjo Regency Environmental Agency, 2022). The Samin River, which flows into Bengawan Solo, starts at the base of Mount Lawu and spans 67 km with a drainage basin covering 345.2 km2 (Zahra, 2023). Meanwhile, the Langsur River traverses the districts of Tawangsari, Sukoharjo, and Grogol, whereas the Premulung River runs through densely populated areas and textile manufacturing hubs in the Kartasura District (Mardiana, 2021). The investigation spanned from November 2023 to August 2024 and included a review of existing literature, fieldwork for data gathering, laboratory-based testing, evaluation of local community involvement, and formulation of strategic recommendations.

2.2 Materials

The materials employed in this study encompassed an administrative map of Sukoharjo Regency, a river flow route map, demographic data, participant profiles, the Clean River Program (PROKASIH) handbook, and various chemical reagents, including calcium chloride ($CaCl_2$), manganese sulfate ($MnSO_4$), sulfuric acid (H_2SO_4), magnesium sulfate ($MgSO_4$), phosphate compounds, ferric chloride ($FeCl_3$), and potassium permanganate ($KMnO_4$). Additionally, the tools utilized consisted of sample containers, measuring vessels, GPS units, filter paper, a pH meter, dissolved oxygen meter, thermometer, Erlenmeyer flasks, and software applications such as Microsoft Excel, SPSS, and ArcGIS 10.8.

2.3 Research Design

The research adopted an exploratory sequential mixed methods framework, blending quantitative and qualitative techniques. It commenced with an initial evaluation drawing on secondary data sourced from the Sukoharjo Regency Environmental Agency (Dinas Lingkungan Hidup), the Central Statistics Agency (BPS), and PROKASIH records to pinpoint sampling sites, contextualize the investigation, and establish assessment criteria.

2.4 Water Quality Sampling and Analysis

2.4.1 Sampling Locations and Techniques

River water quality was assessed using grab sampling at midstream points of each river: Samin (7°38'45.2"S, 110°54'12.5"E), Langsur (7°44'01.7"S, 110°48'33.9"E), and Premulung (7°32'14.6"S, 110°46'42.8"E). Samples were collected at depths of 20–30 cm during the transition from the rainy to the dry season and stored in sterilized containers. The parameters measured included physical, chemical, and biological indicators (Table 1).

Table 1. Water quality parameters

Parameters	Type
Physics	Temperature, turbidity, and total suspended solids (TSS)
Chemistry	pH, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), phosphate, and nitrate
Biology	Fecal coliform

2.4.2 Parameters and Laboratory Methods

All parameters were analyzed following the APHA Standard Methods for the Examination of Water and Wastewater (2017). The physical parameters were measured as follows: temperature using a thermometer (Hanna Instruments HI98501, Italy), and total suspended solids (TSS) using the gravimetric method (SM 2540 D). Chemical parameters were analyzed using a pH meter (Hanna HI98107, Italy), dissolved oxygen (DO) using a DO meter (Lutron DO-5519, Taiwan), biological oxygen demand (BOD_5) by the Winkler titration method (SM 5210 B), and chemical oxygen demand (COD) by the dichromate reflux method (SM 5220 C). Nutrient parameters, such as nitrate (NO_3^-) and phosphate (PO_4^{3-}), were determined using a UV–Vis spectrophotometer (Shimadzu UV-1280, Japan) with standard colorimetric procedures (SM 4500-NO_3^- B and SM 4500-P E). Fecal coliform levels were examined using the multiple-tube fermentation method, as outlined in SM 9221 B. Each test was replicated thrice to ensure reliability. The results were then assessed against the benchmarks set by Indonesia's Class II Water Quality Standards in accordance with Government Regulation No. 22/2021. 22/2021.

2.5 Community Participation Survey

2.5.1 Respondent Selection

A survey questionnaire was distributed to 100 participants aged 17 years or older, living near rivers, and engaged in activities related to the Clean River Program (PROKASIH). Selection of respondents was conducted using purposive sampling, with the sample size calculated using Slovin's formula to allow for a 10% margin of error.

