Analysis of Integrated Clean Water Supply System In Karangasem Regency

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Abstract. The western part of Karangasem Regency is an area that has sufficient water resources to be used as irrigation water and clean water, while the eastern part is experiencing problems due to a lack of existing water sources. The development of clean water services in this regency is experiencing problems because of the limited existing infrastructure so that a lot of water is wasted in the lower reaches of the river, such as in the Nyuling river. The need for water continues to increase due to population growth while the availability of water does not match the existing needs. Therefore, it is very necessary to carry out research related to the potential and demand for water as well as strategies for fulfilling water in the future with the concept of inter-regional integration. The novelty of this research is the existence of an integrated system between clean water and irrigation water for the traditional Subak agricultural system. This study uses a quantitative research method using data sourced from regional clean water companies in Karangasem Regency as well as patterns of clean water policy development in the Province of Bali. The results of the study show that the availability of water in Karangasem Regency currently comes from the Karangasem Regency clean water company (PDAM) and rural clean water company (PAMDES) which are managed independently by the people in their respective areas. The total availability of water in Karangasem Regency is currently 454.54 liters/second. So far, most of the supply systems have come from PDAM, but in some eastern areas with undulating topography more are served by PAMDES. The strategy that can be carried out in clean water services is to take advantage of the potential of other regency, namely the Unda estuary dam in Klungkung Regency with an allocated capacity of 100 liters/second and by exploiting the potential in the Karangasem area itself, namely by utilizing the Telaga Waja Spring with a capacity of 175 liters/second. seconds, Nyuling Long storage with a capacity of 200 liters/second, Arca Springs with a capacity of 80 liters/second, Yeh He Springs with a capacity of 40 liters/second. Integration also pays attention to that the withdrawal of water from the river can only be done after being used for irrigation and does not use groundwater.

Keywords: Karangasem Regency, water potential, water demand, integrated services.

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1. Introduction

The western part of Karangasem Regency is an area that has sufficient water potential because topographically it is drained by rivers that flow throughout the year, but in the eastern part it is a dry area with very limited water sources. The utilization of water so far has been dominantly used for irrigation and the rest is used to fulfill clean water through PDAM Karangasem Regency. PDAM Karangasem's water sources are mostly dominated by groundwater sources through PDAM wells which are scattered throughout the region [1].

The development of population and the need for water for other allocations such as for tourism requires larger water sources that must be managed by the local government [1] [2]. Fulfillment of water can be done in an integrated manner both inside and outside Karangasem Regency. It is urgently needed a system of supplying clean water without reducing the water service for traditional Subak irrigation that already exists today. Therefore it is very necessary to carry out a comprehensive research that can provide an overview of the magnitude of the potential and demand for water that exists today, as well as an integrated strategy for fulfilling water in the future. Based on the problems above, several problems related to the clean water supply system can be conveyed, namely: what is the current availability of water in Karangasem Regency, what is the current clean water supply system and what is the strategy for an integrated clean water supply system in the future? future will be linked to regional developments

2. Research Methods

2.1. Research Design

The research was carried out for six months by mapping current water services sourced from PDAM Karangasem, a regional rural drinking water company (PAMdes), followed by an analysis of river potential and an analysis of future water needs. From the mapping carried out, a water fulfillment strategy based on potential and needs is taken in an integrated manner by utilizing the potential of water that is not used for irrigation and is wasted downstream of the river.

2.2. Field Survey and Observation

The survey was conducted at government agencies and the community such as PDAM, PAMdes, Karangasem Regency Public Works Office, Bali Provincial Public Works Office and the Bali Penida River Basin Office, the Central Bureau of Statistics and the Offices of the Regency and Provincial Regional Development Planning Boards. Surveys and field observations were also carried out in residents' homes regarding the actual use of clean water by the community. Direct observations and measurements were carried out related to the potential instantaneous discharge in each potential river in Karangasem Regency.

2.3. Inventory

Inventory is the collection of data related to research such as: inventory of rivers, small reservoirs and others in Karangasem Regency, inventory of population, inventory of clean water infrastructure development and inventory of local government policies in the water service system in Karangasem Regency.

