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Community perceptions and valuation of freshwater ecosystem services: A case of rural springs

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ABSTRACT

Background: This study aims to analyze public perception and conduct an environmental service valuation of the Puta Spring in Lakapodo Village, Watopute District, Muna Regency. **Methods:** The study was conducted from April to June 2024 with a population of 318 households that use the Puta Spring as their main water source. The research sample was determined using the Slovin formula with a confidence level of 10%, resulting in 76 respondents selected through purposive sampling, with the criterion of people who had used the spring for at least the last five years. Data were collected through observation, interviews, and literature studies, then analyzed descriptively and quantitatively. **Findings:** The results showed that the community's perception of the existence of Puta Spring was in the good category with an average score of 242.47. This indicates a high level of awareness of the importance of preserving this water source in supporting daily needs. The valuation of environmental services calculated based on the prevailing price method shows an economic value of IDR 211,104,000.00 per year, while based on the market price in Muna Regency, it reaches IDR 164,661,120.00 per year. The total volume of water used for domestic needs by the entire community of Lakapodo Village is 42,220.8 m^3 per year, with an average discharge of Puta Spring of 0.0082 m^3/second. **Conclusion:** Public perception of the spring is generally good, with high scores in existence, management, utilization, and economic value. Water availability exceeds community use, resulting in a surplus of 212,283 m^3/year, corresponding to an economic value of IDR 1,061,415,000, indicating sustainable resource potential. **Novelty/Originality of this article:** The novelty of this study lies in integrating community perception assessment with economic valuation and water balance analysis to reveal the surplus value and sustainability potential of the Puta spring.

KEYWORDS: community perception; environmental services; water valuation; puta spring; Muna Regency.

1. Introduction

Nature plays a vital role in human life. Water is a primary means of improving public health, as it is a medium for the transmission of various diseases, especially stomach illnesses. Therefore, water must be protected so that it remains beneficial to human life. Water plays a very strategic role and must remain available and sustainable so that it can support life and development now and in the future (Madjid et al., 2022). For communities living in and inside forest areas, forests are natural resources that offer a variety of advantages, including food, shelter, medicine, and environmental services. Forests must thus be sustainably managed, preserved, and used. The creation of non-timber forest

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products is one facet of forest management that necessitates a strategy to expand communities' alternate revenue streams. While taking ecological considerations into account, forest management must be focused on producing revenue for nearby populations (Betts et al., 2021).

Forests play a unique role both as a life support system and as an economic driver in many countries. Tropical forests are known to have high biodiversity and are a repository of important genetic resources of flora and fauna for the fulfillment of needs for wood and non-wood products, agriculture, medicines, and others (Koulelis et al., 2023). The role of forests has led communities to utilize forests with all their diversity. Encroachment and illegal logging activities in forests have caused changes in their biodiversity, many of whose benefits are still unknown. This condition reduces the capacity of forests to provide services as intended. One of the problems in forest management is the low socioeconomic status of communities living around forests. Local communities around forests generally depend on forests as a source of livelihood, but their lives are still far from prosperous, with inadequate public facilities. The presence of local communities, along with their indigenous knowledge, has the potential to safeguard forest regions, rather than being displaced and having their fundamental rights taken away, despite occasionally being viewed as a source of conflict. It is anticipated that through community-based forest management, the community's income and economy will enhance, thereby preventing illegal logging and the expansion of forest land (Jayadi et al., 2024).

The stability of the global environment is largely dependent on forests. It is impossible to isolate the existence of forests from soil and climate conditions. According to Kandari et al. (2020), one of the elements affecting land and agricultural productivity is climate, and even the kind of vegetation that develops in a given region can provide a significant indication of the climate there. Research indicates that in some situations, the climate has a far greater impact on the flora that grows there than soil does. Distinct climatic circumstances can result in the production of quite distinct forms of plants from the same soil (Rubio et al., 2024). In addition to direct (tangible) benefits like timber and non-timber forest products, forest resources also offer indirect (intangible) benefits like environmental services that are used for ecological, sociocultural, and economic protection (Elly et al., 2020). Even though forests also provide environmental services that are more important than wood production, the value of a forest area is frequently determined only by the value of the timber the forest produces. The rate of forest ecosystem degradation may accelerate as a result of the sometimes overlooked environmental benefits that forests offer, woods also offer biodiversity, carbon storage, water services, and nature tourism (Kumar et al., 2022).

