Water Resources Conservation for Climate Change Mitigation

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Abstract. Apart from having a positive impact on people's welfare, tourism in Bali also harms ecosystem sustainability, especially regarding the issue of the groundwater crisis. The increase number of tourists is of course accompanied by an increase in the need for clean water. PDAM is only able to meet around 40-50% of the need for clean water. Both the results of the Strategic Environmental Study conducted by the Bali Province (2010) and the research by Politeknik Negeri Bali in collaboration with Idep Foundation (2018) reported that there were indicators of groundwater exploitation and seawater intrusion in the tourism area. This program is an International joint research and community service between Politeknik Negeri Bali, Management Science University Malaysia, and Idep to build and strengthen a culture of saving water and awareness for water resources conservation for climate change mitigation. Refers to the SDG No. 6, the main activities in this program were education, training, coaching, and practices for communities related: 1) River Estuaries Water Processing to increase Sustainable Clean Water Resources; 2) Reforestation in the main catchment area of Bali Province; and 3) Waste management of Village level of landfill which implemented Reduce, Recycling, and Reuse system. The finding through this program is that increasing knowledge and competencies and involving the community in water conservation activities encourage the community to preserve water as well as the environment. In this way, the application of various methods and technologies to conserve water sources will ensure their sustainability.

Keywords: Water Resources, Conservation, Climate Change

1 Introduction

The global Sustainable Development Goals were declared on January 1, 2016, as a follow-up to the results of the meeting of Heads of State and Government and High Representatives at the UN Headquarters in New York on September 25-27 2015. 17 SDGs must be realized by all UN member countries, by 2030, starting from no poverty to the importance of partnerships to achieve the stated goals. Indonesia as a member of the UN is also obliged to follow up on this strategic decision. As a concrete step,

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Indonesian President Joko Widodo has issued Presidential Regulation No. 59 of 2017 concerning the implementation of achieving the SDGs in Indonesia. This regulation was then followed up by the Minister of National Development Planning/Head of the National Development Planning Agency, Republic of Indonesia, who was given the mandate to prepare the Indonesian SDGs roadmap. This roadmap contains the problems and projections of 60 main indicators of each goal in Indonesia's SDGs, including progressive policies in achieving SDGs targets.

This collaborative research and community service program aims to contribute to the realization of SDG goals, especially goal number 6, to ensure the availability and sustainable management of water and sanitation. Access to drinking water and basic services is a national priority and it is a closely related issue to other developments such as health, poverty, and climate change mitigation. Untreated wastewater can contaminate water supplies and become a source of the spread of various diseases, especially when society is faced with a water crisis which has now become a global issue that is pressing on all countries. The 10th World Water Forum 2024 in Bali, which was attended by 33 countries and more than 2000 participants, indicated that the water crisis problem has become a serious concern throughout the world. Water demand continues to increase in line with population growth and infrastructure development. Meanwhile, the availability of water resources is decreasing due to uncontrolled land use, thereby reducing the catchment areas and contributing to climate change. This happens in various parts of the world, including in Bali.

Bali has evolved from an agricultural region into one of the world's premier tourist destinations. Tourism has become a cornerstone of the economy and a major source of foreign exchange for Indonesia. While tourism significantly benefits the economy, it also poses challenges to ecosystem sustainability, particularly concerning groundwater depletion and climate change issues that have drawn international environmental attention. According to the Bali Province Central Statistics Agency, the number of international tourists visiting Bali surged from 7,002,944 in 2010 to 16,106,954 in 2019, marking a 130% increase (BPS Bali, 2021). This surge in tourist numbers has inevitably led to a higher demand for clean water. The regional water company, PDAM, which is owned by the Province of Bali, can only supply about 40-50% of the total clean water needs. Around 50-60% of the population, including the tourism sector, still relies on groundwater sources (Parwita et al., 2020). A Strategic Environmental Study (KLHS) conducted by the Bali Provincial Government in 2010 identified 11 rapidly developing tourism areas facing water crises (Bali Province, 2010). Based on KLHS data, in 2018, Bali State Polytechnic collaborated with the Idep Selaras Alam Foundation - an organization dedicated to environmental conservation - to conduct joint research aimed at re-mapping groundwater conditions. The study revealed a decline in groundwater quality. Hardness tests (chlorine content) of 270 water samples from nine regencies in Bali showed high chlorine levels, rendering the water unsuitable for consumption. This included 73% of 44 samples in Badung, 68.3% of 60 samples in Buleleng, 65% of 20 samples in Jembrana, 35% of 40 samples in Karangasem, 12.5% of 40 samples in Gianyar, and 75% of 4 samples in Klungkung (Politeknik Negeri Bali, 2018). This indicates that these areas are experiencing seawater intrusion. Joint research by Bali State Polytechnic (PNB) and Idep Selaras Alam (IDEP) foundation reported high levels of groundwater exploitation in some strategic areas of Bali Province.

