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Community-Driven Water Service Management as a Service-Learning Model for Expanding Rural Drinking Water Access

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Abstract

Despite substantial investments in rural drinking water infrastructure, equitable access to safely managed drinking water remains a persistent challenge in rural and island communities due to institutional limitations and weak community engagement. This study develops and evaluates a Community-Driven Water Service Management (CDWSM) model grounded in service-learning to strengthen sustainable rural drinking water governance. A sequential exploratory mixed-methods design was employed. The qualitative phase involved an intrinsic case study in South Buru Regency, Indonesia, using in-depth interviews, field observations, and document analysis, which were analyzed through constructivist grounded theory to formulate the initial CDWSM framework. The second phase implemented participatory action research integrated with service-learning, engaging universities, local governments, water service providers, and community members in iterative cycles of planning, action, reflection, and evaluation. The final phase validated the proposed model through a household survey analyzed using Partial Least Squares Structural Equation Modeling (PLS-SEM). The findings reveal that drinking water management remains predominantly administratively driven, limiting meaningful community participation despite adequate technical capacity. Service-learning significantly enhanced institutional capacity, collaborative governance, community ownership, and the long-term sustainability of water services, thereby expanding access to safe drinking water. The study introduces the CDWSM model as a novel theoretical framework integrating institutional capacity, community learning, collaborative governance, social ownership, and service sustainability, extending community-based water management theory through the integration of service-learning and collaborative governance perspectives while offering practical guidance for achieving Sustainable Development Goal 6.

Keywords: *Collaborative Governance, Community-Driven Water Service Management, Institutional Capacity, Rural Drinking Water Access, Service-Learning*

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INTRODUCTION

Access to safe and sustainable drinking water remains one of the most pressing development challenges despite substantial investments in water supply infrastructure across many developing countries. While considerable progress has been achieved in expanding physical infrastructure, the persistence of unequal access demonstrates that infrastructure

alone cannot guarantee sustainable service delivery. According to the World Health Organization and the United Nations Children's Fund (Alem, 2025; Koppen et al., 2020), billions of people worldwide still lack access to safely managed drinking water services, with rural and geographically isolated communities experiencing the greatest disparities. These inequalities are particularly evident in archipelagic regions, where dispersed settlements, limited institutional capacity, and financial constraints complicate the operation and maintenance of rural water systems. Consequently, the challenge of achieving Sustainable Development Goal 6 has gradually shifted from merely increasing infrastructure coverage toward ensuring long-term governance, institutional resilience, and community ownership of water services (Hapsari et al., 2025; Jones et al., 2025; Shuja, 2025).

Indonesia reflects many of these global challenges. Over the past decade, the government has invested extensively in rural drinking water infrastructure through various national and local initiatives. Nevertheless, disparities in service quality and continuity remain significant between urban and rural areas. Many rural water supply systems experience declining performance only a few years after construction due to inadequate operation and maintenance, limited financial sustainability, weak institutional arrangements, and insufficient community participation (Gizaw et al., 2023; Malek & Duku, 2024; Sharma et al., 2025). In many villages, communities continue to rely on unprotected water sources despite the existence of piped water infrastructure, suggesting that technical capacity alone is insufficient to ensure equitable access. These conditions are particularly relevant in eastern Indonesia, where geographical isolation and limited administrative capacity frequently constrain the sustainability of public service delivery.

South Buru Regency represents one of these contexts where the sustainability of drinking water services extends beyond technical infrastructure. Although water production capacity has gradually improved, the distribution of piped water services remains uneven, while several communities continue to depend on alternative water sources during periods of supply disruption. More importantly, local water governance remains predominantly administrative, with communities largely positioned as beneficiaries rather than active partners in planning, operating, monitoring, and maintaining water systems. Such conditions indicate that the sustainability of rural drinking water services is fundamentally influenced by institutional arrangements and collective social processes rather than engineering performance alone.

The growing recognition of governance as a determinant of sustainable water services has encouraged scholars to examine community participation as a critical component of rural water management. Earlier studies consistently demonstrate that community involvement enhances operational efficiency, improves accountability, and strengthens local ownership of infrastructure (Melton et al., 2022; Mujeebullah et al., 2025; Prajapati et al., 2025). Community-based water management has therefore become one of the dominant paradigms for rural water service delivery, particularly in developing countries where centralized management often encounters financial and logistical limitations. Rather than treating local

residents solely as service recipients, this approach recognizes communities as key actors capable of maintaining infrastructure, collecting user fees, resolving operational conflicts, and ensuring service continuity.

Subsequent research has further emphasized that institutional capacity plays an equally important role in determining the long-term performance of rural water systems. Akter et al. (2026) and Hou et al. (2023) argue that sustainability depends not only on infrastructure quality but also on the ability of local institutions to adapt, coordinate stakeholders, and respond to emerging challenges. Similar findings have been reported by Danquah et al. (2026) and Nakibuule et al. (2026), who demonstrate that water governance should be understood as a dynamic social process involving negotiation, learning, and institutional adaptation rather than merely compliance with administrative regulations. These perspectives suggest that sustainable water services emerge through continuous interaction among technical, organizational, and social dimensions.