2.5.2 Statistical Analysis

For statistical processing, responses on a five-point Likert scale were evaluated for reliability and validity using the SPSS software. Cronbach's alpha value of 0.86 confirmed strong internal consistency, and corrected item-total correlations were above 0.30. Participation scores from the community were divided into three categories, as detailed in Table 2. Spearman's rank correlation was applied to examine the links between participation levels and sociodemographic factors, such as education, gender, and age.

Table 2. Community participation category scale

Category	Value
Low	85–97
Medium	98-110
High	111-122

Source: *Analysis, 2025*

2.6 Qualitative Data Collection

Qualitative data were gathered through detailed interviews and on-site observations involving officials from the environmental agency, community leaders, small-scale entrepreneurs, and local environmental organizations. These qualitative insights were cross-verified with quantitative results to enhance the overall interpretation.

2.7 SWOT and Strategic Analysis

A SWOT analysis was performed to develop strategic recommendations, incorporating a weighted scoring method via the Internal Factor Analysis Summary (IFAS) and External Factor Analysis Summary (EFAS) matrices for added methodological robustness. Each factor received a weight and rating, and the cumulative scores were mapped onto an internal–external (IE) matrix to pinpoint the strategic stance of the Clean River Program in Sukoharjo Regency. This quantitative foundation ensured that the strategies were evidence-based, meeting scholarly expectations for environmental policy research.

3. Result and Discussion

3.1 Evaluation of the Implementation of the Clean River Program (PROKASIH) in Sukoharjo Regency

Based on information provided by the Sukoharjo Regency Environmental Agency (Dinas Lingkungan Hidup, 2022) and direct field observations, the volume of waste and sewage entering the river has increased in tandem with local population expansion and industrial growth. The findings from water quality assessments at each study site are detailed below.

3.1.1 Quality of Samin River

There was a notable increase in the amount of solid waste produced along the Samin River, which flows through the Polokarto and Kartasura districts, over the course of 2024. Observations from the initial three months revealed an accumulated waste volume of 35 tons monthly. The waste makeup was largely plastic at 60%, with organic materials accounting for 20%, and the remainder consisting of items like fabric, metal, and construction debris. This indicates that household activities along the riverbanks are the chief source of waste, exacerbated by insufficient disposal infrastructure and the ongoing practice of dumping directly into the waterway. Additionally, the Samin River bears a heavy load of liquid effluent, mainly from industrial zones and crowded residential neighborhoods. Estimates place the daily inflow of liquid waste at 800 m^3 at the primary downstream monitoring spot. The key contributors are untreated discharges from small-scale alcohol producers, who typically lack integrated wastewater treatment facilities. This effluent includes leftover organic substances from fermentation, leading to elevated levels of chemical oxygen demand (COD) and total suspended solids (TSS). Moreover, farming in the surrounding catchment adds residues from fertilizers and pesticides, further degrading water quality. The mix of organic and inorganic pollutants positions the Samin River as one of the most contaminated waterways in Sukoharjo Regency.

Table 3. Water quality in samin river

No.	Parameters	Unit	Result		Quality standard**
			Upstream	Downstream	
Chemistry					
1.	pH	-	7	7	6-9
2.	Dissolved Oxygen (DO)	mg/L	8*	5*	4
3.	Biological Oxygen Demand (BOD)	mg/L	2	2	3
4.	Chemical Oxygen Demand (COD)	mg/L	13	27*	25
5.	Phosphate	mg/L	0.1590	0.1331	0.2
6.	Nitrate	mg/L	1.307	1.573	10
Physics					
1.	Temperature	^{O}C	27.3	29.6	-
2.	Turbidity	-	Cloudy	Cloudy	-
3.	Total Suspended Solids (TSS)	mg/L	104*	67*	50
Biology					
1.	Fecal Coliform	MPN/100 ml	390	390	1000

Source: Analysis, 2025
Information:
*) Exceeding quality standards
**) Quality standards based on Government Regulation No. 22 of 2021 concerning the Implementation of Environmental Protection and Management

As shown in Table 3, parameters, such as dissolved oxygen (DO), chemical oxygen demand (COD), and total suspended solids (TSS), surpassed the established quality thresholds. Elevated DO levels in the Samin River are attributed to alcohol waste entering a fast-flowing, well-aerated stream. Effluent from the alcohol industry sector is identified as the main cause of discoloration, foul odors, and a sharp decline in water quality. Pollutants from alcohol manufacturing can be detected by the murky river hue and a distinct alcoholic scent along its banks (Cahyani et al., 2024).