2.4. Analysis

The analytical work carried out includes analysis as a unit. The analysis carried out includes:

1. Analysis of water availability by PDAM Karangasem: this analysis includes the availability of water currently utilized by PDAM and PAMdes as well as wells owned by residents.
2. Instantaneous discharge analysis is carried out to determine instantaneous river discharge for various variations in observation time. This analysis was carried out using several methods, namely the Manning, Strickler and Chezzy approaches [3], [4], [5], [6], [7]
3. Population projection analysis is carried out to determine the population in the future. In population analysis, the approaches used are arithmetic, geometric and last square methods. The selection of the most appropriate method is chosen based on the smallest deviation between the population number and the projected number [8], [9], [10].
4. Analysis of water needs and projections
   Analysis of water needs is adjusted according to the conditions of the local population, geographical conditions, level of welfare, population in an area, climate, water prices, industry and other factors which are the main factors for determining the amount of population's water needs in units of liters/person/day. 11].[12], [13]
5. Analysis of non-domestic water needs
   Domestic water demand analysis is calculated based on usage by each sector such as offices, schools, places of worship, health facilities, tourism facilities, public taps and others. Non-domestic needs can also be determined based on comparison with domestic needs [14], [15], [16].
6. Analysis of current water supplies
   This analysis was carried out to map the current clean water services. This analytical method was carried out by means of a literature study on several case studies of the development of clean water services in Karangasem Regency [17], [18], [19]
7. Analysis of sustainable clean water development systems
   This analysis was carried out by conducting a study of the water supply system development programs that have been and will be carried out in the future. On a wider scale, the Government of Karangasem has limited capacity in developing clean water services, so it is very necessary to coordinate with relevant parties who are competent in the water supply system, such as the Bali Penida River Regional Office, the Bali Regional Settlement and Infrastructure Center, the Bali Regional

Development Planning Agency. as well as from the Public Works Department and the Central Government in Jakarta.

8. Analysis of the Subak Agricultural System and Irrigation Water Needs

   This analysis was conducted to find out the integrated system in Subak which applies the Tri Hita Karana philosophy, namely the concept of agriculture by carrying out a harmonious relationship between farmers and God, farmers, and other farmers and between farmers and the surrounding environment. In this concept, the integration system between farmers and between subak is regulated democratically and upholds the concept of equality. Irrigation water requirements are calculated based on the condition of rice fields in Karangasem Regency by considering reuse factors resulting from the condition of terraced agricultural land. Most of the Bali area, as well as the Karangasem area, are terraced rice fields with carrying and wasting channels forming one link between the irrigation area above it and the irrigation area below it.

9. Integrated water supply system in Karangasem Regency

   Integrated service analysis is carried out by conducting a study of current services, future and various development problems that will be faced. The method used in this analysis is a literature study of several integrated water resource development concepts carried out in various parts of the world. The integrated concept requires balance in the distribution of water assets by considering the interests of water users from several points of view such as economic, ecological, socio-cultural, and technological [20], [21], [22], [23], [24], [25]. The stages of research implementation can be seen in Figure 1

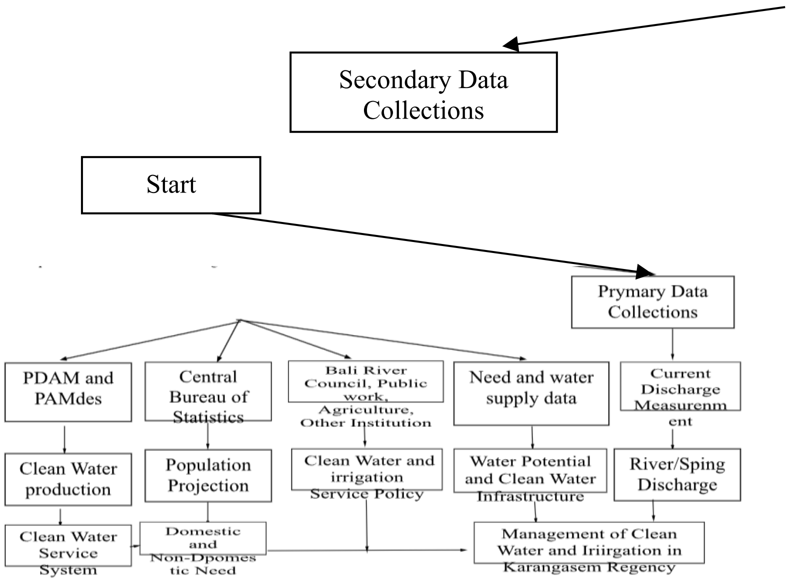

Fig. 1. Research stages

3. Results And Discussion

3.1. Population projections

Based on the results of the analysis and calculations that have been carried out the population of Karangasem Regency in 2025 is 431,025 people, in 2030 there are 447,790 people, in 2035 there are 454,927 people, in 2040 there are 467,449 people, in 2045 there are 480,371 people and in 2050 there are 493,706 people. The full population projection can be seen in table 1