As an integral part of the ecosystem, forests represent a multi-sectoral natural resource. This is due to the inherent interactions between biotic and abiotic components, as well as interactions among biotic components, both within a single ecosystem and across different ecosystems. All these interactions are susceptible to natural events, particularly global warming and climate change. According to Barati et al. (2023) the world is currently confronting significant environmental challenges stemming from global warming and climate change. These two phenomena present intricate and genuine threats, particularly to the environment and living organisms, which are exacerbated by rising population numbers, development activities, technological advancements, and shifts in diet and lifestyle. The environmental degradation observed today is intensifying due to the ongoing effects of global warming and climate change, which are leading to global repercussions, as demonstrated by various occurrences such as extreme temperature fluctuations, disruptions in the hydrological cycle, and the increasing frequency of hydrometeorological disasters worldwide (Chukwuma, 2024).

Human life depends on water; without it, no life could exist. Rainwater, surface water, and groundwater are some of the sources of water that humans use (Ertop et al., 2023). Springs, where groundwater rises to the surface, can supply groundwater needs. The demand for water from springs becomes increasingly essential during extended dry seasons. During this season, springs frequently continue to supply water for everyday requirements, but many places run out of water from other sources. To ensure the sustainability of water resources, integrated water resource management must be put into practice. Implementing an integrated strategy to water resource management that prioritizes community empowerment and environmental conservation is deemed crucial (Weningtyas & Widuri, 2022). According to Law No. 32 of 2009 concerning Environmental Protection and Management, the use of natural resources must be consistent with, equitable with, and harmonious with environmental functions. As a result, development strategies, plans, and/or programs must incorporate the obligation to preserve the environment and accomplish sustainable development goals.

A watershed is an integrated area where interrelated natural processes occur. In addition to material resources, watersheds also provide environmental services, one of which is water services through the hydrological cycle (Sunaedi et al., 2022). Environmental services are necessary to maintain ecosystem balance and ensure the well-being of all living organisms. Environmental services function in maintaining air and soil quality, controlling floods and diseases, and plant pollination, which are very important for the environment. Emerging environmental risks such as air pollution, water pollution, and chemical exposure require stronger measures to address environmental issues (Robichaud, 2020). Air pollution is recognized as an international public health issue in many ways, and the use of fuels such as wood and solid fuels for domestic needs exposes people to poor quality and polluted domestic air (Manisalidis et al., 2020). Environmental services can address these various environmental risks. Environmental services are services provided by natural and man-made ecosystem functions whose value and benefits can be felt directly or indirectly by those who contribute to the preservation and/or improvement of environmental quality and people when applied in a sustainable manner to ecosystem management (Simarmata & Triastuti, 2021).

Ecological systems (ecosystems) produce environmental services, which are crucial for maintaining a sustainable environment that supports human life. Ecosystems offer products and services that either directly or indirectly satisfy human needs. Integrated management of environmental services is very important to realize comprehensive, sustainable, and environmentally-friendly management for the prosperity of society. In addition to providing raw materials, environmental services affect human welfare and are therefore valuable to society (Wu & Tham, 2023). The diverse functions of environmental services have implications for efforts to improve the protection and conservation of forest resources. The importance of community understanding of the benefits of forest resources to the hydrological conditions of the area is key to the success of forest resource conservation programs (Wilkie & Painter, 2021).

Lakapodo community is a 13.04 km^2 community with 1,210 residents that is situated in Watopute District, Muna Regency. The Puta Spring has long been a supply of raw water for the residents of Lakapodo Village, who use it for drinking, cooking, bathing, washing, and toileting. Many aspects of human life are impacted by the availability of water, and human welfare is determined by how water is distributed in a given area (Pierrat et al., 2023). Based on this description, a study was carried out with the aim of ascertaining how the community in Lakapodo Village, Watopute District, Muna Regency, views the existence of the Puta Spring and calculating the economic value of environmental services associated with the Puta Spring's existence in relation to the community's need for clean water.

