



Available online at **HISTORIA**; Jurnal Pendidik dan Peneliti Sejarah
Journal homepage: <https://ejournal.upi.edu/index.php/historia>



RESEARCH ARTICLE

**WATER RESOURCES CARRYING CAPACITY IN THE BALI ISLAND:
A HISTORY AND LOCAL WISDOM FOR ENVIRONMENTAL CONSERVATION**

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To cite this article: Mulyadi, A., Afriana, N.N., Widiawaty, M.A., & Dede, M. (2023). Water resources carrying capacity and local wisdom for environmental conservation in the Bali Island. *HISTORIA: Jurnal Pendidik dan Peneliti Sejarah*, 6(1), 89-96. <https://doi.org/10.17509/historia.v6i1.58168>

Naskah diterima : 7 Desember 2022, **Naskah direvisi :** 20 Maret 2023, **Naskah disetujui :** 30 April 2023

Abstract

Bali is known for its unique nature and culture among tourists. Development and tourism activities have potential threats to environmental sustainability, as occurred in Tampaksiring Village, Gianyar. This research aims to analyze the water resource carrying capacity and local wisdom as inspiration for conservation actions. This research focuses on the Pura Tirta Empul's springs in Gianyar, Bali. Data came from field observations, literature studies, and official statistical information belonging to the local government. The historical aspect of local wisdom is obtained from a comparative study that reveals a culture of environmental conservation, especially in water resources management. Water resource carrying capacity considers the discharge capacity and population, while local wisdom is critically examined against previous literature. This research shows that the Tampaksiring has a water deficit of 38-40 million liters per year. This phenomenon is triggered by logging forests and converting densely vegetated land into built-up land. The village of Tampaksiring has a local wisdom strategy for conserving water resources through Tri Hita Karana. This concept first appeared on November 11, 1966, at Konferensi Daerah I Badan Perjuangan Umat Hindu Bali. In the local wisdom, there are three important elements in human life relationships with God, society, and the natural environment. Tri Hita Karana provides valuable directions for environmental conservation and rehabilitation.

Keywords: Culture; Gianyar; Tampaksiring; Tri Hita Karana; water resources.

INTRODUCTION

Bali is a province in Indonesia that is famous for its natural beauty and cultural uniqueness (Adhika & Putra, 2020). Bali is a very popular destination for domestic and foreign tourists, they enjoy various attractions that are never seen in other places (Pratiwi et al., 2019). All stakeholders, including local communities, local government and the private sector, are taking advantage to increase opportunities and develop the resources there. The local government should establish several policies to improve the tourism industry in Bali. The impact of tourism industry on the environment is still an unresolved problem (Khamdevi & Bott, 2018). These problems include the beach reclamation, golf course construction and accommodation facilities on productive agricultural land as well as water management policies for fulfilling the tourism industry which has damaged the ecosystem and environment on the island (Bräuchler, 2020). The direct impact is the clean water crisis in the Bali Island (Tarigan, 2016).

Massive consumption of water in tourism industries will affect the resource needed by local communities. The clean water crisis in Bali was exacerbated by land conversion and a geothermal power plant development in Bedugul (Hadimuljono et al., 2018). Clean water in Bali no longer functions as a public commodity for local communities but has changed its function to become an economic commodity (Veszteg & Narhetali, 2010). With decreasing and less vegetated land on the island, a more severe clean water crisis could occur in the future (Cole, 2012). Water problems occur in Tampaksiring Village located in Gianyar, Bali, because the spring's discharge capacity cannot meet the increasing needs. A spring, located in Tirta Empul Temple, is the most sacred spring for the Hindu community because it is used in religious ceremonies (Kanto, 2015). Tirta Empul is the oldest temple in Bali which was founded before the other temples. The building has distinctive ornaments and there is a *pelelinggih suci* in *pura utama mandala* (Ardika & Subadra, 2018). According to *Usana Bali's lontar*, Tirta Empul comes from *Tirta Ri Air Hampul*, a holy water source created by Bhatara Indra when he fought against King Mayadenawa in Bedahulu, Gianyar.