Table 1. Projected Population of Karangasem Regency

Sub District	2022	Projected Population					
		2025	2030	2035	2040	2045	2050
Rendang	41,529	42,727	44,803	46,980	49,262	51,655	54,164
Sidemen	33,968	34,562	35,577	36,621	37,695	38,801	39,940
Manggis	46,653	47,286	48,361	49,461	50,585	51,735	52,911
Karangasem	90,800	92,884	96,463	100,181	104,042	108,051	112,216
Abang	63,593	64,225	65,292	66,377	67,480	68,601	69,741
Bebandem	46,789	47,164	47,795	48,435	49,084	49,741	50,406
Selat	40,569	41,171	42,194	43,243	44,318	45,420	46,550
Kubu	60,240	61,006	62,304	63,630	64,984	66,367	67,779
Amount	424,140	431,025	442,790	454,927	467,449	480,371	493,706

Source: analysis

3.2. Needs and Water Balance of Clean Water

The need for clean water is closely related to regional conditions and the level of community welfare. Communities with higher welfare have greater water needs compared to ordinary communities. Based on the results of field research, water demand in the Karangasem Regency area was found to be 150 liters/person/day. The results of the analysis of the district's clean water needs can be seen in table 2 and the water balance can be seen in table 3 and figure 2.

Table 2. The Need for Clean Water in Karangasem Regency

No	Description	2025	2030	2035	2040	2045	2050
1	People	431,025	442,790	454,927	467,449	480,371	493.706
2	Coverage of clean water Services (%)	53.57	53.57	60.00	65.00	75.00	80.00

3	Domestic water need (liter/second)	400.87	411.81	473.88	527.50	625.48	685.70
4	Non-Domestic Water need (liter/second)	80.17	82.36	94.78	105.50	125.10	137.14
5	Lose water (20%), (liter/second)	96.21	98.83	113.73	126.60	150.12	164.57

Source: analysis

Tabel 3 Water Balance in Karangasem Regency

No	Description	2025	2030	2035	2040	2045	2050
1	Water avaibility (liter/second)	454,54	454,54	454,54	454,54	454,54	454,54
2	Water Need (liter/second)	778,24	799,48	821,40	844,01	867,34	1028,55
3	Water Balance (liter/second)	-323,70	-344,94	-366,86	-389,47	-412,80	-574,01