One factor contributing to seawater intrusion is the overuse of groundwater from deep wells, which leads to the infiltration of seawater into the land. Given that nearly all hotels in Bali rely on groundwater for their operations, including for maintaining swimming pools, it is understandable that many people attribute the groundwater crisis to tourism development. To address this issue, groundwater conservation efforts can be implemented through several strategies: (a) establishing conservation zones; (b) enhancing protection and preservation measures; (c) managing and mitigating pollution; (d) addressing and reversing the decline in groundwater levels; and (e) improving environmental and waste management practices. Apart from these technical matters, what is no less important to pay attention to is people's behavior in daily water use (World Water Council, 2024). Refers to the water crisis data and the strategic planning delivered by World Water Forum (WWF), and also the SDGs no 6, Politeknik Negeri Bali, Management Science University Malaysia, and Idep Foundation conducted joint community services program to strengthen a culture of saving water and awareness for water resources conservation and climate change mitigation. The main activities in this program were: 1) Education, training, coaching, and practicing to improve behavior in water usage, including a) River Estuaries Water Processing to increase Sustainable Clean Water Resources; b) Harvesting rainwater through reforestation and rainwater harvesting wells in the main catchment area of Bali Province; and c) Waste management of Village level of landfill which implemented Reduce, Recycling, and Reuse system (TPS3R); 2) Education, training, coaching, and practicing in building rainwater harvesting wells with natural filtering system. It is hoped that this program can encourage people, the government, and all stakeholders to preserve water as well as the environment, so Bali will not face a water crisis in the coming future.

2 Methodology

Education, training, coaching, and practicing to improve behavior in water usage

Based on the background and both previous and preliminary studies on the existing conditions and results of discussion with stakeholders, some main existing problems must be addressed, including:

1) Lack of knowledge and understanding regarding the problem of the groundwater crisis which causes climate change;
2) Lack of knowledge, understanding, and competence regarding efforts that can be taken to take preventive and curative action against the clean water crisis and climate change mitigation;
3) Lack of knowledge and competency regarding waste management, including how to manage the Village level of landfills which implemented the Reduce, Recycling, and Reuse systems to avoid groundwater pollution.

The activities were conducted through training, mentoring, and action as presented in Table 1. Indicators of the improvement of knowledge and competence of participants in the three main activities were measured by distributing questionnaires before and after participating in the activities (pre-post-test).

Table 1. Methodology to improve knowledge and understanding of groundwater crisis

Problems	Solution	Output/empowerments
Lack of knowledge and understanding regarding the problem of the groundwater crisis which causes climate change;	Training, mentoring, and actions for River Estuaries Water Processing and building rainwater harvesting wells to increase Sustainable Clean Water Resources and mitigate climate change	40 participants included communities, students and lectures have increased knowledge, understanding, and practical skills related to groundwater conservation and its various problems
Lack of knowledge, understanding, and competence regarding efforts that can be taken to take preventive and curative action against the clean water crisis and climate change mitigation	Training, mentoring, and actions for reforestation of 200 coffee and durian trees in the main catchment area of Bali	26 students of PNB, 18 students of MSU, 7 lectures of PNB and MSU, 7 of Idep Foundation staff, and 15 members of the farmer community *Tabanan Lestari* have increased knowledge, understanding, and practical skills related to the forestation and have experiences in planting seeds that have properties to prevent floods and landslides and harvesting rainwater as well.
Lack of knowledge and competency regarding waste management, including how to manage the Village level of landfill which implemented the Reduce, Recycling, and Reuse system to avoid groundwater pollution.	Training, mentoring, and actions for TPS3R (Village level of landfill which implemented Reduce, Recycling, and Reuse system	27 students of PNB, 3 lectures of PNB, 5 staff of IDEP Foundation, and 10 communities in Nusa Dua have increased knowledge, understanding, and practical skills related to how to Reduce, Recycling, and Reuse plastic waste and provide economic value that is useful for preserving the environment and obtaining side income

3 Result and Discussion

3.1 Result

Training to Improve Knowledge and Competence

The result of the activities was the improvement of knowledge, understanding, and competence related to groundwater conservation. The results of the pre-post-test of the improvement of knowledge and competence are presented in Table 2 and Figure 1.

