

From formal regulation to local practice: Water governance and community vulnerability among forest-fringe communities in Sumedang, Indonesia

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Abstract

Water governance is particularly important in forest-fringe communities where households depend on spring water while access and management are mediated by multiple formal and community-based institutions. This study examines how formal regulatory authority over water resources is translated into local governance arrangements and shapes community access and vulnerability. A qualitative case study was conducted in Kadakajaya and Genteng Villages, Sumedang Regency, West Java, Indonesia, focusing on spring water sources located within or adjacent to forest areas managed by Perhutani, a state-owned forestry enterprise. The study integrates qualitative content analysis of national legal instruments within the 2014–2021 regulatory corpus with field research conducted from March to October 2024. Primary data were collected through field observations, semi-structured interviews with 15 purposively selected informants from the community and local institutions, and two focus group discussions involving community water-user groups, village officials, and local stakeholders. The focus group discussions also included participatory water-source mapping. The findings show that Indonesia's regulatory framework establishes state responsibility for water-resource regulation and management while recognizing people's rights to water for basic daily needs and providing a basis for community participation. Locally, however, formal authority is mediated through fragmented institutional arrangements involving Perhutani, village governments, the regional public water utility (PDAM), and community water-user groups. Community arrangements known as *paten* play an important role in everyday water distribution and infrastructure maintenance but have more limited influence over broader allocation and inter-institutional decisions. Vulnerability is shaped not only by dependence on particular springs and distribution systems but also by institutional access, coordination, and the capacity to influence decisions. From a structuration perspective, community agency sustains everyday water-governance practices within an uneven distribution of authoritative and allocative resources. The study identifies an institutional mediation gap between formal regulatory authority and local water-governance practices as a key governance challenge.

Introduction

Forest-fringe communities often maintain close and interdependent relationships with surrounding forest ecosystems, particularly where springs provide water for domestic consumption and livelihood activities. In such settings, water availability is shaped not only by ecological conditions but also by the institutions that regulate access, allocation, and use. Population growth, agricultural expansion, environmental degradation,



and changing environmental conditions can increase pressure on water resources, particularly in communities that have limited alternative sources of supply (du Plessis, 2023; Kirby & Mainuddin, 2022). Although Indonesia has substantial water resources, access to safe and reliable water remains uneven, and inadequate infrastructure and institutional capacity continue to constrain water-service provision in some communities (Hargono et al., 2022; Simaniburuk et al., 2025). Research on Indonesian water governance has likewise identified institutional coordination, competing interests, and the relationship between national policy and local implementation as persistent governance challenges. This situation indicates that water-related challenges are not merely environmental or technical problems but are also shaped by governance arrangements, institutional capacity, and social equity.

The governance dimension is particularly important for rural and forest-fringe communities because access to water depends on more than physical availability. Where water sources are located within forest areas, communities may depend on resources that are simultaneously subject to forestry jurisdiction, local government administration, and water-service provision. Previous research in Indonesia has shown that shared water resources can generate complex governance arrangements involving multiple governmental levels and competing institutional interests. Studies of decentralized water governance have emphasized the challenges of coordination and inter-local rivalry, while research on community-based water management has demonstrated that locally developed institutions can play important roles in organizing water distribution but may face limitations in institutional capacity and participation (Samsu et al., 2025; Simaniburuk et al., 2025). These findings suggest that the effectiveness of water governance cannot be assessed solely from the existence of formal regulations; attention is also required to how formal authority is translated into institutional practices and local arrangements.

Existing water-governance research can broadly be distinguished into several overlapping strands. The first examines integrated water resources management and multi-level governance, emphasizing coordination among institutions, stakeholder participation, and the integration of social, economic, and ecological objectives (Pambudi & Kusumanto, 2023; Phelia & Cambodia, 2025). Research in Indonesia has similarly highlighted the importance of coordination and collaborative arrangements in managing water resources across administrative boundaries (Basuki et al., 2022; Simaniburuk et al., 2025). The second strand focuses on legal and regulatory dimensions of water governance, examining how states establish authority over water allocation, conservation, licensing, and service provision (Rizaldy, 2023). Such studies are important for understanding the normative distribution of authority, but they generally provide less attention to how regulatory authority is experienced and negotiated by communities at the point where water is actually accessed and used. The third strand examines community-based water governance and local institutions. For example, research on community-based water management in rural Indonesia demonstrates that locally embedded institutions can organize water distribution, while also showing that institutional capacity and community participation affect the effectiveness of such arrangements (Samsu et al., 2025).

A related body of literature addresses vulnerability and unequal access to environmental resources. Vulnerability is commonly understood as emerging from the interaction of exposure, sensitivity, and adaptive capacity (Brown & Shucksmith, 2017; Cutter et al., 2003; Ford et al., 2018). In the context of this study, however, vulnerability is not treated solely as exposure to environmental change. It also concerns the institutional conditions through which communities obtain and negotiate access to water. Exposure therefore includes dependence on particular spring sources and changes in water availability or competing demands; sensitivity concerns the degree to which domestic and livelihood activities depend on those sources; and adaptive capacity concerns the ability of communities and local institutions to negotiate, organize, modify practices, or obtain alternative access. This perspective connects vulnerability with questions of authority, institutional capacity, and agency rather than treating vulnerability as an exclusively ecological condition.

This study uses authority in a specific institutional sense. Authority refers to the recognized capacity of an actor or institution to make, implement, authorize, regulate, or influence decisions concerning water resources. It is therefore analytically distinct from ownership, jurisdiction, administrative responsibility, physical control, access, and decision-making participation. An institution may possess formal regulatory authority without directly controlling everyday water distribution, while a community may exercise practical control over distribution without possessing formally recognized authority over the source itself. This distinction is important in forest-fringe settings because formal authority over water resources may be distributed across different institutions, while actual access and everyday management may depend on local arrangements. The analytical question is therefore not simply who owns or controls water, but how formal authority is translated into practical control, access, and decision-making at the local level.

To explain this relationship between formal arrangements and everyday practices, this study draws on structuration theory (Giddens, 2010; Whittington, 2010). From this perspective, structures consist of rules, institutional arrangements, and distributions of resources that both constrain and enable social action. In this study, formal regulations, institutional mandates, forestry jurisdiction, and procedures governing water use constitute important elements of structure. Agency refers to the capacity of communities, local institutions, village governments, and other actors to act within, negotiate, or potentially modify these arrangements. Recursive practices are observed where established patterns of water allocation, maintenance, participation, and decision-making are repeatedly reproduced through everyday interaction. This theoretical perspective therefore makes it possible to examine not only how formal structures constrain community action but also how local practices reproduce, negotiate, or potentially transform those structures. It adds an explanatory dimension beyond a general power-relations perspective by connecting institutional rules and resource distributions with the repeated practices through which governance arrangements are maintained or challenged.