Recent literature has increasingly explored collaborative governance as a mechanism for strengthening public service delivery. Collaborative governance encourages governments, civil society organizations, educational institutions, and communities to jointly formulate solutions for complex societal problems (Belay & Andualem, 2022; Browning et al., 2025; Duan et al., 2022). Within the water sector, collaborative arrangements have been shown to improve transparency, strengthen stakeholder trust, and facilitate knowledge exchange across multiple actors (Huber et al., 2024; Nounkeu et al., 2022). Nevertheless, many collaborative governance studies primarily examine institutional coordination among formal organizations while paying comparatively less attention to how communities acquire the knowledge and practical competencies required to sustain these governance arrangements over time.

Parallel to these developments, service-learning has emerged as an influential pedagogical approach that integrates academic learning with meaningful community engagement. Unlike conventional community service activities, service-learning emphasizes reciprocal learning in which students, educators, and community members collaboratively identify problems, implement interventions, and reflect upon practical experiences to generate mutual benefits (Chimombo, 2025; Evance et al., 2025; Mvongo et al., 2022). Extensive evidence suggests that service-learning enhances civic engagement, critical thinking, leadership, and collaborative problem-solving capacities while simultaneously addressing local development challenges (Lutfia et al., 2024; Pace et al., 2022; Singh & Naik, 2024). These outcomes demonstrate that experiential learning can contribute not only to educational objectives but also to broader processes of community empowerment.

Despite its growing popularity, the application of service-learning within rural drinking water governance remains remarkably limited. Existing studies predominantly focus on education, healthcare, environmental awareness, and social development, whereas its potential contribution to strengthening institutional capacity in public utility management has received relatively little scholarly attention. As a result, community learning is often treated

as a supplementary activity rather than as a central mechanism through which governance capacity evolves. This omission is particularly significant because rural water services require continuous learning, adaptation, and collective decision-making long after infrastructure construction has been completed.

Another stream of literature has focused on measuring progress toward Sustainable Development Goal 6 by evaluating access indicators, water quality, affordability, and service reliability (Husein et al., 2023; McClelland et al., 2022). While these indicators provide valuable evidence regarding service outcomes, they offer relatively limited explanation regarding the underlying social mechanisms that enable communities to maintain sustainable services across changing institutional and environmental contexts. Consequently, many evaluation frameworks remain oriented toward technical performance rather than institutional transformation.

Taken together, the existing body of knowledge provides substantial insights into community-based water management, collaborative governance, institutional capacity, and service-learning. However, these perspectives have largely evolved as separate scholarly conversations. Community participation is frequently discussed without sufficiently explaining how learning processes strengthen institutional capacity; collaborative governance often emphasizes organizational coordination while overlooking community learning; and service-learning research rarely extends beyond educational outcomes into the governance of essential public services. This fragmentation limits current understanding of how collective learning can become an institutional driver that transforms community participation into sustainable water service management.

Building upon these complementary yet disconnected strands of scholarship, this study develops an integrated perspective that positions collective learning as the connecting mechanism between institutional capacity, collaborative governance, social ownership, and the long-term sustainability of rural drinking water services. Rather than conceptualizing communities merely as participants in infrastructure management, the study views them as active co-producers of knowledge whose learning experiences gradually reshape governance practices and institutional performance. This perspective offers a more comprehensive understanding of how sustainable water services evolve through continuous interaction among local governments, higher education institutions, water utilities, and community organizations, particularly within geographically isolated rural settings.

Accordingly, this study aims to develop and evaluate the Community-Driven Water Service Management (CDWSM) model through a service-learning approach to strengthen rural drinking water governance in South Buru Regency, Indonesia. Specifically, the study seeks to examine existing institutional conditions, identify factors influencing sustainable community-based water management, formulate an integrated governance model grounded in collective learning, validate the relationships among institutional capacity, community learning, collaborative governance, social ownership, and sustainable water services, and provide policy recommendations that support the achievement of Sustainable Development

Goal 6 while advancing the integration of research and community engagement within higher education.

RESEARCH METHOD

This study employed a qualitative research approach using an intrinsic case study design to develop an in-depth understanding of how community-driven drinking water management can be strengthened through a service-learning approach in rural areas. A qualitative approach was considered the most appropriate because the primary objective of the study was not to measure statistical relationships but to explore the social processes, institutional dynamics, collaborative interactions, and collective learning experiences that shape the sustainability of rural drinking water services. Sustainable water governance is inherently a socially constructed phenomenon involving multiple stakeholders with diverse interests, experiences, and responsibilities. Consequently, understanding these complex interactions requires an interpretive approach capable of capturing participants' perspectives, institutional contexts, and everyday practices rather than relying solely on quantitative indicators (Adom et al., 2023; Azeez et al., 2023; Ishaque et al., 2024). The intrinsic case study design was selected because South Buru Regency represents a unique context where relatively adequate water production capacity coexists with persistent disparities in drinking water access and service sustainability, making it a valuable setting for examining how institutional transformation can emerge through community engagement and collaborative learning (Bolatova, Sharapatova, Kabiyev, et al., 2025; Cohen et al., 2022; Karambiri et al., 2026).

South Buru Regency was purposively selected as the research site for both empirical and contextual reasons. As one of Indonesia's archipelagic rural regions, the regency faces geographical fragmentation, dispersed settlements, and varying levels of access to basic public services. Although local government has invested in drinking water infrastructure through the Regional Drinking Water Supply Unit (UPTD SPAM), several communities continue to experience irregular service, limited participation in water governance, and challenges in infrastructure maintenance. These characteristics provide an appropriate setting for investigating governance issues beyond technical infrastructure. Furthermore, the regency has actively promoted community participation in village development, creating opportunities to examine how service-learning can complement existing institutional arrangements and strengthen local capacities for sustainable water management.

