Integrated Clean Water Service Management in Klungkung Regency (Mainland) with Downstream River Utilization

I Gusti Lanang Made Parwita[1], IGB Sila Dharma[2], Mawiti Infantri Yekti[3], I P Gustave Suryantara[3] and IGAG Suryanegara[1]

[1]*Civil Department Polytechnic State of Bali, Jimbaran, Bali, Indonesia*

[2]*Faculty of Marine and Fisheries, Udyanan University, Bali, Indonesia*

[3]*Civil Department Faculty of Enginering Udayana University, Bali, Indonesia*

Keywords: Clean Water, Klungkung District, Integrated.

Abstract: Klungkung Regency on the mainland actually has sufficient water sources. The problem with the development of clean water services in the district is that it is constrained by limited infrastructure so that a lot of water is wasted in the downstream of the river. On the other hand, the need for water continues to increase due to population growth and the development of various sectors. The research method uses quantitative analysis by juxtaposing the availability and demand for water in the future. The results showed that the service coverage of the regional clean water company (PDAM) in Klungkung Regency was 77.43%. The clean water supply system of PDAM Klungkung Regency has a production capacity of 382.8 Lt/second with sources of water production coming from 7 units of springs and 18 units of wells. Until 2040, Klungkung Regency needs clean water with a capacity of 444.08 liters/second. Based on the existing water shortage, several strategies for fulfillment have been carried out, including the construction of the Sarbagikung Dam with a capacity of around 75 liters/second and through the use of water at the mouth of the Unda River with a capacity of around 150 liters/second.

1 INTRODUCTION

Klungkung Regency is one of the regencies that has sufficient water potential because topographically it is fed by rivers that flow throughout the year, namely the Jinah and Unda rivers. The utilization of existing water has been dominantly used for irrigation purposes and the rest is used for the fulfillment of clean water through the regional drinking water company (PDAM) of Klungkung Regency. The water sources of PDAM Klungkung are mostly dominated by groundwater sources through PDAM wells scattered throughout the region. At this time the service coverage of PDAM Klungkung Regency is 77.43% with a total of 35,750 customers or 152,893 residents with a percentage of water loss due to leakage of 35.56% (BARI Bali 2020)

The development of the population and the need for water for other allocations, such as for tourism needs, requires a larger water source that must be managed by the local government. In other parts of the mouth of the Unda river and the Jinah river, the existing water can still be utilized. The water of the Unda and Jinah rivers in the estuary is currently allowed to flow into the sea in the southern part (BARI Daerah Bali 2020) (Penida 2020). Therefore, it is very necessary to conduct comprehensive research that can provide an overview of the current potential, the pattern of demand and total demand for clean water and strategies for meeting water in the future. The problems faced are how much water potential exists in the mainland part of Klungkung Regency, what is the current clean water supply system, and what is the clean water supply system in the future. The research method is carried out quantitatively related to the potential, needs, and services as well as the fulfillment of water in the future. The purpose of this study is to determine the potential, needs, and strategies for meeting water in the future by utilizing water in downstream that is not utilized for irrigation.

Parwita, I., Dharma, I., Yekti, M., Suryantara, I. and Suryanegara, I.
Integrated Clean Water Service Management in Klungkung Regency (Mainland) with Downstream River Utilization.
DOI: 10.5220/0011845300003575
In *Proceedings of the 5th International Conference on Applied Science and Technology on Engineering Science (iCAST-ES 2022)*, pages 601-607
ISBN: 978-989-758-619-4; ISSN: 2975-8246

2 LITERATURE REVIEW

2.1 Integrated Water Resources Management

2.1.1 Water Scarcity

The development of the number of humans has led to an increase in the amount of water both in quantity and quality. On the other hand, water sources that are not evenly distributed have led to greater water scarcity. Water is transformed into an item of economic value that influences the development of a country. By 2020, most of the world's population will enjoy adequate water services, except in Africa and a few parts of Asia, which experience water shortages. However, in 2050 it is estimated that most African countries and several countries in Asia will experience problems related to clean water. In 2050, water use in Africa and Asia will experience a decrease in water consumption between 1000 and 2000 m3 per person per year, even in some areas with water consumption below 100 m3 per person per year. water scarcity maps show most countries in Africa and Asia experiencing water shortage problems. Water scarcity maps show most countries in Africa and Asia experiencing water shortage problems. More details can be seen in Figure 1, (Xie 2006):