Upstream DO levels in the Samin River exceed those downstream levels, owing to swifter currents that facilitate oxygen diffusion from the atmosphere into the water (Nadila and Kurnia, 2025). Alcohol industry wastewater carries dissolved organic matter that boosts COD. Typically, rising COD levels deplete DO because organic breakdown consumes oxygen. However, under specific scenarios, both DO and COD levels can increase together. Rivers contaminated by fermentation or alcohol production waste often exhibit high COD levels. The decomposition of organic matter demands oxygen; however, if dumped into an oxygen-rich river, it can paradoxically increase DO, along with COD levels. The elevated TSS and COD in the Samin River are driven by alcohol production operations channeling liquid waste directly into the river. High TSS in alcohol effluents arises from suspended organic matter, which causes turbidity, thereby reducing light penetration and hampering photosynthesis in aquatic life (Adina et al., 2023). Another contributor is land use shifts, which trigger greater erosion, resulting in sedimentation that washes extra sediment into the Samin River.

3.1.2 Quality of Langsur River

The Langsur River winds through the Sukoharjo area before joining the Samin River, serving as a vital pathway for drainage and irrigation across the Sukoharjo and Grogol districts, particularly for agricultural fields. Field data show that the total amount of solid waste dumped into this river is 45 metric tons per month in 2024. The majority of this waste consists of textile and plastic scraps, such as leftover fabric fibers, threads, and dye containers. These pollutants are typically washed in via industrial runoff into exposed drains and eventually pollute the river. This buildup leads to sediment accumulation and reduces the river's flow efficiency.

Table 4. Water quality in Langsur river

No.	Parameters	Unit	Result		Quality standard**
			Upstream	Downstream	
Chemistry					
1.	pH	-	7	7	6-9
2.	Dissolved Oxygen (DO)	mg/L	2.9	3.3	4
3.	Biological Oxygen Demand (BOD)	mg/L	3	3	3
4.	Chemical Oxygen Demand (COD)	mg/L	20	16	25
5.	Phosphate	mg/L	0.1198	0.1708	0.2
6.	Nitrate	mg/L	1.272	2.264	10
Physics					
1.	Temperature	^{O}C	26.9	31.3	-
2.	Turbidity	-	Slightly Cloudy	Cloudy	-
3.	Total Suspended Solids (TSS)	mg/L	43	49	50
Biology					
1.	Fecal Coliform	MPN/100 ml	210	470	1000

Source: *Analysis, 2025*
Information:
**) Quality standards based on Government Regulation No. 22 of 2021 concerning the Implementation of Environmental Protection and Management
As shown in Table 4, none of the water quality indicators of the Langsur River exceeded the set standards. In other words, the levels of substances, such as BOD, COD, TSS, pH, DO, and similar parameters, remained within safe or regulated boundaries.

3.1.3 Quality of Premulung River

The Premulung River originates in the Kartasura area of Sukoharjo and flows toward Solo, acting as a feeder stream to the Bengawan Solo River. In 2024, the total amount of solid waste accumulating in this river reached 40 metric tons per month, with plastics comprising approximately 40%, followed by organic materials and various household leftovers. This substantial waste output highlights the shortcomings in waste handling systems in the crowded neighborhoods along its banks, where many residents still toss garbage directly into the river because of inadequate collection and storage options.

Regarding liquid pollutants, the Premulung River receives an influx of approximately 500 cubic meters per day, primarily from domestic sewage and minor industrial sources, such as tofu processing plants and batik dyeing operations. This effluent is typically released untreated, boosting levels of biochemical oxygen demand (BOD) and fecal coliform in the waterway. Additionally, elevated phosphate levels from household cleaning products spark eutrophication, leading to rampant algae proliferation that depletes dissolved oxygen and harms the river ecosystem. From on-site measurements and laboratory analyses, multiple water quality indicators in the Premulung River surpassed the required standards, including dissolved oxygen (DO), BOD, chemical oxygen demand (COD), phosphate levels, and fecal coliform counts.