Participants were selected using purposive sampling because the study required individuals who possessed direct knowledge and practical experience regarding drinking water governance. A total of twenty-four informants participated in the study, comprising four officials from the Regional Drinking Water Supply Unit, three representatives from the district government responsible for public works and community empowerment, five village heads from villages served by piped water systems, six members of community-based water management groups, two local community leaders, two university lecturers involved in

community engagement programs, and two representatives of local civil society organizations working on rural development. These participants were chosen because they represented different institutional perspectives and played complementary roles in planning, operating, maintaining, supervising, and utilizing rural drinking water services. Their diverse experiences enabled the researcher to examine governance challenges from multiple viewpoints while ensuring that the emerging conceptual model reflected the realities of various stakeholders involved in water service delivery.

Data were collected through in-depth semi-structured interviews, participant observation, and document analysis. Semi-structured interviews served as the primary data collection method because they allowed participants to explain their experiences, perceptions, and institutional practices while providing sufficient flexibility for the researcher to explore unexpected issues emerging during conversations (Ahmed et al., 2025; Bolatova, Sharapatova, Kanagat, et al., 2025; Smiley et al., 2025). Each interview lasted between 60 and 90 minutes and was conducted in locations convenient for participants to encourage open and reflective discussions. Participant observation complemented the interviews by enabling the researcher to directly observe the operation of drinking water facilities, community meetings, maintenance activities, and interactions among stakeholders. This approach provided contextual evidence that could not always be fully articulated during interviews and facilitated a deeper understanding of routine governance practices (Castillo et al., 2024; Dongzagla et al., 2022). In addition, policy documents, village regulations, operational reports, development plans, and institutional records were analyzed to understand the formal governance framework and to compare official policies with actual implementation in the field.

The collected data were analyzed using constructivist grounded theory. Data analysis began simultaneously with data collection through an iterative process of constant comparison. Interview transcripts, field notes, and documentary evidence were first subjected to open coding to identify significant concepts related to institutional capacity, community participation, collaborative governance, learning processes, and service sustainability. These initial codes were subsequently organized through axial coding to establish relationships among categories, followed by selective coding to integrate the emerging concepts into a coherent conceptual framework describing Community-Driven Water Service Management. This analytical strategy enabled theoretical insights to emerge inductively from participants' lived experiences while remaining grounded in the empirical context of rural drinking water governance.

RESULTS AND DISCUSSION

Administrative-Centered Water Governance and the Persistence of Unequal Rural Drinking Water Access

The empirical findings indicate that the principal challenge confronting rural drinking water services in South Buru Regency is not primarily associated with water resource availability or production capacity, but rather with the governance arrangements through which drinking water services are managed. This finding emerged consistently across field observations, document analysis, and in-depth interviews conducted with local government officials, water utility managers, village leaders, community representatives, and academics. Although the region possesses relatively adequate raw water resources and existing water supply infrastructure, the effectiveness of service delivery remains constrained by institutional practices that continue to rely predominantly on administrative decision-making. Consequently, improvements in physical infrastructure have not always translated into equitable and sustainable access to drinking water across rural communities.

Field observations at the two largest drinking water supply systems, namely SPAM Namrole and SPAM Leksula, illustrate contrasting conditions regarding infrastructure utilization. In Namrole, two raw water sources are available, namely the KM.9 spring and the Fatmite spring. However, only the KM.9 system remains operational because the treatment facilities associated with the Fatmite source are no longer functioning despite the construction of a new treatment facility funded by the Provincial Government of Maluku. The newly completed facility has yet to be officially transferred to the South Buru Regency Government, preventing its operation and leaving valuable infrastructure idle. During field observation, the Fatmite reservoir was found empty and disconnected from the distribution network, whereas the KM.9 system continued operating through pumping mechanisms supplying treated water to consumers. This condition demonstrates that infrastructure development alone cannot guarantee service expansion when institutional coordination and administrative processes remain incomplete.



Figure 1 Filtration Unit of the Namrole Drinking Water Supply System (SPAM)
Source: Research Documentation, 2026.

A different situation was observed in SPAM Leksula. The system utilizes water from the Wayolo and Likulema springs and operates primarily through gravity-fed distribution. The quality of the raw water is sufficiently high that additional treatment is generally unnecessary, allowing operational costs to remain relatively low. Existing technical records indicate that the installed production capacity remains capable of meeting current service demand. Nevertheless, interviews with local stakeholders revealed that not all households within the service area enjoy continuous and equitable access. Distribution interruptions, delayed maintenance, and limited responsiveness to community complaints continue to affect service reliability. These findings reinforce the notion that adequate technical capacity does not necessarily ensure effective public service delivery when institutional governance remains weak.

To provide a clearer overview of the observed conditions, Table 1 summarizes the main characteristics of the two drinking water systems examined in this study.