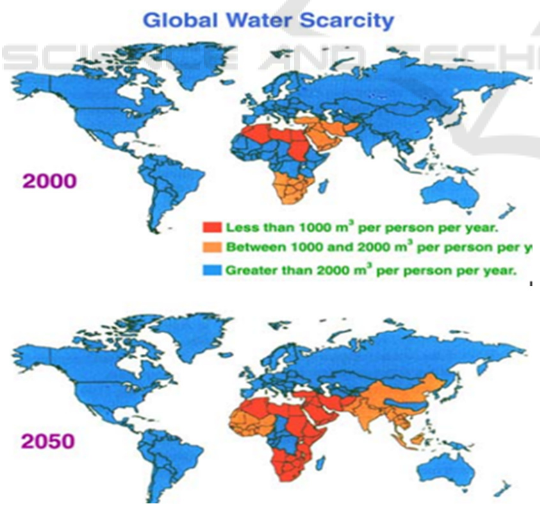

Figure 1: Distribution of Scarcity of Water Resources (Xie, 2006).

Water scarcity in various parts of the world increases fulfilment efforts that lead to integrated cross-sectoral fulfilment. Integration was originally intended purely for water supply but in its development later it involved other sectors which were supported by adequate water availability (Baldwin and Hamstead 2014).

2.1.2 Integrated Water Management Concept

The availability of water on earth is not always evenly always distributed in every place and as expected, thus causing humans with various interests in water to try to fulfil in various ways from various competencies they have as well as in various ways of legitimacy and participation in an integrated manner (Fulazzaky 2014). The water resources management approach in the past has not been sufficient to meet the challenges of global water management. A largely sectoral management approach, where each sector (household use, agriculture, industry, environmental protection, etc.) has been managed separately, with limited coordination between sectors. This approach leads to fragmented and uncoordinated development of water resources. Many uses of water have spillier effects on other uses and sometimes have unintended social and environmental consequences. This is especially true for watersheds where water and land practices upstream have a direct impact on the quantity and quality of water downstream. As water becomes scarcer, it becomes increasingly inefficient to manage water without acknowledging the interdependencies between institutions, sectors, and between geographic areas. (Xie 2006)

The concept of integrated water resource management has been a necessity for a long time and is growing according to current and future developments (MERLA et al. 2005). The United Nations has tried to encourage the development of water resource management that can be carried out in an integrated manner between watersheds and between regions since 1977 through the integrated water resources management (IWRM) program. Since 1992 the IWRM concept has begun to be massively adapted to almost all countries in the world with the common goal of achieving equitable access to water use, which was marked by the existence of a global water partnership (GWP) program in 1996. The main mission of GWP is processes that promote the coordinated development of water, land, and related resources to maximize equitable and sustainable economic and social outcomes (Norken 2003).

The availability of water in the hemisphere is not always evenly distributed in every place and at all times as expected, thus causing humans with various interests in water to try to fulfil in various ways from various competencies they have and in various ways of legitimacy and participation in an integrated manner (Cole, Stroma, 2012). The water resources management approach in the past has not been sufficient to meet the challenges of global water management. A largely sectoral management approach, where each sector (household use, agriculture, industry, environmental protection, etc.) has been managed separately, with limited coordination between sectors. This approach leads to fragmented and uncoordinated development of water resources. Many uses of water have spill over effects on other uses and sometimes have unintended social and environmental consequences. This is especially true for watersheds where water and land practices upstream have a direct impact on the quantity and quality of water downstream. As water becomes scarcer, it becomes increasingly inefficient to manage water without acknowledging the interdependence between institutions, sectors, and between geographic areas (Xie 2006).

The concept of integrated water resource management has been a necessity for a long time and is growing according to current and future developments (MERLA et al. 2005). The United Nations has tried to encourage the development of water resource management that can be carried out in an integrated manner between watersheds and between regions since 1977 through the integrated water resources management (IWRM) program. Since 1992 the IWRM concept has begun to be massively adapted to almost all countries in the world with the common goal of achieving equitable access to water use, which was marked by the existence of a global water partnership (GWP) program in 1996. The main mission of GWP is a process that promotes the coordinated development of water, land and related resources to maximize economic outcomes and social welfare in a fair and sustainable manner. and maintenance and evaluation and monitoring (Durán-Sánchez, lvarez-García, and del Río-Rama 2018).

