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BRIDGING CULTURAL BELIEFS AND RIVER RESTORATION PREFERENCES: A SURVEY OF WATER RESOURCE MANAGERS IN BALI

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Abstract

Water, considered as a sacred element in Balinese culture, is deeply connected to the island's spiritual and communal existence. Despite the traditional beliefs of Tri Hita Kirana and Sad Kertih, which emphasize harmony and conservation, the management of Bali's water resources has become increasingly complex due to current issues including pollution. This study addresses connection between the cultural beliefs of Balinese water resource managers and their approaches for addressing current water management challenges, specifically their preference towards river restoration strategies. This study used a quantitative approach to collect data from water resource managers in the Bali Penida River Basin using an online questionnaire via Google Forms. The questionnaire was developed based on two established frameworks to comprehensively explore perceptions of water values, local wisdom, water resources management issues, and the socio-ecological impacts of various river restoration scenarios. The findings show that the perceptions of water of major water resources managers (65%) are influenced by personal experience and cultural heritage, which extend beyond local wisdom alone. Respondents showed a pronounced preference towards combination designs (75% satisfaction) that combine natural components with functional and recreational facilities when considering restoration scenarios. These findings provide policymakers with a practical framework for designing river restoration projects that ensure higher institutional and public compliance by transforming Tri Hita Karana into tangible socio-ecological infrastructure. To achieve sustainable water governance, future river basin regulations must require stakeholder-backed hybrid models rather than isolated ecological restrictions.

Keywords: Balinese society, cultural beliefs, river restoration, water governance.

Introduction

For centuries, Balinese society has emphasized the harmony among belief, community, and nature. Numerous Balinese sacred rituals suggest that Hinduism has superimposed itself upon indigenous religious practices, augmenting rather than replacing the profound animistic beliefs of the Balinese people. The majority of Balinese persist in honoring local deities associated with agriculture, water, and

earth, who require continual appeasement to avert misfortune, including Dewi Danu, the goddess of water in the island's life-sustaining lakes and rivers. Numerous remnants and inscriptions from ancient Bali also illustrate environmental management practices. Numerous megalithic sites, including dolmens, menhirs, and stone vessels, adjacent to a reservoir, water spring, upstream rivers, and mountainous forest, exemplify this phenomenon. Natural or minimally altered stones continue to be employed in the construction of basic structures, frequently located near a well, confluence, small creek, or irrigation canal. Balinese local wisdom contributes in environmental, including water resources preservation by altering and managing nature to reconcile human needs with conservation efforts (Geria et al., 2023; Huang, 2019).

Water is regarded as a sacred entity and holds significant value in Bali. Water is venerated as a sacred symbol due to its essential role in the survival of all living organisms, including humans, animals, and plants. Balinese ceremonies possess unique visual characteristics as a means of identification (Wahyuni et al., 2023). As a daily and annual expression of gratitude for the universe's divine blessings, their community groups diligently strive to conserve sacred water sources for consumption, irrigation, and purification, among other purposes. The economic rationality of the Balinese Hindu community in their quest for individual happiness is evidenced by the continuity of ritual ceremonies (Saraswati, 2024). However, the global situation of water scarcity has resulted in a paradigm shift, transforming water from a social to an economic asset (Nurcahyono et al., 2022). Navigating the complexities of this transition requires striking a balance between embracing modernization and preserving cultural heritage. Successful case studies from various regions show that it is possible to combine modernization and cultural preservation through supportive policies, community engagement, and educational programs (Angkasawati, 2024). This approach allows the Balinese to preserve their traditions while addressing modern water management challenges. However, there is a profound contradiction between the reverence for water held in spiritual traditions and the fact that it is severely polluted as a result of rapid urbanisation. This gap demonstrates the disconnect between traditional beliefs and modern management practices.

The management of water in Bali is becoming a more intricate social issue due to the frequently conflicting perspectives of stakeholders, each of whom has their own unique interests and significant stakes. Stakeholders may be directly or indirectly impacted by inherent biases that arise when determining the optimal intervention to manage water resources. It is crucial to recognize that the attitudes of stakeholders toward the intervention will be significantly influenced by their beliefs regarding the likely consequences of water management intervention. In order to create sustainable and feasible water resource management strategies that align with public sentiments, it is imperative to understand their societal beliefs regarding water (Faust et al., 2013; Jacobs and Buijs, 2011). Therefore, this paper will provide a more comprehensive examination of the relationship and influence of their beliefs on Balinese water culture, as well as their influence on water management practices in Bali.