2. Methods

The research took place in Lakapodo Village, Watopute Subdistrict, Muna Regency. Geographically, the village sits at coordinates 4°06'01"S, 122°39'03"E, at an elevation of 55 meters above sea level (Figure 1). The study was carried out from early April to late October 2024. See the example of the research location map in Fig. 1. With a total size of 4,14 km2, Lakapodo Village is one of the communities in Muna Regency's Watopute Subdistrict. Lakapodo Village may be found geographically at 4°46'01" S and 122°39'03" E. Lakapodo Village occupies 13,04 km^2, being a portion of Watopute Subdistrict's total area. The boundaries of Lakapodo Village are as follows: Bangusari Village to the north; Dana Subdistrict to the east; Lapodidi Village to the south; and Matarawa Village to the west. Puta Spring is a groundwater stream that emerges on the surface of the earth. Puta Spring is located in the middle of a protected forest, namely the Puta forest in Lakapodo Village, Watopute District, Muna Regency. Therefore, various types of plants can be found in the location of Puta Spring, including teak, mahogany, kihujan/trembesi, tarra, and banyan trees. This spring is the main water source that can be utilized by the people of Lakapodo Village to meet their daily water needs.

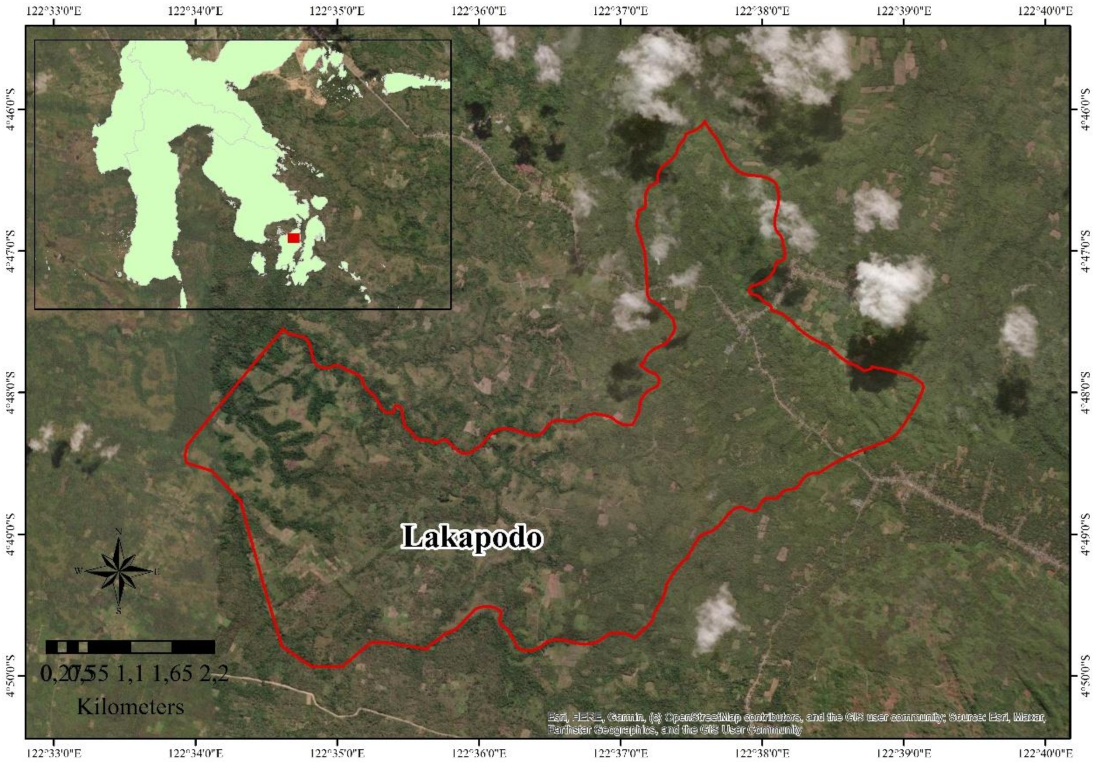

Fig. 1. Research location

Muna Regency generally experiences a warm and humid tropical climate typical of most regions in Indonesia, characterized by relatively stable temperatures throughout the year, averaging between 26°C and 30°C. The area enjoys two distinct and alternating seasons: the rainy season and the dry season, each bringing its own environmental and agricultural significance. The rainy season typically occurs from November to July and is influenced by monsoon winds originating from the Asian continent and the Pacific Ocean. These winds carry high levels of moisture, leading to frequent and often heavy rainfall that replenishes local water resources, supports agricultural activities, and sustains the region's lush vegetation. In contrast, the dry season extends from May to October, dominated by winds blowing from the Australian continent, which are generally dry and contain very little moisture. During this period, rainfall is scarce, temperatures may feel slightly higher, and the landscape tends to become drier. Around April, Muna Regency usually experiences a brief transitional phase between the two major seasons, marked by fluctuating weather conditions, scattered rainfall, and changing wind directions that make the weather somewhat unpredictable. This period is widely recognized as the transition season or musim pancaroba, reflecting the shift in climatic patterns that occur annually in the region (Central Statistics Agency of Muna Regency, 2023).

An object's heat is measured by its air temperature. Air temperature is a geographical indicator of how hot or cold the Earth's surface and atmosphere are. Differences in altitude cause temperature changes far more quickly than variations in latitude (Pepin et al., 2022). One element of weather and climate is air humidity. Absolute humidity, relative humidity, or water vapor pressure deficit are some ways to express the amount of water vapor in the air. The water vapor content (represented as water vapor mass or pressure) per unit volume is known as absolute humidity. Rainfall and temperature have a big impact on air humidity. Appendix 6 displays air temperature and humidity data for the past ten years (2014–2023) based on information from the Central Statistics Agency of Muna Regency.