In relation to the concept of integration of water resources management, it is necessary to carry out cross-sectoral and cross-stakeholder coordination which includes integration between watersheds, regions/countries, and between sub-watersheds. Experience has repeatedly shown that successful IWRM demands vertical integration across levels, from local to cross-border, as well as horizontal integration across sectors at all levels. With cross-sectoral dialogue, it is hoped that the concept of integration with the principle of one river one management will emerge, as shown in Figure 2 below: (Clausen and Smith 2015).

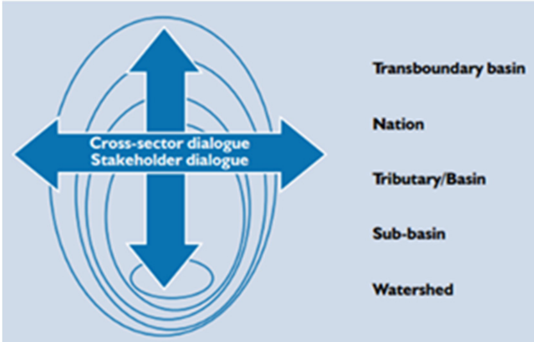

Figure 2: Concept of Integration in Watershed-Based Natural Resources Management (Clausen and Smith, 2015).

2.2 Water Potential

Water potential is the amount of water that exists in nature that has not been utilized. The water potential is on the ground surface and below the ground surface (Cole 2012). Water potential is analysed by converting rain into water potential and then juxtaposed with empirical measurements.

2.3 Water Availability

Availability of water is water that can be used directly through infrastructure buildings that have been developed such as reservoirs, weirs and pipelines (Lu 2007).

2.4 Water Needs

2.4.1 Clean Water Usage Pattern

The use of clean water in an area will never be the same as in other areas due to the characteristics possessed by the area concerned. The pattern of clean water usage is largely determined by climate, population characteristics, environmental issues, industry and trade, fees for water, city size and water conservation needs. (Asian Development Bank 2016).

2.4.2 Climate

The pattern of water use for household activities such as bathing, washing, watering the garden, air conditioning, and other activities will be greater for areas with warm and dry climates than in areas with humid climates. In areas with very cold climates, water may be wasted in the taps to prevent the freezing of clean water pipes (Vairavamoorthy 2007).

2.4.3 Population Characteristics

Water use will be affected by the economic status of the water users as well as the size of the city. The water demand for small cities with low standard housing ranges from 90 to 150 litres/person/day, while for large and modern cities the use of clean water can reach 600 litres/person/day. The higher the welfare, the more complete the household appliances which result in the greater the need for water (Widhiyastuti, Daerobi, and Samudro 2017).

2.5 Instantaneous Discharge

Instantaneous discharge measurements are carried out to determine the amount of water flowing in a certain time unit. Measurement of instantaneous discharge is carried out using a tool in the form of a Current Meter to get the value of water velocity. This water velocity value is calculated on several flow paths at several water depths (Twort 2003).

2.6 Population Projection

The fulfilment of domestic water needs is calculated based on the use of water by the population so it is necessary to make a projection of the existing population. Projection of the population can be done by several methods which are determined based on the characteristics of the population. The method of determining the population can be done using arithmetic, geometric and exponential methods (Fang et al. 2014).

2.7 Clean Water Supply Strategy

The clean water supply strategy is a way of providing clean water which has explained the potential, water availability, water needs, water balance, and water supply schemes in the future (Baldwin and Hamstead 2014).

3 RESEARCH METHOD

The research method uses quantitative analysis by calculating the availability of existing water compared to water needs and solutions for meeting water in the future with fulfilment from various sources. Primary data is obtained by direct measurement and secondary data is obtained from the relevant agencies.

3.1 Research Design

The research was conducted by collecting both primary and secondary data from related agencies such as PDAM Klungkung Regency, Bali Penida River Council, Balinese traditional water user organizations (Subak), water user communities, and other parties.