The Regional Drinking Water Company (PDAM) of Gianyar made a project by utilizing Tirta Empul's spring in 2015 (Permana, 2018). However, in 2018, there was a conflict between the local community and PDAM Gianyar. The local community suspects that PDAM Gianyar has increased the exploitation in the spring (Permana, 2021). The community is worried that the water supply will run out in the future thus they only limited use it for drinking, cooking and toilet needs.

Moreover, PDAM Gianyar argues that the water exploitation is in accordance with the previously made agreement. The clean water crisis in Tampaksiring Village shows how important to preserve the environment as a part of the tourism industry (Putra & Dharma, 2017).

Bali, with all its local wisdom and culture, has an opportunity to develop unique water resource conservation that harmony with community values (Dede et al., 2021). All stakeholders must realize that development and tourism activities have side effects on environmental sustainability (Wirakusuma et al., 2021). Therefore, this study aims to analyze the water resources carrying capacity and local wisdom as an inspiration for conservation actions in Tampaksiring Village, Gianyar, Bali. This island has a lot of local wisdom such as *Desa Adat (agung, madya, pakraman)*, *Subak*, *Sanga Mandala*, *Tri Mandala*, *Tri Kaya Parisudha*, and *Tri Hita Karana* (Suryada & Bagus, 2012). However, this study only focuses on Tri Hita Karana can be used as a reference for water resources conservation.

METHOD

This research is a preliminary study using data collection based on literature studies and field observations. literature study is a method for obtaining relevant data and explanations from previous research to produce new information (Nurbayani et al., 2022a; Dede et al., 2023). Reliable sources, such as books, reports, reports, and relevant previous reports, must comply with scientific rules (Greener, 2008; Leung et al., 2013). The historical aspect of local wisdom is obtained from a comparative study that reveals a culture of environmental conservation, especially in water resources management (Agustina, 2020; Halim et al., 2022). We can find the relevance and application of local wisdom in different contexts according to the actual situation.

Apart from using information from previous studies, a documentation study also uses data from local governments, especially from the Central Bureau of Statistics and the Food Security Service. Meanwhile, field observations were carried out more than once to ensure researchers had obtained credible information (Guo et al., 2017). The field observation used digital cameras and smartphones to get actual conditions in the Tirta Empul. This temple is located in Tampaksiring Village, Gianyar Regency, Bali (Figure 1). Tampaksiring Village has a population of 11,375 (2020) and 11,438 (2021).

Water resources carrying capacity is known by three parameters of water supply, population, and per capita needs (Dede et al., 2022). The need for residents in rural areas for clean water reaches 70 liters per day according to BAPPEDA Bali in 2018. In Tampaksiring's case, the water supply only

involves surface discharge from the Tirta Empul Temple and thus did not involve various factors from the environmental setting such as land use, evapotranspiration geomorphology, infiltration, and groundwater exploration (Widiawaty et al., 2018; Mulyadi et al., 2020).

Water resources carrying capacity refers to the capacity and demand, and the status consists of surplus, break-even (balance), or deficit. Meanwhile, information related to local wisdom originated from previous sources and was studied by descriptive qualitatively. This qualitative analysis aims to obtain more focused information and produce a synthesis according to the research problem (Nurbayani et al., 2022b).

RESULTS AND DISCUSSION

1. Water Resources Carrying Capacity

Increased water consumption by the tourism industry and commercial trade reduces the clean water supply for local residents in Bali. This island has shown a water deficit since 1995, even reaching 7.5 billion m³ per year (2000), and then continuing to reach 27.6 billion m³ (2015). Cole (2012) suggested that the clean water crisis in Bali would get worse between 2020 and 2025 if there are no effective conservation actions and public policies. A village in Bali that is experienced this crisis is Tampaksiring Village. This village is facing a clean water crisis because its primary water source, the Tirta Empul spring, cannot meet the local community's needs. This problem is exacerbated by PDAM Gianyar taking water from the spring.