Innovative and culturally sensitive solutions are required due to the increasing complexity of water management in Bali. Despite the traditional emphasis on spiritual harmony and conservation, current issues including urbanization and pollution require the implementation of novel strategies and intervention, such as river restoration. According to Haeri and Masnavi (2023), rivers are unique geographical features that is imperative to preserve and restore the ecological value in each land through planning. The concept of process-based river restoration has been frequently discussed in recent years with comprehensive ecological-social approach is complemented by integrated techniques that address the primary causes of ecosystem degradation and establish a new equilibrium between sustainable water resource management and socioeconomic needs. However, stakeholder acceptance is a critical factor in the success of any intervention, and it is significantly influenced by their professional and cultural beliefs.

A critical research gap exists in the comprehension of the direct impact of managers' cultural beliefs on their preferential approaches to practical river restoration. Therefore, the objective of the study is to discover this complex relationship by addressing the following fundamental questions: (1) What are the fundamental beliefs and values of Balinese water resource managers in relation to water? and (2) How do their cultural values and perceptions influence their preferences for various river restoration strategies? By addressing these questions, this paper fills this gap and endeavors to contribute valuable insights for the development of water management solutions that are both effective and in accordance with the particular cultural context of Bali by addressing these questions.

Method

This study was carried out in August 2025. Due to the profound cultural relationship between Bali and water, the selected site for this study is the Bali Penida River Basin. Based on Ministerial Regulation of Public Works and Housing No. 04/PRT/M/2015 on the Criteria and Establishment of River Basins, this river basin is designated as a National Strategic River Basin, identified by Code Number 03.01.A3, and consist of the 391 watershed. Information for this study was collected through online questionnaires distributed to the sample respondents via Google Forms. It is utilized as an online data collection tool, which is likely the most appropriate method for social scientists due to its rapidity, precision, and cost-free nature. Data gathered via Google Forms is consistently secure as it is stored in cloud storage (Bhalerao, 2015).

The River Basin Organization of Bali Penida (2019) has documented a water resource management plan for the Bali Penida River Basin, developed through comprehensive and integrated planning to strategize, execute, monitor, and assess efforts for water resource conservation, utilization, and the mitigation of water's destructive potential, in accordance with the water resources management framework. The water resources management plan includes both a non-physical and physical management matrix, employed to develop water resource management programs and activities within the river basin by stakeholders, specifically water

resource management institutions and related sectors, totaling 31, which constitute the population in this study.

According to the Act of the Republic of Indonesia No. 17 of 2019 concerning Water Resources, Water Resources Management involves cross-sectoral and cross-regional interests necessitating integrated actions to sustain the functions and benefits of Water and Water Resources. The intended Water Resources Management is implemented through coordination which incorporates the interests of diverse sectors, regions, and stakeholders in the domain of Water Resources. In Bali Province, the Bali Penida River Basin Water Resources Management Coordination Team, abbreviated as TKPSDA WS Bali Penida, was established in 2011 and is currently in its third period (2023-2028). TKPSDA WS Bali Penida comprises 15 representatives from water resource management institutions at the central, provincial, and district/city levels, alongside 15 representatives from non-governmental organizations across various sectors related to water resources (Ministerial Decree of Public Works and Public Housing No. 1528/KPTS/M/2023 on the Formation of the Coordination Team for Water Resources Management of the Bali-Penida River Basin). The operation of TKPSDA WS Bali Penida is managed by an administrative Secretariat responsible for executing its duties and functions. TKPSDA WS Bali Penida include as the population for this study.