Table 1 Existing Conditions of Rural Drinking Water Supply Systems in South Buru Regency

Drinking Water System	Technical Condition	Governance Condition	Main Challenges
SPAM Namrole	One treatment unit operational (KM.9); Fatmite treatment facility not yet functioning	Administrative authority remains centralized; delayed institutional coordination	Idle infrastructure, limited service expansion, slow asset transfer
SPAM Leksula	Gravity-fed system with adequate production capacity and good raw water quality	Community participation remains limited to service utilization	Unequal distribution, limited maintenance participation, weak feedback mechanisms

Source: Research analysis (2026)

The interviews further revealed that institutional arrangements remain largely government-centered. Planning, budgeting, infrastructure development, and operational decisions are generally initiated by government agencies or technical units with relatively limited involvement from local communities. Most community members participate only as consumers rather than active contributors to decision-making processes. A manager of the Regional Drinking Water Supply Unit (coded I-03) explained that community consultation usually occurs after technical plans have been finalized, reducing opportunities for residents to influence operational priorities. Similarly, a village head (I-09) noted that village governments are rarely involved in determining maintenance priorities, despite possessing detailed knowledge of local service conditions. These narratives suggest that participation has been largely procedural rather than substantive.

The limited involvement of communities extends beyond planning processes into the operational management of water services. Interviews with members of community water user groups (I-14 and I-16) indicated that residents generally contribute only through monthly tariff payments and occasional reporting of pipe leakages. Opportunities to participate in infrastructure monitoring, financial oversight, preventive maintenance, or service evaluation remain minimal. As one community representative (I-16) remarked, "People usually wait for the government to repair the system because they assume it is entirely the government's responsibility." Such perceptions gradually weaken collective responsibility and reduce local capacity to respond when operational problems emerge.

These findings illustrate that the sustainability of drinking water services depends less on engineering performance than on the institutional capacity to facilitate collaboration and shared responsibility. The persistence of administrative-centered governance has limited adaptive capacity by concentrating authority within formal institutions while underutilizing local knowledge and community resources. This observation is consistent with the OECD Principles on Water Governance, which emphasize that effective water governance requires stakeholder engagement, accountability, institutional coordination, and adaptive decision-making rather than solely technical investments (Gizaw et al., 2022; Love et al., 2023). Likewise, Idrissi et al. (2024) argue that collaborative governance becomes effective only when public institutions create opportunities for meaningful interaction, trust building, and shared ownership among stakeholders.

Service-Learning as a Mechanism for Institutional Capacity Building

The participatory action research (PAR) phase revealed that the limited sustainability of rural drinking water services was closely associated with institutional capacity rather than the availability of infrastructure alone. During the initial stage of the action cycle, community members, village authorities, the Regional Drinking Water Supply Unit (UPTD SPAM), university lecturers, and undergraduate students jointly identified operational problems affecting water service delivery. Rather than introducing predetermined technical solutions, the service-learning approach emphasized collaborative problem identification, allowing every stakeholder to articulate their experiences and expectations. This process fundamentally changed the dynamics of interaction among participants. Community members who had previously perceived themselves as passive service users gradually became active contributors to discussions regarding network maintenance, tariff management, and operational planning. As explained by one village leader (coded I-08), "For the first time, discussions about water management were not merely consultations after decisions had already been made. We were invited to identify problems together and determine what could realistically be improved."

Unlike conventional community service programs that often position universities as providers of technical assistance, the service-learning process established reciprocal learning relationships among all participants. Lecturers acted primarily as facilitators who guided discussions, encouraged critical reflection, and connected practical experiences with

evidence-based management practices. Students served as knowledge intermediaries by assisting communities in documenting operational problems, mapping distribution networks, recording customer complaints, and facilitating group discussions. At the same time, students acquired contextual knowledge from local communities regarding seasonal water availability, informal institutional arrangements, and customary practices governing collective resource management. This reciprocal exchange reflects the core principles of service-learning, in which academic knowledge and community experience become mutually reinforcing rather than hierarchically organized (Amoak et al., 2023; Gurung et al., 2023).

One of the most significant outcomes of the PAR process was the emergence of collective learning through iterative cycles of planning, action, reflection, and evaluation. During the planning stage, participants jointly identified priorities based on field observations and community experiences. These priorities included improving customer records, strengthening communication between operators and users, establishing regular maintenance schedules, and introducing transparent financial reporting for user contributions. The implementation stage involved collaborative execution of these agreed activities, followed by structured reflection sessions in which participants critically evaluated both achievements and remaining challenges. Rather than treating reflection as a purely academic exercise, these discussions encouraged stakeholders to reconsider existing institutional practices and identify practical adjustments for subsequent action cycles. Such iterative learning processes enabled institutional knowledge to develop progressively through practical experience, consistent with contemporary interpretations of experiential learning in higher education community engagement (Azat et al., 2024; Santos et al., 2023).

Interviews conducted after several action cycles demonstrated substantial improvements in community organizational capacity. Members of community-based water management groups reported increased confidence in performing routine operational tasks that had previously been regarded as the exclusive responsibility of government agencies. According to one community water committee member (I-15), the training and collaborative field activities helped residents better understand the functioning of distribution networks, enabling them to detect leaks, report pressure fluctuations, and perform simple preventive maintenance before technical failures became more severe. Similar observations were reported by a university facilitator (I-20), who noted that the most important change was not the acquisition of technical knowledge itself but the emergence of collective responsibility for maintaining water services.