3.2 Advanced Data Collection

This follow-up data collection includes field surveys, data collection, especially from factual field conditions. Further data collection includes PDAM Klungkung data collection, data collection for clean water management infrastructure, and measurement of deviant discharge in several rivers.

3.3 Analysis

The analysis carried out is a quantitative analysis consisting of population projection analysis, water demand analysis, analysis of water services by PDAM and analysis of the fulfilment of clean water needs. The stages of the research in more detail can be seen in Figure 3:

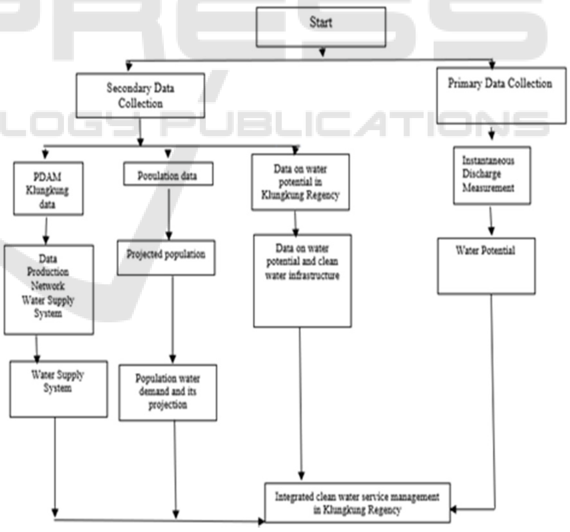

Figure 3: Research flowchart.

4 RESULTS AND DISCUSSION

4.1 Projected Population

Based on the analysis carried out, the population in the mainland of Klungkung Regency in a row for

2025, 2030, 2035, and 2040 as shown in Table 1 and Figure 4 below:

Table 1: Population Projection of Klungkung Regency (mainland).

Sub District	Year			
	2025	2030	2035	2040
Banjarangkan	41,641	43,102	44,563	46,024
Klungkung	61,841	64,002	66,163	68,324
Dawan	36,181	37,142	38,103	39,064
Klungkung Regency	139,663	144,246	148,829	153,412

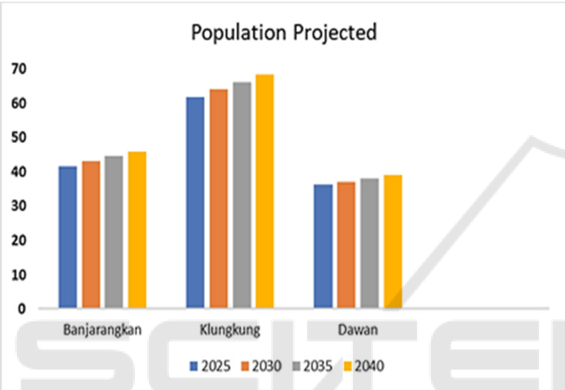

Figure 4: Projected population growth.

4.2 Water Requirement

The water demand in Klungkung Mainland, which covers Banjarangkan, Dawan and Klungkung sub-districts, is 332.40 liters/second. The sub-district that needs the most water is Klungkung District, while the one that needs the least water is Dawan District. At peak hours, Klungkung Mainland requires 668.95 litres of water/second. The maximum day water needs to reach 128.43 liters/second. Water needs in all sub-districts in Klungkung Regency are around 130 litres/person/day. The water demand in Klungkung Regency is shown in table 2 and the figure 5:

Table 2: Recap of Total Clean Water Needs of Klungkung Regency (Mainland).

Klungkung (land)				
Year	2025	2030	2035	2040
Population Projection (people)	139,66	144,25	148,83	153,41
Water demand projection (Lt/second)	294,76	312,53	322,47	322,40

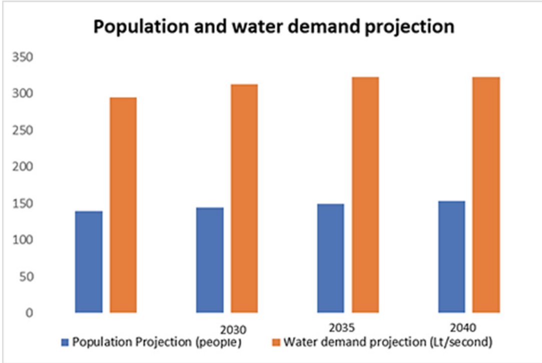

Figure 5: Water demand projection.

