The role of the community in conservation of the Bengawan Solo River - Indonesia to anticipate the impact of climate change

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Abstract. River conservation is one of the priority agendas in overcoming the impact of climate change. River conservation needs to be carried out so that the river can return to its natural function as a clean human resource and free from various kinds of risks. In conservation, the role of the community around the area is needed so that conservation programs can run properly. This research was carried out through a qualitative inquiry approach, data collection was carried out through observation, interviews and focused group discussions (FGD). Data analysis was carried out using the Miles and Huberman interactive analysis model technique. The results of the study show that a strong river conservation role can be built by involving the community; The role of the community can be optimized through the development of communities that care for the river environment as participants in planning and designing programs and conservation actors. The role of the parties as supporting institutions will encourage the stronger *environmental care community needed* to form a sustainable community movement for environmental care in the Bengawan Solo River. This research will provide benefits in the form of formulating a model for community-based river conservation.

1 Introduction

Indonesia is facing challenges in watershed management caused by pollution by garbage and waste and increasing flood intensity. National data shows that in 2020 Indonesia produced around 67.8 million tons of waste [6]. Of this amount, there is 4.9 million tons of plastic waste that is not handled properly or is categorized as *mismanaged.* In addition to Indonesian waste, it is also aggravated by its link, namely waste that is often thrown away by rogue individuals so that it pollutes river waters and damages the ecosystem in the river. There are two types of waste that are often discharged into rivers, namely solid waste (plastics, building materials, wood and others) and liquid waste (used water for fabric dye, soapy water, oil, food). Both wastes are found in watersheds in Indonesia.

The existence of waste disposal, especially solid waste, turns out to cause new problems in the river flow, one of which is flooding. Flooding is one of the problems that arises due to the disposal of solid waste that accumulates in the river flow due to the limited capacity of

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the usngai to accommodate waste materials which every day continues to increase and fill the waters. The Bengawan Solo River is one of the largest rivers on the island of Java. As a large river, Bengawan Solo is a river with a large amount of waste. Research shows that along the Bengawan Solo River there is infiltration of industrial waste, household waste, and also oil waste which has an impact on water quality and sediment [15]. In addition, pollution poses new risks in the form of hydrometrological disasters, especially floods. Bengawan Solo often experiences floods due to river flows that overflow into the mainland. The flood of Bengawan Solo occurs almost every year, especially in the last five years in 2019-2025, which inundated several houses of riverside residents which had an impact on the continuity of their daily lives [9].

There are findings of pathogenic bacteria in river flows due to sewage pollution and also hydrometerological disasters showing the damage to river ecology which will later have an impact on the emergence of health risks and disruption of river ecosystems that will affect people's lives With the problem regarding the idni river, it certainly reflects the urgency that there is a need for protection or conservation of the watershed. The protection of river flows and the provision of clean water have been listed in the sixth *Sustainability Development Goals* or SDG's, namely Clean *Water and Sanitation.* This has consequences for reducing pollution, improving waste treatment, protecting water catchment areas, and strengthening water management institutions at all levels [12]. The United Nations encourages an *integrated water resources management* approach as part of the SDG's fulfillment strategy. In addition to being based on the SDGs, Indonesia also has a law that regulates water management, namely Law Number 37 of 2014 which regulates soil and water conservation. In this Law, it is stated that water management requires the principle of downstream integration, socio-environmental economic functions, and coordination between stakeholders at various levels[11]. This reflects that river water management requires integrated institutions, one of which is community-based river conservation.

Community-based or institutional river conservation is one of the most important driving engines in carrying out community-based river management. The institution in question is a strong institution formed and sustainable in implementing the program and independence in the implementation of the program so that the institution can be optimal in the implementation of the program. Institutions as a symbol of personal and communal independence will be a reference in the implementation of the set of tasks and functions of the institution and see how successful the implementation of the program is carried out. The institutional aspect concerns the procedural aspects of the formation of institutions, organizations and instruments to move the wheels of the organization, the values that underlie the performance of the institution, its supporting regulations and the organizational management or governance that has been built so far. Focusing on institutions will be more beneficial for those interested in community-based natural resources in management [5]. Community-based or institution-based conservation is considered quite strong and responsive in answering the needs of grassroots-based environmental conservation [2].