Figure 2 Reservoir Unit of the Namrole Drinking Water Supply System (SPAM)
Source: Research Documentation, 2026

The learning process also strengthened several administrative functions that are essential for sustainable water governance. Prior to the intervention, customer records were incomplete, tariff collection procedures varied considerably between villages, and maintenance responsibilities were often unclear. Through collaborative workshops and field practice, community organizations gradually developed standardized customer registration systems, improved financial record keeping, established routine monitoring schedules, and clarified operational responsibilities among committee members. These improvements enhanced organizational transparency while reducing dependence on external government intervention for routine management activities.

Table 2 Institutional Capacity Changes Following the Service-Learning Process

Institutional Dimension	Before Service-Learning	After Service-Learning
Network operation	Highly dependent on technical officers	Community capable of basic operational monitoring
Customer administration	Fragmented and inconsistent	Standardized customer registration system
Tariff management	Limited financial documentation	Transparent recording of user contributions
Water quality monitoring	Reactive and irregular	Routine community-based monitoring practices
Organizational roles	Unclear division of responsibilities	Clearly defined operational responsibilities

Source: Research analysis (2026)

Beyond these operational improvements, the findings demonstrate that service-learning generated important institutional changes by strengthening relationships among stakeholders. Reflection sessions became spaces where government officials, community representatives, students, and lecturers openly discussed operational constraints that had

rarely been addressed through formal administrative meetings. This collaborative environment gradually reduced institutional distance, strengthened mutual trust, and encouraged more inclusive decision-making. A UPTD SPAM officer (I-04) acknowledged that community discussions provided practical insights that were previously unavailable through routine administrative reporting, particularly regarding localized service interruptions and user expectations.

These findings suggest that learning should not be understood merely as an educational outcome but as an institutional process through which governance capacity evolves. Rather than simply transferring technical knowledge from universities to communities, service-learning facilitated the co-production of knowledge that enabled local organizations to reinterpret their roles, strengthen internal coordination, and improve operational performance. This process supports recent scholarship arguing that experiential learning contributes directly to institutional capability by embedding reflection, collaboration, and shared problem-solving within community engagement activities (Adenova et al., 2023; Mbana & Sinthumule, 2024). In the context of rural drinking water governance, institutional capacity therefore emerged not from external technical assistance alone but from continuous collective learning that transformed individual experiences into shared organizational competencies. These findings provide the conceptual bridge to the next section, which examines how strengthened institutional capacity subsequently fostered more collaborative forms of water governance across multiple stakeholders.

Collaborative Governance as the Driver of Sustainable Rural Water Services

The participatory action research process demonstrated that strengthening institutional capacity alone was insufficient to ensure sustainable rural drinking water services unless it was accompanied by changes in the relationships among the actors responsible for service provision. Prior to the implementation of the service-learning program, governance arrangements in South Buru Regency were predominantly characterized by a government-led approach in which planning, operational decisions, infrastructure maintenance, and performance evaluation were largely concentrated within the Regional Drinking Water Supply Unit (UPTD SPAM) and local government agencies. Village governments and community members generally assumed supportive or reactive roles, while higher education institutions participated only through periodic community service activities with limited continuity. As a result, communication among stakeholders remained fragmented, institutional responsibilities overlapped, and local knowledge was rarely incorporated into operational decision-making. The findings indicate that the introduction of service-learning gradually transformed these fragmented relationships into a more collaborative governance arrangement characterized by shared responsibility, continuous interaction, and collective problem-solving.

One of the earliest changes observed during the participatory action research cycles was the emergence of more regular communication among stakeholders. The joint meetings facilitated through the service-learning program were not limited to technical discussions

regarding infrastructure but evolved into collaborative forums where operational challenges, financial issues, and community expectations were openly discussed. Government officials, village administrations, UPTD SPAM personnel, university lecturers, students, and representatives of community water user groups participated in these discussions as equal partners rather than within rigid bureaucratic hierarchies. According to a UPTD SPAM officer (coded I-05), previous coordination mechanisms were generally activated only after operational failures occurred, whereas the collaborative forums established during the research encouraged preventive discussions before problems escalated. This shift significantly improved institutional responsiveness because information circulated more rapidly among organizations responsible for water service delivery.

The strengthened communication also contributed to increasing mutual trust among stakeholders. Trust emerged gradually through repeated interactions rather than formal agreements alone. Community members reported that the willingness of government officials and university facilitators to listen to local experiences increased their confidence in participating more actively in governance processes. Likewise, government representatives acknowledged that direct engagement with community organizations enabled them to better understand localized operational challenges that were often absent from administrative reports. One community representative (I-17) explained that previous interactions with technical agencies were generally limited to reporting damaged infrastructure, whereas the collaborative meetings created opportunities to discuss alternative solutions collectively. Such reciprocal exchanges reduced institutional distance and fostered relationships based on mutual respect rather than administrative authority.

The findings further indicate that collaborative governance substantially improved joint decision-making. Instead of relying exclusively on technical assessments prepared by government agencies, operational priorities increasingly emerged through deliberative discussions involving multiple stakeholders. Decisions regarding maintenance schedules, customer registration, tariff collection procedures, and community awareness activities were negotiated collectively, allowing each institution to contribute according to its expertise and responsibilities. Village governments facilitated community mobilization, UPTD SPAM provided technical guidance, universities supported knowledge generation and capacity building, while community organizations contributed practical understanding of local conditions. This distribution of responsibilities created greater institutional flexibility and reduced dependence on centralized administrative decisions. As noted by a village head (I-10), collaborative planning generated stronger community commitment because residents perceived that they had genuinely contributed to determining priorities rather than merely receiving externally designed programs.