The Indonesian context provides an important setting for examining these relationships. The enactment of Law No. 17 of 2019 on Water Resources marked a significant development in the country's water-resource regulatory framework following the replacement of Law No. 7 of 2004. The current framework establishes state responsibility for water-resource management while also articulating principles concerning public needs, conservation, utilization, and institutional coordination. Legal scholarship has examined the relationship between water-resource regulation, public rights, and principles of justice in Indonesia, while more recent governance research continues to identify challenges concerning regulatory effectiveness, institutional coordination, and implementation at the local level (Pambudi & Kusumanto, 2023; Rizaldy, 2023). The existence of formal regulatory provisions, therefore, does not by itself establish how authority is exercised in particular local contexts.

This distinction is particularly relevant where forest institutions and water-service providers interact with communities. Empirical research in Sumedang Regency has documented a situation in which springs located in Perhutani (a state-owned forestry enterprise) forest areas serve village communities while also being used by the regional water utility to supply urban populations. The study found that shared use of these sources was associated with changes in rural livelihoods, infrastructure, and local water-user arrangements. Research on water contestation in state production forests elsewhere in Indonesia has likewise shown that spring-water governance can involve multiple government institutions and community-based actors with different interests and levels of power. These studies demonstrate the empirical relevance of examining water governance at the intersection of forestry jurisdiction, local community institutions, and formal water-service provision.

Nevertheless, empirical evidence indicates that strengthened regulations have not necessarily translated into improved implementation at the local level. Many communities continue to experience unequal access to clean water, institutional conflicts over water management, and dependence on locally important water sources that are governed through overlapping institutional arrangements. Studies of Indonesian water governance have identified institutional coordination problems, policy-practice tensions, and challenges in community participation, while research on shared water resources and community-based management demonstrates the difficulty of translating formal governance principles into effective local arrangements (Basuki et al., 2022; Samsu et al., 2025; Simanihuruk et al., 2025). In forest settings specifically, the Sumedang case documented the coexistence of community dependence on water sources located in Perhutani-managed forest areas and their use for urban water provision, illustrating how different institutional demands can intersect around the same resource. Thus, the issue is not simply whether regulations exist, but how formal authority is mediated by the institutions that control or administer particular water sources and how communities respond to those arrangements.

This leads to a more specific research gap. Existing studies provide important insights into water-resource regulation, multi-level governance, community-based management, and vulnerability, but these strands are not always analytically connected. In particular, less attention has been given to the mechanisms through which formal regulatory authority is translated into local water-governance practices and subsequently shapes community authority, access, and vulnerability. The present study addresses this gap by examining four interconnected mechanisms: (1) how formal regulations define and distribute authority over water resources; (2) how that authority is mediated by institutions operating at the forest, regional, village, and community levels; (3) how locally developed institutions such as *paten* exercise agency within these formal constraints; and (4) how these institutional arrangements shape community access and vulnerability. Rather than treating regulation and local practice as separate domains, the study examines the processes connecting them.

The study focuses on Sumedang Regency, West Java, as a purposively selected qualitative case in which these institutional relationships can be examined in a concrete setting. The case is characterized by community dependence on spring water, the location of relevant water sources within forest areas, the involvement of Perhutani and the regional water utility, and the existence of locally organized water-user arrangements. The purpose of selecting Sumedang is not to statistically represent water governance conditions across Indonesia, but to provide an information-rich case through which the interaction between formal authority and local governance can be examined analytically. The findings may therefore contribute to the theoretical and analytical understanding of similar governance configurations without implying national representativeness.

Against this background, this study addresses three interrelated research questions. First, how is authority over water resources constructed and distributed within Indonesia's regulatory framework? Second, how is formal authority translated, negotiated, and exercised among state institutions, including forest-management and water-service institutions, village governments, and community-based water-governance institutions such as *paten*? Third, how do these institutional arrangements shape community access to spring water, the capacity of local actors to participate in decision-making, and the vulnerability of forest-fringe communities? These questions allow the study to examine the mechanisms linking formal regulation to local practice, particularly how regulatory authority is mediated through overlapping institutional jurisdictions, local governance arrangements, and community agency.

The study contributes to the literature by identifying the mechanism through which formal water authority is mediated at the local level rather than treating regulation and community governance as separate domains. Empirically, it shows how forestry jurisdiction, regional water-service provision, village-level institutional arrangements, and locally embedded water-user groups interact around shared spring resources. Conceptually, it uses structuration theory to explain how formal rules and resource distributions constrain community agency while everyday practices simultaneously reproduce existing governance arrangements. In this way, the study extends analysis of water governance from the question of what regulations formally prescribe to the question of how authority is translated, negotiated, and reproduced in local practice and with what implications for community vulnerability.

Method

Research design

This study employed a qualitative research approach using an instrumental case-study design integrated with qualitative content analysis of regulatory documents. The case was bounded within two forest-fringe villages, Kadakajaya and Genteng, in Sumedang Regency, West Java, Indonesia. These villages were selected because their communities depend on spring and other local water sources for domestic and livelihood needs, while access to several water sources is situated within or associated with forest areas managed by Perhutani and involves multiple institutional actors. The case was therefore considered information-rich for examining how formal regulatory authority over water resources is translated, negotiated, and exercised through local governance practices.

The primary unit of analysis was the institutional arrangement governing access to and management of local water resources. This included formal regulatory provisions, institutional responsibilities, decision-making processes, community-based water-management arrangements, and everyday practices concerning water access and distribution. Individual participants were not treated as independent units of analysis; rather, interviews and FGDs were used as sources of evidence for understanding institutional relationships and community experiences within the case.

The research integrated regulatory content analysis with field-based thematic analysis. The regulatory analysis examined how laws and regulations construct water-resource authority, institutional responsibilities, conservation and utilization arrangements, and community interests. The field analysis examined how these formal arrangements were experienced and practiced by communities and local institutions. The two forms of analysis were subsequently integrated through analytical triangulation by comparing regulatory provisions with the roles of institutional actors, observed practices, interview accounts, FGD discussions, and community consequences. This procedure enabled the study to identify both correspondence and gaps between formal regulatory arrangements and local water-governance practices.

Study area

The study was conducted in Sumedang Regency, West Java Province, Indonesia. Field data were collected from March to October 2024 in two villages, namely Kadakajaya and Genteng. The two villages were purposively selected as an information-rich case because their communities rely on local water sources, including springs located within or associated with forest areas managed by Perhutani, while water access and distribution involve village governments, community water-management groups, local community leaders, and the regional public water utility (PDAM). These conditions provide an appropriate setting for examining the interaction between formal institutional authority, forest-area jurisdiction, local water-management practices, and community access to water resources.