Table 5. Water quality in premulung river

No.	Parameters	Unit	Result		Quality standard**
			Upstream	Downstream	
Chemistry					
1.	pH	-	7	7	6-9
2.	Dissolved Oxygen (DO)	mg/L	2.9	6*	4
3.	Biological Oxygen Demand (BOD)	mg/L	24*	2	3
4.	Chemical Oxygen Demand (COD)	mg/L	86*	17	25
5.	Phosphate	mg/L	0.7058*	0.3896*	0.2
6.	Nitrate	mg/L	0.5667	1.613	10
Physics					
1.	Temperature	^{O}C	26.4	27.9	-
2.	Turbidity	-	Slightly Cloudy	Slightly Cloudy	-
3.	Total Suspended Solids (TSS)	mg/L	39	11	50
Biology					
1.	Fecal Coliform	MPN/100 ml	240	1100*	1000

Source: *Analysis, 2025*
Information:
*) Exceeding quality standards
**)Quality standards based on Government Regulation No. 22 of 2021 concerning the Implementation of Environmental Protection and Management

Elevated BOD readings suggest that the Premulung River carries a heavy load of organic substances. The surplus of organics points to high BOD levels because of diminished oxygen supply (Singh et al., 2025). The major contributors to this are untreated household waste dumped directly into the river, along with small-scale operations such as tofu factories. These materials easily break down via microbes but demand considerable oxygen in the process.

Household chores and minor industries, such as tofu production, near the Premulung River generate waste rich in phosphate. Phosphate concentrations in the river have been found to exceed regulatory limits, indicating nutrient contamination. Phosphate (PO_4^{3-}) is a vital nutrient for plant and aquatic life growth; however, an overload can spark major ecological issues, especially eutrophication. Nutrient-driven eutrophication frequently results in unchecked algae blooms, which slash dissolved oxygen and severely impair water quality (Guansan et al., 2025). This scenario jeopardizes biodiversity and undermines the overall role of freshwater habitats.

3.2 Implementation of the Clean River Program (PROKASIH) in Sukoharjo Regency

The Clean River Program, known as PROKASIH, has been running in Sukoharjo Regency since its nationwide rollout. From what we have observed on the ground, implementing this program still runs into major institutional hurdles, even with the setup framework in place. Monitoring and follow-through are mostly done in silos, lacking real teamwork. For instance, the local Environmental Agency, or Dinas Lingkungan Hidup Sukoharjo Regency, checks water quality; however, these findings do not always lead to strong enforcement from law officials or extra support from the body handling industry. This points to a breakdown in how different agencies work together to tackle pollution as a whole. Institutional fragmentation, with agencies having varied roles and focuses, can block smooth cooperation (Hedlund et al., 2022).

Even though environmental problems are usually linked, clashes in objectives, setups, and resources among institutions often result in poor coordination and synergy in managing the environment. Interviews showed that shortages in staff and funding are key barriers to effectively implementing the Clean River Program in Sukoharjo Regency. The local Environmental Agency, Dinas Lingkungan Hidup Sukoharjo Regency, is short on monitoring staff, and the budget for ongoing river checks is insufficient to cover all the important spots along the three main rivers under study: Samin, Premulung, and Langsur. Consequently, checks occur infrequently and primarily in response to complaints, rather than as regular, thorough checks.

Analysis of water quality data reveals that monitoring of these three rivers (Samin, Langsur, and Premulung) shows that some areas remain contaminated, mainly by household and factory waste, although there has been some progress downstream due to growing public awareness. Regarding waste, figures indicate an increasing amount of trash, especially from homes and small industries, which is not being handled fully. Efforts to reduce waste are hampered by insufficient treatment facilities and low community involvement. From an institutional perspective, the Clean River Program's framework is in place, but real-world execution faces challenges such as poor coordination between agencies, scarce staff and funds at the DLH, and minimal involvement from industries. Nevertheless, from 2023 to 2024, there are plans for renewal through training and outreach to businesses, although it is still on a small scale.

