Utilization of the Tukad Unda River for the Development of Clean Water Services Denpasar, Badung, Gianyar and Klungkung (Sarbagikung) Areas

I Nyoman Sedana Triadi, Ir. I Made Tapa Yasa, Ir. Made Mudhina, I G. L. Made Parwita, I Nyoman Anom P. Winaya and Ketut Wiwin Andayani
Jurusan Teknik Sipil, Politeknik Negeri Bali,
Jl Kampus Bukit Jimbaran, Kuta Selatan, Kab. Bandung-Bali-8036, Indonesia

Keywords: Availability, Area, Need, Balance, Water, Development.

Abstract: The area of irrigated rice fields used by subak in the Unda River Basin is 3,891.89 ha, spread over the Klungkung and Karangasem regencies. Specifically, the study of the discharge downstream of Tukad Unda is in the Unda Dam, the irrigation area is called the Unda Irrigation Area, with a total area of 1,104.89 ha of the Unda Irrigation Area. The population of Denpasar City in 2021 is 981,824 people, Badung Regency 696,850 people, Gianyar Regency 521,215 people and Klungkung Regency 181,989 people, currently trying to fulfill clean water sourced from Tukad Unda water flow.To find out the potential of Tukad Unda downstream in providing clean water, an analysis of its water availability and existing water needs was carried out. Analysis of water availability with 90% reliability in the downstream Tukad Unda river was carried out using frequency analysis based on the type of distribution of discharge data obtained in Tukad Unda. Analysis of domestic and non-domestic water needs from 2020 to 2040 is based on the socio-economic development conditions of the community. From the results of these calculations, an analysis of the water balance is carried out, namely comparing the availability of water with the demand for water, so that the deficit or surplus is known from time to time. The need for clean water in the Sarbagikung area until 2040 is 7,757 m^3/s. The planned allocation of water from Estuary of Tukad Unda Reservoir for the Sarbagikung area is 1,400 liters/second, covering 850 liters/second to meet the needs in South Denpasar District, 100 liters/second in South Kuta District, 300 liters/second which will distributed to the Districts of Gianyar and Klungkung at 150 liters/second.

1 INTRODUCTION

1.1 Background

Provision of drinking water is a basic need and socio-economic right of the community that must be fulfilled by the central and local governments. The availability of drinking water is one of the determinants in improving people's health, welfare, and productivity in the economic field. Therefore, the provision of drinking water facilities and infrastructure is one of the keys to regional economic development. (Minister of Public Works Regulation, 2007).

Specifically, the study of the discharge downstream of Tukad Unda is in the Unda Dam, the irrigation area is called the Unda Irrigation Area, with a total area of 1,104.89 ha of the Unda Irrigation Area. The current condition of the cropping pattern in the Unda irrigation area is Paddy Paddy Palawija.

The increasing demand for water has caused several problems in the process of providing adequate quantity and quality of water supply. The population of Denpasar City in 2021 is 981,824 people, Badung Regency 696,850 people, Gianyar Regency 521,215 people and Klungkung Regency 181,989 people, currently trying to fulfill clean water sourced from Tukad Unda water flow

To find out the potential of Tukad Unda downstream in providing clean water, an analysis of its water availability and existing water needs was carried out. Analysis of water availability with 90% reliability in the downstream Tukad Unda river was carried out using frequency analysis based on the type of distribution of discharge data obtained in Tukad

Triadi, I., Yasa, I., Mudhina, I., Parwita, I., Winaya, I. and Andayani, K.
Utilization of the Tukad Unda River for the Development of Clean Water Services Denpasar, Badung, Gianyar and Klungkung (Sarbagikung) Areas.
DOI: 10.5220/0011876400003575
In *Proceedings of the 5th International Conference on Applied Science and Technology on Engineering Science (iCAST-ES 2022)*, pages 751-756
ISBN: 978-989-758-619-4; ISSN: 2975-8246

Unda. Analysis of domestic and non-domestic water needs from 2020 to 2040 is based on the socio-economic development conditions of the community. From the results of these calculations, an analysis of the water balance is carried out, namely comparing the availability of water with the demand for water, so that the deficit or surplus is known from time to time.

