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Sustainable Management Model for Springs Water in Remote Areas as an Effort to Fulfill Water Needs

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Abstract – *Pesiraman Manik Tirta Spring in Timuhun Village can potentially discharge water to meet the need for clean water. This spring's problematic source is a lack of infrastructure to distribute water from the source to locals' residences, requiring residents who want to get water to travel through fairly steep terrain to the spring. A management plan for the Pesiraman Manik Tirta spring region is required to continue providing Timuhun Village's water needs. The sustainability of the current water potential can be maintained by acquiring an appropriate management approach. This research is a descriptive study that combines quantitative and qualitative analysis. Microsoft Excel was used to evaluate quantitative data. SWOT analysis, a suitable management model, was produced to satisfy Timuhun Village's need for sustainable water. This model was then implemented as the management model for that village's Pesiraman Manik Tirta Springs Area. This model can be accomplished by constructing infrastructure with relatively low operating expenses, such as hydro pumps that run without electricity. A clean water distribution infrastructure's accessibility can enhance people's quality of life. Water is not far away in relatively steep locations.*

Keywords: *Sustainable, Management, Spring Water, Remote Area.*

I. Introduction

Water is essential for all living things, especially human life [1]–[4]. However, until recently, providing clean water for the community has been hampered by several complicated issues that have yet to be fully resolved. The limited availability of clean water for both urban and rural communities is one of the issues still present today [5]–[7]. Water resources include surface, ground, and spring water [8]–[10]. Springs are karst-shaped natural water sources generated when groundwater rises to the surface via fissures in the topography. These gaps or surface springs can generally be found in mountainous or highland environments. Springs are high-quality water resources that can produce raw water [11]–[13]. The potential of springs that exist but have not been managed causes potential that can be wasted in the rivers [14], [15]. However, there are still a few places not reached by clean water distribution facilities that meet the required quality standards [16]–[20].

In Klungkung Regency's Timuhun Village, this occurred. The community has not yet had access to a sufficient amount of drinking water. Society must travel 700 meters to reach water [21]. In contrast, the Pesiraman Manik Tirta spring in Timuhun Village has the potential to discharge water to meet the need for clean water.

This spring's problematic source is a lack of infrastructure to distribute water from the source to locals' residences, requiring residents who want to get water to travel through fairly steep terrain to the spring. Furthermore, Pesiraman Manik Tirta Springs is being developed as a Hindu religious ecotourism destination known as "*melukat*". For Hindus in Bali, "*melukat*" is a ritual purifying their bodies and minds.

The sustainability of the water potential itself will be threatened by improper management of water resources [4], [22]–[25]. As a result, a management plan for the Pesiraman Manik Tirta spring region is required to continue providing Timuhun Village's water needs. This model is believed to enable the optimal management approach to be adjusted to the site's specific issues. The SWOT analysis method will be used create this management model by considering the strengths, weaknesses, opportunities, and threats [26]–[30]. A management model is usually created using a SWOT analysis. The sustainability of the current water potential can be maintained by acquiring an appropriate management approach.

II. Research Methods

Primary and secondary data are used in this study. The Internal Factor Analysis Summary (IFAS) and External Factor Analysis Summary (EFAS) weights in the SWOT analysis, which will be utilized to construct a spring area management model, were determined using information from stakeholder interviews. The secondary data utilized

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to establish the socio-cultural circumstances in the Pesiraman Manik Tirta Springs area include village profiles. In addition, climatology data from https://power.larc.nasa.gov/data-access-viewer/ is used. The climatological data used in this study range from 1990 to 2021. This information is used to forecast the climatological conditions in the area around the spring. This study also conducted the water quality to know the spring's water quality.

II.1. Study Area

The Pesiraman Manik Tirta spring is in Timuhun Village, Klungkung Regency, at 8° 28' 34.39" South Latitude and 115° 23' 3.48" East Longitude. This spring has the potential to reach 1.6 liters per second. Throughout the year, this spring discharges continuously. The study area location can be seen in Fig. 1.