3.3 Community Participation in the Implementation of the Clean River Program (PROKASIH) in Sukoharjo Regency

Community involvement in the Clean River Program (PROKASIH) in Sukoharjo Regency is fairly even between men and women, although men tend to be slightly more active overall. This gap is not significant, but it mirrors the usual social roles in eco-friendly efforts. Men usually participate in hands-on tasks, such as scrubbing rivers, picking up trash, and repairing riverbanks. In contrast, women make solid contributions through less physically demanding activities, such as teaching about the environment, handling household waste, and organizing neighborhood clean-up drives. Previous research has shown that increasing the involvement of women and underrepresented groups improves the performance, longevity, and effectiveness of water and sanitation systems (Mommen et al., 2017). Therefore, increasing women's roles, especially in teaching and social aspects, could help ensure the long-term success of the Clean River Program.

Participants in the Clean River Program came from all ages, from 17 to over 60 years. The largest turnout was from the 27–33 age group, who brought strong energy, motivation, and care for the planet. The 40–50 group also stepped up significantly, often as local leaders or organizers who kept things connected and supervised in the community. This mix of ages proves that the program has built good teamwork across generations, with the younger, active group leading the charge on grassroots environmental projects.

Overall, community engagement in the Sukoharjo Regency chapter of the Clean River Program was in the moderate-to-high range, with only a few individuals showing low involvement. This suggests that people are generally aware of the importance of keeping rivers clean and sustainable; however, wider and steadier participation is still needed. This finding aligns with Baehaqi et al. 's(2025) observation that community input significantly shapes environmental awareness and the effectiveness of programs, as well as with Brawijaya et al. 's(2021) assertion that mid-level involvement necessitates more inclusive approaches to protecting the environment. Similarly, Lubis and Hamidipradja (2025) noted that team-based environmental efforts struggle with poor coordination, limited resources, and insufficient public knowledge. To increase participation, we should focus on building social skills, establishing community groups dedicated to environmental protection, and fostering collaboration among government agencies, businesses, and the general public to ensure lasting care for rivers.

Cronbach's alpha for reliability check was 0.86, showing strong consistency across the survey questions. In addition, the corrected item-total correlations were above 0.30, indicating that the tool accurately captured community participation. However, these checks used a small pretest group; therefore, the results should be regarded as a starting point and not the final word. More studies with larger and more varied samples would help confirm the reliability and validity of the tool and provide a firmer grasp on measuring community involvement in river management.

3.4 Factors Influencing the Implementation of the Clean River Program (PROKASIH) in Sukoharjo Regency

The determinants shaping community engagement in the Clean River Program (PROKASIH) within Sukoharjo Regency can be categorized into two primary dimensions: respondent awareness and accountability, alongside the extent of involvement in program sustainability. The awareness and accountability dimension incorporates elements such as attitudes, knowledge, concern, motivation, and accountability toward river cleanliness. In contrast, the community participation dimension encompasses involvement in the program's planning, execution, and assessment phases.

Regarding the awareness and accountability dimensions, the mean score for community awareness of river cleanliness attained 50.77 out of a maximum of 75, equating to 67.69%. This score falls within the high category. The highest mean scores were observed for statements like "River cleanliness is a communal responsibility, including my own," "I prefer to observe clean rivers," and "Communities that cause pollution face reprimands or sanctions." These findings underscore a robust level of community recognition of collective accountability in upholding river cleanliness and endorsement of regulatory enforcement against environmental polluters. Conversely, the lowest score was recorded for "River cleanup activities are mandatory," suggesting that participation in such initiatives is predominantly motivated by voluntary awareness rather than compulsion.

In the realm of community participation, the mean score was 107.86 out of a maximum of 150, classifying it as moderately high. This implies that while awareness is elevated, practical engagement in the Clean River Program, across planning, execution, and assessment, remains suboptimal. The highest scores appeared for items such as "The community must partake in implementing the clean river program" and "The community endorses the clean river program." The lowest scores were noted for "The community consistently attends socialization sessions" and "Program implementation is optimal and effective." Participants tended to exhibit greater activity during the execution phase compared to planning or assessment. Wende et al. (2024) elucidated in their study that community roles exert more influence during implementation than in initial planning. Assessment was perceived as overly technical and lacking direct relevance to daily life. Communities are more inclined to engage when tangible outcomes are evident, rather than during strategic planning or impact evaluation.