The total population of this study is 61. The minimum sample size was then determined using the Slovin formula with a 15% margin of error, considering the small population and the inclusion of certain water resource management agencies that are also members of the TKPSDA WS Bali Penida. The potential sample pool was intentionally restricted by a 15% margin of error, as the target population is highly specific, small, and institutional, which restricts the sample size. The exploratory purpose of this study is adequately represented by a smaller but highly qualified sample size, as the respondents are specialized water resource experts rather than the general public. Therefore, the total number of required samples is 26, consistent with the completed online questionnaire.

$$n = \frac{N}{1+Ne^2} \tag{1}$$

where:
n : the number of samples
N : the number of population
e : the margin of error

The questionnaire will address two study frameworks, including the study conducted by Pradipta et al. (2023), regarding perceptions of water values, sources of perceptions, local wisdom in water resource management, and major problems in water governance in Bali. To evaluate river status assessments, perceptions of the socio-ecological impacts of urban rivers, and viewpoints on restoration scenarios as a water resource management strategy, the questionnaire will be derived from the research conducted by Cao et al. (2024). The combination of these two frameworks facilitates comprehensive data collection to properly address the social, ecological, and governance aspects of water.

This study included four unique restoration scenarios developed by Cao et al. (2024), each indicated by a specific hue of blue to illustrate enhanced water quality. Scenarios 2 and 4 exhibited a greener hue attributable to aquatic and riparian vegetation, whereas Scenarios 1 and 3 displayed a bluer tone due to the absence of vegetation and the presence of concrete. Regarding design, Scenarios 1 and 3 incorporated concrete riverbanks; however, Scenario 3 also encompassed recreational facilities. In contrast, Scenarios 2 and 4 displayed natural riverbanks characterized by diverse vegetation. The scenarios emphasized the possible conflicts and harmonies between the ecological and recreational roles of urban rivers. Scenario 3 presented numerous recreational opportunities, perhaps at the sacrifice of suitable habitats, whereas Scenario 2 ensured high biodiversity but lacked direct water access. Scenario 4 endeavored to achieve equilibrium by incorporating elements such as benches and stones to facilitate human interaction while preserving certain ecological attributes. The detail can be seen in Figure 1.

(Source: Cao et al., 2024)

Figure 1. River restoration scenario

In accordance with Cao et al. (2024), the interpretation of the questionnaire results was established by calculating the mean for each response, achieved by converting qualitative responses into a quantitative scale. In the initial dataset, responses categorized as 'Poor', 'Neutral', and 'Satisfactory' were allocated numerical values of 1, 2, and 3, respectively. The second dataset, pertaining to significance, employed a 5-point scale with 'Very unimportant' as 1, 'Not important' as 2, 'Neutral' as 3, 'Important' as 4, and 'Very Important' as 5. The third set regarding satisfaction was likewise transformed into a 5-point scale, where 'Very dissatisfied' corresponds to 1, 'Dissatisfied' to 2, 'Neutral' to 3, 'Satisfied' to 4, and 'Very satisfied' to 5. The mean values were subsequently analyzed according to their placement within the numerical spectrum. For example, on a 3-point scale (1-3), a mean score ranging from 1.00 to 1.66 signified a "Poor" tendency, whereas for the 5-point scales, the ranges were proportionately modified to represent varying degrees of significance

or satisfaction. This methodology converts subjective feedback into objective, quantifiable data, offering a definitive statistical foundation for comprehending the overall sentiment of the respondents.

Result and Discussion

Respondent Characteristic

This study demonstrates substantial demographic diversity among respondents, encompassing a range of perspectives from various generations and professional tiers (Table 1). Demographic and socio-economic factors could influence water resources governance (Gondo et al., 2020). The study successfully gathered viewpoints from participants that covered a wide age range, i.e., 30-42 years (34.6%), 43-54 years (30.8%), and 55-67 years (35%), encompassing both early-career individuals and experienced professionals, with a slight male majority (61.5%). The participation of respondents from water resource management institutions provided technical and institutional insights, whereas the involvement of members from TKPSDA WS Bali Penida added a collaborative and policy dimension.