1.2 Problem Formulation

The formulation of the problem from the research on Utilization of the Tukad Unda river for the development of clean water services in the Denpasar, Badung, Gianyar and Klumgkung (Sarbagikung) areas is, how big the Tukad Unda river can be used for the Sarbagikung area.

1.3 Purpose

The purpose of this study was to obtain answers to the problems presented, is calculating how big the Tukad Unda river can be used for the Denpasar, Badung, Gianyar and Klungkung (Sarbagikung) areas.

2 LITERATURE REVIEW

2.1 Need for Irrigation

Taking into account the level of effectiveness and efficiency of the water distribution pattern, the need for irrigation water will be calculated based on a 15-day period, this period is effective and efficient enough to be implemented in the later operating pattern. The methods that will be used in this analysis are, (Kementrian Pekerjaan Umum, 2013).

- Analysis of potential evapotranspiration (ETo) using the Modified Penman method

$$ETo = ETo^* . C \quad (1)$$

- Analysis of effective rainfall using the Basic Year method, For Rice and For Palawija
- Crop coefficient (Kc) based on FAO . method
- Consumptive use (Etc)

$$Etc = Kc . Eto \quad (2)$$

- Efficient irrigation based on Planning Criteria
- The need for clean water for rice is calculated based on the formula.

$$IR1 = Etc1 + P + WLR + LP – Re \quad (3)$$

- Water Needs for Palawija .

$$IR2 = Etc2 – Rep \quad (4)$$

- water in the intake

$$DR = \frac{IR_1 + IR_2}{Eff} 0,1157 \; A \quad (5)$$

2.2 Water Potential

Water potential is the amount of water contained in water bodies, both as surface water and as underground water. In the analysis of the amount of water potential, it can be obtained through data series from recording weir discharge, river or it could be based on the mainstay discharge analysis by using several methods of diverting the variance of rain associated with the conditions of the existing watershed. The method commonly used is the FJ Mock method or the NRECA method, (Soemarto CD, 2011)

2.3 Strategy Management

Strategic management is defined as a way to guide companies to achieve a number of goals, including corporate responsibilities, managerial capabilities, to administrative systems related to strategic decision making, and operations.Strategic management is a series of fundamental decisions and actions from the highest management, which are applied by all members of an organization, for the realization of organizational goals. (Agrifa Masir, 2017)

2.4 Population

The calculation of the population is important, because knowing the population of an area will be the basis for making population policies at a certain time. The province of Bali, which includes nine regencies and cities, has a relatively varied population. Population development in the province of Bali has not been evenly distributed. As a result of the uneven development of the region, especially related to the development of the tourism industry sector, community social centers, and government, which are still in the district capital.

Calculation of the population using arithmetic, geometric and least square formulas. To determine the method used in each sub-district, the smallest standard deviation value of the three approaches will be determined. (Minister of Public Works Regulation, 2007).

2.5 Clean Water Development System

Part of a clean water distribution network system, are the components that exist in a series of clean water distribution network systems. These parts consist of pipes and their connections, valves, pumps, reservoirs, all of which must work properly.

Based on the instructions of the Integrated City Infrastructure Development Program regarding Guidelines for Planning and Technical Design for the drinking water sector, it is stated that the raw water sources that can be treated are springs, namely water sources that are above the ground surface, shallow wells, namely water sources resulting from excavations or drilling depths. less than 40 meters deep, deep wells, namely water sources from excavation or drilling with a depth of more than 40 meters, rivers, namely water drainage channels formed from upstream to empties into the sea or lakes, lakes and water reservoirs, namely deep water storage units a certain amount of which the water comes from streams or rainwater reservoirs.