Table 2. The improvement of knowledge and competence

No.	Training Activity	Score – before training	Score – after training	Increasing score	% of increasing score
1	Water Processing	51	61	10	19.61%
2	Reforestation	61	75	14	22.95%
3	Waste Management	79	98	19	24.05%
	Total	191	234	43	66.61%
	Average	64	78	14	22.20%

Table 3. Validity of knowledge and competence improvement in Water Processing

Statements	Total number of subjects (N)	Very good		Good	
		N	Proportion	N	Proportion
The theoretical explanation of the water purification process is presented clearly and is easy to understand	18	11	61.11%	7	38.89%
The theoretical explanation and demonstration of the water purification process are beneficial	18	10	55.56%	8	44.44%
Water purification practices are demonstrated clearly and are easy to understand	18	9	50.00%	9	50.00%
After attending the training my understanding of the water purification process increased	18	7	38.89%	11	61.11%
Total			205.56%		194.44%
Average			51.39%		48.61%

Table 4. Validity of knowledge and competence improvement in Reforestation

Statements	Total number of subjects (N)	Very good		Good	
		N	Proportion	N	Proportion
The theoretical explanation of the reforestation is presented clearly and is easy to understand	23	16	69.57%	7	30.43%
The theoretical explanation and demonstration of reforestation are beneficial	23	20	86.96%	3	13.04%
reforestation is demonstrated clearly and is easy to understand	23	16	69.57%	7	30.43%

After attending the training my understanding of reforestation increased	23	11	47.83%	12	52.17%
Total		63	273.91%		126.09%
Average		15.75	68.48%		31.52%

Table 5. Validity of knowledge and competence Improvement in Waste Management

Statements	Total number of subjects (N)	Very good		Good	
		N	Proportion	N	Proportion
The theoretical explanation of waste management is presented clearly and is easy to understand	27	18	66.67%	9	33.33%
The theoretical explanation and demonstration of waste management are beneficial	27	20	74.07%	8	25.93%
waste management is demonstrated clearly and is easy to understand	27	16	59.26%	9	40.74%
After attending the training my understanding of waste management increased	27	17	62.96%	11	37.04%
Total		71	262.96%		137.04%
Average		17.75	65.74%		34.26%

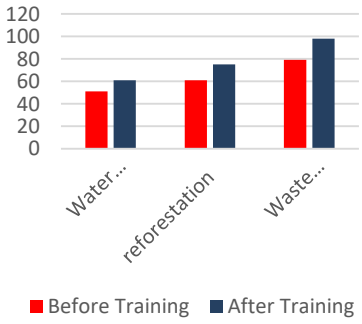

Figure 1. The improvement of knowledge and competence

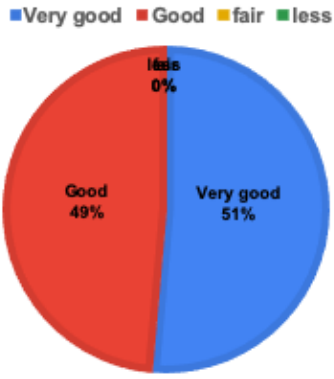

Figure 2. Validity of knowledge and competence improvement in water processing

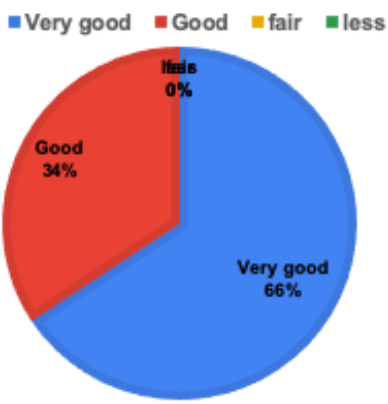

Figure 3. Validity of knowledge and competence improvement in reforestation

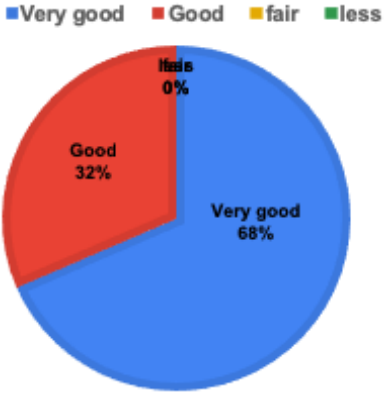

Figure 4. Validity of knowledge and competence improvement in waste management

Table 2 and Figure 1 showed all activities of education and training increased the knowledge and competence of the participants by about 14 scores (± 22.20%). This result is in line with the result of the validity of the training method as presented in Table 3 to Table 5 and Figure 2 to Figure 4. It is more than 50% of participants stated that the method of implementing education and training in all activities was very good, and easy to understand, and at the end of the training participants' understanding and competence regarding the material received had increased, while the rest were good.