Table 1. Respondent characteristics

Characteristics		Percentage
Gender	Male	61.5%
	Female	38.5%
Age Group	30-42	34.6%
	43-54	30.8%
	55-67	34.6%
Higher Education Level	Diploma	3.8%
	Bachelor	42.3%
	Master	46.2%
	Doctoral	7.7%
Salary	Less than or equal to Rp3,000,000.00	11.5%
	Rp3,000,001.00 to Rp5,000,000.00	26.9%
	Rp5,000,001.00 to Rp10,000,000.00	34.6%
	More than Rp10,000,000.00	26.9%
Origin	Native Balinese	84.6%
	Not native Balinese, domiciled in Bali for more than 10 years	11.5%
	Not native Balinese, domiciled in Bali for less than 10 years	3.8%

The majority of respondents hold a bachelor's degree (42.3%) or a master's degree (46.2%), indicating a significant level of academic and professional proficiency. The incorporation of individuals possessing diplomas and doctorates enhances the diversity of academic viewpoints. A collection of salary data was necessary for reflecting the socio-economic diversity of the participants. The state of a economic status can affect viewpoints on water management matters, including the cost of water services and the equitable distribution of resources. The salary data indicates

a relatively uniform distribution across all income levels, with the highest concentration occurring in the Rp5,000,001.00 to Rp10,000,000.00 range (34.6%). The study predominantly emphasizes the perspectives of native Balinese individuals (84.6%), thereby establishing a robust foundation in local wisdom and cultural comprehension. The remaining participants are non-native Balinese residents, several of whom have resided on the island for an extended period, providing an additional perspective. This particular integration of practical experience, historical insight, and understanding of local wisdom is crucial for a profound understanding of how Bali's water culture can adapt to current challenges in sustainable water resource management.

Value and Perceptions of Water Resources

Values are developed through the acquisition and contemplation of knowledge, revealing the differences across cultures and historical periods. Although some fundamental values seem to be universally acknowledged, the particular valuation of goods and services, especially water, is profoundly subjective. An individual's readiness to exchange one item for another determines its value (Haileslassie et al., 2022). Figure 2 shows a profound and comprehensive understanding of the value of water. Out of 39 responses, as respondents could select multiple perceptions, the majority (48.7%) mainly considered water as a source of life for all living organisms. This demonstrates a profound understanding of the essential function of water. The data reveals an acknowledgment of the multifaceted value of water, with 17.9% perceiving it as a fundamental resource for basic needs, 10.3% believe it as an economic asset, and 10.3% considering water as a crucial component of the natural environment. The diverse perceptions suggest that stakeholders in Bali regard water holistically, considering multiple interrelated dimensions, including ecological, social, and economic aspects.

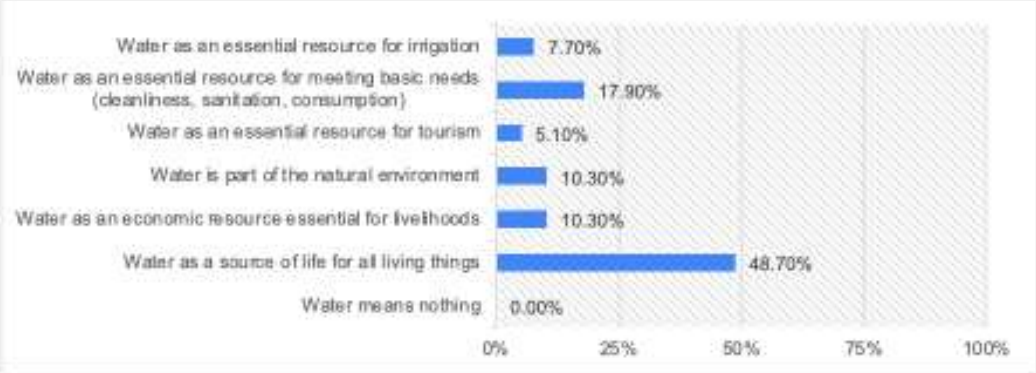

Figure 2. Perception about the value of water

Individuals evaluate new information not solely through objective analysis but also through a perspective influenced by their personal and cultural backgrounds. The claim that people evaluate evidence independently of prior beliefs is challenged by this observation (Sambrook et al., 2021). Their perceptions of water are distinctly diverse, including both indigenous knowledge and personal experience, as shown in Figure 3. 46.2% indicated that their perceptions stem from personal observations

of their surroundings. This suggests that firsthand experience and interaction with the environment profoundly shape their viewpoints. Cultural and spiritual values have considerable influence; 26.9% cited *Tri Hita Karana* (THK) values, whereas 19.2% referred to *Sad Kertih* (SK) values. Furthermore, 7.7% attributed their perceptions to teachings from their parents or ancestors, representing cultural heritage transmitted across generations. The cultural heritage and empirical experiences of the Balinese serve as significant filters, shaping their perceptions and valuation of water resources. Therefore, when analyzing the perspectives of Balinese stakeholders regarding water, it is essential to recognize these foundational influences instead of dismissing them as mere bias.