The Earth's surface is shaped by its topography. The elevation of Muna Regency typically ranges from 0 to 1,000 meters above sea level (masl). Watopute District features flat topography with potential for planting land, although the majority of Muna Regency is situated between 25 and 100 meters above sea level (masl), making up 33.13% of the entire region. Lakapodo Village is a land area and not a coastal area. Geologically, the Muna Regency area consists of several types of rock, so it is called a karst area. The Muna Regency area has red-yellow, pedsolid soil. Lakapodo Village has red soil that can be used for plantations. Residing in a certain region or area in accordance with applicable laws. Lakapodo Village is one of eight villages in Watopute Subdistrict, Muna Regency. Lakapodo Village has two hamlets with a total population of 1,210, consisting of 318 households. Data on the composition of the population in Lakapodo Village by gender is presented in Table 1.

Table 1. Population composition by gender in Lakapodo Village, Watopute Subdistrict, Muna Regency

No.	Gender	Number (people)	Percentage (%)
1	Male	662	54.71
2	Female	548	45.29
	Total	1,210	100%

(Central Statistics Agency of Muna Regency, 2023)

Table 1 shows that the largest population based on gender is male, with 662 people or 54.71%, while the female population is 548 people or 45.29%. Thus, the dominant population in Lakapodo Village is male. Social interaction in society is an action to foster norms that develop in society or an attitude of mutual care and mutual enhancement of common interests. The social attitudes fostered and instilled by the community in Lakapodo Village, Watopute District, Muna Regency, are inseparable from historical values. Traditions also aim to ensure that all members of society live in harmony with one another and preserve the culture that has been respected by their ancestors since ancient times.

Lakapodo Village's majority population is Muslim and descended from the Muna tribe. The custom of the Muna tribe is known as "Khabasano Dhoa," which translates to 32 "reading prayers." The residents of Lakapodo Village continue to follow this custom today. and has endured into the present day. This custom has been inherited from one generation to the next and is thought to be an expression of appreciation from the neighborhood following a successful completion, offering convenience and security in carrying out an action. Additionally, the Khabasano Dhoa custom is followed when Kapopanga is the process of removing trees and creating fresh land. One of the customs of the Kapopanga is community in removing trees and clearing land as a farewell or seek approval from the local supernatural inhabitants. Kapopanga is an indication that the residents of Lakapodo Village are certain that in areas with trees, Respect must also be shown to other living things. Accordingly, the woodland in Lakapodo Village has been conserved so effectively that even if a tree is taken down, It is necessary to gather a large number of people and make offerings for the creatures. there. This demonstrates that the residents of Lakapodo Village recognize the critical role of woods in preserving the soil's water balance.