We need to examine the institutional aspects in depth to provide input in optimizing river conservation programs in an effort to support the sustainable management of the Bengawan Solo river. Upstream-downstream management institutions need to be realized in order to maintain the health of the river. Downstream communities will be able to feel the benefits and consequences of river conservation [8]. The community around the river will also be guaranteed its welfare. The awareness of riverside communities also arises when it is expected that there will be a need for river conservation behavior. The planning that is the motto in the management of Bengawan Solo is *"One River, One Plan, One Integrated Management:* Or another motto "*Many Species, One Planet, One Future* ". All of this makes the main vision in mobilizing institutions in conservation to support the management of the

Bengawan Solo river, but the vision is still limited to jargon or slogans that have not been optimally applied.

Therefore, the Bengawan Solo river area needs to receive serious attention to overcome the above problems, one of which is optimizing the institutional performance of river management. Thus, the role of the institution is a tool of behavioral expectations carried out through institutional analysis. Institutional analysis provides an overview of the distribution of roles and responsibilities built in an institutional structure as well as the factors that affect the institutional structure that is built. Institutions are social buildings that regulate the behavior of a person or a group of people in society. In river conservation, the behavior and movement of residents are important indicators to realize forest and land conservation in the context of sustainable conservation of the Bengawan Solo river. The purpose of this study is to formulate an institutional model of community-based river conservation in the management of the river environment of Bengawan Solo, Central Java, Indonesia. This study analyzes the institutional nature of river conservation in *the common pool resoursce* (CPR) framework of Ostrom.

2 Research Methods

This research is a *cooperative inquiry* research, which holds that human beings with certain help can live longer, freeing themselves from social pressures that shackle joint activities in a group based on open norms[3]. This research was conducted in two locations, namely: the Bengawan solo river in the Surakarta Region; the second is the Bengawan Solo river which is in the Sukoharjo Region.The data collection techniques used include FGD, interviews and institutional mapping. The informants in this study are Policy Makers related to river management, Field Extension Officers (PPL), Administrators of River Community Institutions, NGOs and documentation in the form of literature, documents related to the research. Informants were determined by purposive sampling technique with criteria for linkages and relationships with river environmental management. For sampling, *Extreme of Deviant Case Sampling* and *Maximum Variation Sampling* were used [7]. *The extreme of deviant case sampling* is focused on the person who knows the problem best, namely the chairman of the Bengawan Solo River Conservation Community Group. *Maximum variation sampling* is a sampling selection that aims to find variations in information collection under different conditions. Data analysis was carried out qualitatively, used in this study is an *interactive model of analysis* from Miles & Hubberman.

3 Results and Discussion

3.1 The role of river communities in the conservation of the Bengawan Solo River

The management of the Bengawan Solo River, which is the main freshwater ecosystem on the island of Java, cannot be separated from the social and environmental problems that surround it. Rivers are a common resource that is vulnerable to ecological quality degradation if not managed properly through cross-sectoral collaboration, one of which is community [11]. The community is a very important part of river conservation efforts. In order for the river not to be damaged, it is necessary to carry out river conservation efforts that are carried out in an integrated and sustainable manner, through the involvement of the community who are members of river conservation institutional activities. The community needs to be involved in the managerial ability of river management and institutional capacity building and involvement in decision-making needs to be optimized to support sustainable river

management [5]. Everything is done to support ecological protection and so that the damage to the river environment does not spread. The results of the study show that the river already has a community, namely the Bengawan Solo River Care Community Group. This community group has carried out its role in a strategic and practical way that has an impact on the sustainability of river ecology.

The strategic role carried out by the Sungai Bengawan Solo community is reflected in the real contribution of the community through regional development planning, namely the urban development planning deliberative forum. Based on the findings of field research, this community group is not only passive but also active in submitting proposals related to river conservation policies such as the construction of hygiene facilities, the arrangement of banks, the revitalization of public spaces and the submission of budgets for environmental education programs. This participation shows that the community has a significant bargaining position in environmental management. This involvement reflects the fulfillment of the principle of *collective-choice arrangements,* which states that the community needs to be involved in the formulation of rules and decisions that they will carry out[10]. This strategic role not only provides facilities that are just horizontal communication but also strengthens vertical communication between the community and the government so that the policies decided will be more responsive to the local needs of the community. In addition to the planning aspect, the role of the community is also shown by direct practice in environmental advocacy. The community actively reported illegal waste disposal, damage to banks that damage the river ecosystem to the Environment Agency and the Bengawan Solo River Area Center. This action emphasizes the community's function as *an environmental watchdog* [10]. That way, the community not only acts as the subject of government policies but also policy makers who participate in planning management through deliberative, representative and advocacy mechanisms.

