



Critical Analysis of Riverbank Control Governance in Tukad Badung, Bali: An Environmental Law Perspective

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Abstract. This study examines the legal protection and implementation of riverbank control in Indonesia, with particular focus on the Tukad Badung riverbank in Bali. The study aims to analyze how riverbank protection is constructed within Indonesia's environmental, water-resource, and spatial-planning framework and to identify the main implementation challenges affecting its effectiveness. The study uses a socio-legal approach combining normative legal analysis with empirical examination of riverbank management and governance practices. The findings show that Indonesia has a broad legal framework for riverbank protection, covering constitutional principles, environmental law, water-resource regulation, river boundaries, spatial planning, environmental quality standards, and administrative enforcement. However, the main challenge is an implementation gap rather than a regulatory vacuum. In Tukad Badung, this gap is reflected in inconsistent control of existing land uses, fragmented institutional responsibilities, limited continuous supervision, reactive enforcement, socio-economic pressures, limited community participation, and weak integration with wider watershed and urban environmental management. The study highlights the need for coordinated regulatory implementation through clear institutional responsibilities, continuous preventive supervision, fair enforcement, and meaningful community participation. Riverbank control should also integrate drainage, waste management, water-quality protection, flood management, and urban development policies to strengthen accountable and sustainable riverbank governance.

Keywords: Environmental Law, Riverbank Protection, Spatial Planning, Tukad Badung, Water-Resource Governance.



Abstrak. *Studi ini mengkaji perlindungan hukum dan pelaksanaan pengendalian kawasan sempadan sungai di Indonesia, dengan fokus khusus pada sempadan Sungai Tukad Badung di Bali. Penelitian ini bertujuan untuk menganalisis bagaimana perlindungan sempadan sungai dikonstruksikan dalam kerangka hukum lingkungan, sumber daya air, dan penataan ruang di Indonesia, serta mengidentifikasi tantangan utama dalam pelaksanaannya yang memengaruhi efektivitasnya. Studi ini menggunakan pendekatan sosio-legal yang memadukan analisis hukum normatif dengan kajian empiris mengenai praktik pengelolaan dan tata kelola sempadan sungai. Hasil penelitian menunjukkan bahwa Indonesia memiliki kerangka hukum yang komprehensif untuk perlindungan sempadan sungai, yang mencakup prinsip-prinsip konstitusional, hukum lingkungan, regulasi sumber daya air, ketentuan batas sungai, penataan ruang, standar mutu lingkungan, dan penegakan hukum administratif. Namun, tantangan utamanya terletak pada kesenjangan pelaksanaan, bukan pada kekosongan regulasi. Di Tukad Badung, kesenjangan ini tercermin dalam pengendalian penggunaan lahan yang tidak konsisten, tanggung jawab kelembagaan yang terfragmentasi, pengawasan berkelanjutan yang terbatas, penegakan hukum yang bersifat reaktif, tekanan sosial-ekonomi, partisipasi masyarakat yang minim, serta integrasi yang lemah dengan pengelolaan daerah aliran sungai (DAS) dan lingkungan perkotaan secara lebih luas. Studi ini menyoroti perlunya pelaksanaan regulasi yang terkoordinasi melalui pembagian tanggung jawab kelembagaan yang jelas, pengawasan preventif yang berkelanjutan, penegakan hukum yang adil, dan partisipasi masyarakat yang bermakna. Pengendalian sempadan sungai juga harus mengintegrasikan kebijakan drainase, pengelolaan limbah, perlindungan kualitas air, pengendalian banjir, dan pengembangan perkotaan guna memperkuat tata kelola sempadan sungai yang akuntabel dan berkelanjutan.*

Kata kunci: *Hukum Lingkungan, Perlindungan Bantaran Sungai, Penataan Ruang, Tukad Badung, Tata Kelola Sumber Daya Air.*

1. Introduction

Rivers constitute an important component of ecological systems and perform interconnected hydrological, environmental, and social functions. They provide water, convey runoff, support biodiversity, and contribute to the livelihoods and spatial development of communities. Consequently, river management cannot be understood merely as the utilization of water resources or the construction of flood-control infrastructure. It also concerns the protection of ecological functions and the regulation of human activities that may alter river systems.¹ From an environmental law perspective, this position requires the state to establish rules that balance resource utilization, environmental protection, spatial order, and the interests of present and future generations. The socio-ecological character of natural resources further indicates that sustainable management requires institutional arrangements capable of reconciling collective interests with ecological limits. In Indonesia, this principle is reinforced by the constitutional mandate that natural resources be controlled by the state and utilized for the greatest prosperity of the people.

The constitutional basis for river protection is reflected particularly in Articles 28H paragraph (1) and 33 paragraph (3) of the 1945 Constitution of the Republic of Indonesia. Article 28H paragraph (1) establishes the right of every person to a good and healthy environment, while Article 33 paragraph (3) places water and natural resources under state control for the greatest prosperity of the people. These provisions create a constitutional foundation for environmental governance in which state authority over water resources is accompanied by a responsibility to prevent environmental degradation and ensure sustainable utilization. Environmental protection therefore requires more than the formulation of normative prohibitions; it requires effective administration, supervision, compliance, and enforcement. Previous studies of Indonesian environmental governance have demonstrated that the effectiveness of environmental law remains affected by regulatory fragmentation, institutional capacity, and weaknesses in enforcement.²

¹ Marulak Pardede et al., "Perspectives of sustainable development vs. law enforcement on damage, pollution and environmental conservation management in Indonesia," *Journal of Water and Climate Change* 14, no. 10 (2023): 3773. See also, Hunggul Yudono Setio Hadi Nugroho et al., "Forty years of soil and water conservation policy, implementation, research and development in Indonesia: a review," *Sustainability* 14, no. 5 (2022): 2972.

² Adriaan Bedner, "Consequences of decentralization: environmental impact assessment and water pollution control in Indonesia," *Law & Policy* 32, no. 1 (2010): 39. See also, Arifin Maruf, "Legal aspects of environment in Indonesia: An efforts to prevent environmental damage and pollution," *Journal of Human Rights, Culture and Legal System* 1, no. 1 (2021): 332; Ummi A'Zizah

Within this framework, riverbank or river boundary areas (*sempadan sungai*) occupy a particularly important legal position. Government Regulation Number 38 of 2011 concerning Rivers defines the river as a natural or artificial watercourse bounded on both sides by river boundaries and places river management within the broader functions of conservation, utilization, and control of the destructive forces of water. More specifically, Minister of Public Works and Housing Regulation Number 28/PRT/M/2015 concerning the Determination of River and Lake Boundaries establishes criteria for determining river boundaries according to the characteristics and location of the river. The regulation remains in force and provides a technical-normative basis for determining river boundary lines. Thus, the riverbank is not simply an area adjacent to a river but a legally regulated spatial zone intended to safeguard river functions and limit incompatible uses.

The legal framework, however, is distributed across several regulatory regimes. River protection intersects with environmental protection under Law Number 32 of 2009 concerning Environmental Protection and Management, water-resource governance under Law Number 17 of 2019 concerning Water Resources, spatial planning, regional government authority, and implementing regulations concerning river boundaries and water quality. Law Number 17 of 2019 emphasizes that water-resource management must consider social, environmental, and economic functions in an integrated manner and provides roles for central and regional governments as well as community participation. Meanwhile, the environmental regulatory framework has also undergone changes through the Job Creation regime, including Law Number 6 of 2023, which enacted Government Regulation in Lieu of Law Number 2 of 2022 concerning Job Creation. This multi-layered framework demonstrates the importance of examining riverbank protection not through a single regulation, but through the relationship between environmental law, water-resource law, spatial regulation, and administrative authority.³

Urbanization, residential and commercial development, infrastructure expansion, and increasing land demand place pressure on river boundaries, potentially reducing river flow space, disrupting ecological functions, increasing flood risks, and causing pollution.⁴ Weaknesses in Bali's spatial-planning regulation

Zahroh, and Fatma Ulfatun Najicha, "Problems and challenges on environmental law enforcement in Indonesia: AMDAL in the context of administrative law," *Indonesian State Law Review* 5, no. 2 (2022): 57.

³ Eko Ariwidodo and Ruslina Dwi Wahyuni, "The Applying Modern Environmental Law in Southeast Asia: A Legal Philosophy Point of View," *Jurnal Hukum Unissula* 42, no. 3 (2026): 838.