Even though in accordance with the agreement between the village's head as the community representative with the company, this PDAM Gianyar is only allowed to take 3-5 liters per second to meet the business but actually it can be more than 15 liters per second (Sri, 2016). Population growth which continues to increase yearly also causes an increase in the need for clean water, especially due to certain ceremonial activities (Arsana, 2016). Without proper management, this is a potential conflict for the community and becomes a tragedy of the commons (Strauß, 2011).

Tampaksiring is located at the foothills of Mount Kintamani and receives its water supply from the Pura Tirta Empul Spring to meet people's water needs (Figure 10.2). This spring has a discharge of 8 liters per second, local residents use it for bathing, cooking, washing clothes, washing cutlery, and sanitation purposes. Based on these data, Tampaksiring Village happened a clean water crisis of 38,403,250 liters per year in 2020, and which increased to 40,012,900 liters per year in 2021 (Table 10.1).

The government has built a PDAM installation to meet water needs pragmatically. However, for a long-term solution, the community must conserve water and be willing to do social movements with non-governmental organizations (Cole et al., 2021). The clean water crisis that occurred in Tampaksiring was caused by environmental damage, such as illegal logging and deforestation (vegetated areas) which reduced water catchment (Lewis & Lewis, 2019; Sutawa, 2012; Rimna et al., 2021). These activities are contrary to the local values known as *Tri Hita Karana*, which obliges humans to take good care of their surroundings.

The Provincial Government of Bali has actually made *Tri Hita Karana* the basis for the Governor Regulation Number 24 of 2020 concerning the Protection of Lakes, Springs, Rivers and Sea. The Provincial Government of Bali accommodates local values in the policy to be easily understood and obeyed by everyone because the Balinese still take great care of their culture. Article 10 paragraph 2 states that traditional villages have an obligation to make regulations (*pararem*) to plant trees at every *Tumpek Wariga* ceremony, prohibit villagers and guests from throwing garbage, excrement and waste carelessly, and prohibit cutting down trees around water sources (Budiantara, 2017).

The violations would be subject to sanctions, even every entrepreneur who uses water is also required to protect these sources in all aspects. Traditional villages have an important role in shaping the local wisdom *Tri Hita Karana*, which involves three important aspects in achieving prosperity (Ardika, 2018). These aspects are a good relationship between humans and God, a good relationship between humans with one another, and human concern for the surrounding environment (Wibawa & Putu, 2017).



Figure 10.1. Tirta Empul Temple, a place for the sacred water.

Source: Authors Data.

Table 10.1. Water resources carrying capacity in Tampaksiring.

Year	Population	Water needs (liters per year)	Water capacity	Carrying capacity (liters per year)	Debit (liters per second)
2020	11,375	290,631,250	252,288,000	-38,403,250	-1.217
2021	11,438	292,240,900		-40,012,900	-1.268

Note: Negative value for carrying capacity means deficit and surplus for vice versa.

Source: Authors Data.

2. Tirta Empul Temple

Lontar Usana Bali tells about the history of Tirta Empul Temple (*Tirta Ri Air Hampul*) as a spring created by Bhatara Indra when he fought against King Mayadenawa in Bedahulu, Gianyar (Kantina, 2020). Mayadenawa declared as God and ordered people to worship him. In the battle, Mayadenawa and his troops were pressed. To trick Bhatara Indra, Mayadenawa walked with his feet tilted, and the place was later named Tampak Siring. Under siege by Bhatara Indra, Mayadenawa created a poisonous spring called *Yeh Cetik* to destroy Bhatara Indra's troops, they drank the water and were poisoned. To get rid of the poisoned water, Bhatara Indra stuck his weapon into the ground, and from there emerged a spring named *Yeh Empul*, which is now known as Tirta Empul (Titasari, 2016). The water flows along the Pakerisan River, but it may not be used to irrigate the rice fields.

Over time, there have been efforts to improve the local economy in Tampak Siring through Tirta Empul Temple as a tourist attraction. Since becoming a tourist attraction, Tirta Empul has become the main attraction in Gianyar Regency, even reaching more than 200 thousand tourists per year (Kantina, 2020). Tirta Empul serves a natural panorama, tourists can see a permanent procession in the temple and Hindu prayers. However, this situation also carries risks and potential problems (Sudita & Antara, 2006). Therefore, several conservation efforts, such as forest conservation in *Laba Pura* and community forestry need to be accompanied by local wisdom as inspiration for environmental management.