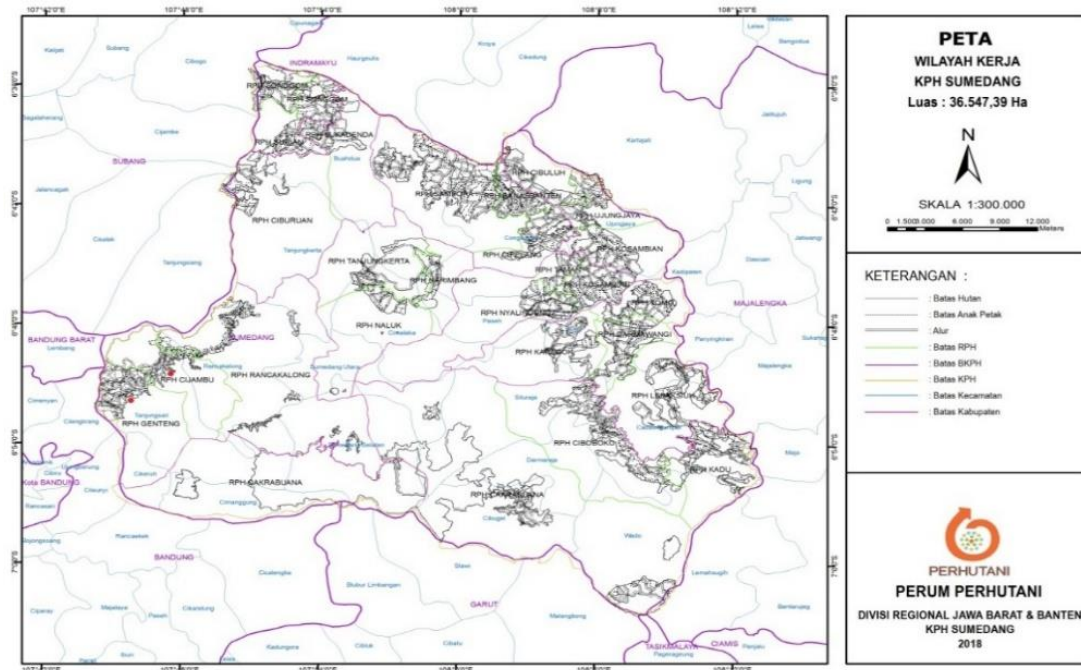


Figure 1. Study area in Sumedang Regency, West Java Province, Indonesia

Source: (Perum Perhutani KPH Sumedang, official forest-management spatial data; Sumedang Regency Geospatial Information System (SIGEOL); and field data collected by the authors (March–October 2024). Map prepared by the authors, 2024. Coordinate reference system (CRS). Used with permission from the respective data providers).

The study-area map identifies the administrative locations of Kadakajaya and Genteng, the relevant forest areas, and the mapped water-resource locations examined during the fieldwork.

In Kadakajaya, the field mapping identified nine water sources or facilities used by surrounding communities. These included Parigi, Cisereh, Cismungka, Bale Kambang, Ciwilah, Cigarut, Cibiru, a water-supply system developed under Pamsimas (Indonesia’s Community-Based Drinking Water and Sanitation Program), and a borewell. Several of these sources are located within or near Perhutani-managed forest areas, including the Parigi, Cisereh, and Cismungka sources. The identified sources serve different parts of the village, including Dusun 1 to Dusun 9, where *dusun* refers to a sub-village territorial unit within Indonesia’s village governance system. The Pamsimas system and the borewell also provide additional water resources, particularly for social needs, clean water provision during the dry season, and mosque activities.

In Genteng, eleven water sources were identified, namely Ciharung, Bubuai, Bubuai, Cipancur, a private water source, Gugunungan, Cipacet, Amsari, Blok Lame, Blok Cangkore, and Blok Sirasitu. Several of these sources are located within Perhutani-managed forest areas, while others are located in village or privately managed areas. The sources serve different *dusun* and community areas, and some water is also associated with PDAM services. This spatial and institutional diversity enabled the study to examine how access to water is shaped by different forms of institutional responsibility and local management practices.

The two villages were selected as an instrumental case rather than as a statistically representative sample of water-governance conditions throughout Indonesia. Their analytical relevance lies in the coexistence of community dependence on local water sources, state forest management, village-level administration, community-based water management, and formal water-service institutions. The case therefore provides analytical insight into the mechanisms through which formal regulatory authority is translated and negotiated

at the local level. The findings are intended to provide analytical and theoretical insight that may be relevant to other forest-fringe settings with comparable institutional and socio-environmental conditions, rather than to statistically generalize the findings to Indonesia as a whole.

For the regulatory analysis, the study examined legal and policy instruments enacted between 2014 and 2021. This period was selected to capture an important phase in the development of Indonesia's water-resource governance framework, including regulations concerning water conservation, water utilization, institutional responsibilities, and the development of the regulatory framework surrounding Law No. 17 of 2019 on Water Resources. The regulatory period constituted the documentary boundary of the content analysis, while fieldwork conducted in 2024 provided empirical evidence of how relevant institutional arrangements operated in the selected villages.

Data collection

The study used primary and secondary data. Primary data were collected through field observations, semi-structured in-depth interviews, and two focus group discussions (FGDs). Field observations and water-source mapping were conducted to document the physical location and characteristics of water sources, water-distribution infrastructure, patterns of community water use, and local arrangements for water management. The mapping process was also used during the FGDs to facilitate the collective identification and discussion of water sources, their users, and their distribution within the study area.

Semi-structured interviews were conducted with 15 purposively selected informants comprising community members and local stakeholders involved in water governance. The informants included community leaders, water-resource managers or representatives of community water-user groups, village government officials, heads of *Rukun Tetangga* (RT; neighborhood-level community units comprising several households) and *Rukun Warga* (RW; community units comprising several RTs), heads of *dusun*, and other local actors with knowledge of water-resource management. Women community members were also included to obtain perspectives on household water use and everyday experiences of water access. The inclusion of both community and institutional actors enabled the study to compare formal and community perspectives on water governance.

Purposive sampling was used because the research required participants with relevant knowledge and experience concerning local water resources and governance. Participants were selected based on their involvement in water-resource management or decision-making, direct experience with local water use, or knowledge of institutional arrangements governing water access and distribution. The selection criteria were adapted to the participants' roles. Community members were selected based on their experience in using and managing local water resources, while village officials, RT/RW representatives, heads of *dusun*, and other local stakeholders were selected based on their institutional or practical involvement in water governance. Community leaders and water managers were included because of their knowledge of local water-distribution arrangements and community practices.

Two FGDs were conducted as a complement to the individual interviews. Each FGD was conducted for approximately two hours, from around 14:00 to 16:00, and included discussion and participatory mapping of local water-resource locations. The FGDs involved community and local stakeholder representatives with knowledge of the relevant water sources and their use. The discussions addressed water-resource locations, water distribution, institutional authority, community participation, local water-management arrangements, conflicts or negotiations, and community experiences of water-related challenges. The participatory mapping component enabled participants to collectively identify the spatial distribution of water sources and the communities or institutions associated with their use. The FGD findings were subsequently compared with individual interviews, observations, and regulatory documents.