3 METHODOLOGY

3.1 Scope of Research

The scope of the utilization of the Tukad Unda river for the development of clean water services in the Denpasar, Badung, Gianyar and Klungkung (Sarbagikung) areas are:

- Conduct a literature study or review of relevant studies related to the remaining water in the lower reaches of Tukad Unda
- Measure the downstream Tukad Unda instantaneous discharge
- Analyzing the Tukad Unda discharge data based on the Unda Dam discharge recording data, AWLR, and rain data.
- Analyzing the mainstay of the Tukad Unda debit
- Analyzing the availability of Tukad Unda water and current irrigation water needs
- Analyzing the water balance downstream of Tukad Unda

3.2 Data Source

The data source is a very important part related to the validity of the data. With regard to the data to be retrieved, the data that will be needed are as follows:

- Daily rain data for 15 years from Besakih Rain Station, Rendang Rain Station, Duda Rain Station, and Klungkung Rain Station.
- Data on debit recording at the Tukad Unda AWLR Post for 15 years.
- Data on debit recording in Unda Dam for 15 years.
- Demographic data of the population, socio-cultural facilities and infrastructure, tourism, industry.
- Clean water supply system data
- Data on current sources of clean water
- Clean water quality and quantity data

3.3 Measurement with Current Meter

The tool used to measure the flow velocity is a current measuring instrument, which is commonly referred to as a current meter. The main equipment commonly used in measuring flow is a flow meter, including all its accessories, namely a timer and a rotation counter, a depth gauge, a width gauge, assembly equipment and some additional tools. The selection of the use of equipment and equipment must be adjusted to the physical condition of the river being measured.

3.4 Analysis of Clean Water Availability

In calculating the mainstay discharge using the basic year planning method. The planning base year is a reliable debit pattern where the debit pattern has actually happened in previous years. The mainstay discharge calculation is intended to find the quantitative value of the available discharge throughout the year, in the dry season and in the rainy season.

3.5 Population Analysis

Calculation of the population using arithmetic, geometric and least square formulas. To determine the method used in each sub-district, the smallest standard deviation value of the three approaches will be determined.(Minister of Public Works Regulation 2007).

3.6 Clean Water Needs Analysis

The Directorate General of Human Settlements has set the water usage standard for metropolitan cities of 190 liters/person/day, standard waterrequirements for large cities at 170 liters/person/day, medium cities at

150 liters/person/day, and small cities at 130 liters people. /day.

3.7 Water Balance

The water balance is intended to determine how much potential is available each month, as well as how much water is needed. The Water Balance will know the months of surfing as well as the months that are in deficit. Mathematically, the calculation method for obtaining the residual water discharge in this water balance analysis is the mainstay discharge minus the demand discharge.

3.8 Clean Water Supply System Strategy

The clean water supply system strategy is carried out by means of a literature study, with the development of the concept of sustainable water source management, based on the condition of the current system that has been running, taking into account the sustainability of clean water supply in the future. Inventory of existing clean water sources and clean water sources that are in the process of being built.

4 DISCUSSION RESULT

4.1 Population

Calculation of population using arithmetic, geometric and least square formulas. Determination of the method used in each sub-district will be determined with the smallest standard deviation value of the three approaches. (Minister of Public Works Regulation, 2007)

Table 1: Population of the Sarbagikung Area.

Districts	Projected population (person)				
	2020	2025	2030	2035	2040
Denpasar	962.900	1.057.362	1.165.838	1.285.734	1.418.286
Badung	683.200	750.730	816.460	880.390	942.520
Gianyar	516.300	539.827	563.645	588.099	613.217
Klungkung	180.780	186.824	192.869	198.913	204.957
Total	2.343.180	2.534.743	2.738.812	2.953.136	3.178.980

4.2 Water Demand Projection

The sub-district's domestic water needs are determined based on the population. In 2020 and 2021, it is assumed that the service level has reached 80%, an increase of 5% annually, until in 2025 the service level has reached 100%. Non-domestic needs are 20% of domestic needs, water leakage is 20% of total domestic and non-domestic needs. The total of water needs is the sum of domestic, non-domestic, and water leaks.

Table 2: Average Water Demand Capacity.