3. Tri Hita Karana as a Local Wisdom

Tri Hita Karana provides strong support for water conservation. Tri Hita Karana is a Balinese local wisdom that involves three main aspects of human life named *Rahyangan* (relationship with God), *Pawongan* (social relations), and *Pekahan* (concern for nature) (Kristinayanti et al., 2020). This concept teaches us to maintain the balance of nature and respect divine values (Suharta et al., 2017). In Hinduism, the *Pamahahan* aspect emphasizes the importance of protecting

nature as a place for humans to live and food needs. This local wisdom reminds us of the urgency of water resources that we need for our daily lives. Avoiding wastage of water, reducing water pollution, and involving the community in water management are implementing the values in Tri Hita Karana.

Currently, the efficiency of water management is still not optimal because existing pipelines often leak and seem redundant because of their loss discharge (1.7 liters per second) amid the water crisis threat on Bali island (Chairunnisa et al., 2021).

Tri Hita Karana contains Pawongan which emphasizes the importance of human relations (Purnamawati et al., 2021). Water conservation refers to the collaboration and participation in protecting and managing resources together. By respecting, loving and advising kindness to each other, communities can work together in implementing sustainable water conservation practices. Local wisdom also provides moral and ethical guidance in treating nature wisely (Susanto, 2006). Using technology and scientific methods that are environmentally friendly as well as integrating religious, cultural, and human behavior towards nature, can assist in water conservation efforts.

In this case, a water conservation approach based on local wisdom provides a simple solution and is rooted in traditions passed down from our ancestors. Of course, it is ironic when the holy spring actually lacks discharge and is even polluted by unwise manners (Matondang & Muslimah, 2022). Water conservation can use the sacred values, Tirta Empul spring which are believed to be able to heal human complaints, this can be accompanied by restrictions on exploitation for water use needs and tourism (Figure 10.3). On the other hand, a structural approach from customary stakeholders and the local government is needed to make a new agreement that is more pro-environmental actions.

Local wisdom contains religious values, ethics, and norms that provide valuable guidance for environmental preservation and management. Current environmental problems must be handled through the cooperation of all social elements in human life, such as technology, scientific methods, religions, culture, and human behavior toward nature. For the Balinese, this local wisdom shows their ancestors' values in protecting nature and achieving sustainable water management (Sudita & Antara, 2006; Nastiti et al., 2022). The approach of utilizing local wisdom aims to preserve nature, including tradition-based water conservation. The values contained in local wisdom need to be maintained, people feel they have an obligation to protect nature because it provides a source for human life (livelihoods) in many aspects.



Figure 10.3. *Tirta Empul Temple as a favorite tourist destination, there were offerings (sesajen) near the pond inlets.*

Source: Authors Data.

CONCLUSION

Tampaksiring is facing a water crisis with a total need of 38,403,250 liters per year in 2020, and it increased to 40,012,900 in the next year. To quickly solve this problem, the government has established PDAM Gianyar to meet the water needs. However, in the long term, the surrounding community needs to conserve water. The clean water crisis that occurred in Tampaksiring was caused by natural damage due to illegal logging and land conversion (vegetated areas) into the built environment, which resulted in reduced water catchment areas. Tri Hita Karana as the local wisdom can be a basis for water conservation efforts. This local wisdom covers three important aspects of human life, namely maintaining good relations with their God, humans, and nature. Tri Hita Karana contains religious values, ethics, and norms that provide valuable guidance for environmental preservation and management. Current environmental problems must be overcome through collaboration between all social elements such as technology, scientific methods, religious forces, and human behavior toward nature to achieve sustainable development. In the future, serious efforts are needed to understand the water balance in Tampaksiring by involving various environmental and socio-cultural factors.

ACKNOWLEDGMENTS

The authors thanks to Mrs. Agung Rai who helped us in field documentations. The authors declare there is no conflict of interests.

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