3.5 Environmental and Human Health Impacts of Polluted Rivers

The deterioration of water quality in the Samin, Langsur, and Premulung Rivers has profound consequences for both ecological systems and public health. Elevated levels of biochemical oxygen demand (BOD) and chemical oxygen demand (COD) signify substantial organic matter loads, resulting in oxygen depletion and disturbance to aquatic habitats. This leads to the decline of sensitive aquatic species, diminished biodiversity, and proliferation of resilient organisms, such as cyanobacteria, which may trigger harmful algal blooms. Excess phosphates and nitrates exacerbate eutrophication, fostering excessive algal proliferation that further diminishes dissolved oxygen, generates unpleasant odors, and compromises river aesthetics (Guansan et al., 2025).

From a human health perspective, the detection of fecal coliform bacteria and other pathogens in river water indicates contamination from domestic sewage. Populations dependent on river water for domestic or agricultural purposes face heightened risks of waterborne illnesses, including diarrhea, cholera, and typhoid fever (Pratiwi, 2020). Moreover, heavy metals and organic contaminants from industrial effluents, notably from the textile and alcohol sectors, may bioaccumulate in aquatic life and infiltrate the food chain, presenting chronic hazards, such as organ impairment and carcinogenic effects. Consequently, sustained monitoring and wastewater remediation are essential to safeguard ecosystem stability and public health in the Sukoharjo Regency.

3.6 The Clean River Program (PROKASIH) Development Strategy based on Social Integration and Green Technology

The implementation of the Clean River Program (PROKASIH) in Sukoharjo Regency continues to encounter multiple challenges, including substantial pollution from domestic and industrial sources, inadequate inter-agency coordination, constrained operational funding, and insufficient public awareness and involvement. Therefore, a more adaptable, structured, and context-specific strategy for program advancement is imperative. This study employs a SWOT (strengths, weaknesses, opportunities, and threats) analysis framework to appraise internal and external factors affecting the implementation of the Clean River Program in Sukoharjo. SWOT analysis is a robust tool for evaluating technological advancements within an industry. By integrating both internal and external elements, this approach facilitates the identification of optimal strategies (Khoshsirat et al., 2025).

Table 6. Strengths, weaknesses, opportunities, threats (SWOT) analysis

Strategy	Strategy formulation
Strength–opportunity	• Integrating national policies on water pollution control with river-centric ecotourism initiatives to foster environmental preservation and stimulate local economic growth. • Utilize environmental agencies and river stewardship communities to enhance public education and grassroots monitoring efforts. • Maximize the potential of primary river systems as sites for pilot water conservation projects and educational endeavors involving schools, NGOs, and academic institutions • Establish a green river partnership initiative that involves the private sector in financing and innovating waste management technologies
Weakness–opportunity	• Establish a green river partnership initiative that involves the private sector in financing and innovating waste management technologies • Expand outreach and community engagement by creating river communication forums in each sub-district. • The allocation of village funds for clean river program activities should be promoted, such as the development of integrated waste treatment facilities and communal wastewater processing plants. • Develop community training programs to strengthen the local technical and institutional capacity for environmental management.
Strength–threat	• Leverage regulatory and institutional support from the local Indonesian environmental agency, called Dinas Lingkungan Hidup, to strengthen law enforcement against river pollution violations.

Strategy	Strategy formulation
Weakness–threat	● Develop a participatory monitoring program that involves the public in digital pollution reporting (community-based monitoring system). ● Establish regional environmental performance indicators (environmental performance indices) to ensure the effectiveness of the clean river program (prokasih). ● Establish partnerships with the industrial sector to implement environmentally friendly waste processing technologies to reduce pollution potential. ● Improve the effectiveness of cross-sector and regional coordination by establishing an integrated water pollution control work unit ● Develop a program sustainability action plan with alternative funding sources from CSR and private sector collaborations. ● Develop a behavior-change communication approach to raise environmental awareness among riverbank communities ● Reinforce on-site monitoring and evaluation to mitigate program stagnation arising from budgetary limitations and inadequate supervision.

Source: *Analysis, 2025*

The green–community river management (G-CRM) model is well-suited for application in Sukoharjo Regency, given its geographical and societal attributes that resonate with the principles of community-driven environmental stewardship and green infrastructure. Sukoharjo is intersected by major rivers, the Samin, Langsur, and Premulung which suffer pollution from textile industry discharges, household wastewater, and agricultural runoff laden with fertilizers and pesticides. The multifaceted nature of these pollution sources demands a cooperative and flexible river management paradigm, rather than a solely top-down governmental model.