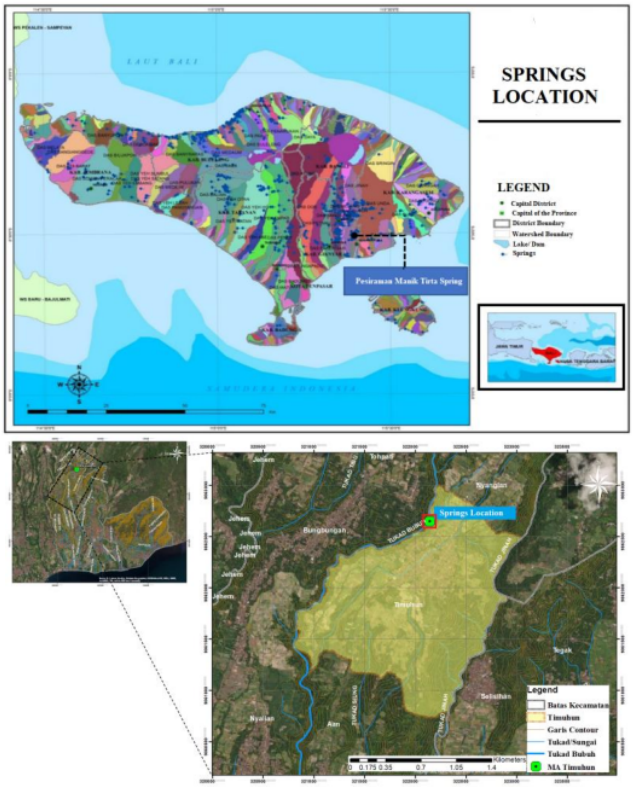

Fig. 1. The Pesiraman Manik Tirta Spring Location

II.2. Data Analysis Methods

This study is a descriptive study that combines quantitative and qualitative analysis. Microsoft Excel was used to evaluate quantitative data. Regarding the qualitative analysis, questionnaire-based interviews and in-depth discussions with chosen respondents were conducted utilizing survey methods, observations, literature reviews, and survey methodologies. A Management Model for the Pesiraman Manik Tirta Springs Area was developed as a result of analysis, surveys, and questionnaires to manage the potential of Pesiraman Manik Tirta Springs to meet Timuhun Village's water needs. The flowchart of data analysis can be seen in Fig. 2.

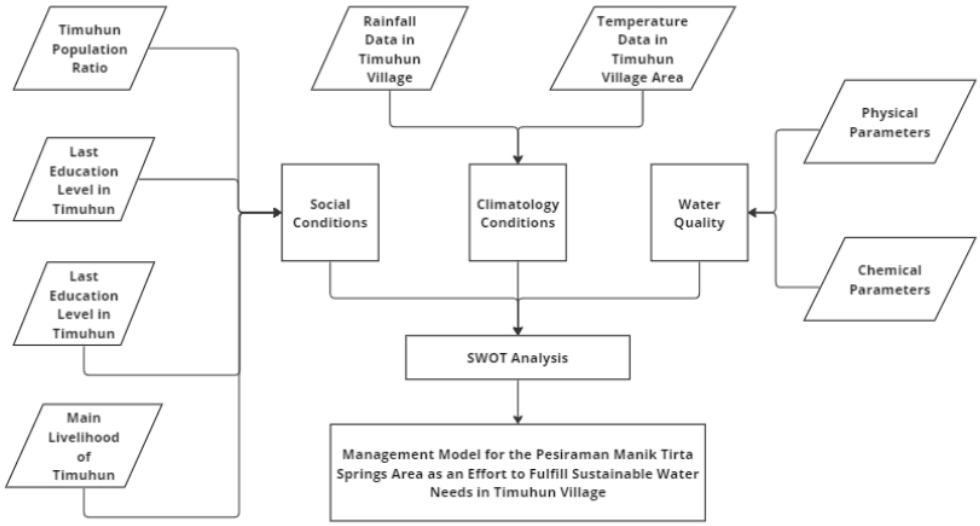

Fig. 2. The Flowchart of Data Analysis

III. Result

III.1. Social Conditions in the Pesiraman Manik Tirta Springs Area

The population of Timuhun Village is 3314 people, consisting of 1644 males and 1670 females, or a ratio of roughly 50/50. Residents, particularly women, find it difficult to obtain water sources due to the distance from the springs and the steep terrain of the water access. The population ratio of Timuhun Village can be seen in Fig. 3.