Another significant outcome concerned the emergence of systematic knowledge sharing across institutional boundaries. Before the implementation of the service-learning initiative, technical knowledge regarding water distribution systems was concentrated primarily within UPTD SPAM, while local experiential knowledge remained embedded within

communities without being systematically documented or incorporated into institutional planning. Through collaborative workshops, field observations, and reflection sessions, these different forms of knowledge became integrated into a shared learning process. Students documented operational experiences, lecturers translated field observations into practical management recommendations, government officials explained regulatory frameworks, and community members contributed contextual knowledge regarding seasonal water availability, user behavior, and local maintenance practices. This reciprocal exchange substantially expanded the collective knowledge base supporting drinking water management. Rather than representing one-way knowledge transfer from universities to communities, the findings illustrate a process of knowledge co-production in which every actor simultaneously contributed to and benefited from collective learning.

The collaborative process also strengthened social accountability within rural water governance. Regular reflection meetings encouraged greater transparency regarding financial management, maintenance activities, and institutional responsibilities. Community organizations increasingly monitored the implementation of agreed activities, while government agencies became more responsive to operational concerns raised by residents. Informants consistently reported that the existence of shared monitoring mechanisms reduced misunderstandings regarding institutional responsibilities and increased confidence in the management of user contributions. A community water committee member (I-14) emphasized that transparency in financial reporting encouraged more households to contribute regularly because they clearly understood how community funds were utilized for maintaining water infrastructure.

Social Ownership as the Missing Link Between Community Participation and Service Sustainability

One of the most significant findings emerging from this study is that community participation, by itself, does not necessarily lead to sustainable drinking water services. While previous studies have consistently emphasized participation as a prerequisite for successful community-based water management, the empirical evidence from South Buru Regency suggests that participation assumes different forms and generates different outcomes depending on how it is institutionalized within local governance processes. During the initial stages of the study, community participation was largely limited to attending occasional meetings, reporting infrastructure failures, or paying monthly water tariffs. Although these activities reflected a certain degree of public involvement, they remained transactional rather than transformative. Communities participated because they were expected to do so, not because they perceived themselves as co-owners of the drinking water system. Consequently, participation alone proved insufficient to sustain water services once technical or institutional challenges emerged.

The participatory action research process revealed that a qualitative shift occurred when service-learning facilitated repeated interaction, collaborative problem-solving, and collective reflection among stakeholders. Rather than simply increasing the frequency of

participation, these learning processes gradually nurtured what can be understood as social ownership, namely a shared sense of responsibility in which communities no longer regarded drinking water infrastructure as government property but as a collectively owned public asset whose sustainability depended upon their own continuous involvement. This transformation became visible through observable behavioral changes rather than formal institutional arrangements. Community members began to initiate routine inspections of distribution pipelines, voluntarily reported potential leakages before service disruptions became severe, organized collective maintenance activities, and assumed greater responsibility for protecting water sources from environmental degradation. Such initiatives were rarely observed before the implementation of the service-learning process.

Interviews with community members further illustrate how this transformation unfolded. One member of the village water management committee (coded I-13) explained that prior to the collaborative learning activities, residents generally waited for government technicians whenever pipeline failures occurred because infrastructure maintenance was perceived as exclusively belonging to public authorities. Following several participatory action cycles, however, residents increasingly organized voluntary repair activities for minor damages while coordinating with technical officers only when specialized expertise was required. Another participant (I-16) noted that discussions facilitated by lecturers and students gradually changed public perceptions regarding collective responsibility. According to the informant, "People now understand that if we wait for government assistance every time something happens, the entire village will experience water shortages. We have learned that maintaining the system is also our responsibility." These reflections indicate that social ownership emerged not through administrative instruction but through continuous collective learning and shared practical experience.

The strengthening of social ownership was equally evident in financial management practices. Before the intervention, several informants described community reluctance to pay water user contributions because many households perceived tariffs merely as financial obligations imposed by service providers. Following the implementation of collaborative governance activities, willingness to contribute financially increased because residents better understood the direct relationship between user contributions and the long-term operation of the water system. Transparent financial reporting, participatory budgeting discussions, and regular reflection meetings enhanced confidence that community resources were being managed responsibly. Consequently, tariff payments gradually shifted from compliance with administrative requirements toward voluntary investment in a collectively valued public service. This finding suggests that financial sustainability is closely associated with institutional trust and social ownership rather than with tariff regulations alone.

Another important manifestation of social ownership involved the emergence of voluntary collective action beyond routine operational responsibilities. During field observations, researchers documented community initiatives such as organizing cleaning activities around spring catchment areas, monitoring unauthorized water connections,

assisting vulnerable households during temporary service interruptions, and participating in village meetings concerning water management priorities. These activities were not formally mandated by government agencies nor compensated through financial incentives. Instead, they reflected a growing perception that safeguarding water services constituted a shared community obligation. Such voluntary engagement substantially strengthened the adaptive capacity of local institutions because operational problems could often be identified and addressed before escalating into more significant infrastructure failures.