The preference for empirical observation over strict adherence to traditional doctrines (THK and SK) reflects a critical cognitive shift among contemporary managers. While cultural identity remains important, real-time exposure to environmental degradation necessitates a pragmatic reassessment of water value. This dual-lens phenomenon is consistent with cross-cultural research in regions with strong indigenous water ethics. Thus, Balinese local wisdom is not a static dogma, but rather an adaptive socio-ecological framework that changes in tandem with the physical landscape.

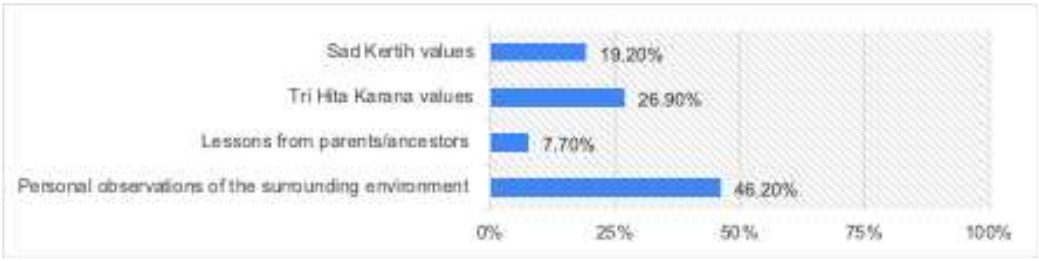

Figure 3. Source of perceptions about water

THK is a Balinese Hindu philosophy representing the three sources of happiness, wherein Balinese individuals assert that genuine happiness in daily life is achieved by preserving harmonious relationships among God and humans (*parahyangan*), society (*pawongan*), and nature (*palemahan*). SK represents a philosophical framework encompassing six virtues that serve as life guidance for the Balinese, e.g., *Atma Kertih* (preserving the purity of the soul), *Jana Kertih* (pursuing knowledge), *Jagat Kertih* (upholding social harmony), *Wana Kertih* (safeguarding forests), *Danu Kertih* (sustaining water sources), and *Sagara Kertih* (ensuring marine and coastal sustainability). SK is more popular in the government than in the public, whereas THK has consistently been regarded as a source of life guidance (Pradipta and Putri, 2024). This study (Figure 4) shows that the main manifestation of both local wisdom values, i.e., THK and SK in water governance, is the preservation of water sources, as stated by 69.2% of respondents. This signifies the most important commitment of stakeholders in preserving ecosystems of water. Moreover, 23.1% of respondents viewed wise water usage as a manifestation of local wisdom, whereas 7.7% selected avoiding from discarding waste into water bodies. Notably, no respondents linked local wisdom to rituals for purifying water sources or equitable water distribution, suggesting that, within the framework of

current water management, local wisdom is primarily perceived as conservation efforts and individual behaviors rather than ritualistic or distributional elements. The results validate that the principles of THK have evolved from theoretical values into concrete actions, especially in the area of water management. The significant proportion of respondents emphasizing the preservation and prudent use of water sources suggests that the philosophical principle of maintaining a harmonious relationship with nature (*palemahan*) has been effectively internalized, resulting in a collective, deep-seated commitment to environmental conservation rather than merely a theoretical notion.