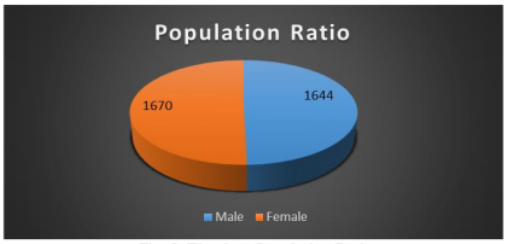

Fig. 3. Timuhun Population Ratio

Varied levels of education will result in different attitudes about addressing their water demands. Elementary is the most common level of last education in Timuhun Village. The inability to create a sustainable area management pattern is due to the poor level of education in the local community. The last education level in Timuhun Village can be seen in Fig. 4.

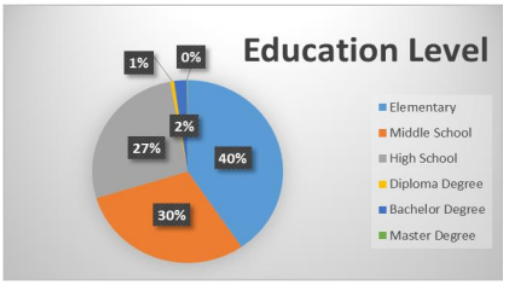

Fig. 4. Education Level in Timuhun Village

Most Timuhun Village residents earn their living as housewives or students. Because of the poor level of residents' livelihoods, residents cannot employ electric pumps to lift water from the source to their separate residential zones. This condition is due to the community's inability to cover the operational costs of the pumps. The main livelihood in Timuhun Village can be seen in Fig. 5.

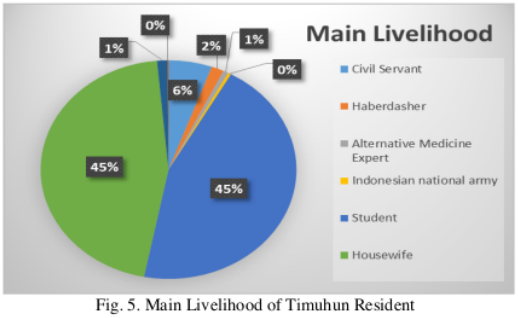

Fig. 5. Main Livelihood of Timuhun Resident

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III.2. Climatology Conditions in the Pesiraman Manik Tirta Springs Area

Timuhun Village has 1630.3 mm of precipitation on average every year. The annual maximum rainfall is 2606.55 mm, and the annual minimum rainfall is 1075 mm. Fig. 6 shows that rainfall in Timuhun is relatively high.

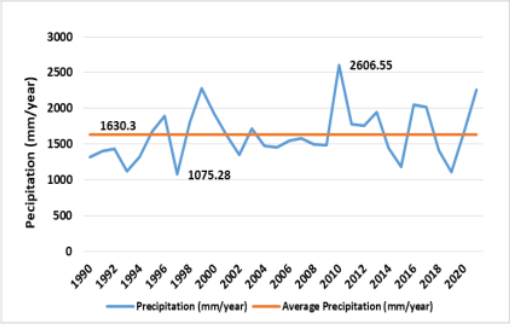

Fig. 6. Rainfall Data in Timuhun Village Area

Because of the heavy rainfall will impact the Pesiraman Manik Tirta Spring's flow. This condition demonstrates that the possibility of spring water in Timuhun Village, now confined by distance and without proper drinking water distribution infrastructure that matches the standards, might be considered to meet the village's water demands.

The average temperature in Timuhun Village is 26.56°C. The maximum temperature is 27.43°C. Temperature changes in Timuhun Village are depicted in Fig. 7. The rate of evaporation increases with increasing temperature. Fig. 7 shows that temperature changes in Timuhun Village are not very significant.