These findings suggest that social ownership represents a distinct institutional mechanism that extends beyond conventional interpretations of community participation. Participation generally describes the involvement of individuals in specific activities or decision-making processes, whereas social ownership reflects a deeper psychological and collective commitment through which communities internalize responsibility for sustaining public services over time. In this regard, participation may initiate engagement, but social ownership determines whether that engagement persists when external support diminishes. This distinction provides an important conceptual refinement to the literature on community-based water management, which has frequently assumed that higher levels of participation will automatically generate more sustainable outcomes without adequately explaining the underlying social processes that sustain long-term collective action.

The findings resonate strongly with Community Ownership Theory, which argues that public services become more sustainable when communities perceive themselves as legitimate custodians rather than passive beneficiaries of shared resources. They also support the perspective of Social Capital for Collective Action, where trust, reciprocity, and shared norms facilitate cooperative behavior capable of addressing common resource challenges (Espinoza et al., 2022; Falk et al., 2022; Gurung et al., 2024). More recent work by Murei et al. (2022) similarly emphasizes that adaptive governance depends upon locally embedded capacities for collective action, particularly in complex socio-ecological systems where institutional resilience cannot rely solely on formal government intervention. However, the present findings extend these perspectives by demonstrating that social ownership does not emerge spontaneously from participation itself; instead, it develops through sustained processes of collaborative learning, reflection, and institutional interaction facilitated by service-learning.

From a theoretical perspective, this distinction represents a critical contribution of the proposed Community-Driven Water Service Management (CDWSM) framework. Rather than conceptualizing participation as the direct antecedent of service sustainability, the findings indicate that participation first generates collective learning, which strengthens institutional relationships and ultimately cultivates social ownership. It is this shared sense of ownership that motivates communities to protect infrastructure, contribute financial resources, monitor service quality, participate in collective decision-making, and voluntarily support maintenance activities. Social ownership therefore functions as the institutional bridge through which community participation is translated into sustainable water service

governance. By positioning social ownership as the mediating mechanism connecting collaborative participation with long-term service sustainability, this study advances a more comprehensive explanation of why some community-based drinking water systems remain resilient while others experience institutional decline despite similar levels of public participation. This insight constitutes one of the principal theoretical contributions of the study and provides the conceptual foundation for the integrated Community-Driven Water Service Management model developed in the subsequent section.

Validation of the Community-Driven Water Service Management (CDWSM) Model

Following the qualitative exploration and the implementation of participatory action research, the proposed Community-Driven Water Service Management (CDWSM) model was empirically validated using Partial Least Squares Structural Equation Modeling (PLS-SEM). This analytical approach was selected because the study sought to examine complex causal relationships among multiple latent constructs while simultaneously validating a newly developed conceptual framework. PLS-SEM is particularly appropriate for exploratory model development and theory extension, where the primary objective is prediction and explanation rather than confirmation of an established theory (Pineda et al., 2022; Sudiyani et al., 2022). The quantitative validation therefore served not only to assess the statistical robustness of the proposed model but also to determine whether the institutional mechanisms identified during the qualitative phase could be empirically supported.

The assessment began with the evaluation of the measurement model (outer model) to ensure the reliability and validity of each construct. The analysis indicated that all indicator loading factors exceeded the recommended threshold of 0.70, demonstrating that each observed variable adequately represented its corresponding latent construct. Indicator loadings ranged from 0.742 to 0.918, confirming satisfactory indicator reliability (Hair et al., 2022). Likewise, the Average Variance Extracted (AVE) values for Institutional Capacity (0.681), Community Learning (0.734), Collaborative Governance (0.718), Social Ownership (0.751), and Sustainable Water Service (0.706) all surpassed the minimum criterion of 0.50, indicating adequate convergent validity. These findings suggest that the indicators consistently captured the conceptual dimensions identified during the qualitative phase of the research.

Construct reliability was further confirmed through Composite Reliability (CR), with all values ranging between 0.889 and 0.941, substantially exceeding the recommended minimum value of 0.70. This demonstrates strong internal consistency among indicators within each construct. In addition, discriminant validity was evaluated using the Heterotrait-Monotrait Ratio (HTMT). All HTMT values remained below the conservative threshold of 0.85, indicating that Institutional Capacity, Community Learning, Collaborative Governance, Social Ownership, and Sustainable Water Service represented empirically distinct yet conceptually related constructs. The satisfactory performance of the measurement model provides confidence that the subsequent structural analysis accurately reflects the relationships among the proposed dimensions of the CDWSM framework.

The structural model (inner model) revealed statistically significant relationships across all hypothesized paths. Institutional Capacity exhibited a positive and significant influence on Community Learning (β = 0.641, $p < 0.001$), suggesting that stronger local institutions create favorable conditions for collective learning processes. This finding aligns closely with observations from the qualitative phase, where community organizations possessing clearer administrative structures and stronger leadership demonstrated greater capacity to facilitate learning activities during the participatory action research cycles. As explained by one university facilitator (coded I-20), communities with more organized institutional arrangements were more willing to experiment with new management practices because responsibilities had already been clearly distributed among members.

Among all structural relationships, Community Learning demonstrated the strongest direct influence on Collaborative Governance (β = 0.758, $p < 0.001$). This result confirms one of the central propositions emerging from the qualitative analysis, namely that collaborative governance develops primarily through continuous learning rather than formal institutional arrangements alone. The repeated cycles of planning, implementation, reflection, and evaluation enabled stakeholders to establish shared understanding, strengthen interpersonal trust, and develop common strategies for addressing operational challenges. Consequently, collaborative governance emerged as the outcome of sustained collective learning rather than administrative coordination alone. This finding extends recent discussions in collaborative governance by highlighting learning as a fundamental mechanism underlying institutional collaboration (Mendez-Ruiz et al., 2023; Silveira et al., 2024).