⁴ Afri Ahyarky Abidin et al., "Impact of population growth and housing development on the riverine environment: Identifying environmental threat and solution in the Wangu River, Indonesia," *Ecological Modelling* 486 (2023): 110541. See also, Tyas Mutiara Basuki et al., "Water pollution of some major rivers in Indonesia: The status, institution, regulation, and recommendation for its mitigation," *Polish Journal of Environmental Studies* 33, no. 4 (2024): 3532.

further demonstrate that riverbank protection is both an environmental-law and spatial-governance issue.⁵

The problem is particularly relevant to Tukad Badung in Denpasar, Bali, where the river functions within a densely developed urban environment. Previous studies have primarily examined the river from hydrological and environmental perspectives. Research on Tukad Badung has identified water-quality pressures associated with anthropogenic activities. Harmayani et al.⁶ for example, found that several water-quality parameters exceeded applicable standards and classified the monitored sections as lightly polluted. Earlier research likewise associated community activities and wastewater with changes in the quality of Tukad Badung.⁷ These findings demonstrate that ecological pressure on Tukad Badung is not merely hypothetical but has been empirically documented.

The river also presents an important dimension of urban flood governance. The establishment of an early-warning system for flooding along Tukad Badung by the Denpasar Regional Disaster Management Agency in 2026 illustrates the continuing importance of river discharge and flood risk in the urban area. The experience of severe flooding in Bali in 2025 further intensified public and governmental attention to river management, including concerns regarding development, land-use change, and structures located close to waterways. These developments strengthen the argument that riverbank protection should be treated as a preventive legal mechanism rather than merely as a post-disaster response.

Nevertheless, existing scholarship reveals a research gap. Studies concerning Indonesian rivers have extensively addressed water pollution, hydrology, watershed management, spatial planning, community participation, and environmental governance.⁸ Studies concerning Bali have additionally examined Subak, customary environmental practices, water management, and pollution.⁹ However, these

⁵ I. Gusti Ngurah Parikesit Widiatedja, "The regulatory failure of spatial planning and its environmental impact: a case study of hotel projects in Bali, Indonesia," *Journal of Property, Planning and Environmental Law* 14, no. 1 (2022): 28.

⁶ Kadek Diana Harmayani et al., "Initial indication of microplastics in the water and sediment of the Tukad Badung River in Bali, Indonesia," *Water, Air, & Soil Pollution* 236, no. 11 (2025): 727.

⁷ Riyanto Haribowo, and Tri Budi Prayogo, "Analisa Kualitas Air Sungai Tukad Badung, Denpasar, Bali Menggunakan Program QUAL2Kw," *Jurnal Teknologi dan Rekayasa Sumber Daya Air* 1, no. 1 (2021): 44.

⁸ Abidin et al., "Impact of population growth," 110542. See also, Basuki et al., "Water pollution of some major rivers," 3532.

⁹ I. Made Geria et al., "Built environment from the ancient Bali: The Balinese heritage for sustainable water management," *Helikon* 9, no. 11 (2023), 23. See also, Lukman Hakim et al., "Integrating Adat Law in Indonesia: Challenges and Opportunities in a Centralized Legal Framework," *Indonesian State Law Review* 8 (2025): 59; Dik Roth, "Environmental sustainability and legal plurality in irrigation: the Balinese subak," *Current Opinion in Environmental Sustainability* 11 (2014): 3; I. Utama et al., "Balancing Tourism and Conservation: The Role of Local Communities in Bali's Ecotourism Management," *Available at SSRN 6175620* (2025): 232.

strands of research have generally examined ecological conditions, customary governance, or environmental management separately. There remains limited legal analysis that specifically connects the normative construction of riverbank protection, the allocation of governmental authority, the implementation of riverbank control, and the effectiveness of legal enforcement in an urban river such as Tukad Badung. In particular, the relationship between national river-boundary rules and their implementation within local spatial and environmental governance in Denpasar has not been sufficiently examined.

This gap is important because the existence of regulations does not necessarily demonstrate effective legal protection. Indonesian environmental-law scholarship has repeatedly identified the difference between formal legal norms and their implementation, including problems of institutional coordination, overlapping regulatory authority, supervision, and enforcement.¹⁰ Riverbank governance presents an especially complex example because enforcement may affect property use, settlements, economic activities, public infrastructure, disaster prevention, and community interests simultaneously. Consequently, effective control requires not only prohibitive rules but also clear institutional responsibilities, consistent supervision, community involvement, and legally accountable enforcement.

The Balinese context reflects a pluralistic environmental governance system in which state law interacts with local knowledge and customary institutions. The Subak system and community participation support sustainable water and river governance.¹¹ However, these mechanisms should complement, not replace, formal legal obligations governing river boundaries, spatial use, supervision, and enforcement.

Accordingly, this study positions Tukad Badung as a case study of the implementation of Indonesian environmental law in urban riverbank governance. Rather than measuring the ecological condition of the river or evaluating flood-control engineering, the study focuses on the legal relationship between regulatory norms and their implementation. The analysis is directed toward identifying whether the existing legal framework provides sufficient normative clarity, whether

¹⁰ Bedner, “Consequences of decentralization,” 40. See also, Pardede et al., “Perspectives of sustainable development,” 3774; Zahroh, and Najicha, “Problems and challenges on environmental law,” 58.

¹¹ Parida Angriani et al., “Local community-based river management: A case study of Kuin river, Banjarmasin, South Kalimantan–Indonesia,” *Ecology, Environment and Conservation* 25, no. 1(2019): 12. See also, Ismail Aris, “Strengthening environmental law policy and its influence on environmental sustainability performance: Empirical studies of green constitution in adopting countries,” *International Journal of Energy Economics and Policy* (2020): 32; Geria et al., “Built environment from the ancient Bali,” 24; Angela Osorio et al., “Community water supply service systems in the high basin of the Guarino River (Marulanda, Caldas, Colombia) as territorialities for sustainability,” *Frontiers in Water* 8 (2026): 1732846; Roth, “Environmental sustainability and legal plurality,” 4.

riverbank control has been implemented consistently with those norms, and where legal and institutional gaps remain. Such an approach is relevant to environmental law because the central issue is not simply whether environmental regulations exist, but whether the regulatory system is capable of translating environmental protection obligations into effective control of activities affecting river boundaries.

Based on this legal problem and research gap, this study seeks to examine the environmental-law framework and implementation of riverbank control along Tukad Badung in Denpasar. The study is guided by three research questions:

RQ1. How is the legal protection and control of riverbank areas constructed within Indonesia's environmental, water-resource, and spatial-planning regulatory framework?

RQ2. How is the legal framework for riverbank protection implemented in the management and control of the Tukad Badung riverbank in Denpasar?

RQ3. What legal and institutional gaps affect the effectiveness of riverbank control in protecting the ecological function of Tukad Badung?

2. Research Methods

This study employed an empirical legal research design with a qualitative approach to examine the construction, implementation, and effectiveness of legal protection for the Tukad Badung riverbank in Denpasar. The empirical legal approach was selected because the study examines not only the content and structure of legal norms but also how those norms are implemented by government institutions and experienced in the management of an urban riverbank.

The study addressed three dimensions: the legal construction of riverbank protection within Indonesia's environmental, water-resource, and spatial-planning framework; the implementation of that framework in Tukad Badung; and the legal and institutional gaps affecting the effectiveness of riverbank control. A statutory approach was used to examine relevant legal provisions, while a conceptual approach was applied to interpret principles of environmental protection, sustainable development, state responsibility, prevention, and ecological protection. A socio-legal approach was used to examine the interaction between formal legal requirements, institutional practices, and community interests.

Primary data were obtained through semi-structured interviews with relevant stakeholders involved in riverbank management, including officials responsible for environmental affairs, public works and spatial planning, and members of communities located around Tukad Badung. Secondary data consisted of legislation, regional spatial-planning instruments, government documents, policy materials, and relevant academic literature. Key legal instruments examined included the 1945 Constitution, Law Number 32 of 2009 concerning

Environmental Protection and Management, Government Regulation Number 38 of 2011 concerning Rivers, and relevant regional spatial-planning regulations.

Data were analyzed qualitatively through reduction, categorization, comparison, and interpretation. The analysis compared normative requirements with empirical implementation to identify areas of consistency, implementation constraints, institutional overlaps, and legal gaps. Findings from interviews were used to contextualize the normative analysis and assess the effectiveness of riverbank control in maintaining the ecological function of Tukad Badung.