Secondary data consisted of legal and policy documents obtained from official Indonesian government legal databases, including the Government Regulation Database, the National Legal Documentation and Information Network, and the Audit Board of Indonesia Regulation Database. The regulatory corpus consisted of fourteen legal and policy instruments, including laws, government regulations, presidential regulations, and ministerial regulations concerning water-resource conservation, utilization, institutional authority, and governance. Documents were selected based on their relevance to the research questions, particularly provisions concerning the allocation of authority, institutional responsibilities, water utilization, conservation, licensing, coordination, and community interests.

The interview guide was developed based on the research questions, the conceptual framework, and relevant literature on water governance, institutional authority, community agency, and vulnerability. Before field implementation, the interview guide was reviewed by experts in environmental governance and qualitative research to assess the clarity, relevance, and consistency of the questions. The guide addressed institutional authority, access to and allocation of water, institutional responsibilities, community participation, water-related conflicts, conservation, relationships among Perhutani, PDAM, village governments, and community water-user groups, local water-management arrangements, and perceptions of vulnerability and community responses to water-related challenges.

Data analysis

Data analysis employed a hybrid deductive and inductive approach. Deductive analytical categories were derived from the research questions and conceptual framework, particularly institutional authority, water access, decision-making, community agency, institutional arrangements, and vulnerability. At the same time, inductive coding was used to identify practices, experiences, and institutional relationships emerging from the field data. This approach enabled the analysis to remain theoretically informed while allowing locally specific issues to emerge from participants' accounts and observations.

The first analytical stage involved qualitative content analysis of the fourteen regulatory documents. The analysis identified provisions concerning the construction and allocation of authority, institutional mandates, water conservation, water utilization, licensing, coordination, and community interests. Particular attention was given to how formal authority was distributed among relevant institutions and how community interests and participation were positioned within the regulatory framework. The regulatory analysis focused on the substantive content and institutional orientation of the documents and was distinguished from a comprehensive doctrinal legal analysis. Interpretations concerning institutional authority were therefore grounded in the relevant regulatory provisions and their institutional context.

The second analytical stage involved thematic analysis of interviews, FGDs, and field observations. The analysis proceeded through data familiarization, initial coding, categorization, theme development, and interpretation. Interview materials, FGD discussions, and field notes were examined repeatedly to identify evidence relevant to the research questions. Initial codes included institutional authority, forestry jurisdiction, water access, water allocation, community participation, local water-management practices, conflict, negotiation, institutional legitimacy, agency, and vulnerability. Related codes were subsequently grouped into broader themes explaining how formal institutional arrangements were translated into local water-governance practices.

Vulnerability was analyzed in relation to the institutional and governance conditions identified in the field data. Exposure was examined through community dependence on local water sources and exposure to institutional decisions concerning access and allocation. Sensitivity was examined through the dependence of domestic and livelihood activities on those water resources. Adaptive and agency capacity was examined through community organization, collective water management, negotiation with institutional actors, maintenance of water infrastructure, and the ability of community actors to respond to water-related constraints. These dimensions were used as analytical sensitizing concepts rather than as a quantitative vulnerability index.

The regulatory and field analyses were subsequently integrated through an analytical matrix linking four elements: regulatory provisions, institutional actors and responsibilities, observed or reported governance practices, and consequences for community access, agency, and vulnerability. The matrix enabled systematic comparison between formal rules and empirical practices. Where documentary and field evidence converged, the evidence was treated as mutually corroborating. Where differences emerged between regulations, institutional accounts, community accounts, and observations, these discrepancies were retained as analytical evidence rather than removed. Such differences were examined to understand how formal authority was negotiated, constrained, accommodated, or reproduced in local practice.

The integration process also examined local institutions and practices such as *paten* in relation to the formal regulatory framework. The analysis considered whether such local arrangements were formally recognized, accommodated, constrained, or left outside formal institutional structures. This procedure allowed the study to move beyond a simple comparison between policy and implementation and instead explain the institutional mechanisms through which formal authority interacted with local agency and produced particular patterns of water access and vulnerability.

Trustworthiness

The trustworthiness of the findings was strengthened through methodological triangulation involving regulatory documents, interviews, FGDs, and field observations. Triangulation was conducted by systematically comparing evidence from different sources rather than assuming that the use of multiple methods automatically established validity. Convergent evidence was used to strengthen interpretations, while divergent or contradictory accounts were retained and examined as part of the analysis. This was particularly important because the study involved actors with different institutional positions and forms of authority.

The participatory mapping conducted during the FGDs also provided an additional means of comparing participants' descriptions of water sources, distribution, and use with field observations. Information obtained from community members was compared with accounts from local institutional actors and with the regulatory framework. The researchers maintained attention to differences between formal institutional responsibilities and actual local practices throughout the analytical process. This approach strengthened the credibility of the interpretation while recognizing that water governance may be understood differently by actors occupying different institutional and social positions.

Research ethics

Ethical considerations were integrated throughout the fieldwork and data-collection process. The researchers recognized that qualitative research involves not only the production of empirical knowledge but also ethical responsibilities concerning relationships with participants and the potential consequences of research activities. In accordance with the principles of ethical qualitative research, the study was guided by the principles of honesty, respect, responsibility, and non-maleficence.

Before data collection, participants were informed honestly about the research topic, objectives, and intended contribution of the study. The researchers explained that the study examined water governance, institutional arrangements, and community experiences concerning access to local water resources. Participation was voluntary, and participants were given the opportunity to decide whether they wished to provide information. The researchers sought to avoid exploiting participants and were attentive to the potential risks associated with discussing institutional relationships, water access, and local conflicts.

Confidentiality was also considered throughout the research process. Participants were given the right not to have their identities disclosed in the publication of the findings. Information was therefore treated carefully, and identifying details were not unnecessarily included when reporting participants' experiences. Participants could also request clarification concerning how information from the research would be represented. These procedures were intended to reduce the possibility that participation would cause social, institutional, or personal harm.

Results and discussion

Formal distribution of water resource authority in the regulatory framework

The regulatory analysis indicates that water-resource governance in Indonesia is constructed through a multilayered distribution of authority rather than through exclusive ownership by a single actor (Pambudi & Kusumanto, 2023; Rizaldy, 2023; Wulandari & Ilyas, 2019). Article 33(3) of the 1945 Constitution provides the constitutional foundation for state control over water and other natural resources for the greatest prosperity of the people. This principle is further elaborated in Law No. 17 of 2019 on Water Resources, which establishes the state's responsibility to guarantee people's basic rights to water and assigns regulatory and management responsibilities to the central and regional governments (Rizaldy, 2023; Wulandari & Ilyas, 2019). Importantly, Law No. 17 of 2019 does not treat water as an object that can be privately owned by individuals, community groups, or business entities. Instead, Article 6 guarantees people's rights to water for minimum daily needs, while Article 8 establishes priorities for fulfilling those rights. The regulatory framework therefore needs to be interpreted as establishing public authority over water resources and institutional responsibilities for their management, rather than as establishing exclusive state ownership of water resources.