Districts	Average Water Demand Capacity (liter/second)				
	2020	2025	2030	2035	2040
Denpasar	1.925,80	2.643,41	2.914,59	3.214,34	3.545,72
Badung	1.255,95	1.764,52	2.001,67	2.153,88	2.347,57
Gianyar	929,31	1.176,09	1.303,79	1.361,04	1.419,81
Klungkung	306,77	371,4	417,88	430,98	444,08
TOTAL	4.417,83	5.955,42	6.637,93	7.160,24	7.757,18

4.3 Mainstay Debit Analysis

Mainstay debit is the amount of discharge available to meet water needs with a calculated risk of failure. In planning a water supply project, a reliable discharge must first be sought, the purpose of which is to determine the planned discharge which is expected to always be available in the river (Soemarto, 1987). The mainstay discharge is intended to find the quantitative value of the available discharge throughout the year, both during the dry season and in the rainy season. The mainstay debit is the minimum debit that can be guaranteed reliability with a probability of P% or has a failure risk level of (1-P%).

Table 3: Mainstay debit 90% at Weir Unda.

Description	Mainstay Discharge 90% in Unda Dam (m3/s)					
	Jan	Feb	Mar	Apr	May	Jun
AWLR Debit Data	3,84	3,88	3,66	3,59	2,76	1,57
Recording Debit Data at Unda Dam	7,95	6,23	7,62	8,22	7,54	5,97
FJ. Mock Debit Data	7,20	12,50	7,00	6,50	3,70	0,20
Average	6,33	7,54	6,09	6,10	4,67	2,58
Description	Mainstay Discharge 90% in Unda Dam (m3/s)					
	Jul	Aug	Sep	Oct	Nov	Dec
AWLR Debit Data	2,74	2,21	3,34	1,40	2,11	3,60
Recording Debit Data at Unda Dam	6,41	5,40	4,24	3,76	7,56	5,61
FJ. Mock Debit Data	4,70	1,50	4,30	2,10	1,20	7,60
Average	4,61	3,04	3,96	2,42	3,63	5,60

4.4 Irrigation Water Needs

The area of irrigated rice fields utilized by the Unda Irrigation Area is 1,104.89 ha. The condition of the existing cropping pattern in DI Unda is Paddy Paddy Palawija, early planting of rice 1 is March 1, paddy 2 is on July 1 and palawija is on October 1st.

Table 4: Irrigation Water Needs in Unda Weir.

Description	Irrigation Water Needs in Unda Weir (m3/sec)					
	Jan	Feb	Mar	Apr	May	Jun
Existing Irrigation Needs	0,04	0,68	1,46	0,59	0,56	0,77
Description	**Irrigation Water Needs in Unda Weir (m3/sec)**					
	Jul	Aug	Sep	Oct	Nov	Dec
Existing Irrigation Needs	1,54	1,31	1,14	0,55	0,31	0,70

4.5 Water Balance

Water-balance is an analysis that describes the utilization of water resources in a review area based on a comparison between water demand and availability. The calculation of the water balance is intended to determine the remaining Tukad Unda water after being used, which indicates a shortage or excess of water, in the downstream part of the Tukad Unda watershed, in terms of the availability of surface water.

Table 5: Mainstay Discharge 90% in Unda Dam.

Description	Mainstay Discharge 90% After Use of Irrigation in Unda Weir (m^3/sec)					
	Jan	Feb	Mar	Apr	May	Jun
AWLR Debit Data	3,80	3,20	2,20	3,00	2,20	0,80
Recording Debit Data at Unda Dam	7,20	5,90	6,30	6,90	6,50	4,80
FJ. Mock Debit Data	3,90	9,60	5,20	3,70	1,80	0,10
Average	4,97	6,23	4,57	4,53	3,50	1,90
Description	**Mainstay Discharge 90% After Use of Irrigation in Unda Weir (m^3/sec)**					
	Jul	Aug	Sep	Oct	Nov	Dec
AWLR Debit Data	1,20	0,90	2,20	0,85	1,80	2,90
Recording Debit Data at Unda Dam	5,80	4,10	3,50	3,60	6,20	5,20
FJ. Mock Debit Data	4,20	1,30	2,50	2,00	0,10	5,50
Average	3,73	2,10	2,73	2,15	2,70	4,53