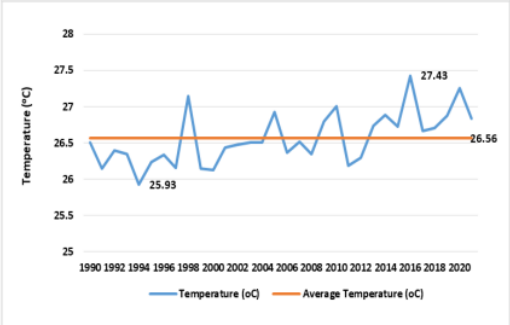

Fig. 7. Rainfall Data in Timuhun Village Area

III.3. Water Quality of the Pesiraman Manik Tirta Springs Area

Several physical and chemical water quality experiments were conducted to ascertain the springs' water quality at Pesiraman Manik Tirta. Table 1 displays the outcomes of the spring quality test. Table 1 demonstrates that the spring in Timuhun Village satisfies the criteria for drinking water from a physical and chemical standpoint. Because it satisfies the requirements for both quantity and quality, this spring is ideal for use as a drinking water supply for the residents of Timuhun Village.

TABLE I
RESULTS OF WATER QUALITY TESTS

No	Parameter	Unit	Result	Quality Standards	Method Specification	Description
	Physical					
1	Smell	-	Odorless	Odorless	Organoleptic	Meet the quality standard
2	Color	TCU	0.51	15	Spectrophotometry	Meet the quality standard
3	Total Dissolved Solids	mg/L	177.4	500	Electrometric	Meet the quality standard
4	Turbidity	NTU	0.56	5	Spectrophotometry	Meet the quality standard
5	Flavor	-	Tasteless	Tasteless	Organoleptic	Meet the quality standard
6	Temperature	˚C	25	Air temperature ± 3˚C	SNI.06.6989.23.2005	Meet the quality standard
	Chemical					
7	Fluoride	mg/L	0.302	1.5	Spectrophotometry	Meet the quality standard
8	Nitrite	mg/L	<0.001	3	Spectrophotometry	Meet the quality standard
9	Nitrate	mg/L	5.33	50	Spectrophotometry	Meet the quality standard
10	Cyanide	mg/L	<0.002	0.07	Spectrophotometry	Meet the quality

No	Parameter	Unit	Result	Quality Standards	Method Specification	Description
						standard
11	Iron	mg/L	0.089	0.3	Spectrophotometry	Meet the quality standard
12	Hardness	mg/L	101.2	500	Titrimetric	Meet the quality standard
13	Chloride	mg/L	12.84	250	Titrimetric	Meet the quality standard
14	Manganese	mg/L	<0.01	0.4	Spectrophotometry	Meet the quality standard
15	PH	-	7.28	6.5 – 8.5	SNI 6989.11:2019	Meet the quality standard
16	Sulfate	mg/L	21.462	250	Spectrophotometry	Meet the quality standard
17	Ammonia	mg/L	<0.001	1.5	Spectrophotometry	Meet the quality standard
18	Zinc (Zn)	mg/L	0.0134	3	AAS	Meet the quality standard
19	Copper (Cu)	mg/L	<0.0153	2	AAS	Meet the quality standard
20	Lead (Pb)	mg/L	<0.0036	0.01	AAS	Meet the quality standard
21	Total chrome	mg/L	<0.003	0.05	AAS	Meet the quality standard
22	Cadmium (Cd)	mg/L	<0.001	0.003	AAS	Meet the quality standard
23	Aluminum (Al)	mg/L	<0.01	0.2	AAS	Meet the quality standard
24	Nickel (Ni)	mg/L	<0.003	0.07	AAS	Meet the quality standard
25	Selenium (Se)	mg/L	<0.0006	0.01	AAS	Meet the quality standard
26	Arsenic	mg/L	<0.0003	0.01	AAS	Meet the quality standard

III.4. SWOT MODEL

Timuhun Village has 1630.3 mm of precipitation on average every year. The annual maximum rainfall is 2606.55 mm, and the annual minimum rainfall is 1075 mm. Fig. 6 shows that rainfall in Timuhun is relatively high.