This distinction is important for interpreting community access in the study area. In this article, authority refers to the legally or institutionally recognized capacity to regulate, manage, allocate, supervise, and coordinate water-resource use. Authority is therefore distinguished from ownership, jurisdiction, practical control, administrative responsibility, access, and decision-making power. A community may have socially recognized access to a spring without holding formal regulatory authority over the source, while an institution may have

jurisdiction over a particular territorial space without necessarily holding exclusive authority over all uses of the water located within that space. This distinction becomes particularly important in forest-fringe settings, where water sources, forest land, drinking-water services, and community-based arrangements are governed through different institutional mandates.

The regulatory framework also demonstrates that formal authority is distributed across several levels and institutional functions. Law No. 17 of 2019 assigns responsibilities for water-resource management to the central and regional governments and also recognizes a role for village governments in assisting water-resource management and encouraging community initiatives and participation (Pambudi & Kusumanto, 2023; Wulandari & Ilyas, 2019). Government Regulation No. 122 of 2015 regulates drinking-water supply systems, including community-based provision, while the technical framework for drinking-water services is further elaborated through ministerial regulations. Government Regulation No. 121 of 2015, which was applicable during much of the regulatory period examined in this study, established conditions for water-resource utilization and required basic daily and agricultural needs to be fulfilled before water-resource exploitation could be undertaken. It also provided for public participation in supervision.

The regulatory mapping therefore suggests that the formal system contains opportunities for public protection and community participation, but these provisions do not automatically establish community authority over water sources (Pambudi & Kusumanto, 2023; Rosso, 2025). This distinction is analytically important. The relevant question is not simply whether communities are recognized by regulation, but where and through which institutional mechanisms their participation, access, and decision-making capacity are translated into local governance arrangements. The regulations provide the formal framework, but the empirical significance of that framework depends on how responsibilities are mediated among government institutions, forestry authorities, drinking-water providers, village governments, and local water-user groups.

The regulatory framework examined for the 2014–2021 period is summarized in Table 1. Rather than treating the final column as a direct consequence stated by the regulations, the implications for communities should be understood as the authors’ analytical interpretation based on the relevant provisions and subsequently compared with field evidence.

Table 1. Regulatory mapping of water-resource governance in Indonesia, 2014–2021

No.	Regulation	Regulatory scope	Authority / governance function	Community participation or rights	Analytical implication
1	Law No. 37 of 2014 on Soil and Water Conservation	Soil and water conservation and protection of water-related ecological functions	Establishes the legal framework for conservation and governmental responsibilities for soil and water conservation	Provides a conservation framework involving stakeholders in conservation activities; it does not establish specific community decision-making authority over individual spring sources	Provides an ecological and conservation basis for water-resource governance, but does not by itself establish a mechanism through which local water-user groups exercise formal authority over individual springs.
2	Government Regulation No. 121 of 2015 on Exploitation of Water Resources	Regulation of water-resource utilization and exploitation	Establishes requirements and institutional mechanisms for water-resource utilization, including authorization and supervision	Prioritizes basic daily needs and people’s agricultural needs before exploitation; participation is recognized in supervision	Establishes formal conditions for water-resource utilization while keeping broader authorization, allocation, and supervision within formal institutional arrangements.
3	Government Regulation No.	Organization and provision of	Regulates the roles of government,	Provides a formal basis for	Creates a regulatory basis for coexistence

	122 of 2015 on Drinking Water Supply System	drinking-water services	enterprises, and community-based arrangements in drinking-water supply	community involvement in drinking-water provision	between formal drinking-water services and community-based arrangements, with implementation depending on local institutional configuration.
4	Presidential Regulation No. 10 of 2017 on the National Water Resources Council	Cross-sectoral coordination of water-resource governance	Establishes a national coordination mechanism for water-resource policy and management	Community participation is mediated through the broader water-resource governance framework rather than established as direct authority over individual springs	Strengthens formal inter-institutional coordination but does not itself establish direct integration of local water-user institutions into village-level decision-making.
5	Presidential Regulation No. 46 of 2019 on Support for Drinking-Water Service Provision	Support and strengthening of drinking-water service provision	Strengthens coordination and implementation of formal drinking-water services	Community water needs are addressed within the broader objective of improving drinking-water provision	Reinforces the formal service dimension of water governance and may increase interaction between formal providers and existing community-based water arrangements.
6	Law No. 17 of 2019 on Water Resources	State control, people's rights to water, water-resource management, utilization, and participation	Assigns water-resource management responsibilities to central and regional governments and establishes the state's regulatory role	Article 6 guarantees people's right to water for minimum daily needs; Article 8 establishes priorities for fulfilling basic needs; the law also provides a framework for community participation	Establishes a public-interest framework for water governance and recognizes people's basic water rights, but does not automatically confer formal regulatory authority over individual springs on community groups.
7	Ministerial regulations on water resources and drinking-water systems	Technical and administrative implementation of water-resource and drinking-water governance	Translates general regulatory principles into technical procedures, institutional responsibilities, and service arrangements	Community participation and community-based service arrangements are addressed through relevant technical provisions	Provides the operational mechanisms through which broader legal principles are translated into local implementation; the specific implications depend on the individual ministerial instruments examined.

Source: (Authors' compilation based on the regulations analyzed).

The empirical significance of this framework becomes clearer when it is examined in relation to the spatial location of the water sources. In the study area, several spring sources are located in or near forest areas

associated with Perhutani management. Consequently, formal water-resource governance intersects with the governance of forest space. This does not mean that Perhutani automatically possesses exclusive legal authority over the water itself. Rather, its institutional position in relation to the forest area becomes an important factor mediating community access to sources located within or adjacent to that area. The resulting governance arrangement is therefore characterized by overlapping institutional domains rather than a simple division between a state “manager” and a community “user.”

The field inventory illustrates this institutional and spatial complexity. In Kadakajaya Village, the sources identified by the research included Parigi, Cisereh, Cisumengka, Bale Kambang, Ciwilah, Cigarut, Cibiru, Pamsimas, and a drilled well. Several sources, including Parigi, Cisereh, and Cisumengka, are located in or associated with forest areas managed by Perhutani, while others are located closer to village settlement areas or community agricultural land. These sources serve different *dusun* and have different patterns of use. In Genteng Village, the study identified sources including Ciharung, Bubuai, Cipancur, a private source, Gugunungan, Cipacet, Amsari, Blok Lame, and Blok Cangkore. Several of these sources are located in Perhutani-managed forest areas, whereas others are located within village or privately managed areas. This spatial variation demonstrates that community water access cannot be explained solely by the national water-resource regulatory framework; it is also shaped by the location and institutional status of individual sources.

Institutional configuration at the local level

The field findings show that the formal regulatory framework is translated into local governance through several institutional actors whose responsibilities do not always coincide (Pambudi & Kusumanto, 2023; Phelia & Cambodia, 2025). These actors include village governments, Perhutani, PDAM, community water-user groups, and individual or household users. Their roles differ according to the location of the source, the type of water infrastructure, and the intended use of the water. Consequently, local water governance operates through a combination of formal authority and socially established practices (Pambudi & Kusumanto, 2023; Phelia & Cambodia, 2025).