According to Reijerkerk and derKleiy (2012), the paradox is that despite the fact that water is highly valued in prominent cultural and religious beliefs, it is frequently taken for granted, polluted, and fought over in everyday life. This phenomenon was also observed in Bali, where Hinduism holds water as a prime purifying substance representing a divine source that cleanses both the physical body and the spiritual soul. This deeply ingrained spiritual reverence for water highlights the significant disconnect between cultural values and current environmental practices. The results of this study (Figure 5) show the respondent continues to believe that Bali has the most critical issue, which is water pollution (61.5%), followed by water distribution problems (23.1%). This is expected, as recent socio-economic developments, including increased population density and urbanization, have resulted in a notable worsening of water quality. River water has been contaminated with pollutants including organic substances, heavy metals such as nickel and lead, and fecal matter. Further, intensive agricultural methods and the direct release of industrial effluents have exacerbated this pollution, presenting a substantial threat to Bali's water resources. Despite these challenges, the government continues to advocate for the utilization of surface water, especially rivers, as the primary source of raw water (Chapagain et al., 2022; Parwita et al., 2020).

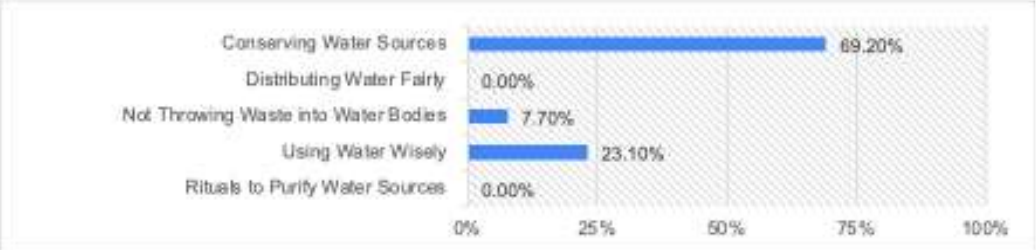

Figure 4. Local wisdom in water resources management

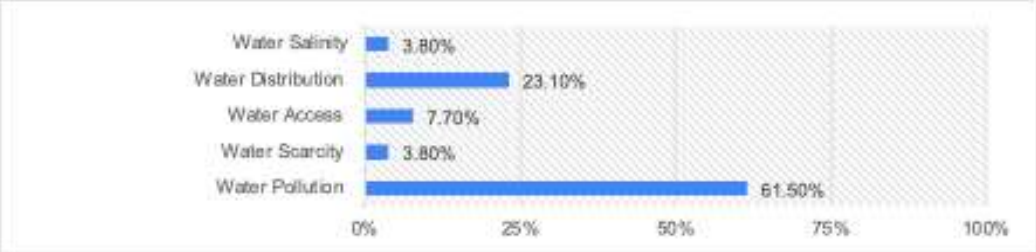

Figure 5. Most urgent issues on water governance in Bali

Perception and Evaluation of Rivers

As noted by Ko and Sakai (2022), leveraging public perception data can help water resource managers create more effective policies and methodologies, which in turn leads to a better understanding of how to sustainably manage and improve water systems. The data in Figure 6 of the study shows that most respondents gave a "Neutral" rating for their perception of river status, with one notable exception. The "Level of Naturalness" received a "Satisfactory" rating, which suggests that managers' efforts to preserve the natural state of Bali's water resources have been well-received. However, for other aspects like "Watershed Cleanliness," "River Water Quality," "Openness to the Public," "Level of Visitor Engagement," and "Quality of Public Facilities," the overall rating was "Neutral". While not indicating a poor state, this neutral perception highlights a clear opportunity for improvement and enhancement in these areas to achieve a higher level of public satisfaction, particularly concerning water quality and public facilities near rivers.

The commitment of all stakeholders, strengthened by the appropriate use of technology and knowledge, is essential for the realization of ecological and social justice in integrated watershed management. The challenges and opportunities are contingent upon this commitment. It is possible to achieve the optimal goal of water resource sustainability, which includes rivers, through the strong synergy between various stakeholders (Bakari, 2025). Most social and ecological impact of water resources, particularly rivers, are rated as "Neutral" to " Important" by respondents, according to the data in Figure 7. Accordingly, the following are deemed to be of importance, i.e. "Provide habitat for plant and animal species," "Constitute cultural heritage", "Help develop environmental stewardship", and "Make the environment prosper". Two negative aspects were assigned a 'Neutral' rating, i.e., "Increase flood risk" and "Dense riverbank vegetation makes people feel unsafe". This rating suggests that water resource managers do not firmly approve or reject these statements. This suggests that water resource managers are highly aware of the beneficial aspects of water resources, including their ecological, social, and cultural importance.