3. Results and Discussion

3.1. Legal Construction of Riverbank Protection and Control

Riverbank protection in Indonesia is supported by several legal instruments covering environmental protection, water resources, river management, spatial planning, environmental standards, and administrative enforcement. These regulations establish the authority to protect river functions and control activities that may cause pollution, erosion, flooding, or other environmental degradation.¹² At the constitutional level, Article 33 paragraph (3) of the 1945 Constitution establishes state control over land, water, and natural resources for the greatest prosperity of the people. This provides the basis for government authority to regulate the use, protection, and conservation of water resources. Article 28H paragraph (1) further recognizes the right to a good and healthy environment. Accordingly, river protection is not only a matter of resource management but also part of the government's responsibility to protect environmental rights. Indonesian environmental-law studies similarly identify these constitutional provisions as important foundations for environmental protection and enforcement (Ningrum, 2023).¹³

These constitutional principles are further developed through Law Number 32 of 2009 concerning Environmental Protection and Management (*Undang-Undang Perlindungan dan Pengelolaan Lingkungan Hidup/UUPPLH*), as subsequently amended, including through Law Number 6 of 2023. Although the UUPPLH does not specifically regulate riverbanks, it provides the general framework for environmental planning, utilization, protection, supervision, and enforcement.

¹² Laely Nurhidayah, and Shawkat Alam, "The forest and its biodiversity: Assessing the adequacy of biodiversity protection laws in Indonesia," *Asia Pacific Journal of Environmental Law* 23, no. 2 (2020): 179. See also, Basuki et al., "Water pollution of some major rivers," 3533; Pardede et al., "Perspectives of sustainable development," 3777.

¹³ Dwi Haryadi et al., "Environmental regulations (its identification and downstream implementation in Bangka Belitung)," In *E3S Web of Conferences*, (EDP Sciences, 2021), 5002. See also, Maruf, "Legal aspects of environment," 334.

Activities around riverbanks may therefore be subject to environmental requirements when they have the potential to cause pollution or environmental damage. The law also provides preventive instruments, environmental assessment, environmental approval, monitoring, and administrative, civil, and criminal enforcement.¹⁴

The preventive approach is important because environmental regulation seeks to control risks before serious damage occurs. Environmental Impact Assessment (*Analisis Mengenai Dampak Lingkungan/AMDAL*), for example, provides a mechanism for assessing potential environmental impacts before development activities are undertaken.¹⁵ This approach is consistent with environmental governance principles that emphasize anticipating and reducing environmental risks rather than relying only on action after damage has occurred. For riverbanks, potentially harmful activities should therefore be assessed based on both their environmental impacts and their location.

The second regulatory basis is water-resource law, particularly Law Number 17 of 2019 concerning Water Resources, which regulates the conservation, use, and control of water resources. For riverbank protection, this framework is specified through the concept of the river boundary (*sempadan sungai*).

Government Regulation Number 38 of 2011 concerning Rivers establishes river boundaries as protected areas for maintaining river functions. This is complemented by Minister of Public Works and Housing Regulation Number 28/PRT/M/2015, which provides technical requirements for determining river boundaries. Together, these regulations provide a legal basis for defining protected river space and controlling activities within it. However, their implementation may still face problems involving communication, coordination, institutional capacity, and enforcement resources. The river boundary is therefore not merely a distance measured from the river. It functions as a protective space for maintaining water flow, flood control, ecological functions, and public safety. Its regulation consequently connects river protection with spatial control, making the location of buildings, settlements, commercial activities, and waste disposal legally and environmentally significant.

The third regulatory basis is spatial-planning law. Riverbank protection cannot depend only on water-resource regulations because riverbank conditions are also

¹⁴ Yonani Hasyim, and Serlika Aprita, "The aspects of environmental law enforcement in Indonesia and the implementation of international agreements in the environmental field in Indonesia," *Nurani: jurnal kajian syari'ah dan masyarakat* 21, no. 2 (2021): 211. See also, Hao Huang, and Joti Rockwell, "Relational practices in Bali: Balinese Hinduism, subak, and music," *International Journal of Asia Pacific Studies* 19, no. 1 (2023), 87; Maruf, "Legal aspects of environment," 336; Andi Sundari et al., "Victims of Crime and Environmental Pollution in Indonesia: The Right to Restitution and Legal Inadequacies," *Journal of Law, Environmental and Justice* 3, no. 2 (2025): 501.

¹⁵ Zahroh, and Najicha, "Problems and challenges on environmental law," 59.

affected by settlements, buildings, infrastructure, tourism, commercial activities, and other land-use changes. Law Number 26 of 2007 concerning Spatial Planning, together with Government Regulation Number 21 of 2021 concerning the Organization of Spatial Planning, provides the legal framework for spatial planning, land use, development control, and supervision.

In urban river areas, spatial planning is important because riverbanks are often subject to competing uses, including housing, commerce, tourism, infrastructure, and public space. Spatial planning therefore also serves as an environmental control mechanism by determining which activities are permitted and how development should be controlled. Weak integration between spatial planning and environmental protection can increase pressure on river systems, particularly under urban growth and expansion.¹⁶ Riverbank protection therefore requires not only control of activities at the riverbank but also control of the wider spatial development that affects it.

These regulations together provide a connected legal framework for riverbank protection. Constitutional provisions establish state responsibility and environmental rights; environmental law provides general protection and enforcement instruments; water-resource law regulates water conservation and use; river regulations establish protected boundaries; and spatial-planning law controls land use and development.¹⁷ Environmental-quality regulations and administrative enforcement support their implementation.

Government Regulation Number 22 of 2021 is also relevant because it provides environmental quality standards, including water-quality requirements. Activities near rivers may generate wastewater, solid waste, sediment, and other pollutants, making control of environmental impacts as important as control of land use. Indonesian river studies continue to identify pollution and institutional coordination as governance challenges.¹⁸ In Bali, urbanization, tourism, and population growth further increase pressure on water resources.¹⁹ Riverbank

¹⁶ Abidin et al., “Impact of population growth,” 110543. See also, Widiatedja, “The regulatory failure of spatial planning,” 29.

¹⁷ I Gusti Bagus Suryawan et al., “Reinforcing the Ultimatum Remedium Principle in Environmental Law Enforcement: A Three-Layered Approach Under Law No. 32 of 2009,” *Jurnal Hukum Unissula* 41 (2025): 492.

¹⁸ Basuki et al., “Water pollution of some major rivers,” 3535. See also, Utama et al., “Balancing Tourism and Conservation,” 235.

¹⁹ Saroj Kumar Chapagain et al., “Analyzing the relationship between water pollution and economic activity for a more effective pollution control policy in Bali Province, Indonesia,” *Sustainable Environment Research* 32, no. 1 (2022): 5. See also, Nyoman Satyayudha Dananjaya, and Fuchikawa Kazuhiko, “The citizens’ constitutional rights regarding habitable and wholesome environment: Towards a law state that protects the environment,” *Udayana Journal of Law and Culture* 4, no. 1 (2020): 89.

protection therefore requires control of both where activities occur and what environmental impacts they produce.

This issue is relevant to Tukad Badung. Previous research has identified water-quality concerns in the river, while recent research has also found microplastics in its water and sediment.²⁰ These findings indicate that riverbank protection should not be understood only as controlling buildings or land occupation. It should also form part of wider pollution and environmental-quality control.

The effectiveness of the framework also depends on administrative supervision and enforcement. A legal boundary has limited value if violations are not identified, prevented, sanctioned, or remedied. Environmental law provides administrative, civil, and criminal enforcement mechanisms, although implementation may be affected by institutional capacity and coordination.²¹ Effective riverbank governance therefore requires boundary identification, land-use monitoring, permit control, inspection, enforcement, and, where necessary, restoration. Indonesia's regulatory framework is extensive, but implementation remains challenged by overlapping administrative boundaries, decentralized authority, and institutional coordination.²² Community participation under Article 70 of the UUPPLH can complement government supervision by enabling residents to monitor pollution, waste, unauthorized construction, and other riverbank changes.

In Bali, community-based institutions can further support formal regulation. Subak, *awig-awig*, and principles associated with Tri Hita Karana show how local institutions can contribute to water and environmental governance. Studies indicate that customary institutions can coexist with formal legal arrangements and support collective resource management.²³ Customary environmental norms may therefore strengthen collective responsibility and environmental stewardship.²⁴

²⁰ Harmayani et al., "Initial indication of microplastics," 729. See also, Haribowo, and Prayogo, "Analisa Kualitas Air Sungai Tukad Badung," 45.

²¹ Hasyim, and Aprita, "The aspects of environmental law enforcement," 212. See also, Pardede et al., "Perspectives of sustainable development," 3778; Sundari et al., "Victims of Crime and Environmental," 504.

²² Bedner, "Consequences of decentralization," 42. See also, Md Hasnath Kabir Fahim, and Ramisa Jahan, "Environmental Management and Justice System in Bangladesh: Issues and Legal Framework," *Lex Publica* 12, no. 2 (2025): 319.