4.3 Water Potential of Klungkung Regency

Klungkung Regency has 3 rivers that have the potential to be utilized. The river that has the lowest capacity is the Cau River with a capacity of 30.70 liters/second. The river that has the largest capacity is the Jinah River with a capacity of 674.45 liters/second. In addition to the three rivers, Klungkung Regency is also traversed by the Unda River which has a capacity of more than 1000 liters/second and originates in Karangasem Regency. The utilization of Unda River water can be carried out downstream by utilizing the remaining capacity after utilization for irrigation.

4.4 Water Availability

PDAM production in Klungkung Mainland currently has a capacity of 115.3 liters/second, which is smaller than the demand in 2025 of 294.76 liters/second. This gap will become even greater in 2030, 2035, and 2040 as shown in Table 3 and Figure 6:

Table 3: Comparison between Water Demand and Availability.

	2025	2030	2035	2040
Demand (Liter/ second)	294,76	312,53	322,47	332,40
Supply (Liter/ second)	115,30	115,30	115,30	155,30

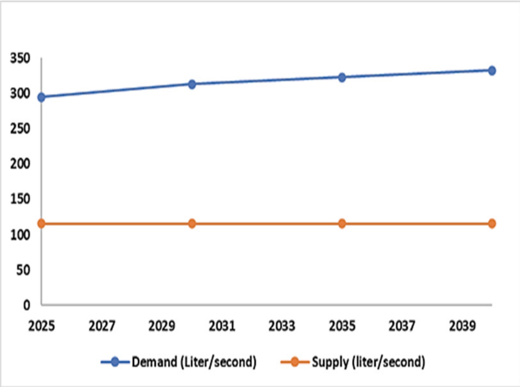

Figure 6: Comparison between water demand and supply in Klungkung Regency (mainland).

4.5 Integrated Water Resource Management

To meet the water needs of Klungkung Regency (mainland) in the future, this is done by utilizing existing sources in Klungkung Regency or by utilizing other sources in the surrounding Regency, namely in Gianyar Regency in the west (through the Melangit long storage scheme) or Karangasem Regency in the North (Telaga Waja springs and Nyuling Long Storage). Sources in Klungkung Regency are carried out by utilizing the capacity of the Sarbagikung Dam development on the Unda river located in Akah village which is allocated 75 liters/second and through the Unda River Estuary Reservoir construction scheme of 150 liters/second. If this scheme can be implemented, by 2040 there is no need to ask for water from Karangasem and Gianyar Regencies, this scheme is as shown in Figure 7:

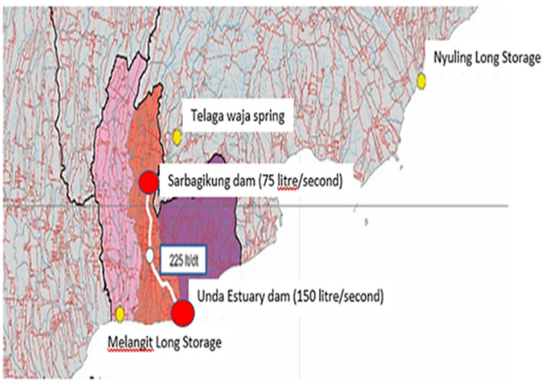

Figure 7: Integrated clean water service development strategy.

Apart from the Sarbagikung dam and the Muara Unda reservoir, there are also several rivers with potential for water development including: Cau River with a capacity of 30.70 liters/second, the Jinah River with a capacity of 674.45 liters/second and the Unda River which has a capacity of more than 1000 liters/second.

5 CONCLUSION

Based on the results of the analysis, the water supply is carried out by Klungkung water company with a discharge of 115.30 liters/second which is smaller than the demand in 2025 of 294.76 liters/second. This gap will become even greater in 2030 (312.53 liters/second), 2035 (322.47 liters/second), and 2040 (332.40 liters/second). To meet the water needs of Klungkung Regency (mainland) in the future, this is done by utilizing existing sources in Klungkung Regency or by utilizing other sources in the surrounding Regency.

Sources in Klungkung Regency are carried out by utilizing the capacity of the Sarbagikung Dam development on the Unda river located in Akah village which is allocated 75 liters/second and through the Unda River Estuary Reservoir construction scheme of 150 liters/second.