In contrast to the strategic role, the people of the Bengawan Solo River community realize their practical role directly in caring for and improving the condition of the river. The community actively carries out waste cleaning activities on the banks and river bodies, conducts monthly community service, and involves other social groups such as youth organizations and nature loving communities. This participation shows that the community has implemented *monitoring and graduated sanctions* [10]. The community not only cleans the river but also supervises and forms internal ecological norms which is shown by the prohibition on dumping garbage or waste into the Bengawan Solo River. This norm is realized by the existence of collective compliance owned by the community. Another practical role is realized through planting riparian vegetation in areas prone to abrasion. This planting aims to ensure that the Bengawan Solo riverbank area does not experience a subsidence in the soil surface caused by floods and other ecological conditions. The planting of this vegetation is also often followed by cleaning the river from solid and liquid waste. This activity has a significant impact on improving soil stability, reducing the rate of sedimentation and improving the quality of riverside habitation. The community in this case has affirmed its role that in preserving nature it is necessary *to maintain the maintenance of resource system* — a long-term action that maintains the integrity of the ecological system into a common resource [5].

In addition, the community also complements public facilities on the banks of the Bengawan River Solo such as communal garbage dumps, environmental education boards (prohibition of garbage, invitations to guard the river, invitations to plant trees and others) and toilet facilities (MCK). The facility is a form of infrastructure support which, according to Ostrom, is one of the important elements in preventing behavior that damages the river ecosystem such as littering. Ostrom said that infrastructure support both independently by local communities and the government has a significant impact on building public awareness to care for and maintain the surrounding environment [10]. The existence of a supporting

infrastructure provides changes in the ecological behavior of the community. The existence of social infrastructure such as regular meetings, environmental campaigns, and citizen involvement in activities or activities in the river also strengthen the capacity of the community to be able to participate in the long term.

The dynamics of the strategic and practical role of the Bengawan Solo River community explains that river governance can only develop and be sustainable if it is supported by institutions that are adaptive in responding to socio-ecological changes. The existence of river care communities not only strengthens capacity at the site level but also establishes a significant bargaining position before the state, in this case the government. The Bengawan so River is not only an ecological space but also a deliberative, participatory social arena and is part of social reconstruction together.

3.2 Factors that are obstacles in river management

In the context of river conservation, community participation is not only complementary but also a major factor in the running and success of the movement. However, the reality shows that community participation can be said to be not ideal. This is based on the findings of research which states that there are two obstacles that affect community participation in the conservation efforts of the Bengawan Solo River. These obstacles are limited free time for the community (especially those who work in the informal sector, such as traders) and lack of technical knowledge regarding applicable and effective river management. These two obstacles are factors that cannot be underestimated as personal problems but have become part of the structural configuration that affects how the Bengawan Solo River is managed.

3.2.1 Limited public leisure time

The majority of the people in the Bengawan Solo River area have a livelihood in the informal sector such as small traders, freelancers, day laborers, domestic workers and home-based micro uaha owners. The informal sector has characteristics in the form of irregular income, flexible but long-term working hours, dependence on daily activities to meet economic needs. This condition has the consequence that people try their best to use their time to meet the needs of their families. As a result, activities that are considered not to bring economic value tend to be abandoned and not prioritized. This limited free time has an impact on the low level of community participation in river conservation programs, such as community service, garbage patrols, riparian vegetation planting, and water quality monitoring. Participation is considered an additional burden that reduces daily work time. In Ostrom's view, the quality of resource management (in this case watersheds) is greatly influenced by consistent collective action. When community members do not have time to participate, there will be a tendency to *free-rider* or enjoy the benefits of conservation but without contributing.

In addition, the condition of the informal sector makes the relationship between income and time sensitive. For people who work in the informal sector, the reduction in working hours will have a direct impact on family economic stability. In this case, voluntary conservation activities are often considered not to be activities that can support ecological sustainability and usefulness but as social activities that reduce productive time [2]. This reality shows that the conservation of the Bengawan Solo river cannot be separated from the economic condition of the community. When meeting needs is a priority, conservation activities will not receive significant attention so that river area management becomes unsustainable.