²³ I. Nyoman Arsana et al., "SUBAK: Traditional ecological knowledge for sustainable biodiversity conservation," In *IOP conference series: Earth and environmental science*, (IOP Publishing, 2025), 12005. See also, Abdul Madjid et al., "Cumulative ecological impacts of river sand mining under weak environmental governance in Indonesia," *Environment and Water Engineering* 12, no. 1 (2026): 29; Roth, "Environmental sustainability and legal plurality," 5; Irina Safitri Zen et al., "Sustaining subak, the balinese traditional ecological knowledge in the contemporary context of Bali," In *IOP Conference Series: Earth and Environmental Science*, (IOP Publishing, 2024), 12034.

²⁴ Eva Nuriyah Hidayat Imamulhadi et al., "Customary environmental law and its transformation models in Indonesia," *Cogent Social Sciences* 11, no. 1 (2025): 251468. See also, Moch Rifan et al., "Environmental Legal Protection Regulation through a Judicial Process Based on Legal

However, these institutions should be viewed as a supporting governance layer, not as a replacement for formal state regulation.

Indonesia has a broad legal basis for riverbank protection through environmental, water-resource, spatial-planning, and river regulations. Effective protection requires coordinated implementation through boundary determination, planning, assessment, monitoring, participation, enforcement, and restoration, particularly in Tukad Badung, where pollution and ecological risks remain concerns.²⁵

3.2. Implementation of Riverbank Protection and Control in the Tukad Badung Riverbank

The empirical findings show that protection and control of the Tukad Badung riverbank are implemented through spatial planning, water-resource management, environmental protection, monitoring, infrastructure management, community engagement, and administrative control. These measures operate through multiple governmental functions and community practices within an established urban environment. Spatial planning is particularly important because it translates river-protection obligations into restrictions on buildings, land use, businesses, settlements, and public infrastructure.²⁶ However, implementation is complicated by the highly urbanized character of Tukad Badung, where settlements, commercial activities, public facilities, and infrastructure have developed along the river over time. Consequently, riverbank control cannot simply impose new restrictions on previously undeveloped areas but must regulate existing uses while preventing further inappropriate development. This creates an ongoing governance challenge in balancing ecological protection, river functions, urban development, and community interests, particularly given the environmental pressures associated with population and housing growth in Indonesian river areas.²⁷

The empirical findings show that monitoring and supervision are essential instruments for controlling the Tukad Badung riverbank. Government supervision helps identify potentially harmful activities, structures, waste disposal, and inappropriate land use, while enabling administrative responses and follow-up actions. The effectiveness of environmental regulation therefore depends not only on formal legal restrictions but also on institutional capacity to ensure

Certainty and Anti-SLAPP Principles,” *Jurnal Suara Hukum* 8, no. 1 (2026): 233; I. Nengah Lestawi, and Dewi Bunga, “The role of customary law in the forest preservation in Bali,” *Journal of Landscape Ecology* 13, no. 1 (2020): 29.

²⁵ Harmayani et al., “Initial indication of microplastics,” 730. See also, Haribowo, and Prayogo, “Analisa Kualitas Air Sungai Tukad Badung,” 47.

²⁶ Widiatedja, “The regulatory failure of spatial planning,” 31.

²⁷ Abidin et al., “Impact of population growth,” 110545.

compliance.²⁸ This function is particularly important given the environmental pressures affecting Tukad Badung, including water-quality concerns and initial evidence of microplastics in its water and sediment.²⁹ These conditions indicate that riverbank protection is closely connected to broader pollution and water-quality management. River degradation involves not only physical encroachment but also waste accumulation, pollution, and ecological deterioration. Accordingly, effective protection requires continuous environmental and spatial monitoring supported by coordinated regulatory and enforcement measures.³⁰

Government intervention is also reflected in efforts to maintain the environmental and public functions of the river. These include river cleaning, management of riverbank spaces, improvement of environmental quality, maintenance of supporting infrastructure, and measures intended to reduce risks associated with flooding and riverbank degradation. Such interventions demonstrate that river protection is not implemented exclusively through prohibitions. It also involves positive government action to maintain and restore the river as part of the urban environmental system. This approach is consistent with the broader development of environmental governance, which increasingly emphasizes integrated management rather than isolated regulation of individual environmental problems.³¹ The riverbank therefore functions simultaneously as a protected environmental space, a water-management area, and a component of urban public infrastructure.

The implementation findings also indicate the importance of inter-institutional coordination. Riverbank management involves different administrative responsibilities, including water resources, environmental protection, spatial planning, public works, urban infrastructure, sanitation, and enforcement. The effectiveness of riverbank protection consequently depends on coordination between institutions rather than on the performance of a single agency. This is consistent with research showing that water and environmental governance in Indonesia can be weakened by institutional fragmentation and overlapping sectoral responsibilities.³² In the Tukad Badung context, coordination is particularly necessary because a decision concerning land use may have consequences for water

²⁸ Zahroh, and Najjicha, "Problems and challenges on environmental law," 61. See also, Maruf, "Legal aspects of environment," 337.

²⁹ Harmayani et al., "Initial indication of microplastics," 732. See also, Haribowo, and Prayogo, "Analisa Kualitas Air Sungai Tukad Badung," 48.

³⁰ Basuki et al., "Water pollution of some major rivers," 3536.

³¹ Abdulkadir Rahardjanto et al., "Ecocultural practices in East Java, Indonesia: A hermeneutic phenomenological study on "Reresik Kali" as local wisdom for river conservation," *Social Sciences & Humanities Open* 12 (2025): 102176. See also, Pardede et al., "Perspectives of sustainable development," 3779.

³² Basuki et al., "Water pollution of some major rivers," 3538. See also, Bedner, "Consequences of decentralization," 43.

management, environmental quality, flood risk, and community livelihoods simultaneously.

The empirical findings show that local communities actively support Tukad Badung protection through cleaning, awareness, reporting, and maintenance.³³ Balinese customary values, including Subak and Tri Hita Karana, further strengthen collective environmental stewardship.³⁴ However, such participation remains supplementary to government legal responsibility.

The interviews conducted as part of the empirical research further illustrate how formal riverbank regulations are experienced and implemented at the local level. A local government official explained:

“Monitoring along the Tukad Badung River is conducted periodically, particularly to observe river cleanliness, the condition of the riverbank area, and community activities around the river. When activities that may interfere with the river’s function are identified, the government coordinates with the relevant agencies and provides guidance to the community to ensure that such activities comply with the applicable regulations.”
(Interview with a local government official in Denpasar, November 2025).

From the community perspective, a riverbank resident described the practical experience of these measures as follows:

“There are now more frequent cleaning activities and reminders not to dispose of waste into the river. Residents also participate when collective activities are organized. However, not everyone clearly understands the regulations concerning the riverbank boundary or what activities are permitted around the river. What we generally understand is that the river must be protected and should not be used indiscriminately.”
(Interview with a riverbank resident in Denpasar, November 2025).

These interviews indicate that the implementation of riverbank protection is perceived by communities primarily through visible forms of government intervention, including monitoring, environmental campaigns, cleaning activities,

³³ Tri Hayatining Pamungkas et al., “Optimising Flood Risk Reduction in Bali’s Provincial Government Center through Cultural Philosophy Approach and GIS-based Conservation of Infiltration Wells,” *Jurnal Presipitasi: Media Komunikasi Dan Pengembangan Teknik Lingkungan* 20, no. 3 (2023): 742. See also, Osorio et al., “Community water supply service systems,” 1732849; Yeni Rosilawati, and Jamilah Ahmad, “Local wisdom and Stakeholder engagement for corporate social responsibility (CSR) initiatives in Indonesia,” *Opción: Revista de Ciencias Humanas y Sociales* 21 (2019): 207.

³⁴ Joko Setiyono, and Aga Natalis, “Ecocides as a Serious Human Rights Violation: A Study on the Case of River Pollution by the Palm Oil Industry in Indonesia,” *International Journal of Sustainable Development & Planning* 16, no. 8 (2021): 1465. See also, Geria et al., “Built environment from the ancient Bali,” 24; Imamulhadi et al., “Customary environmental law,” 251469; Roth, “Environmental sustainability and legal plurality,” 6.

and restrictions on activities around the river. At the same time, the community response suggests that general environmental awareness is stronger than detailed knowledge of the applicable legal requirements. This distinction is important because compliance with riverbank protection cannot depend solely on the existence of formal regulations. Effective implementation also requires residents to understand the purpose and practical implications of those regulations. The findings therefore demonstrate a continuing interaction between formal state regulation, administrative supervision, and community participation in the protection of the Tukad Badung riverbank.