Pesiraman Manik Tirta Spring is one of the springs with high potential and a year-round flow. Despite its immense potential, the neighboring population cannot fully utilize it due to a lack of suitable water distribution infrastructure. Based on the outcomes of interviews with critical stakeholders, a SWOT model was developed to get a spring area management model to address the clean water needs of the Timuhun Village community, as shown in Fig. 8.

Fig. 8. SWOT Matrix Management Model for the Pesiraman Manik Tirta Springs Area as an Effort to Fulfill Sustainable Water Needs in Timuhun Village

Strength

- Spring water flows continuously throughout the year, with a discharge rate of up to 1.6 liters per second.
- Based on water quality tests, the water quality satisfies drinking water regulations.
- Forest area habitat with massive vegetation that is still well kept.
- The ease with which the location can be reached
- There is strong community support to conserve the region.

Weakness

- Because there are insufficient water supply facilities, the Pesiraman Manik Tirta spring's potential is wasted.
- The terrain is steep, making it challenging to build water supply infrastructure.
- The people's income is still relatively poor, so they cannot afford the electricity charges even using an electric pump.
- The water source does not have an area arrangement.
- The inability to create a sustainable area management pattern is due to the poor level of education in the local community.

Opportunity

- The potential for large springs can meet the water needs of the surrounding community
- The community's economy can increase if there is clean water distribution infrastructure available
- The ease of accessing the location of the springs can be used as "melukat" religious ecotourism.
- The maintenance of forest areas as recharge areas can maintain a sustainable spring discharge
- A good community can manage the spring area and can utilize the spring to meet sustainable water needs

Threaten

- Water scarcity caused by climate change
- Land conversion causes damage to nature and the recharge area.
- Water pollution caused by human activities
- Excessive use of water resources
- Damage to the spring area results from inadequate area management.

TABLE 2
MATRIX IFAS AND EFAS

Questionnaire	Total	Rating	Score
Strength (IFAS)			
Spring water flows continuously throughout the year, with a discharge rate of up to 1.6 liters per second.	106	3.53	1.38
Based on water quality tests, the water quality satisfies drinking water regulations.	101	3.37	1.18
Forest area habitat with massive vegetation that is still well kept.	95	3.17	1.10
The ease with which the location can be reached	83	2.77	0.83

There is strong community support to conserve the area	107	3.57	1.09
	279	**9.30**	**3.12**
Weakness (IFAS)			
Because there are insufficient water supply facilities, the Pesiraman Manik Tirta spring's potential is wasted.	113	3.77	0.75
The terrain is quite steep, which makes it challenging to build water supply infrastructure	111	3.70	0.72
The inability to create a sustainable area management pattern is due to the poor level of education in the local community.	83	2.77	0.55
The water source does not have an area arrangement.	94	3.13	0.62
The people's income is still relatively poor, so they cannot afford the electricity charges even using an electric pump.	116	3.87	0.81
	517	**-17.23**	**-3.45**
Opportunity (EFAS)			
The maintenance of forest areas as recharge areas can maintain a sustainable spring discharge	104	3.47	0.70
The maintenance of forest areas as recharge areas can maintain a sustainable spring discharge	86	2.87	0.56
The community's economy can increase if there is clean water distribution infrastructure available	87	2.90	0.56
The ease of accessing the location of the springs can be used as "*melukat*" religious ecotourism.	88	2.93	0.54
A good community can manage the spring area and can utilize the spring to meet sustainable water needs	98	3.27	0.74
	463	**15.43**	**3.10**
Threaten (EFAS)			
Water pollution caused by human activities	83	2.77	0.63
Damage to the spring area results from inadequate area management.	93	3.10	0.42
Excessive use of water resources	100	3.33	0.57
Land conversion causes damage to nature and the recharge area.	110	3.67	0.79
Water scarcity caused by climate change	113	3.77	0.95
	499	**-16.63**	**-3.35**