The ostrom framework also emphasizes on the success of CPR being influenced by *congruence* between local rules and conditions [10]. In the case of the Bengawan Solo River community, the rules or schedules for the implementation of conservation programs often do

not consider the work rhythm of the community because they are considered necessary to make decisions. The program is often carried out during productive working hours where people work for insignificant hours or can be said throughout and every day. Obstacles to free time reflect that river conservation programs are often contrary to the reality of the life of the people in the river area. When the rules are not aligned with the local situation, then participation will not be built sustainably. Furthermore, time constraints confirm that the community is still weak in terms of *collective-choice arragements* as Ostrom said is an important condition in resource management. This condition requires that there be space for the community to be directly involved in the planning process, drafting rules and program evaluation [10]. The intended space has been owned but with less participation due to the absence of the community in meetings or forums, every program or activity decided only involves a small part of the community or can be said to be only a small number of volunteers. This situation and condition certainly create a gap between the needs of the community and the conservation carried out, because it can be said that the decisions taken do not reflect the needs of the majority.

In the long run, the absence of the community in conservation activities will weaken the sense of ownership of the program and eliminate the social legitimacy of the program being carried out. Ostrom said that a rule, whether policy or program, can only be said to be effective if it involves the affected individuals in every decision-making[10]. In other words, time constraints not only reduce community participation in conservation but also hinder real contributions at the institutional level so that a truly community-based and sustainable river management system does not run as it should.

3.2.2 Limited public knowledge of river management techniques

The limited knowledge of the community about river management techniques is a significant obstacle in the conservation efforts of the Bengawan Solo River. The main problem is not only caused by the limitation of information but also the incompatibility of the form of information provided to the public with needs and capacity. As well as the social conditions of the community. In many cases, often training, socialization and education materials about river management tend to use academic and overly complex terms. The terms used are often difficult to understand by the community because of the varied community backgrounds [5].

The difficulty is also caused by the terms used sometimes impractical but theoretical. The use of this term causes a gap in terms of people's knowledge capacity. This distance makes people feel unconfident, do not want to be involved or feel that river conservation is the domain of the government or environmentalists. As a result, conservation activities that should be collective become exclusive.

According to Ostrom, the limitation of knowledge has quite serious implications for the governance of shared resources. One of the important principles emphasized is local knowledge and the ability of communities to formulate rules, implement and supervise resource management. Knowledge is not only understood as technical data, but also the ability to understand problems, formulate strategies, negotiate with other actors and monitor compliance with rules. When basic knowledge is not possessed by the community, their involvement in making joint decisions becomes of poor quality.

This problem is often exacerbated by the fact that government programs or donor agencies tend to be one-way in the planning and implementation process. This approach is based on the assumption that experts are the owners of knowledge and the community is the recipient subject. Ostrom says that this approach ignores the ideal interaction structure between actors, the arena of action and the social context of the environment. The knowledge provided tends to be technocratic, formal and academic, not in harmony with the practical knowledge possessed by the people of the river area. This inconsistency causes an epistemic tension

between *scientific knowledge* and *local knowledge* [10]. When these tensions are not resolved properly, conservation implementation tends to be a project rather than a long-term initiative. This is because the position of the community is only a workforce or a participant in socialization, not as a planner of social rules that bind collective behavior.

The limitation of technical knowledge has a more serious consequence, namely the low ecological awareness possessed by the community. Ecological awareness not only arises from an emotional understanding that rivers are the source of life, but requires scientific knowledge that can show a causal relationship between human behavior and the decline in river quality. Without such an understanding, destructive behaviors such as waste disposal, sedimentation and exploitation would be considered commonplace.

3.3 Strategies to be carried out in river conservation

Conservation efforts of the Bengawan Solo River as one of the largest freshwater ecosystems on the island of Java require sustainable, inclusive, and strategic planning based on the participation of various stakeholders. Water quality degradation, sedimentation, domestic waste pollution, industrial pressure, and community behavior that is not yet based on ecological ethics are major challenges that require more systemic interventions. In this context, it is not enough for conservation strategies to rely solely on government policies or technical activities, but must accommodate the collective commitment of communities, NGOs, education agencies, women's empowerment and child protection agencies, environmental agencies, and universities. Such multi-actor collaboration can form a *common-pool resources* governance mechanism that is in line with Elinor Ostrom's principles of collective management of natural resources. Ostrom emphasized that successful resource management is not the result of state regulation or privatization, but is born from an institutional design that allows local communities to be actively involved in planning, implementing, and monitoring resource management [10]. Therefore, the conservation strategy of Bengawan Solo must be built through a collaborative process that strengthens local capacity and ensures that each actor has a clear role in inputs, processes, and outputs in the form of communities that care about the river.