Importantly, community participation does not necessarily eliminate implementation tensions. Restrictions on riverbank activities may affect residents and businesses whose livelihoods or daily activities are connected to the river. This creates a need for communication, socialization, negotiation, and proportional enforcement. Indonesian experience demonstrates that top-down riverbank control may generate resistance when communities perceive enforcement as threatening housing or livelihood security. Participatory approaches can therefore improve both legitimacy and compliance by allowing affected communities to understand the purpose of restrictions and participate in finding workable solutions. Such an approach is consistent with evidence that sustainable river governance requires the integration of environmental objectives with social and economic interests.³⁵

The findings indicate that Tukad Badung protection requires regulatory enforcement alongside physical protection and environmental restoration. While structural measures can reduce erosion, they cannot address pollution, inappropriate land use, or uncontrolled development alone. Their effectiveness also depends on ecological considerations, standardization, and institutional capacity.³⁶ Therefore, integrated structural, regulatory, environmental, and social measures are necessary.

Riverbank protection in Tukad Badung remains multidimensional but faces an implementation gap. Although legal mechanisms cover spatial planning, environmental management, monitoring, participation, and enforcement, urban pressures persist. Water-quality and microplastic problems highlight that legal

³⁵ Osorio et al., “Community water supply service systems,” 1732851. See also, Suryawan et al., “Reinforcing the Ultimum Remedium,” 494.

³⁶ A. Mosyafitani et al., “Bio-Retaining wall as an adaptive design of constructed riverbank into sustainable urban riparian landscape management,” In *IOP Conference Series: Earth and Environmental Science*, (IOP Publishing, 2018), 12015. See also, I. Putu Gede Arya Kusdyana, “Conservation and utilization: Community-based natural and cultural tourism site design in West Bali National Park,” *Jurnal Kajian Bali (Journal of Bali Studies)* 15, no. 1 (2025): 93.

protection alone cannot ensure ecological recovery, reflecting broader weaknesses in coordination, supervision, compliance, and enforcement.³⁷

3.3. Legal and Institutional Gaps Affecting the Effectiveness of Riverbank Control

The findings identify several interconnected legal and institutional gaps that affect the effectiveness of riverbank control in protecting the ecological function of Tukad Badung. These gaps do not primarily arise from the absence of a legal basis. Indonesia already has a relatively comprehensive environmental and water-management framework, supported by constitutional environmental rights, environmental protection legislation, water-resource regulation, spatial-planning instruments, and specific provisions concerning rivers and riverbanks. The more fundamental problem is the distance between normative requirements and their practical implementation. This distance is particularly visible in legal certainty, regulatory integration, institutional coordination, supervision, enforcement, and the management of existing socio-economic interests along the riverbank. Similar problems have been identified in Indonesian environmental governance, where the existence of formal legal rules does not necessarily ensure effective environmental protection because implementation capacity and institutional coordination remain decisive.³⁸

The first gap concerns the relationship between legal norms and existing land-use conditions. Although Government Regulation Number 38 of 2011 and spatial-planning regulations establish riverbank protection, Tukad Badung contains long-established settlements, economic activities, infrastructure, and other uses with varying legal statuses. Enforcement therefore requires verification of land-use status, spatial conformity, environmental impacts, and river functions, followed by appropriate administrative, civil, or criminal measures.³⁹ The second gap concerns

³⁷ Bedner, “Consequences of decentralization,” 44. See also, Harmayani et al., “Initial indication of microplastics,” 734; Pardede et al., “Perspectives of sustainable development,” 3779; Utama et al., “Balancing Tourism and Conservation,” 238; Haribowo, and Prayogo, “Analisa Kualitas Air Sungai Tukad Badung,” 50.

³⁸ Josi Khatarina et al., “Natural Resources Management under Indonesian Law,” In *Routledge Handbook of Indonesian Law*, (Routledge, 2026), 615. See also, Haryadi et al., “Environmental regulations (its identification), 5003; Aditia Syaprih, and Fuad Shehab Shyyab, “Legislative framework for decentralized administration in addressing river pollution,” *Journal of Sustainable Development and Regulatory Issues (JSDEI)* 3, no. 1 (2025): 57.

³⁹ Dzulfikar Ahmad Fauzi, “Extrajudicial dispute resolution in handling environmental cases in Indonesia (Case study: River water pollution by PT Sugar Labinta in South Lampung),” *Indonesian Journal of Environmental Law and Sustainable Development* 3, no. 1 (2024): 99. See also, Hasyim, and Aprita, “The aspects of environmental law enforcement,” 214; Annisa Fianni Sisma, and Rahayu Subekti, “Comprehensive and Measurable Environmental Monitoring: A Comparison of Indonesian and Danish Concepts,” *Udayana Journal of Law and Culture* 8: 8.

regulatory integration and legal certainty. Overlapping environmental, water-resource, spatial-planning, land, and local-government regulations may create uncertainty in authority and implementation (Istislam et al., 2026), reflecting regulatory silos that hinder integrated river management.⁴⁰

The third gap concerns institutional capacity and continuous supervision. Effective riverbank protection requires regular monitoring because land-use changes, new construction, waste accumulation, and encroachment can reappear after enforcement. In Tukad Badung, this responsibility involves multiple institutions, including environmental, water-resource, spatial-planning, local-government, and enforcement authorities. Without clear coordination, monitoring may become fragmented and enforcement reactive rather than preventive. This reflects the importance of institutional arrangements, accountability, and supervision in effective environmental governance.⁴¹ Strengthening Tukad Badung governance therefore requires clearer responsibilities, integrated monitoring, information sharing, and coordinated enforcement.

The fourth gap concerns the preventive dimension of environmental regulation. Weak or discontinuous supervision can make enforcement reactive, with authorities responding only after development, pollution, erosion, or other impacts have occurred. Although environmental impact assessment and environmental quality standards provide preventive instruments, their effectiveness depends on integration with spatial control and post-permit monitoring.⁴² For Tukad Badung, protection should therefore address not only visible violations but also land-use changes, drainage, waste disposal, and infrastructure development whose cumulative impacts may affect river functions. Riverbank control consequently needs to be integrated with broader urban and catchment environmental management.

The fifth gap concerns the social and economic dimensions of enforcement. Tukad Badung is not only an ecological space but also supports residential, commercial, informal economic, and community activities. Strict enforcement

⁴⁰ Alan H. Vicory, and Peter Tennant, "River Basin Planning and Management in 2050," *Toward a Sustainable Water Future, Visions for 2050* (2012): 77. See also, Khatarina et al., "Natural Resources Management," 619; Zhaoyin Wang et al., "Principles of river training and management," *International Journal of sediment research* 22, no. 4 (2007): 247.

⁴¹ Scott Fulton, and Steve Wolfson, "Strengthening national environmental governance to promote sustainable development," In *Global Environmental Law at a Crossroads*, (Edward Elgar Publishing, 2014), 29. See also, A. M. Haque et al., "Integrating environmental governance into sustainable urban development in Bangladesh," *Planning* 17, no. 5 (2022): 1473; Sisma, and Subekti, "Comprehensive and Measurable Environmental," 9.

⁴² Rosye Hefmi Rechnetly Tanjung et al., "Analysis of surface water quality of four rivers in Jayapura Regency, Indonesia: CCME-WQI approach," *Journal of Ecological Engineering* 23, no. 1 (2022): 78. See also, I. Utama, and I. Nengah Suharta, "The challenges of water pollution: Enforcement of water pollution control," *Hasanuddin Law Review* 4, no. 1 (2025): 86.

without considering these interests may generate resistance and weaken regulatory legitimacy, while excessive accommodation may undermine river functions. Indonesian experience shows that dialogue, participation, and negotiated approaches can strengthen the legitimacy of riverbank interventions, including through relocation assistance for affected communities.⁴³ Community awareness, monitoring, and environmental activities can further support compliance.⁴⁴ Thus, participation should complement, rather than replace, legal enforcement.

The sixth gap concerns the limited integration of formal regulation with local knowledge and community institutions. Bali's environmental governance includes customary practices and local ecological knowledge, particularly through Subak, Awig-Awig, and the Tri Hita Karana philosophy.⁴⁵ Collaborative river-preservation initiatives also show that community, government, and other stakeholders can strengthen environmental participation.⁴⁶ For Tukad Badung, communities should therefore be treated as governance actors who can support monitoring, reporting, riverbank maintenance, clean-up activities, and environmental awareness. Integrating local knowledge with formal regulation can strengthen sustainable river governance and improve responsiveness to local environmental conditions.⁴⁷

The seventh gap concerns integrating riverbank control with watershed and urban environmental management. Riverbank protection alone is insufficient when upstream land-use change, drainage, waste disposal, and urbanization increase runoff and environmental risk. Therefore, control should be integrated with drainage, waste management, water-quality protection, flood control, and watershed conservation, consistent with integrated water-resources management

⁴³ John Taylor, "A tale of two cities: comparing alternative approaches to reducing the vulnerability of riverbank communities in two Indonesian cities," *Environment and Urbanization* 27, no. 2 (2015): 623.