The water potential that can be developed comes from river water downstream which is the rest of irrigation water. There are three rivers that have potential for water use, namely the Cau River with a capacity of 30.70 liters/second, the Jinah River with a capacity of 674.45 liters/second and the Unda River which has a capacity of more than 1000 liters/second.

ACKNOWLEDGMENT

On this occasion, the authors would like to thank PDAM Klungkug Regency, Bali Penida River Council, and all parties who have assisted in completing the research.

REFERENCES

Asian Development Bank. 2016. *Asian Development Bank Indonesia Country Water Assessment Indonesia Country Water Assessment*. www.adb.org.

Baldwin, Claudia, and Mark Hamstead. 2014. “Integrated Water Resource Planning.” *Integrated Water Resource Planning*.

BARI Daerah Bali. 2020. *Masterplan Penyediaan Air Bersih Di Provinsi Bali*. Denpasar: Badan Riset dan Inovasi Daerah Bali.

Clausen, Torkil Jønch, and Mark Smith. 2015. "Integrated Water Resource Management : A New Way Forward Mark Smith Governor, World Water Council Member of the World Water Council Task Force on IWRM Director-Global Water Programme, International Union for Conservation of Nature (IUCN) Chair of the World." *World Water Council*. http://www.worldwatercouncil.org/sites/default/files/2017-10/7th_world_water_forum_-_Daegu-Gyeongbuk_-_Republic_of_Korea_-_Integrated_Water_Resource_Management_0.pdf.

Cole, Stroma. 2012. "A Political Ecology of Water Equity and Tourism. A Case Study From Bali." *Annals of Tourism Research* 39(2): 1221–41.

Durán-Sánchez, Amador, José Álvarez-García, and María de la Cruz del Río-Rama. 2018. "Sustainable Water Resources Management: A Bibliometric Overview." *Water (Switzerland)* 10(9).

Fang, Hong Bin, Tie Song Hu, Xiang Zeng, and Feng Yan Wu. 2014. "Simulation-Optimization Model of Reservoir Operation Based on Target Storage Curves." *Water Science and Engineering* 7(4): 433–45. http://dx.doi.org/10.3882/j.issn.1674-2370.2014.04.008.

Fulazzaky, Mohamad Ali. 2014. "Challenges of Integrated Water Resources Management in Indonesia." *Water (Switzerland)* 6(7): 2000–2020.

Lu, Tingyi. 2007. "Research of Domestic Water Consumption : A Field Study in Harbin , China By." *A research project report submitted in partial fulfilment of the requirements for the award of the degree of Master of Science of Loughborough University* (September): 1–89. http://www.switchurbanwater.eu/outputs/pdfs/W3-1_GEN_PHD_Research_of_domestic_water_consumption_-_a_field_study_in_Harbin_China.pdf.

MERLA, Andrea et al. 2005. Strategic Action Program for the Integrated Management of the Pantanal and the Upper Paraguay River Basin *Implementation of Integrated River Basin Management Practices in the Pantanal and Upper Paraguay River Basin ANA/GEF/UNEP/OAS Strategic Action Program for the Integrated Management of the Pantanal and the Upper Paraguay River Basin*.

Norken, I Nyoman. 2003. "Pengembangan dan Pengelolaan SDA Secara Terpadu dan Berkelanjutan." In Denpasar: Prosiding Seminar Nasional HATHI, 2003.

Penida, Balai Wilayah Sungai Bali. 2020. Penyediaan Air Baku di Wilayah Sungai Bali Penida Dewnpasar.

Twort. 2003. *Water Supply*. 5th ed. IWA.

Vairavamoorthy, K. 2007. "Challenges For Urban Water Supply." *Urban Water* (June).

Widhiyastuti, Rahmah Risqi, Akhmad Daerobi, and Bhimo Rizky Samudro. 2017. "Community-Based Water Management: An Institutional Study In PAMDes Sumberagung, Bantul, DIY." *Eko-Regional Jurnal Pengembangan Ekonomi Wilayah* 12(2): 37–42.

Xie, Mei. 2006. "Integrated Water Resources Management (IWRM) – Introduction to Principles and Practices 1." *Water*: 1–15.