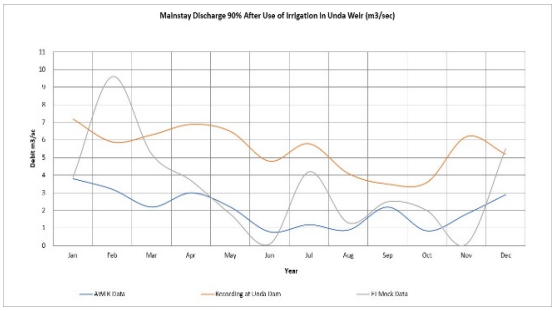

Figure 1: Mainstay Discharge 90% in Unda Weir (Remaining Water downstream of the Unda Weir).

5 CONCLUSION

The conclusion of the research is :

- The average value of the residual water discharge in Tukad Unda is 3,638 m3/sec.
- The need for clean water in the Sarbagikung area until 2040 is 7,757 m3/s.
- The planned allocation of water from Estuary of Tukad Unda Reservoir for the Sarbagikung area is 1,400 liters/second, covering 850 liters/second to meet the needs in South Denpasar District, 100 liters/second in South Kuta District, 300 liters/second which will distributed to the Districts of Gianyar and Klungkung at 150 liters/second.

REFERENCES

Agarwa (2000). Integarted Water Resources Managemen. tehnicel Advisory Commitee (TAC). Global Water Parnership (GWP) Stokholo. Sweden, Home Page of GWP www.gwpforum.org

Agrifa Masir (2017). JISIP., Journal of Social and Political Sciences. Vol 6. N0.2. PDAM Strategy in Improving Clean Water Quality to Support Development in Batu Tourism City.

Kementrian Pekerjaan Umum (2013). Criteria for Irrigation Planning KP-01. Planning of irrigation networks. Jakarta: Directorate General of Water Resources.

Minister of Public Works Regulation No.18/PRT/M/2007 (2007). Concerning Implementation of Drinking Water Supply System Development.

Andito Sidiq Swastomo (2020). Sukowati Research and Development Journal, Community-Based Rural Water Supply System Sustainability.

Central Statistics Agency (2020). Denpasar City in Figures, Badung Regency in Figures, Jembrana Regency in Figures, Klungkung Regency in Figures.

Beecher, Janice A (1995). Integarated Resources Planiing Fundamentals, Journal of American Water Works Assosiation (AWWA)

Chow, VT (1992). Open Channel Hydraulics. Bandung: PT Erlangga.

Erwin Nugraha. (2009). Department of Planning Engineering. Bandung Institute of Technology.

Joerson Loebis, Soewarno, Suprihadi B (1993). River Hydrology, Jakarta: Public Works Publishing Agency Foundation.

Kamulyan, P. Wiguna, I.P.A. and Slamet, A. (2017). Assessment of the Sustainability of Community-Based Drinking Water Supply System Management in Blitar City. Ten November Institute of Technology Journal Of Civil Engineering. 32(2). 60-6.

Kamiana, I. M. (2012). The technique of calculating the discharge plan of the water structure. Yogyakarta: Graha Ilmu.

Mock, F.J. (1973). Water Availability Appraisal. Basic study prepared for FAO/ UNDP Land Capability Appraisal Project. Bogor.

Minister of Public Works Regulation No.18/PRT/M/2007 (2007). Concerning Implementation of Drinking Water Supply System Development

Soemarto CD (2011). Engineering Hydrology. Jakarta : Erlangga.

Soewarno (1995). Hydrology Application of Statistical Methods for Data Analysis. Bandung : Nova

Sudirman et al (2021). Irrigation Systems and Waterworks, Publisher: Yayasan Kita Menukis . Medan.

Slamet Suprayogi (2020). Watershed Management. Publisher : UGM Press. Yogyakarta.

Norken, I Nyoman (2003). Integrated and Sustainable Development and Management of Water Resources (A Challenge in Water Resources Management in Indonesia), Paper in Seminar on Integrated and Sustainable Development and Management of Water Resources, F.T. UNUD, Denpasar.