⁴⁴ Gabriel A. Kristanto et al., "The Citarum River as our front yard: A case of community engagement in Bintang Alam, Indonesia," In *IOP Conference Series: Earth and Environmental Science*, (IOP Publishing, 2021), 12003. See also, Daniel Mambo Tampi et al., "Bottom up approach: Kancil, The strive of local informal communities," *Section 1 Urban Strategies* (2017): 437.

⁴⁵ Mirsa Umiyati, "The existence of natural lexicons in 'awig-awig' Tenganan Pegriingsingan Bali: An ecolinguistic approach," *Jurnal Kajian Bali (Journal of Bali Studies)* 10, no. 1 (2020): 194. See also, Arsana et al., "SUBAK: Traditional ecological knowledge," 12006; Zen et al., "Sustaining subak, the balinese traditional, 12037.

⁴⁶ Yeni Rosilawati et al., "Penta Helix Model Communication to Promote Appropriate and Green Technologies for Ayung River Preservation Program in Bali," In *E3S Web of Conferences*, (EDP Sciences, 2023), 401.

⁴⁷ Osorio et al., "Community water supply service systems," 1732854. See also, Ana Carolina Torregroza-Espinosa et al., "Ancestral knowledge and river systems: pathways to sustainability, peace, and community resilience," *Water* 17, no. 13 (2025): 1967.

and adaptive environmental governance, rather than treated as isolated land-use enforcement.⁴⁸

Table 1. Legal and Institutional Gaps Affecting Tukad Badung Riverbank Control

No.	Legal and Institutional Gap	Empirical/Regulatory Finding	Implication for Tukad Badung	Required Response	Governance
1	Legal norms vs. existing land use	Riverbank protection requirements coexist with long-established settlements, commercial activities, infrastructure, and other land uses with different legal and administrative statuses.	Direct enforcement may create conflict, while excessive tolerance may weaken riverbank protection.	Verify land-use status, spatial conformity, environmental impacts, and apply proportional and procedurally fair enforcement.	
2	Regulatory integration and legal certainty	Riverbank governance involves environmental, water-resource, spatial-planning, land, and local-government regulations. Overlapping mandates may create fragmented implementation and different institutional interpretations.	Uncertainty may arise over monitoring responsibility, enforcement authority, and applicable regulatory instruments.	Harmonize regulations and clarify institutional mandates and enforcement procedures.	
3	Institutional capacity and continuous supervision	Riverbank conditions are dynamic, while monitoring responsibilities are distributed among multiple institutions.	Fragmented monitoring may allow violations to recur and make enforcement predominantly reactive.	Establish continuous monitoring, clearer responsibilities, information sharing, and coordinated follow-up.	
4	Preventive environmental regulation	Environmental impact assessment and environmental quality standards provide preventive instruments, but their effectiveness depends on spatial control and post-permit monitoring.	Environmental problems may be addressed only after development, pollution, erosion, or other impacts have occurred.	Strengthen preventive monitoring and integrate riverbank control with development, drainage, waste, and catchment management.	
5	Social and economic dimensions of enforcement	Riverbanks support residential, commercial, informal economic, and community activities that may conflict with ecological protection.	Strict enforcement may generate resistance, while excessive accommodation may normalize activities that impair river functions.	Combine legal enforcement with dialogue, participation, procedural fairness, and, where appropriate, negotiated arrangements.	
6	Limited integration of local knowledge and community institutions	Bali has community-based environmental institutions and knowledge, including Subak, Awig-Awig, and Tri Hita Karana, but these are not fully integrated into formal riverbank control.	Government regulation may be less responsive to local environmental conditions and community capacities.	Involve communities in monitoring, reporting, maintenance, awareness, and conservation while integrating relevant local knowledge into governance.	
7	Riverbank control vs. wider watershed and urban management	Riverbank conditions are influenced by upstream land use, drainage, waste, urbanization, runoff, and watershed processes beyond the physical river boundary.	Boundary-based enforcement alone cannot adequately maintain the river's ecological function.	Integrate riverbank protection with drainage, waste management, water quality, flood control, spatial planning, and watershed management.	

Source: Author's synthesis based on the findings and relevant literature

⁴⁸ Michael Kidd et al., *Water and the law: Towards sustainability*, (Edward Elgar Publishing, 2014), 323. See also, Naori Miyazawa, "Impact of Policies on Traditional Resource Management: Case Studies on Subak in Bali, Indonesia," In *Climate Change Issues and Social Sciences: Towards a Carbon Neutral Society*, (Singapore: Springer Nature Singapore, 2025), 173.

The synthesis in Table 1 demonstrates that the effectiveness of Tukad Badung riverbank control is constrained primarily by an implementation gap rather than a regulatory vacuum. Although Indonesia provides a substantial legal framework for river protection, its effectiveness depends on regulatory coherence, institutional coordination, continuous supervision, consistent enforcement, and community participation.⁴⁹ The identified gaps are interconnected: regulatory fragmentation affects institutional coordination; weak supervision limits preventive enforcement; existing socio-economic uses complicate compliance; and limited integration of community knowledge and wider watershed management constrains the effectiveness of formal riverbank control.

Accordingly, effective riverbank protection requires harmonized regulations, clear institutional responsibilities, continuous supervision, fair enforcement, and meaningful community participation. Its success depends not merely on legal boundaries or enforcement, but on an integrated, accountable, coordinated, and socially legitimate governance system capable of maintaining ecological function and supporting sustainable Tukad Badung riverbank protection.

4. Conclusion

This study finds that riverbank protection in Indonesia is supported by a comprehensive legal framework involving constitutional principles, environmental law, water-resource regulation, river regulations, spatial planning, environmental quality standards, and administrative enforcement. For Tukad Badung, the main issue is therefore not the absence of legal rules, but the gap between legal provisions and their implementation. The findings identify several interconnected challenges: inconsistent control of existing land uses, fragmented institutional responsibilities, limited continuous supervision, reactive rather than preventive enforcement, social and economic pressures on riverbank areas, limited integration of community knowledge, and weak connection between riverbank control and wider watershed and urban environmental management.

These findings have important implications for river governance. Legal protection will be effective only when different regulatory instruments are implemented coherently and supported by capable institutions. Riverbank control should also consider the historical and socio-economic conditions of existing uses while maintaining the ecological and public functions of the river. Community

⁴⁹ Absori et al., "Critical analysis of River basin management regulation in Bengawan solo for water tourism: Local legislation in 7 regencies," *WSEAS Trans. Environ. Dev* 19 (2023): 852. See also, Edoardus E. Maturbongs, and Theresia Widi Asih Cahyanti, "Management and environmental conservation based on local wisdom," *Advanced Science Letters* 23, no. 3 (2017): 2513; Syapriallah, and Shyyab, "Legislative framework for decentralized administration," 58.

participation should complement, rather than replace, formal legal enforcement. Moreover, riverbank protection needs to be connected with water quality, drainage, waste management, flood control, and urban development policies.

Accordingly, several improvements are recommended. First, relevant regulations and spatial-planning requirements should be better coordinated. Second, institutional responsibilities for monitoring, enforcement, and follow-up should be clearly defined. Third, supervision should be continuous and preventive. Fourth, enforcement should be consistent while applying fair procedures to existing communities and land uses. Finally, communities should be actively involved in monitoring, reporting, environmental education, and river maintenance. These measures can strengthen integrated, preventive, and accountable governance of the Tukad Badung riverbank.