Source: analysis

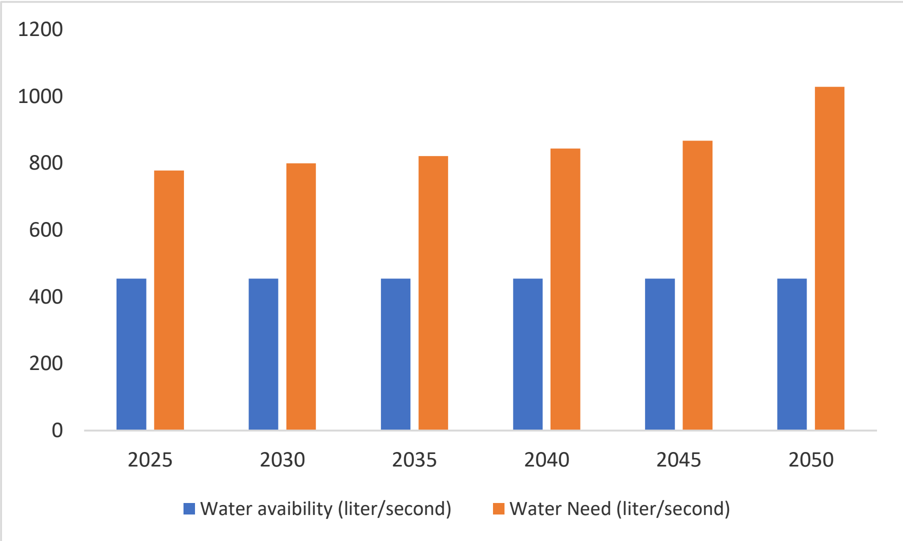

Fig. 2. Prediction Water Balance in Karangasem Regency

3.3. Water Needs for Traditional Subak Irrigation

The irrigation in Bali is a traditional Balinese irrigation system called Subak. This irrigation system is driven by a system of regulations that apply in each Subak. In terms of regulation, building maintenance and development systems, Subak is in synergy with government institutions such as the Public Works Department for improving infrastructure networks and with the Culture Service for structuring institutional organizations. To date, Karangasem Regency has 116 weirs, with a rice field area of 6,091 hectares with water requirements for rice irrigation of 1.17 liters/second/hectare or the equivalent of 14.13 m3/second. The need for irrigation water cannot be reduced because it could cause conflicts with farmers. Therefore, the integration system is carried out in the downstream part of the river or in the middle part by carefully recalculating the water requirements for rice plants. Likewise, the social, cultural, technological, and institutional systems in water development still pay attention to the conditions of Subak and its sustainability in the future. Subak has very specific characteristics compared to other irrigation systems in Indonesia. In rice cultivation, Subak has around 21 religious rituals according to Balinese Hinduism, starting from planting rice until the rice is raised in the barn. Subak has the principle of a sustainable environmentally based management system known as the Tri Hita Karana principle. Tri means three, Hita means happiness and Karana means cause. The meaning of Tri Hita Karana is three harmonious relationships that cause true happiness, namely the harmonious relationship between humans and God, humans and other humans and humans and the environment around them. In the management of Subak this concept is applied by having a building worshiping God/temple at each Subak, a democratic Subak membership system and a well-managed Subak environment.

3.4. Integrated Clean Water Service System

By looking at the analysis of the clean water balance, it shows that Karangasem Regency is an area that is vulnerable to clean water because starting in 2025 it will continue to experience water shortages if not added to the availability of new infrastructure. This new infrastructure can be done by utilizing water from nearby areas such as in Klungkung Regency or by increasing the availability of water through the water potential of Telagawaja River in the Rendang and Selat Districts. The concept of integration in providing irrigation water has traditionally been carried out by Subak institutions independently with coordination by Subak in one institution or with other Subak institutions on a river. The concept of integration is carried out by alternating rice planting seasons. Meanwhile, the concept of integration in the provision of clean water becomes more complex because it involves a wider area with hilly topography in the eastern part of Karangasem Regency. In very dry areas with limited water sources and a sparse population, the water supply system in the dry season is carried out by adding clean water through mobile cars targeting the entire population. On a larger scale, the integration of clean water services is carried out by taking water from Klungkung Regency in the lower reaches of the Unda River. In the central part, it is still possible to draw water from several springs after a strict water allocation calculation for irrigation has been carried out. The integration of clean water supply has actually taken into account the minimum water level during the dry season which is still available in river bodies for tourism activities, namely rafting tours. Along the Telaga Waja and Unda rivers there are several companies engaged in white water rafting. Communities make a real contribution to the integration of the clean water supply system through local wisdom in customary law which has included the conservation values of water resource management such as maintaining springs in their area, protecting vegetation around rivers and avoiding excessive land conversion

The clean water production of Karangasem Regency by PDAM and PAMdes reaches 454.54 liters/second. In 2050, Karangsem Regency needs 1,028.55 liters/second of water, so an additional 574.01 liters/second of clean water is needed. To be able to meet this shortage, there are several plans for a clean water supply system that can be developed in Karangasem Regency until 2050, including: Muara Unda Reservoir in Klungkung Regency with an allocated capacity of 100 liters/second, Telaga Waja spring with a capacity of 175 liters/second seconds, Nyuling River long storage with a capacity of 200 liters/second, Arca spring with a capacity of 80 liters/second, Yeh He spring with a capacity of 40 liters/second.

4. Conclusion

Based on the results of the analysis, several conclusions can be drawn as follows: The availability of water in Karangasem Regency currently comes from PDAM Karangasem Regency and PAMdes which are managed independently by the people in their respective areas. The total availability of water in Karangasem Regency is currently 454.54 liters/second. So far, the supply system has mostly come from PDAM, but in some eastern areas which are topographically difficult and water potential is served more by PAMdes. The strategy that can be carried out in clean water services is to take advantage of the potential of other districts, namely the Muara Unda Reservoir in Klungkung Regency with an allocated capacity of 100 liters/second and by exploiting the potential in the Karangasem area itself, namely by utilizing the Telaga Waja Spring with a capacity of 175 liters/second. seconds, Nyuling long storage with a capacity of 200 liters/second, Arca Springs with a capacity of 80 liters/second, Yeh He Springs with a capacity of 40 liters/second. The target of fulfilling clean water is highly dependent on financing from the government in building the necessary infrastructure. Every five or ten years there must be development of water supply infrastructure to avoid a buildup of demand in the future.

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