Community contributions are a key element in the input phase because they are the closest parties and feel the impact of river degradation the most. The community not only functions as a recipient of the program, but also as a subject who has local *knowledge* about river dynamics, flood patterns, pollution points, and river user habits [8]. In Ostrom's framework, the community is *an appropriator* as well as *a provider* who has the ability to develop social rules and internal supervision mechanisms. Input from the community can be manifested in the form of documentation of local experiences, recognition of traditional conservation practices, identification of destructive behaviors, and prioritization of needs that are considered most relevant. The community also plays a role in instilling social norms related to responsible behavior towards rivers. When community contributions are integrated from the initial stage, the design of conservation programs will be more contextual and can answer the needs of the field directly. This is related to Ostrom's principle of *congruence between rules and local conditions*, namely that rules and management strategies must be aligned with local conditions in order to be effective and can be carried out voluntarily by the community [10].

In addition to the community, NGOs have an important function as facilitators and *bridging institutions* between grassroots communities and government structures. NGOs often have the capacity to conduct participatory research, community mentoring, environmental advocacy, and develop training modules based on practical approaches. In the context of Bengawan Solo, NGOs can provide input in the form of ecological problem maps, water quality monitoring results, policy recommendations, and community empowerment

models. NGOs are also able to bridge the interests between actors and ensure that the voice of the community is not marginalized in the decision-making process. In Ostrom's perspective, the existence of NGOs helps to reduce the problem *of asymmetric information* and strengthen the *monitoring* system, which is one of the important institutional designs in *Governing the Commons* [10]. NGOs can train community groups to become *river watchers* or community-based river watchers. Thus, input from NGOs strengthens the governance structure through information transparency, technical assistance, and community capacity building.

The role of the education office is very strategic in building river conservation based on ecological literacy from an early age. The education office can provide input in the form of integrating local content on river ecology into the elementary to secondary school curriculum, providing environmental learning modules, as well as the development of extracurricular programs such as adiwiyata schools, nature lovers clubs, or field practice activities on river conservation [14].

. Education has the power to form *environmental values* and *ecological citizenship* in the younger generation, so that river conservation is not only understood as a technical obligation but also a moral responsibility. In Ostrom's framework, education plays a role in strengthening the principle *of shared understanding*, which is the common knowledge that is the basis for the formation of collective rules. When ecological knowledge is embedded early, communities tend to be more likely to internalize shared resource management norms and are better able to participate reflectively in decision-making.

The Women's Empowerment and Child Protection (DP3AP2KB) Office has a unique contribution that is often underappreciated in river conservation. Women are important actors who have intense interaction with water resources for household needs, family economy, and parenting [13].

Inputs from DP3AP2KB can be in the form of the preparation of ecological-based women's empowerment programs, such as waste bank training, household waste management, recycling-based creative economy, and environmental campaigns involving housewives. DP3AP2KB can also design child and family education programs to instill eco-friendly values. Within the framework of Ostrom's theory, women's empowerment strengthens the principle of *participation of affected individuals*, i.e. the involvement of individuals who are most affected by resource conditions [10]. When women are empowered and have adequate knowledge capacity, they can be a significant agent of change in improving people's habits towards rivers. Conservation that ignores gender perspectives tends to give birth to policies that are insensitive to social realities, so DP3AP2KB engagement is critical.

The Environment Agency (DLH) is the main actor in providing technical, administrative, and regulatory inputs. DLH is responsible for compiling river zoning maps, setting boundary boundaries, supervising industrial waste disposal, and providing valid water quality data. Input from DLH also includes the preparation of standard operating procedures (SOPs) for pollution control, the provision of experts, and the preparation of regional regulations related to river protection. Within the framework of Ostrom, DLH plays a role in strengthening *external recognition of rights to organize*, namely external recognition from the government of the right of the community to be involved in resource management. With the regulatory support from DLH, community rules agreed upon with the community have legal legitimacy and can be implemented more consistently. DLH can also provide input in the form of technology integration such as river monitoring information systems, pollution reporting applications, and the procurement of physical facilities to support conservation.

The college serves as a provider of scientific inputs, academic criticism, technological innovation, and the research base necessary in river conservation. Students and lecturers can conduct research on water quality, ecological restoration, watershed management, flood risk

analysis, and evaluation of policy effectiveness. Universities can also develop capacity building modules based on *community-oriented research*, so that academic knowledge can be transformed into training materials that are easy for the public to understand. Within the framework of Ostrom, universities strengthen the principle *of nested enterprises*, which is management carried out through a multi-level structure from the community level, local government, to scientific institutions [10]. The existence of universities ensures that conservation strategies are not only based on intuition or traditional practices, but are also supported by accountable scientific data [14].