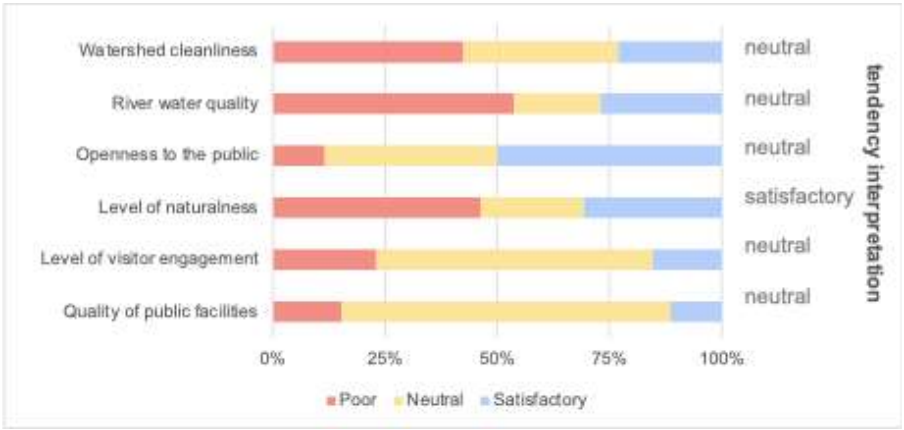

Figure 6. Evaluation of river status

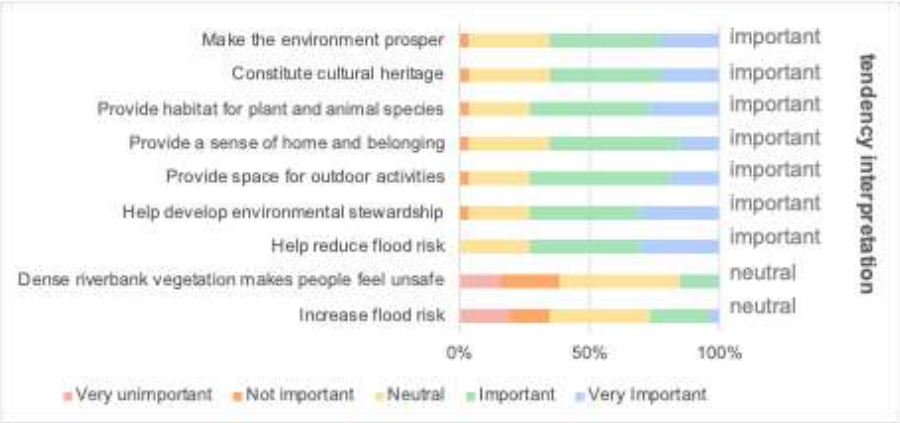

Figure 7. Social and ecological impact of river

Preferences for Restoration Scenarios

River restoration is a key component of water resources management, especially if a river ecosystem has deteriorated to the point that it can no longer deliver vital services, including adequate water quality. Restoration is necessary when direct interventions are essential to restore lost services or enhance the river's ability to offer new ones. This strategic method enables informed decision-making regarding restoration priorities, trade-offs, and intervention strategies (Speed et al. 2016). The significance of this strategic comprehension is underscored by data presented in Figure 8, which indicates that water resource managers in Bali demonstrate particular preferences for various restoration scenarios. Scenarios 1, 3, and 4 were significantly rated as "satisfied," while Scenario 2 received a "neutral" response. The finding is noteworthy due to the fact that Scenarios 1 and 3 (which feature concrete riverbanks and artificial designs) drew equally favorable responses as Scenario 4 (which features natural riverbanks and direct water access). This suggests that respondents' satisfaction is reliant upon the functional and recreational factors, in addition to the naturalistic approach. Scenario 3, which combined recreational facilities into the concrete riverbanks, illustrated that the public is receptive to enhanced public space functionality, regardless of the artificiality of the design. Furthermore, Scenario 2, which featured natural vegetation, received a neutral rating. This rating was probably affected by the absence of direct water access or additional facilities that drew respondents to the scenario in comparison to the other scenarios.