The position of Perhutani is particularly important because several of the water sources identified in the study are located within or adjacent to Perhutani-managed forest areas. The field evidence therefore supports the conclusion that forestry jurisdiction constitutes an important mediating structure for community access. However, the evidence does not justify treating Perhutani as the exclusive legal authority over the water itself. Its relevance lies primarily in the relationship between forest-space management and access to water sources located in that space. This distinction avoids conflating territorial jurisdiction over forest land with ownership or exclusive regulatory authority over water.

The village government occupies a different institutional position. Villages are directly connected to community water users and local infrastructure, but the field findings indicate that water management remains substantially organized through individual community groups and source-specific arrangements rather than through a single integrated village-level institution. This becomes visible in the distribution of water sources across different *dusun* and user groups. Some sources serve particular *dusun*, while other sources have wider distribution networks. Pamsimas and drilled wells also provide additional forms of water infrastructure, particularly for domestic and social needs during periods when existing sources are less reliable.

The presence of multiple water sources does not eliminate vulnerability. Instead, it produces differentiated patterns of access. Households located near particular sources may have easier physical access, while households dependent on particular distribution networks may be more affected by changes in source availability or infrastructure. The evidence therefore suggests that vulnerability is not uniform across the community. It is shaped by dependence on particular sources, the reliability of distribution infrastructure, the availability of alternative sources, and the institutional arrangements governing access.

The two FGDs also provided a collective setting for discussing these arrangements and were accompanied by a mapping process of water-source locations. The approximately two-hour FGDs, conducted from around 2:00 p.m. to 4:00 p.m., helped identify how participants associated particular springs with specific *dusun* and user groups. This process was important because the governance of water in the study area is strongly connected to spatial relationships: who lives near a source, which *dusun* receives water from it, which institution manages the infrastructure, and whether the source is located within or outside the forest area.

Community access and the relationship between local users and PDAM

One of the most important findings concerns the coexistence of community use and formal drinking-water service provision (Carvalho & Spataru, 2023; Pambudi & Kusumanto, 2023). The study-area inventory

indicates that some water sources used by local communities are also connected to formal water-service arrangements (Yunita et al., 2022, 2024). In Genteng Village, for example, the inventory identified a privately managed source from which part of the water supply had not entered the PDAM system, indicating that formal and community-based supply arrangements coexist rather than operating as completely separate systems.

The field evidence therefore points to a more nuanced relationship between community users and PDAM than a simple opposition between the two. The issue is not that PDAM necessarily eliminates community access at every source, but that formal service provision can introduce a different institutional logic into sources that have historically been managed through local arrangements. Community access is organized through proximity, social membership, collective maintenance, and established distribution practices, whereas formal drinking-water provision operates through organizational procedures, infrastructure, service coverage, and administrative arrangements.

This difference becomes significant when the same source is expected to satisfy multiple users. A spring located within or near a forest area may simultaneously support household consumption, agriculture, livestock, local social needs, and formal drinking-water services. Under such circumstances, the allocation of water cannot be understood only as a technical question of supply. It is also a question of whose needs are recognized, who participates in allocation decisions, and which institution has the authority and resources to modify the distribution arrangement.

The empirical findings should therefore be interpreted in terms of institutional mediation rather than automatic displacement. Where formal water-service expansion occurs, its effect on communities depends on the characteristics of the source, existing distribution infrastructure, the availability of alternative sources, and the relationship between PDAM, village governments, and local users. The study does not establish that all PDAM expansion reduces community water availability. Rather, it demonstrates that the coexistence of formal service provision and community-based access creates a governance interface that requires coordination among institutions with different mandates.

An important limitation should also be acknowledged. The empirical material provides stronger evidence on community and local institutional perspectives than on PDAM's institutional decision-making. Consequently, claims concerning PDAM's motives or organizational priorities should not be interpreted beyond the evidence collected. Further research involving systematic interviews with PDAM officials and documentary evidence concerning source allocation would be necessary to establish the institutional perspective of PDAM more fully.

***Paten* as a local institution of water governance**

The most distinctive community-level governance arrangement identified in the study is the locally recognized institution referred to as *paten*. In the study area, *paten* functions as a community-based arrangement through which users organize the distribution and maintenance of water infrastructure. Its existence demonstrates that local water governance does not depend entirely on formal government institutions. Communities have developed their own arrangements for coordinating access to water based on social relationships, geographical proximity, and established patterns of use (Lema, 2025).

The membership of *paten* is primarily associated with households or users connected to particular water-distribution arrangements. Consequently, the boundaries of membership are not necessarily equivalent to formal administrative village boundaries. This explains why one water source may serve particular *dusun* or groups of households while another source serves a different group. The arrangements are therefore socially and spatially embedded rather than organized through a single standardized institutional model.

Paten also performs practical functions (Lema, 2025). These include organizing distribution, maintaining simple water infrastructure, and sustaining continuity of supply among recognized users. These functions constitute an important form of community agency because local actors do not simply receive water passively; they collectively maintain the infrastructure and social arrangements necessary for everyday access (Lema, 2025). The field findings therefore challenge an interpretation of communities as merely passive recipients of formal water governance.

At the same time, the role of *paten* is primarily operational rather than regulatory at the broader resource level. The groups can organize distribution among their members, but the study did not find evidence that they possess formal authority to determine the status of the spring source, alter the jurisdiction of the forest area, or make decisions concerning broader allocation among competing institutional users. Their influence is therefore strongest at the level of distribution and maintenance, while their influence over the wider allocation and institutional governance of the source remains more limited.

This distinction is important for understanding the relationship between social and formal legitimacy (Görmar et al., 2023; Salman Khan & Syrett, 2022). *Paten* may possess social legitimacy because users recognize its rules and rely on its arrangements, but social recognition does not necessarily provide formal standing in decisions made by institutions operating at a higher administrative or sectoral level. The resulting gap is not evidence that *paten* is ineffective. Rather, it indicates that local institutional capacity and formal decision-making authority operate at different levels.

The study also indicates that *paten* arrangements can create differentiated access because membership is connected to particular groups and distribution networks. Such differentiation should not automatically be interpreted as unjust exclusion. In a community-based system, membership rules may function as a mechanism for defining responsibility for infrastructure, maintenance, and distribution. However, the arrangement raises an important governance question concerning households that are outside established networks or that have different levels of dependence on a particular source. This variation demonstrates why community-based institutions should be examined not only in terms of their capacity to provide access, but also in terms of who is included, who participates in decisions, and how conflicts are addressed.

Water use practices, agency, and structuration

The findings concerning everyday water practices can be more clearly understood through Giddens' structuration theory (Giddens, 2010, 2014; Whittington, 2010). In this study, structure refers to the rules, institutional mandates, resources, and established patterns that shape water governance; agency refers to the capacity of actors to act within, negotiate, reproduce, or modify those arrangements; and recursive practices refer to repeated activities through which existing governance arrangements are reproduced over time. This framework is useful because it avoids treating formal institutions and communities as completely separate entities. Instead, it directs attention to how institutional arrangements are reproduced through everyday action.