All inputs from these various actors are the basis of the core conservation process, namely capacity building, training, and practical language-based socialization. The capacity building process must be designed in a tiered, participatory, and contextual manner. Training should not be one-way, technocratic, or too academic, but must prioritize experiential learning methods, direct demonstrations in the field, simulations, participatory mapping, and group discussions. Within the framework of Ostrom, this process reinforces the principle of *collective-choice arrangements*, i.e. community participation in determining rules and strategies for action [10]. For example, the community is involved in determining river patrol schedules, waste management mechanisms, forms of social sanctions, and restoration program priorities.

Simple and easy-to-understand language-based socialization is essential to bridge the knowledge gap between experts and the general public. Technical language such as "sedimentation", "pollutant load", or "biotic indicator" need to be translated into practical concepts such as "sand buildup that reduces flow", "waste that makes water smell", or "diversity of small creatures as a sign of healthy water". Simplifying language does not mean lowering the capacity of society, but is a strategy to ensure that knowledge can be internalized and practiced in daily life. In Ostrom's perspective, common understanding is the basis of collective adherence to rules. If people understand the rationale behind conservation rules, then they are more likely to implement and supervise them independently.

The expected output of all these strategies is the realization of a *river-conscious community* that has the capacity to become a major actor in river governance. This output is not only in the form of changes in individual behavior, but also changes in institutional structures at the community level. People who care about rivers are able to formulate local rules, carry out monitoring, provide proportionate social sanctions, and collaborate with the government and other institutions in a sustainable manner. In Ostrom's framework, this is a manifestation of a *self-governing community*, which is a community that has capacity, norms, and local institutions that function effectively. When these outputs are achieved, river conservation is no longer dependent on short-term projects, but becomes part of a social culture that is firmly embedded in society. The entire process can be seen in figure 1. Conservation strategy of the Bengawan Solo River.

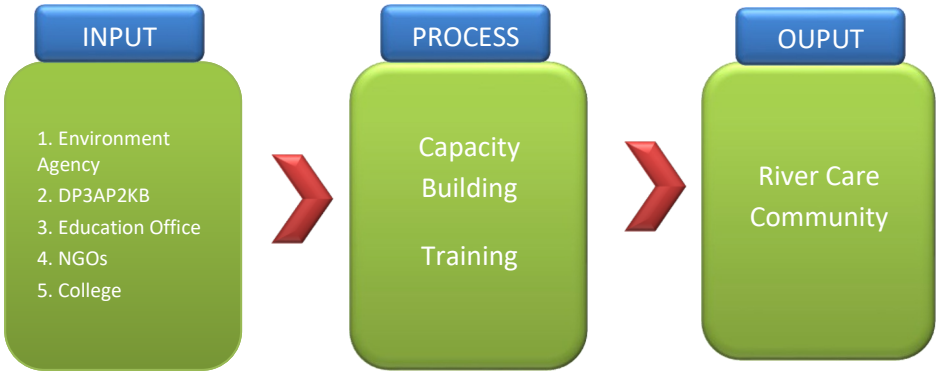

Figure 1. Conservation Strategy of the Bengawan River Solo

4 Conclusion

The role of the community in the conservation of the Bengawan Solo River is divided into two categories, namely the strategic role shown by participation in the preparation of conservation plans and the practical role manifested in the willingness to take care of the Bengawan Solo River. In carrying out their roles, there are obstacles that become obstacles in the conservation process. Barriers are caused by people's livelihoods dominated by jobs in the informal sector that demand long working hours. In addition, obstacles are also caused by a lack of public knowledge about river management due to the delivery of information that tends to be academic and technocratic, creating a distance between public knowledge and experts and low ecological awareness. By looking at the role of communities that have obstacles in their implementation, a strategy is needed that can involve all elements of society and stakeholders in the conservation process. In this case, river conservation needs to involve the environmental agency, DP3AP2KB, NGOs, universities, and the community. The strategy is divided into three processes, namely Input (parties involved), Process (capacity building and training) and Output (community care for the river).

Acknowledgement

This work was supported by grants from the Non-State Budget Funds Universitas Sebelas Maret Indonesia Fiscal Year 2025 Number: 371/UN27 22/PT01 03/2025.

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