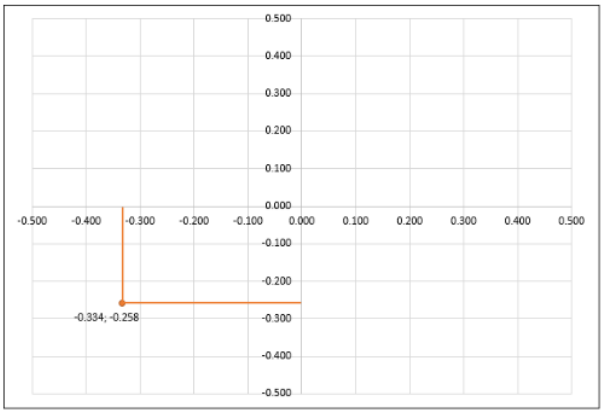

Fig. 9. SWOT Analysis Position Diagram

IV. Discussion

The SWOT matrix, as depicted in Fig. 8, will explain the external opportunities and threats encountered by the strengths and weaknesses it possesses. Several strategies are possible based on the SWOT matrix, as shown below.

- The SO strategy (using strength to maximize opportunities) can be used to manage the potential of the springs by arranging the area around the springs, particularly in recharge zones. Furthermore, the existing water quality must be preserved so that the existing water potential can be used to meet Timuhun Village's clean water needs in the future.
- The WO strategy (minimizing weaknesses to capitalize on opportunities) can be used to create and implement water usage rules to ensure the existing water potential is sustainable in quantity and quality. In Bali, these regulations can be created in "*awig-awig*" (traditional law source in Bali) and engage the traditional villages. In addition to establishing laws, this spring region has the potential to be developed as a place for "melukat" (cleansing our body and spirit), which might raise the area's economic condition.
- The ST strategy (using strength to overcome threats) can be carried out by providing affordable infrastructure in operational costs, such as using hydro pumps that do not use electricity to operate. Having a clean water distribution infrastructure can enhance people's quality of life. People do not have to walk far to find water in fairly steep locations.
- The WT strategy (minimizing weaknesses to avoid threats) can be implemented by forming a community group concerned with managing the area and water potential of the Pesiraman Manik Tirta spring.

The SWOT analysis position diagram in Fig. 9 determines the current priority strategic positions. This diagram is based on Table 2, where the location of the existing condition is in quadrant 1. There are 4 quadrants, each with a unique category. Because it uses strength to take advantage of chances already present, Quadrant 1 is a very advantageous position. In this situation, the best course of action is to promote a policy of rapid expansion.

In the second quadrant, there is internal strength even in the face of several threats. The necessary plan is to use strength combined with a diversification strategy to seize long-term chances. The company is in quadrant three and has many prospects but has significant internal limitations and vulnerabilities. In this role, the strategic priority is to reduce internal company issues so that the organization can take advantage of more excellent prospects. Due to several internal risks and weaknesses, the organization is in Quadrant 4, a very unfavorable condition.

Fig. 8 shows that the chosen strategic position is in quadrant 3, where it can be implemented as the management model for the Pesiraman Manik Tirta Springs Area as an effort to fulfill sustainable water needs in Timuhun Village. This management can be done by providing affordable infrastructure for operational costs, such as using hydro pumps that do not require electricity.

The availability of a clean water distribution infrastructure can improve people's quality of life. In fairly steep places, no one needs to travel far to find water. We can distribute water from the Pesiraman Manik Tirta spring without using energy by creating the necessary infrastructure, which will enhance the standard of living for the residents of Timuhun Village.

V. Conclusion

The Pesiraman Manik Tirta Spring in Timuhun Village is currently not optimal owing to the lack of affordable infrastructure to distribute clean water to people's homes. After a SWOT analysis, a suitable

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management model was produced to satisfy Timuhun Village's need for sustainable water. This model was then implemented as the management model for that village's Pesiraman Manik Tirta Springs Area. This management can be accomplished by constructing infrastructure with relatively low operating expenses, such as hydro pumps that run without electricity. A clean water distribution infrastructure's accessibility can enhance people's quality of life. Water is not far away in relatively steep locations. By establishing the required infrastructure, we can convey water from the Pesiraman Manik Tirta spring without requiring energy, raising the living level for those who live in Timuhun Village.

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