The community's management of water through *paten* is one example of agency operating within structural constraints (Giddens, 2010, 2014). Community members organize distribution, maintain infrastructure, and follow locally established arrangements. These activities reproduce the practical availability of water within their respective user groups. At the same time, the community does not possess the same institutional resources as actors responsible for forest management or formal drinking-water provision. Thus, community agency exists, but it operates within an uneven distribution of authoritative and allocative resources.

The field findings concerning water-metering practices also illustrate this interaction between structure and agency. Community responses to water meters were initially characterized as outright 'rejection'; however, a more cautious interpretation is warranted. The evidence indicates that the introduction of more formal control mechanisms encountered resistance or hesitation because such mechanisms were perceived as inconsistent with established local arrangements of water use. This should not be interpreted simply as resistance to rational management. Rather, it indicates a difference between the institutional logic of metering and the social logic through which community water distribution has historically been organized.

Within a communal system, water distribution is connected not only to quantity measurement but also to reciprocity, membership, maintenance responsibilities, and established social relationships. Introducing a meter can therefore be perceived as changing the basis on which access is organized. The empirical significance of this finding is that technical innovations are not implemented in a social vacuum (Carvalho & Spataru, 2023; Goldschmeding et al., 2025). Their acceptance depends on whether communities perceive the new mechanism as legitimate, affordable, fair, and compatible with existing responsibilities.

The same process demonstrates the recursive character of local governance. Existing rules and social expectations shape individual behavior, while repeated compliance with those arrangements reinforces their legitimacy. *Paten* therefore persists not simply because a formal authority requires it, but because community members repeatedly reproduce the arrangements through everyday distribution and maintenance practices. At the same time, these practices can limit institutional transformation when alternative arrangements are perceived as threatening established social relationships.

However, the findings do not support the conclusion that community agency is absent. The existence of *paten*, collective maintenance, water-source mapping, and community participation in discussions demonstrate practical forms of agency. The more precise finding is that community agency is stronger at the operational level than at the level of broader resource allocation and institutional decision-making. Communities can organize how water is distributed among users, but their ability to influence decisions involving forest jurisdiction, formal water-service expansion, or broader resource allocation is more constrained.

The relationship between structure and agency is therefore not adequately described as a simple dominance of formal institutions over communities. Rather, the evidence shows an asymmetrical relationship. Formal institutions possess greater access to authoritative and allocative resources, while communities possess socially embedded knowledge, collective practices, and operational capacity. Vulnerability emerges partly from the limited connection between these two forms of capacity.

Community vulnerability and the reproduction of unequal access

The findings indicate that vulnerability should not be understood solely as physical water scarcity (Brown & Shucksmith, 2017; Cutter et al., 2003; Ford et al., 2018). In this study, vulnerability has at least four empirically relevant dimensions: dependence on particular water sources, reliability of access and distribution, dependence of household and livelihood activities on water, and the capacity to influence decisions affecting access. These dimensions correspond to the analytical distinction between exposure, sensitivity, and adaptive or agency capacity introduced earlier in the article.

First, communities are exposed to institutional and ecological changes because several households depend on springs associated with forest areas and established distribution systems. Dependence becomes particularly important where alternative sources are limited or where infrastructure connects particular households to specific springs. Second, sensitivity is reflected in the use of water for domestic needs and livelihood activities, including agriculture and livestock. Disruption of a source can therefore affect more than drinking-water availability; it can also affect everyday household and livelihood activities.

Third, adaptive capacity varies according to access to alternative sources and institutional resources (Ford et al., 2018). The presence of Pamsimas and drilled wells in Kadakajaya demonstrates that communities are not entirely dependent on a single water source. These alternatives can function as coping mechanisms, particularly for social and domestic needs. However, their presence does not eliminate dependence on spring systems because different sources serve different *dusun* and user groups. This variation is important because it demonstrates that vulnerability is differentiated rather than uniform.

Fourth, agency capacity is reflected in the ability of communities to organize collective water distribution and maintenance. *Paten* provides an institutional mechanism through which users can collectively respond to everyday water needs. Nevertheless, the group-level capacity to manage distribution does not necessarily translate into authority over wider allocation decisions. This distinction helps explain why communities can demonstrate substantial capacity to maintain local water access while simultaneously having limited influence over decisions made by institutions operating beyond the community.

The resulting vulnerability is therefore partly institutional (Brown & Shucksmith, 2017; Görmär et al., 2023). It is produced not simply by the quantity of available water but by the relationship between resource dependence and the distribution of decision-making power. Where communities have practical responsibilities for maintaining water systems but limited influence over broader decisions concerning sources, infrastructure, or institutional allocation, a gap emerges between responsibility for everyday management and authority over strategic decisions.

This finding also complicates the argument that stronger formal regulation automatically produces better local outcomes. The regulatory framework contains provisions intended to protect people's basic water needs and recognizes community participation, but the translation of these principles into specific arrangements at the forest-fringe level depends on institutional coordination. Where village-level mechanisms do not effectively connect *paten*, village government, Perhutani, and formal water-service institutions, the community's operational capacity remains separated from broader decision-making processes.

Implications for justice and policy implementation

The findings have implications for three dimensions of water governance justice: distribution, procedure, and recognition (Higgs et al., 2025; McKee, 2025). Distributive justice concerns how water and the benefits of water infrastructure are allocated among users. In the study area, different sources serve different groups and institutional users, creating differentiated patterns of access. The study does not establish that every difference in access is unjust; rather, it demonstrates that allocation needs to account for differences in dependence, alternative sources, and livelihood needs.

Procedural justice concerns who participates in decisions affecting water access (McKee, 2025). The existence of *paten* demonstrates that communities participate actively in operational management, but their participation in broader decisions concerning source management and inter-institutional allocation appears more limited.

This difference between participation in everyday management and participation in strategic decision-making is central to understanding the governance gap identified in this study (Higgs et al., 2025).

Recognition concerns whether local institutions and knowledge are acknowledged within wider governance arrangements. *Paten* represents an established social institution that performs concrete water-management functions, yet its role is primarily recognized within the community rather than as part of a broader formal coordination mechanism. The issue is therefore not simply whether *paten* should be formalized, but whether existing governance arrangements provide an institutional channel through which its knowledge, responsibilities, and interests can be considered in decisions concerning water resources.

The evidence also suggests that institutional integration should not mean replacing existing community arrangements with a standardized formal system (Pambudi & Kusumanto, 2023; Phelia & Cambodia, 2025). *Paten* has demonstrated practical capacity in distribution and maintenance, while formal institutions possess different resources and legal responsibilities. A more context-sensitive governance arrangement would therefore connect these capacities rather than eliminate one in favor of the other (Phelia & Cambodia, 2025; Rossi, 2022). Village governments could function as an institutional bridge between community water-user groups and higher-level institutions, while coordination with Perhutani and PDAM could clarify responsibilities concerning sources located within or adjacent to managed forest areas.