The social traditions of the Lakapodo Village community also include a habit of cooperation or helping each other (Pokadulu) in forest conservation efforts. The people of Lakapodo Village understand the importance of forest vegetation in protecting the water cycle in the soil (hydrological function). The community's knowledge and understanding of the importance of forest vegetation is due to their dependence on the Puta Spring, which is used as a source of raw water to meet their daily water needs. The variables observed in this study are generally two, namely the main variables and supporting variables in Lakapodo Village, Watopute Subdistrict, Muna Regency, as follows: primary variables, including community perceptions of the existence of Puta Spring (existence, management, and utilization), and environmental service valuation (water discharge, water usage volume, and economic value of water) based on prevailing prices (IDR/year). Supporting variables, including respondent characteristics (gender, age, education, occupation, income, and family member data), climate data (temperature, rainfall, and air humidity for the last 10 years), and vegetation conditions around the water source.

2.1 Research variables

Data is an important element in research, because every background, problem formulation, and research objective will lead to data that can prove the issue raised. Data is very valuable in research, because the results of the research are determined by the validity and reliability of the data (Sürücü & Maslakci, 2020). In the research regarding Community Perceptions and Evaluation of the Environmental Services of the Puta Water Source in Lakapodo Village, Watopute Subdistrict, Muna Regency, two types of variables are identified primary variables and secondary variables.

The primary variables in this research consist of the community's perceptions regarding the Puta Water Sources, which encompass their presence, management practices, and usage. The assessment of environmental services, which includes factors such as water discharge, volume of water used, and the economic valuation of water based on the current price (HB) (in IDR/year). Supporting variables include respondent characteristics (gender, age, education, occupation, income, and family member data), climate data (temperature, rainfall, and air humidity for the last 10 years), and the condition of vegetation around the spring.

2.2 Data analysis

On the basis of the variables stated, a descriptive analysis of the research findings was conducted. The Likert scale was employed as the tool for analyzing the research variables. According to South et al. (2022), the Likert scale is used to gauge how people or groups feel about a certain event or social phenomenon. The score is determined by accumulating the highest number of respondents who chose a particular category and tabulated using the following formula:

$$\text{Total Score} = (\sum \text{Respondents choosing SS} \times \text{Weight of SS}) + (\sum \text{Respondents choosing S} \times \text{Weight of S}) + (\sum \text{Respondents choosing RR} \times \text{Weight of RR}) + (\sum \text{Respondents choosing TS} \times \text{Weight of TS}) + (\sum \text{Respondents choosing STS} \times \text{Weight of STS}) \quad \text{(Eq. 1)}$$

The following categories were used in research on public perceptions of puta springs: Strongly Agree/Very Good (SS/SB = 5), Agree/Good (S/B = 4), Somewhat Agree/Somewhat Good (CS/CB = 3), Disagree/Not Good (DD/NG = 2), and Strongly Disagree/Very Not Good (SD/SNG = 1); the Likert scale was used to gauge respondents' agreement or disagreement with an object.

$$\text{Perception category} = \frac{\sum total\ score}{\sum question} \quad \text{(Eq. 2)}$$

Based on the calculation using equation 2, the scoring of respondents' answers for each variable is as described in Table 2.

Table 2. Respondents' answer scores for each variable

No.	Answer options	Weight	Number of respondents (Households)	Score
1	VG/VSA	5	76	380
2	G/S	4	76	304
3	FG/FA	3	76	228
4	P/D	2	76	152
5	VP/SD	1	76	76

The description of the abbreviations above is as follows. VG is very good, G is good, FG is fairly good, P is poor, VP is very poor, VS is very strongly agree, S is strongly agree, FS is fairly agree, PA is disagree, STS is strongly disagree. The ideal score that indicates the extent of public perception of the existence of puta springs can be determined using the following formula:

$$\text{Score interval value} = \frac{\text{maksimum value} - \text{minimum value}}{5} = \frac{380 - 76}{5} = 60.8 \quad \text{(Eq. 3)}$$

The description of the abbreviations above is as follows: 5 is the number of categories. Table 3 displays the evaluation criteria for respondents' opinions regarding the presence of puta springs.