3.2 Discussion

Conservation is an effort to preserve the environment so that its benefits can be felt in the future. Conservation activities can be carried out from the simplest methods to those using high technology. All countries in various parts of the world are competing to issue policies related to conservation programs, including groundwater conservation. Indonesia has launched 4 (four) biodiversity conservation areas: National Parks, Nature Reserves, Botanical Gardens, and Marine Parks (Ministry of Finance of the Republic of Indonesia, 2023). Those four conservation areas are also tourist destinations visited by both domestic and foreign tourists. This national conservation tourism destination is very suitable as a means of education, outreach, and promotion related to water conservation programs and their benefits for nature and future generations. Unfortunately, some visitors only do tourism and don't care about environmental sustainability. Therefore, it is important to carry out this education, socialization, and promotion program on an ongoing basis, including through community service activities. The Malaysian government has implemented numerous regulations to address environmental issues, including the protection of water quality, enforcement of laws and standards on water pollution, establishment of water quality monitoring systems, and raising public awareness about the importance of maintaining water quality (My Government, 2024). As a tropical country with significant annual rainfall,

Malaysia has placed a strong emphasis on groundwater conservation through the use of rainwater harvesting wells (RWHW). Since 1999, there have been at least eight regulations addressing this issue, complemented by various related policy initiatives. These policies demonstrate the Malaysian government's commitment to tackling the water crisis. Additionally, the implementation and advancement of RWHW technology have been observed in several other countries, including the European Union, the United States, Japan, Taiwan, and Australia.

Strategic programs related to the water crisis and climate change have been seriously designed by various countries, but the issue of the water crisis is still pressing the world. Among these various large programs, many simple things can be contributed to efforts to save water and mitigate climate change disasters, including education and socialization of how important the water is, building a culture of saving water, caring for the environment, and positive behavior in using water. Social media platforms are an accessible and cost-effective tool, yet their use in raising environmental awareness has been limited. However, they hold promise as social learning environments for enhancing environmental consciousness (Waititu, 2021). Factors such as capital, trust, social norms, community belonging, and voluntarism can mediate the relationship between environmental awareness, habitat quality, and pro-environmental behaviors (Wentao Si et al., 2022). Despite this, public environmental awareness remains relatively low (Hadian et al., 2016). The lack of sufficient environmental knowledge poses a significant barrier to achieving a sustainable future at both global and local levels (Sola, 2014). To address this, the program aimed to boost public awareness, particularly among teenagers and students by fostering positive attitudes towards environmental conservation through education, training, and hands-on activities in natural settings. The effectiveness of the program was evaluated by distributing questionnaires both before and after the training sessions (pre-post-test). Of the 3 main activities that were carried out (Water Processing, Reforestation, and Waste Management), there was an increase in participants' knowledge and competency of 19.61%, 22.95%, and 24.05% respectively. It was emphasized by the result of the validity assessment. It is more than 50% of participants stated that the method of implementing education and training in all activities was very good, and easy to understand and at the end of the training participants' understanding and competence regarding the material received had increased, while the rest were good.

This finding is reinforced by the results of in-depth interviews with key persons who stated that so far many programs initiated by both the government and large corporate CSR programs have not been sustainable because the planning and implementation have not involved the community enough. The community is only used as an object for certain interests. If the community knows the goals and benefits of the technology being implemented and how to maintain it, it is certain that the community will automatically be moved to maintain its sustainability. These findings are similar to the research results of F. V. Uzuna and O. Kelesa (2012) which show that the nature education program made significant contributions to both the environmental awareness and attitude of the participants

4 Conclusion

Water is life, a drop of water for a million living creatures, the role of water is so important in life, in the past, present, and in the future. The water crisis can have an impact on various aspects of life, from social, economic, environmental, and political, to local wisdom values. Currently, issues related to the water crisis and climate change are of global concern. all countries develop a special vision and mission related to this disaster. This is what is important to highlight, emphasize, and socialize with the entire community, from early childhood, teenagers to adults, continuously and sustainably. This joint community activity between PNB-MSU-IDEP Foundation is a small action, but it is real and is believed to provide great benefits in the future. Involving students, teenagers, and the community in taking part in education, training, practice, and being directly involved in environmental preserving activities has been proven to increase knowledge, understanding, and competence and increase awareness and positive behavior towards environmental sustainability. The finding in this program is that increasing knowledge and competencies and involving the community in water conservation activities encourage the community to preserve water as well as the environment. In this way, the application of various methods and technologies to conserve water sources will ensure their sustainability.

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