Such integration would also require clearer allocation of responsibilities. Community groups should not be assigned responsibility for functions that require formal regulatory authority or resources beyond their capacity. Conversely, formal institutions should not assume that community-based arrangements can simply be replaced by technical interventions without considering existing social relationships and distribution practices. The findings on water-metering illustrate why technical measures require institutional and social negotiation before they can become legitimate in practice.

Overall, the evidence indicates that the central problem is not the absence of a formal regulatory framework. Indonesia has established a relatively extensive framework governing water resources, basic water rights, drinking-water provision, and institutional responsibilities. The more specific problem identified by this case is the mediation gap between formal authority and community-level governance. Formal authority is translated through territorial jurisdiction, drinking-water service arrangements, village institutions, and local water-user groups. Where these institutional layers are weakly connected, communities may retain strong operational agency while having limited influence over broader decisions affecting the resources on which they depend.

The Sumedang case therefore demonstrates how vulnerability can be reproduced through the interaction of formal structures and everyday practices (Giddens, 2014; Whittington, 2010). Formal institutions possess greater authoritative and allocative resources, while communities reproduce locally effective practices through *paten* and other collective arrangements (Giddens, 2014). Neither structure nor agency alone explains the observed outcomes. Vulnerability emerges from their interaction, particularly where local agency is sufficient to maintain existing arrangements but insufficient to influence the wider institutional configuration governing water resources.

For policy implementation, the findings point toward several evidence-based directions. First, local water-user institutions should have an identifiable channel for participation in village-level water planning rather than remaining disconnected from formal governance. Second, water sources serving both community and formal service users require transparent arrangements concerning allocation, infrastructure, monitoring, and communication. Third, governance of springs located in or adjacent to forest areas requires clearer coordination between water-resource authorities, village governments, forestry institutions, and water-service providers. Fourth, technical interventions such as metering should be preceded by consultation concerning affordability, distributional effects, existing community responsibilities, and the reasons for local acceptance or resistance. Finally, any institutional reform should preserve the practical capacities already demonstrated by community groups while creating mechanisms through which those capacities can be connected to formal decision-making.

In this sense, the empirical contribution of the study lies not in demonstrating that formal institutions are inherently incompatible with community governance, but in showing how different forms of authority and agency operate at different institutional levels. The case illustrates that equitable water governance depends on whether formal regulatory authority can be translated into arrangements that recognize local practices, accommodate community participation, and connect operational community capacity with decisions concerning the wider management of water resources.

Conclusion

This study examined how formal regulatory authority over water resources is translated into local governance arrangements and how these arrangements shape community access and vulnerability in forest-fringe communities in Sumedang Regency. Three main conclusions can be drawn.

First, the regulatory analysis shows that Indonesia's water-resource framework establishes state responsibility for regulating and managing water resources while recognizing people's rights to water for minimum daily needs and provisions for community participation. The framework therefore provides a normative basis for public-interest-oriented water governance, but formal recognition of these principles does not automatically establish community authority over individual water sources. Authority over regulation, management, supervision, and service provision remains distributed across different institutional levels and functions.

Second, the field findings demonstrate that this formal authority is mediated through a locally fragmented institutional configuration involving Perhutani, village governments, PDAM, and community water-user groups. Several community water sources are located in or adjacent to Perhutani-managed forest areas, making forestry jurisdiction an important factor in access to water without implying exclusive legal authority over the water itself. At the community level, *paten* provides a socially recognized mechanism for organizing water distribution and maintaining infrastructure among connected users. Its capacity is strongest in everyday operational management, while its influence over broader allocation and inter-institutional decisions is more limited. The coexistence of community-based arrangements and formal drinking-water services therefore creates a governance interface that requires coordination rather than assuming automatic displacement of community access.

Third, the study identifies vulnerability as partly institutional rather than solely a consequence of physical water scarcity. Dependence on particular springs and distribution networks, differences in access to alternative sources, livelihood dependence on water, and limited influence over broader allocation decisions create differentiated forms of vulnerability among households and user groups. From a structuration perspective, communities demonstrate agency through collective distribution, infrastructure maintenance, and locally established practices, but this agency operates within an uneven distribution of authoritative and allocative resources. Vulnerability can therefore be reproduced when community capacity to manage water operationally is not matched by meaningful access to wider decision-making processes.

The specific contribution of the Sumedang case is to demonstrate the mechanism through which formal authority is translated into local water governance: regulatory authority is mediated by forestry jurisdiction, fragmented local institutions, unequal institutional resources, and the coexistence of community-based and formal drinking-water arrangements. This mechanism helps explain why formal recognition of public water rights may coexist with differentiated community access and limited influence over strategic decisions. The findings should not, however, be generalized as a representation of all forest-fringe communities in Indonesia. Rather, the case provides an empirically grounded illustration of how formal and informal institutions interact in a specific forest-fringe setting.

Several limitations should be acknowledged. The study uses a single regional case and purposive selection of 15 local community and stakeholder informants, supplemented by two focus group discussions and field observations. The empirical material provides stronger representation of community and local institutional perspectives than of ordinary households and PDAM's institutional perspective. In addition, the regulatory analysis covers the 2014–2021 period, whereas fieldwork was conducted from March to October 2024. These differences in analytical period and participant representation limit the extent to which the findings can be generalized to other locations or used to characterize subsequent institutional changes. Future research could therefore examine multiple forest-fringe regions, include a broader range of household perspectives and institutional actors, and investigate changes in water governance following subsequent regulatory developments.

Policy implications follow from these findings but should be understood as institutional directions rather than as conclusions directly established by the empirical evidence. First, village-level water planning could provide a clearer institutional channel through which community water-user groups, including *paten*, can communicate their operational knowledge and concerns to formal institutions. Second, where water sources are shared by community users and formal service providers, clearer arrangements for allocation, infrastructure management, monitoring, and communication are needed. Third, coordination among village governments, forestry institutions, water-service providers, and community groups is important for sources located within or

adjacent to managed forest areas. Finally, technical interventions should be accompanied by consultation concerning affordability, existing community responsibilities, distributional effects, and local perceptions of legitimacy.

Overall, the study shows that the central governance challenge identified in the Sumedang case is not simply the absence of regulation, but the institutional mediation gap between formal authority and local water-governance practices. Strengthening the connection between formal decision-making and community operational capacity may provide a pathway for reducing institutional sources of vulnerability while retaining the locally embedded practices through which communities maintain everyday access to water.

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Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this manuscript, the author used Grammarly (free version) solely for grammar, spelling, and language editing. The author reviewed and approved all revisions and assumes full responsibility for the content of the manuscript.

Statement of originality and plagiarism-free

The author declares that this article is an original work that has not been published elsewhere and is not currently under consideration for publication in any other journal. The manuscript is free from plagiarism, and all sources, references, and citations have been properly acknowledged in accordance with applicable academic and publication standards.

Declaration of conflicts of interest

The author declares no conflicts of interest related to this research, authorship, or publication.

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