References

- Abidin, Afri Ahyarky, Endang Triningsih Soetrisno, and Dwiprayogo Wibowo. "Impact of population growth and housing development on the riverine environment: Identifying environmental threat and solution in the Wanggu River, Indonesia." *Ecological Modelling* 486 (2023): 110540.
- Absori, Absori, Trias Hernanda, K. Wardiono, A. Fitriadi, and Arief Budiono. "Critical analysis of River basin management regulation in Bengawan solo for water tourism: Local legislation in 7 regency." *WSEAS Trans. Environ. Dev* 19 (2023): 844-851.
- Angriani, Parida, Sumarmi, Ruja, I. N., and Bachri, S. "Local community-based river management: A case study of Kuin river, Banjarmasin, South Kalimantan–Indonesia." *Ecology, Environment and Conservation* 25, no. 1(2019).
- Aris, Ismail. "Strengthening environmental law policy and its influence on environmental sustainability performance: Empirical studies of green constitution in adopting countries." *International Journal of Energy Economics and Policy* (2020). <https://doi.org/10.32479/ijecp.8719>
- Ariwidodo, Eko and Ruslina Dwi Wahyuni." The Applying Modern Environmental Law in Southeast Asia: A Legal Philosophy Point of View." *Jurnal Hukum Unissula* 42, no. 3 (2026): 836-863. <https://doi.org/10.26532/jh.v42i3.40196>.
- Basuki, Tyas Mutiara, Dewi Retna Indrawati, Hunggul Yudono Setio Hadi Nugroho, Irfan Budi Pramono, Ogi Setiawan, Nunung Puji Nugroho, Firda Maftukhakh Hilmya Nada et al. "Water pollution of some major rivers in Indonesia: The status, institution, regulation, and recommendation for its mitigation." *Polish Journal of Environmental Studies* 33, no. 4 (2024): 3515-3530. DOI: <https://doi.org/10.15244/pjoes/178532>
- Bedner, Adriaan. "Consequences of decentralization: environmental impact assessment and water pollution control in Indonesia." *Law & Policy* 32, no. 1 (2010): 38-60. <https://doi.org/10.1111/j.1467-9930.2009.00313.x>
- Chapagain, Saroj Kumar, Geetha Mohan, Andi Besse Rimba, Carolyn Payus, I. Made Sudarma, and Kensuke Fukushi. "Analyzing the relationship between water pollution and economic activity for a more effective pollution control policy in Bali Province, Indonesia." *Sustainable Environment Research* 32, no. 1 (2022): 5. <https://doi.org/10.1186/s42834-021-00115-6>
- Dananjaya, Nyoman Satyayudha, and Fuchikawa Kazuhiko. "The citizens' constitutional rights regarding habitable and wholesome environment: Towards a law state that protects the environment." *Udayana Journal of Law and Culture* 4, no. 1 (2020): 81-103. <https://doi.org/10.24843/UJLC.2020.v04.i01.p05>
- Fahim, Md Hasnath Kabir, and Ramisa Jahan. "Environmental Management and Justice System in Bangladesh: Issues and Legal Framework." *Lex Publica* 12, no. 2 (2025): 317-330. <https://doi.org/10.58829/lp.12.2.2025.304>
- Fauzi, Dzulfikar Ahmad. "Extrajudicial dispute resolution in handling environmental cases in Indonesia (Case study: River water pollution by PT Sugar Labinta in South Lampung)." *Indonesian Journal of Environmental Law and Sustainable Development* 3, no. 1 (2024): 97-124.
- Fulton, Scott, and Steve Wolfson. "Strengthening national environmental governance to promote sustainable development." In *Global Environmental Law at a Crossroads*, pp. 13-29. Edward Elgar Publishing, 2014.
- Geria, I. Made, Titi Surti Nastiti, Retno Handini, Wawan Sujarwo, Acwin Dwijendra, Mohammad Ruly Fauzi, and Ni Putu Eka Juliawati. "Built environment from the ancient Bali: The Balinese heritage for sustainable water management." *Heliyon* 9, no. 11 (2023).

- Hakim, Lukman, Qatrunnada Hamparan Melati, and Purnawan Dwikora Negara. "Integrating Adat Law in Indonesia: Challenges and Opportunities in a Centralized Legal Framework." *Indonesian State Law Review* 8 (2025): 58-82. DOI: 10.1016/j.heliyon.2023.e21248
- Haque, A. Muhammad, S. A. Ullah, Md Masum Sikdar, Md Mehedi Hasan Shohag, Md Mokhtar, Mst Antara Masuda Ahmed, and Md Mahmud Alam. "Integrating environmental governance into sustainable urban development in Bangladesh." *Planning* 17, no. 5 (2022): 1471-1478. <https://doi.org/10.18280/ijstdp.170511>
- Haribowo, Riyanto, and Tri Budi Prayogo. "Analisa Kualitas Air Sungai Tukad Badung, Denpasar, Bali Menggunakan Program Qual2kw." *Jurnal Teknologi dan Rekayasa Sumber Daya Air* 1, no. 1 (2021): 40-51. <https://doi.org/10.21776/ub.jtresda.2021.001.01.04>
- Harmayani, Kadek Diana, Tony Hadibarata, Risky Ayu Kristanti, Pande Kadek Putri Mira Dayanti, Kadek Laksmi Satyawati, Putu Agus Ary Wiratama, and Putu Primantari Vikana Suari. "Initial indication of microplastics in the water and sediment of the Tukad Badung River in Bali, Indonesia." *Water, Air, & Soil Pollution* 236, no. 11 (2025): 727. <https://doi.org/10.1007/s11270-025-08365-5>
- Haryadi, Dwi, Ibrahim Ibrahim, and Darwance Darwance. "Environmental regulations (its identification and downstream implementation in Bangka Belitung)." In *E3S Web of Conferences*, vol. 241, p. 05002. EDP Sciences, 2021.
- Hasyim, Yonani, and Serlika Aprita. "The aspects of environmental law enforcement in Indonesia and the implementation of international agreements in the environmental field in Indonesia." *Nurani: jurnal kajian syaria'ah dan masyarakat* 21, no. 2 (2021): 209-218. <https://doi.org/10.19109/nurani.v21i2.8958>
- Huang, Hao, and Joti Rockwell. "Relational practices in Bali: Balinese Hinduism, subak, and music." *International Journal of Asia Pacific Studies* 19, no. 1 (2023). <https://doi.org/10.21315/ijaps2023.19.1.8>
- Imamulhadi, Eva Nuriyah Hidayat, Sherly Melintan Surya, and Hazmi Rusli. "Customary environmental law and its transformation models in Indonesia." *Cogent Social Sciences* 11, no. 1 (2025): 2514680. <https://doi.org/10.1080/23311886.2025.2514680>
- Khatarina, Josi, Mas Achmad Santosa, Difa Shafira, and Gridanya Mega Laidha. "Natural Resources Management under Indonesian Law." In *Routledge Handbook of Indonesian Law*, pp. 601-615. Routledge, 2027.
- Kidd, Michael, Loretta Feris, Tumai Murombo, and Alejandro Iza, eds. *Water and the law: Towards sustainability*. Edward Elgar Publishing, 2014.
- Kristanto, Gabriel A., Mochamad A. Pratama, Paras AC Nandhita, Dini Kemala, Abdurrahman Munif, and Divia A. Ahmad. "The Citarum River as our front yard: A case of community engagement in Bintang Alam, Indonesia." In *IOP Conference Series: Earth and Environmental Science*, vol. 716, no. 1, p. 012003. IOP Publishing, 2021.
- Kusdyana, I. Putu Gede Arya. "Conservation and utilization: Community-based natural and cultural tourism site design in West Bali National Park." *Jurnal Kajian Bali (Journal of Bali Studies)* 15, no. 1 (2025): 92-118. <https://doi.org/10.24843/JKB.2025.v15.i01.p04>
- Lestawi, I. Nengah, and Dewi Bunga. "The role of customary law in the forest preservation in Bali." *Journal of Landscape Ecology* 13, no. 1 (2020): 25-41. <https://doi.org/10.2478/jlecol-2020-0002>
- Madjid, Abdul, Nur Hidayah, Evi Satispi, Rahmat Salam, and Azhari Aziz Samudra. "Cumulative ecological impacts of river sand mining under weak environmental governance in Indonesia." *Environment and Water Engineering* 12, no. 1 (2026): 28-36. <https://doi.org/10.22034/ewe.2026.244330>