Table 3. Criteria for rating categories of respondents' perceptions of the existence of puta springs

No.	Perception category	Score interval
1	VG/VSA	319.2 – 380
2	G/S	258.3 – 319.1
3	FG/FA	197.4 – 258.2
4	P/D	136.5 – 197.3
5	VP/SD	76 – 136.4

The total volume of water used for household needs can be calculated using the following formula:

$$\text{TPA} = \frac{PA\ X\ 30}{n}\ x\ 12 \quad \text{(Eq. 4)}$$

The description of the abbreviations above is as follows. TPA is total volume of water usage for households (m^3/year). PA is water usage (cooking, bathing, washing, and toilet (m3/household/day). n is number of respondents. The economic value of water is calculated based on the current price set by the local government for water use for household needs. It can be calculated using the Current Price (HB) method with the following formula:

$$NA_{RT} = \text{TPA x HB} \quad \text{(Eq. 5)}$$

The description of the abbreviations above is as follows. NA_{RT} is household water value (IDR/year). TPA is total volume of household water usage (m3/year). HB is applicable price (IDR/m3). The flow rate of the Puta spring can be calculated using the following formula Puta Spring Flow Rate.

$$Q = \frac{V}{t} \quad \text{(Eq. 6)}$$

The description of the abbreviations above is as follows. Q is discharge (liters per second), V is volume (liters), and t is time (seconds).

3. Results and Discussion

3.1 Public perception

Public perception is the view given by the community in response to a phenomenon that occurs in the neighborhood. Thus, public perception is the response and knowledge of the environment from a group of individuals who interact with one another, because they have values, norms, ways or procedures that are shared needs in the form of a system of customs that has a continuous nature and is bound by a shared identity obtained through the interpretation of sensory data (Nisa et al., 2023). Perception is a process that begins with an individual's understanding of themselves as an assessment of a tourist attraction, whether it is tangible or intangible.

3.1.1 Community perceptions of the existence of puta spring

A summary of the findings is shown in Table 4, and the findings of the study on how the general public views Puta Spring's existence based on the parameters observed have been tabulated and reported in Appendix 4. Table 4 demonstrates that everyone in Lakapodo Village is aware of the ecotourism area's existence.

Table 4. Community perception of the existence of puta spring

No.	Indicator	Answer category	Weight	Frequency (Respondents)	Score	Percentage (%)
1	Location of the area	VG/VSA	5	42	210	55.26
		G/S	4	26	104	35.14
		FG/FA	3	7	21	9.46
		P/D	2	1	2	1.35
		VP/SD	1	0	0	0
	Amount			76	337	100
2	Supervision	VG/VSA	5	12	60	16.22
		G/S	4	7	28	9.46
		FG/FA	3	24	72	31.57
		P/D	2	15	30	20.27
		VP/SD	1	18	18	24.32
	Amount			76	208	100
3	Area size	VG/VSA	5	4	20	5.40
		G/S	4	14	56	18.92
		FG/FA	3	10	30	13.51
		P/D	2	45	90	59.21
		VP/SD	1	3	3	4.06
	Amount			76	199	100
4	Assessment	VG/VSA	5	12	60	16.22
		G/S	4	44	176	57.89
		FG/FA	3	11	33	14.86
		P/D	2	8	16	10.81
		VP/SD	1	1	1	1.35
	Amount			74	286	100
5	Hygiene	VG/VSA	5	6	30	8.11
		G/S	4	39	52	17.57
		FG/FA	3	16	48	21.05
		P/D	2	13	78	52.70
		VP/SD	1	2	2	2.70
	Amount			74	210	100
	Grand total				1,240	
	Average				248	

With a score of 337, the ecotourism region site category has the highest level of public awareness, indicating this. With 55.26% of respondents responding in the affirmative, the majority of the community claimed to be aware of Puta Spring's location. With a score of 199, the knowledge category about the place itself had the lowest level of community awareness. When asked about the Puta Spring location, the majority of responders (59.21%) provided unsatisfactory answers. With an average score of 248 however, the general public's opinion of Puta Spring as an ecotourism destination remained favorable.