Collaborative Governance also exerted a significant positive influence on Social Ownership (β = 0.694, $p < 0.001$), indicating that collaborative institutional relationships encourage communities to internalize greater responsibility for public services. The statistical findings corroborate the qualitative evidence demonstrating that transparent communication, joint decision-making, and shared accountability gradually transformed community perceptions from passive beneficiaries to active custodians of drinking water infrastructure. During interviews, one community leader (I-15) explained that residents became increasingly committed to protecting the water system because they were directly involved in determining operational priorities rather than merely receiving information after decisions had already been made. Such experiences illustrate how collaborative governance facilitates the emergence of collective ownership through meaningful institutional participation.

The final structural relationship revealed that Social Ownership significantly enhanced Sustainable Water Service (β = 0.713, $p < 0.001$), representing one of the strongest effects within the model. This result substantiates the qualitative finding that long-term service sustainability depends not simply on technical infrastructure or institutional participation but on the collective willingness of communities to safeguard, maintain, and continuously improve the drinking water system. Communities demonstrating stronger social ownership also reported more consistent participation in infrastructure maintenance, routine

monitoring, tariff compliance, and voluntary support for operational activities. These empirical results therefore reinforce the argument that social ownership functions as the principal institutional mechanism linking collaborative governance with sustainable service outcomes.

The explanatory power of the model further supports the robustness of the proposed framework. The coefficient of determination (R^2) indicates that Institutional Capacity explains 41.1% of the variance in Community Learning, while Community Learning accounts for 57.5% of the variation in Collaborative Governance. Collaborative Governance explains 48.2% of the variance in Social Ownership, whereas the combined effects of the preceding constructs explain 64.8% of Sustainable Water Service. According to Fentie et al. (2024), these values indicate moderate to substantial explanatory capacity, demonstrating that the integrated CDWSM model possesses considerable predictive strength. Furthermore, effect size (f^2) analysis revealed that Community Learning exerted the largest substantive influence on Collaborative Governance, while Social Ownership produced the strongest contribution to Sustainable Water Service. Blindfolding procedures also generated positive predictive relevance (Q^2) values for all endogenous constructs, confirming that the model possesses satisfactory predictive capability beyond the observed sample.

Perhaps the most important finding emerging from the structural analysis concerns the mediating role of Social Ownership. Indirect effect analysis demonstrated that Institutional Capacity and Community Learning influenced Sustainable Water Service primarily through sequential pathways involving Collaborative Governance and Social Ownership. This result provides quantitative support for the conceptual proposition developed during the qualitative phase, namely that institutional strengthening alone does not automatically produce sustainable water services. Rather, sustainable outcomes emerge when enhanced institutional capacity stimulates collective learning, collective learning strengthens collaborative governance, collaborative governance cultivates social ownership, and social ownership ultimately motivates communities to sustain water services over time. This sequential mechanism distinguishes the CDWSM framework from conventional community-based water management models that generally assume direct relationships between participation and service sustainability.

CONCLUSION

This study demonstrates that the sustainability of rural drinking water services is determined less by the availability of physical infrastructure than by the institutional capacity that enables communities to actively participate in water governance. The findings show that administrative-centered management in South Buru Regency has constrained meaningful community engagement despite relatively adequate technical capacity. Through the integration of service-learning within a participatory action research process, community members, local governments, the Regional Drinking Water Supply Unit, and higher education institutions were able to develop collective learning processes that strengthened institutional

capacity, improved collaborative governance, and fostered a stronger sense of social ownership over drinking water services. The quantitative validation further confirms that the proposed relationships among Institutional Capacity, Community Learning, Collaborative Governance, Social Ownership, and Sustainable Water Service are statistically significant, with Community Learning emerging as the primary catalyst for strengthening collaborative governance and Social Ownership serving as the key mechanism through which collaborative processes are translated into long-term service sustainability. These findings suggest that expanding rural drinking water access requires governance transformation rather than infrastructure expansion alone. Accordingly, this study contributes to the advancement of community-based water management by introducing the Community-Driven Water Service Management (CDWSM) model, which integrates service-learning and collaborative governance into a coherent framework that explains how collective learning can transform institutional relationships and support sustainable drinking water services. Beyond its theoretical contribution, the model offers a practical reference for local governments, water service providers, and higher education institutions seeking to strengthen community-centered governance as part of broader efforts to achieve Sustainable Development Goal 6 through more adaptive, participatory, and sustainable rural water management.

ETHICAL STATEMENT AND DISCLOSURE

This study was conducted in accordance with established ethical principles, including informed consent, protection of informants' confidentiality, and respect for local cultural values. Special consideration was given to participants from vulnerable groups to ensure their safety, comfort, and equal rights to participate. No external funding was received, and the authors declare no conflict of interest. All data and information presented were collected through valid research methods and have been verified to ensure their accuracy and reliability. The use of artificial intelligence (AI) was limited to technical assistance for writing and language editing, without influencing the scientific substance of the work. The authors express their gratitude to the informants for their valuable insights, and to the anonymous reviewers for their constructive feedback on an earlier version of this manuscript. The authors take full responsibility for the content and conclusions of this article.

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