The G-CRM model prioritizes active community participation across all facets of river management, encompassing water quality surveillance, pollution mitigation, and riparian ecosystem upkeep. Communities function not merely as recipients but as co-managers, sharing accountability and a sense of proprietorship in maintaining river vitality. Augmented by green infrastructure elements, such as biofiltration gardens, constructed wetlands, and vegetated buffer zones, this model bolsters ecological functionality and cultivates public consciousness through accessible and instructive riverfront areas.

Institutionally, the Dinas Lingkungan Hidup Sukoharjo Regency has already established a structured framework for the Clean River Program, which can underpin G-CRM deployment. Partnerships with universities, NGOs, and the private sector can evolve this into a holistic system that merges social engagement with environmental engineering. This strategy aligns with PermenLHK No. 68/2016 on domestic wastewater standards and the Ministry of Environment Clean River Program Roadmap 2023–2030, which advocate for community empowerment and green technologies in pollution abatement. As a scalable and policy-aligned framework, G-CRM advances Indonesia's commitments to Sustainable Development Goals (SDGs) 6.3 and 11.6, promoting cleaner waterways, diminished pollution burdens, and resilient urban ecosystems.

4 Conclusions

The implementation of the Clean River Program (PROKASIH) in Sukoharjo Regency demonstrates a promising trajectory through monitoring, outreach, and heightened public consciousness, albeit with a need for enhanced efficacy via institutional reinforcement and intersectoral collaboration. Community participation is moderate to high, with relatively equitable involvement across demographic groups, reflecting commendable yet incomplete environmental awareness. This engagement is shaped by individual awareness, social accountability, communication efficacy, and the caliber of program execution and appraisal. Consequently, future strategies for the Clean River Program should emphasize social integration through community empowerment and the adoption of adaptive green technologies, thereby achieving sustainable river governance and enduring benefits for environmental and societal well-being.

Acknowledgement

The authors express sincere gratitude to the Sukoharjo Regency Environmental Agency for granting permission and providing assistance with fieldwork data gathering, as well as access to water quality monitoring data. We also extend heartfelt thanks to the local communities along the Samin, Langsur, and Premulung Rivers for their involvement in completing questionnaires and participating in interviews. Additionally, the authors acknowledge Sebelas Maret University for offering academic support and essential research resources.

Ethics Statement

This study did not involve human participants, animals, or sensitive data; therefore no ethical approval was required.

CRediT Author Statement

Dwi Intan Nur Evianovita: Conceived and Designed Analysis, Collected Data, Contributed and Analysis Tools, Performed Analysis, Wrote Paper. **Prabang Setyono:** Conceived and Designed Analysis, Contributed and Analysis Tools. **Evi Gravitani:** Conceived and Designed Analysis, Collected Data. **Callista Fabiola Candraningtyas:** Contributed and Analysis Tools, Wrote Paper.

References

American Public Health Association (APHA), American Water Works Association (AWWA), and Water Environment Federation (WEF). 2017. Standard methods for the examination of water and wastewater.

Badan Pusat Statistik. 2021. Banyaknya desa/kelurahan menurut jenis pencemaran lingkungan hidup periode 2014–2021.

Baehaqi, A, and Alicia, P, N. 2025. Community involvement in Bandung river cleanup for flood control. Bangunan 5(1), 75–84.

Brawijaya, U, Bisri, M, Juwono, T, P, Suhartanto, E, Kurniawan, T, and Sarastika, T. 2021. Community participation in river conservation in the Babon River, Central Java. Jurnal Pendidikan Teknik Bangunan 48(10).

Cahyani, M, P, L, Kurniasari, E, and Rajib, R, K. 2024. Penegakan hukum lingkungan guna menanggulangi pencemaran air akibat limbah industri minuman beralkohol di Sungai Bengawan Solo. Jurnal Ilmiah Wahana Pendidikan 10(24), 90–99.

Dinas Lingkungan Hidup Kabupaten Sukoharjo. 2022. Dokumen informasi kinerja pengelolaan lingkungan hidup daerah Kabupaten Sukoharjo Tahun 2022.