Figure 8. Preference for river restoration

The differences in ratings between Scenario 2 and the other scenarios offer critical insights for the design of river restoration in Bali. The neutral score that Scenario 2, which promotes bike paths and natural vegetation without direct access to water, received indicates that a "green" approach may not be sufficient to satisfy water resource managers' expectations. They seem to be in pursuit of solutions that not only restore river ecology but also maximize human benefits. This could be achieved through structured and clean landscaping (Scenario 1), direct access to nature (Scenario 4), or recreation (Scenario 3). Therefore, it is crucial to incorporate ecological (water quality, vegetation) and functional and social (function) factors into future restoration projects which aligns with the findings of Semeraro et al. (2021), who state that it is essential to consider social and environmental factors in restoration projects. Thus, successful initiatives in highly populated areas need to reconcile habitat restoration with local activities and promote social involvement. This allows them to extend their purpose beyond solely ecological restoration to include social use and institutional management. Therefore, in order to effectively gain support from a wider range of stakeholders and achieve a more comprehensive result, future restoration efforts in Bali should adopt a hybrid approach. This approach would involve combining naturalistic elements with public access and recreational facilities.

The pronounced preference for Scenario 4 over the strictly ecological Scenario 2 results in clear operational guidelines for both policymakers and hydraulic engineers in Bali. In terms of policy, future river basin regulations in the Bali Penida River Basin must shift away from rigid, exclusionary conservation zones. However, legislation should establish 'Socio-Ecological Co-benefit Zones' in which funding is linked to public access and integrated recreational metrics. As a result, engineering plans must shift away from traditional hard-engineered concrete channels (as seen in Scenarios 1 and 3) and toward bio-engineered hybrid structures. This includes using bio-textiles and rip-raps interwoven with native riparian vegetation to stabilise the bank, as well as building modular public

boardwalks that allow for safe human interaction while not disrupting the river's hydrological connectivity or aquatic habitat.

Conclusion and Recommendation

Conclusion

The study shows that water in Bali is considered not only a physical resource but also a sacred entity that is essential for survival. Despite the fact that this perspective is supported by local wisdom values, including Tri Hita Karana and Sad Kertih, the study revealed a contradiction. Although stakeholders acknowledge the ecological and cultural significance of water, significant issues such as water pollution and unequal distribution continue to exist, emphasizing the gap between their beliefs and reality. This persistent gap emphasizes a crucial point, i.e., addressing these complex challenges requires a collaborative effort, as individual actions alone are insufficient to overcome systemic issues like widespread pollution and infrastructure deficiencies. The study further shows that stakeholders' perceptions of water are greatly affected by their personal experiences and cultural heritage, rather than solely by objective analysis. Rather than scenarios that concentrate solely on ecological restoration, they expressed a preference for approaches that integrate natural and functional elements, such as recreational facilities and public access, when prompted to select river restoration scenarios. This study provides a novel conceptual contribution by demonstrating that traditional philosophies like Tri Hita Karana can be structurally operationalized into a 'socio-ecological infrastructure' framework. These findings indicate that in order to be effective, water management solutions in Bali must be hybrid, incorporating social and recreational benefits that are directly experienced by the community with environmental conservation. Therefore, it is essential to have an in-depth understanding of the cultural beliefs and values of the local community in order to develop water management strategies that are both sustainable and acceptable to all parties. In practical terms, this challenges conventional top-down ecological restrictions and shifts the paradigm toward stakeholder-backed hybrid models in river basin governance.

Recommendation

This study provides a strong foundational analysis of water management in Bali. For future research, it would be highly beneficial to broaden the scope of respondents to include a wider range of key stakeholders, e.g., local community leaders, farmer, and river conservation community, utilizing a mixed-methods approach or Analytical Hierarchy Process (AHP) to quantify stakeholder prioritization. This could provide a more comprehensive and nuanced understanding of the local practices and challenges. Additionally, building on this valuable foundation, a follow-up study could effectively explore potential river restoration intervention options, including both traditional Balinese methods such as the integration of subak-based water distribution logic and modern engineering solutions, specifically eco-hydraulic modeling for hybrid riverbanks. This would offer practical and actionable insights for improving water health and sustainability in the region.

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