- Maruf, Arifin. "Legal aspects of environment in Indonesia: An efforts to prevent environmental damage and pollution." *Journal of Human Rights, Culture and Legal System* 1, no. 1 (2021). <https://doi.org/10.53955/jhcls.v1i1.4>
- Maturbongs, Edoardus E., and Theresia Widi Asih Cahyanti. "Management and environmental conservation based on local wisdom." *Advanced Science Letters* 23, no. 3 (2017): 2512-2514. <https://doi.org/10.1166/asl.2017.8661>
- Miyazawa, Naori. "Impact of Policies on Traditional Resource Management: Case Studies on Subak in Bali, Indonesia." In *Climate Change Issues and Social Sciences: Towards a Carbon Neutral Society*, pp. 171-190. Singapore: Springer Nature Singapore, 2025.
- Mosyaftiani, A., Kaswanto, and H. S. Arifin. "Bio-Retaining wall as an adaptive design of constructed riverbank into sustainable urban riparian landscape management." In *IOP Conference Series: Earth and Environmental Science*, vol. 179, no. 1, p. 012015. IOP Publishing, 2018. DOI 10.1088/1755-1315/179/1/012015
- Nugroho, Hunggul Yudono Setio Hadi, Tyas Mutiara Basuki, Irfan Budi Pramono, Endang Savitri, Purwanto, Dewi Retna Indrawati, Nining Wahyuningrum et al. "Forty years of soil and water conservation policy, implementation, research and development in Indonesia: a review." *Sustainability* 14, no. 5 (2022): 2972. <https://doi.org/10.3390/su14052972>
- Nurhidayah, Laely, and Shawkat Alam. "The forest and its biodiversity: Assessing the adequacy of biodiversity protection laws in Indonesia." *Asia Pacific Journal of Environmental Law* 23, no. 2 (2020): 178-201. <https://doi.org/10.4337/apjel.2020.02.04>
- Nyoman Arsana, I., Ni Ketut Ayu Juliasih, I. Putu Sudiartawan, Anak Agung Komang Suardana, I. Made Sumarya, and A. A. A. Sauca Sunia Widyantari. "SUBAK: Traditional ecological knowledge for sustainable biodiversity conservation." In *IOP conference series: Earth and environmental science*, vol. 1438, no. 1, p. 012005. IOP Publishing, 2025.
- Osorio, Angela, Malory Mazuera, Fabio Andres Baez Perez, and Hellen Cristancho Garrido. "Community water supply service systems in the high basin of the Guarino River (Marulanda, Caldas, Colombia) as territorialities for sustainability." *Frontiers in Water* 8 (2026): 1732846. <https://doi.org/10.3389/frwa.2026.1732846>
- Pamungkas, Tri Hayatinig, Mawiti Infantri Yekti, and Kadek Budhi Warsana. "Optimising Flood Risk Reduction in Bali's Provincial Government Center through Cultural Philosophy Approach and GIS-based Conservation of Infiltration Wells." *Jurnal Presipitasi: Media Komunikasi Dan Pengembangan Teknik Lingkungan* 20, no. 3 (2023): 740-754. <https://doi.org/10.14710/presipitasi.v20i3.740-754>
- Pardede, Marulak, Mosgan Situmorang, Syprianus Aristeus, Ismail Rumadan, Henry Donald Lumban Toruan, Diogenes, Djamilus, and Ellen Lutya Putri Nugrahani. "Perspectives of sustainable development vs. law enforcement on damage, pollution and environmental conservation management in Indonesia." *Journal of Water and Climate Change* 14, no. 10 (2023): 3770-3790. <https://doi.org/10.2166/wcc.2023.417>
- Rahardjanto, Abdulkadir, Atok Miftachul Hudha, and Tutut Indria Permana. "Ecocultural practices in East Java, Indonesia: A hermeneutic phenomenological study on "Reresik Kali" as local wisdom for river conservation." *Social Sciences & Humanities Open* 12 (2025): 102176.
- Rifan, Moch, Nilam Ayu Kasanah, Hezron Sabar Rotua Tinambunan, and Najah Baroud. "Environmental Legal Protection Regulation through a Judicial Process Based on Legal Certainty and Anti-SLAPP Principles." *Jurnal Suara Hukum* 8, no. 1 (2026). <https://doi.org/10.26740/jsh.v8n1.p101-131>
- Rosilawati, Yeni, and Jamilah Ahmad. "Local wisdom and Stakeholder engagement for corporate social responsibility (CSR) initiatives in Indonesia." *Opción: Revista de Ciencias Humanas y Sociales* 21 (2019): 205-220.

- Rosilawati, Yeni, Atik Septi Winarsih, Zain Rafique, and Muhammad Iqbal Khatami. "Penta Helix Model Communication to Promote Appropriate and Green Technologies for Ayung River Preservation Program in Bali." In *E3S Web of Conferences*, vol. 425, p. 04001. EDP Sciences, 2023. <https://doi.org/10.1051/e3sconf/202342504001>
- Roth, Dik. "Environmental sustainability and legal plurality in irrigation: the Balinese subak." *Current Opinion in Environmental Sustainability* 11 (2014): 1-9.
- Setiyono, Joko, and Aga Natalis. "Ecocides as a Serious Human Rights Violation: A Study on the Case of River Pollution by the Palm Oil Industry in Indonesia." *International Journal of Sustainable Development & Planning* 16, no. 8 (2021): 1465. doi. 10.18280/ijstdp.160807
- Sisma, Annisa Fianni, and Rahayu Subekti. "Comprehensive and Measurable Environmental Monitoring: A Comparison of Indonesian and Danish Concepts." *Udayana Journal of Law and Culture* 8: 83-108.
- Sundari, Andi, Irwansyah Irwansyah, Iin Karita Sakharina, Muhammad Irwan, and Rasulov Ilkhom Inamovich. "Victims of Crime and Environmental Pollution in Indonesia: The Right to Restitution and Legal Inadequacies." *Journal of Law, Environmental and Justice* 3, no. 2 (2025): 476-505. <https://doi.org/10.62264/jlej.v3i2.178>
- Suryawan, I Gusti Bagus, I. Putu Ngurah Aryana, Yohanes I. Wayan Suryadi, M. Ngurah Arya Yogie Krsna, and Mirela Maria Ribeiro Guterres. "Reinforcing the Ultimatum Remedium Principle in Environmental Law Enforcement: A Three-Layered Approach Under Law No. 32 of 2009." *Jurnal Hukum Unissula* 41 (2025): 490-513. <https://doi.org/10.26532/jh.v41i2.43298>.
- Syaprih, Aditia, and Fuad Shehab Shyyab. "Legislative framework for decentralized administration in addressing river pollution." *Journal of Sustainable Development and Regulatory Issues* 3, no. 1 (2025): 55-77. <https://doi.org/10.53955/jsderi.v3i1.39>
- Tampi, Daniel Mambo, Widyawati Sumadio, and Jachrizal Sumabrata. "Bottom up approach: Kancil, The strive of local informal communities." *Section 1 Urban Strategies* (2017): 437. doi:10.2495/SC170381
- Tanjung, Rosye Hefmi Rechnelty, Marcelino Novryanto Yonas, Suwito Suwito, Hendra Kurniawan Maury, Yulius Sarungu, and Baigo Hamuna. "Analysis of surface water quality of four rivers in Jayapura Regency, Indonesia: Ccme-Wqi approach." *Journal of Ecological Engineering* 23, no. 1 (2022): 73-82. <https://doi.org/10.12911/22998993/143998>
- Taylor, John. "A tale of two cities: comparing alternative approaches to reducing the vulnerability of riverbank communities in two Indonesian cities." *Environment and Urbanization* 27, no. 2 (2015): 621-636. <https://doi.org/10.1177/0956247815594532>
- Torregroza-Espinosa, Ana Carolina, Nayerlis Guzmán, Juan Camilo Restrepo, Ana Cristina De la Parra-Guerra, Mónica Acuña Rodríguez, David Alejandro Blanco Álvarez, and Rebecca Stumpf. "Ancestral knowledge and river systems: pathways to sustainability, peace, and community resilience." *Water* 17, no. 13 (2025): 1966. <https://doi.org/10.3390/w17131966>
- Umiyati, Mirsa. "The existence of natural lexicons in 'awig-awig' Tenganan Pegringsingan Bali: An ecolinguistic approach." *Jurnal Kajian Bali (Journal of Bali Studies)* 10, no. 1 (2020): 191-216. <https://doi.org/10.24843/JKB.2020.v10.i01.p09>
- Utama, I., and I. Nengah Suharta. "The challenges of water pollution: Enforcement of water pollution control." *Hasanuddin Law Review* 4, no. 1 (2025): 81-87. <https://doi.org/10.20956/halrev.v4i1.1414>
- Utama, I., Christimulia Purnama Trimurti, I. Junaedi, and Ni Putu Dyah Krismawintari. "Balancing Tourism and Conservation: The Role of Local Communities in Bali's Ecotourism Management." *Available at SSRN 6175620* (2025).
- Vicory, Alan H., and Peter Tennant. "River Basin Planning and Management in 2050." *Toward a Sustainable Water Future, Visions for 2050* (2012): 76-83.

- Wang, Zhaoyin, Shimin Tian, Yujun Yi, and Guoan Yu. "Principles of river training and management." *International Journal of sediment research* 22, no. 4 (2007): 247.
- Widiatedja, I. Gusti Ngurah Parikesit. "The regulatory failure of spatial planning and its environmental impact: a case study of hotel projects in Bali, Indonesia." *Journal of Property, Planning and Environmental Law* 14, no. 1 (2022): 25-44. <https://doi.org/10.1108/JPPPEL-10-2021-0048>
- Zahroh, Umami A'Zizah, and Fatma Ulfatun Najicha. "Problems and challenges on environmental law enforcement in Indonesia: AMDAL in the context of administrative law." *Indonesian State Law Review* 5, no. 2 (2022): 53-66. <https://doi.org/10.15294/islrev.v5i2.46511>
- Zen, Irina Safitri, S. P. K. Surata, Prima Wahyu Titisari, S. A. Ab Rahman, and S. Zen. "Sustaining subak, the balinese traditional ecological knowledge in the contemporary context of Bali." In *IOP Conference Series: Earth and Environmental Science*, vol. 1306, no. 1, p. 012034. IOP Publishing, 2024. DOI 10.1088/1755-1315/1306/1/012034