Guansan, D, Avtar, R, Meraj, G, Alsulamy, S, Joshi, D, Gupta, L, N, Pramanik, M, and Kumar, P. 2025. Integrating remote sensing and machine learning for dynamic monitoring of eutrophication in river systems: a case study of Barato River, Japan. Journal of Water 17(1).

Hedlund, J, Nohrstedt, D, Morrison, T, Moore, M, L, and Bodin, Ö. 2022. Challenges for environmental governance: policy issue interdependencies might not lead to collaboration. Sustainability Science 18(1), 219–234.

Khoshsirat, Z, Panahi, R, Ezzati, E, Valizadeh, R, Rezapour, A, and Sadeghi, A. 2025. SWOT analysis of teleconsultation in healthcare: strategies for effective implementation. Healthcare, 13(3).

Kilic, Z. 2021. Water pollution: causes, negative effects and prevention methods. IZU Journal of the Institute of Science and Technology 2(3), 129–132.

Lubis, R, L, and Hamidipradja, K. 2025. Harnessing community engagement to reduce river pollution: a case study of collaborative initiatives along the Cikapundung River in Bandung City, Indonesia. Journal of City Climate Policy and Economy 3(1), 135–167.

Mardiana, K. 2021. Pengelolaan limbah industri kecil produksi tahu di Kartasura (studi pelaksanaan Peraturan Daerah Kabupaten Sukoharjo Nomor 6 Tahun 2013 tentang Perlindungan dan Pengelolaan Lingkungan Hidup). Thesis.

Mommen, B, Humphries, K, and Gwavuya, S. 2017. Does women's participation in water committees affect management and water system performance in rural Vanuatu? Waterlines 36(3), 216–232.

Mumpuni, A, Rahayu, P, and Rini, E, F. 2020. Partisipasi masyarakat dalam program pengelolaan sungai (studi kasus: Sungai Pepe, Sungai Anyar, dan Sungai Premulung, Kota Surakarta. REGION 15(1), 67–80.

Nadila, K, and Kurnia, T, I, D. 2025. Pengaruh aktivitas antripogenik terhadap BOD (Biological Oxygen Demand) di Sungai Badeng Banyuwangi. Journal Biosense: Penelitian Biologi dan Terapannya 8(3), 415–427.

Pratiwi, D, Y. 2020. Dampak pencemaran logam berat (timbal, tembaga, merkuri, kadmium, krom) terhadap organisme perairan dan kesehatan manusia. Jurnal Akuatek 1(1), 59–65.

Riyanto, M, and Kovalenko, V 2023. Partisipasi masyarakat menuju negara kesejahteraan: memahami pentingnya peran aktif masyarakat dalam mewujudkan kesejahteraan bersama. Jurnal Pembangunan Hukum Indonesia 5(2), 374–388.

Sari, E, K, and Wijaya, O, E. 2019. Penentuan status mutu air dengan metode indeks pencemaran dan strategi pengendalian pencemaran Sungai Ogan Kabupaten Ogan Komering Ulu. Jurnal Ilmu Lingkungan 17(3), 486–491.

Singh, P, Dar, J, G, Dhanorkar, M, and Warke, A. 2025. Multivariate statistical analysis of water quality of major rivers in Pune: a case study. International Journal of Mathematical, Engineering and Management Sciences 10(4), 1013–1031.

Suriadi, L, M, Denya, N, P, Shabrina, Q, A, Yuliana, R, Agustina, G, Kuspraningrum, E, and Asufie, K, N. 2024. Perlindungan sumber daya genetik ekosistem mangrove untuk konservasi lingkungan dan keseimbangan ekosistem. Jurnal Analisis Hukum 7(2), 234–253.

Wende, M, E, Meyer, M, U, Perry, C, Prochnow, T, Hamilton, C, N, Abildso, C, and Porter, K, M. 2024. Implementation characteristics that may promote sustainability of a rural physical activity initiative: examination of play streets through the lens of community implementers. Implementation Science Communications 5(48).

Zahra, J, A. 2023. Analisis sifat fisika dan kimia air sungai Tempuran Langsur–Samin pada tata guna lahan yang berbeda. Ekosains 15(1)