3.1.2 Community perceptions of puta spring management

A summary of the findings is shown in Table 5, and the results of the study on public opinion of Puta Spring management based on the parameters observed have been tabulated and reported in Appendix 4. Table 5 shows that the level of public perception of spring water management is widely known by the people of Lakapodo Village. This is indicated by the highest public perception of the educational function, which is shown by a score of 308, with the majority of the community responding positively with a percentage of 52.70%. The lowest level of perception is in the involvement category, with a score of 218, where the community gave a negative response with a percentage value of 43.27%. Meanwhile, the overall community perception of spring water management is good, with an average of 252.8.

Table 5. Community perceptions of puta spring management

No.	Indicator	Answer category	Weight	Frequency (Respondents)	Score	Percentage (%)
1	Sustainability	VG/VSA	5	7	35	9.46
		G/S	4	15	60	20.27
		FG/FA	3	22	66	28.94
		P/D	2	29	58	39.19
		VP/SD	1	3	3	4.05
	Amount			76	222	100
2	Protection	VG/VSA	5	9	45	12.16
		G/S	4	43	172	56.57
		FG/FA	3	16	48	21.62
		P/D	2	8	16	10.81
		VP/SD	1	0	0	0
	Amount			76	281	100
3	Involvement	VG/VSA	5	9	45	12.16
		G/S	4	12	48	16.22
		FG/FA	3	19	57	25
		P/D	2	32	64	43.24
		VP/SD	1	4	4	5.41
	Amount			76	218	100
4	Education	VG/VSA	5	23	115	30.26
		G/S	4	39	156	52.70
		FG/FA	3	9	27	12.16
		P/D	2	5	10	6.76
		VP/SD	1	0	0	0
	Amount			76	308	100
5	Management system	VG/VSA	5	7	35	9.46
		G/S	4	18	72	24.33
		FG/FA	3	29	87	38.15
		P/D	2	19	38	25.66
		VP/SD	1	3	3	4.06
	Amount			76	235	100
	Total				1,264	
	Average				252.8	

3.1.3 Community perceptions of puta spring utilization

The results of the study on community perceptions of Puta Spring utilization based on the parameters observed are tabulated and presented in Appendix 4, while the summary results are presented in Table 6. Table 6 shows that the level of public perception of the utilization of Puta Spring is widely known by the community in Lakapodo Village. This is indicated by the highest public perception being on social benefits, with a score of 279, with the majority of the community responding positively, with a percentage of 41.89%. The lowest level of perception is in the socio-cultural function, with a score of 178, with the majority of the community responding negatively, with a percentage value of 52.70%. Meanwhile, the overall community perception of the utilization of the Puta spring is considered good, with an average value of 213.

Table 6. Community perceptions of the utilization of the puta spring

No.	Indicator	Answer category	Weight	Frequency (Respondents)	Score	Percentage (%)
1	Availability	VG/VSA	5	31	155	40.78
		G/S	4	18	72	23.68
		FG/FA	3	26	78	34.21
		P/D	2	1	2	1.31
		VP/SD	1	0	0	0
	Amount			76	229	100
2	Social	VG/VSA	5	12	60	16.22
		G/S	4	31	124	41.89
		FG/FA	3	29	87	39.19
		P/D	2	4	8	2.70
		VP/SD	1	0	0	0
	Amount			76	279	100
3	Ecology	VG/VSA	5	3	15	4.05
		G/S	4	4	16	4.05
		FG/FA	3	26	78	35.14
		P/D	2	42	84	55.40
		VP/SD	1	1	1	1.35
	Amount			76	194	100
4	Socio-cultural	VG/VSA	5	3	15	1.35
		G/S	4	3	12	4.05
		FG/FA	3	21	63	28.38
		P/D	2	39	78	52.70
		VP/SD	1	10	10	13.51
	Amount			76	178	100

3.1.4 Community perceptions of the economic value of the puta spring

The results of the study on community perceptions of the economic value of the Puta Spring based on the parameters observed are tabulated and presented in Appendix 4, while the summary results are presented in Table 7. Table 7 shows that the community's perception of the economic value of springs is known to the entire community of Lakapodo Village. This is indicated by the highest community perception being in the economic benefits category, with a score of 289, with the majority of the community responding very positively, with a percentage of 56.57%. The lowest community perception is in the category of production knowledge, with a score of 218 and a percentage value of 43.24%. Meanwhile, the overall community perception of the economic value of the Puta spring is good, with an average score of 255.8.

Table 7. Community perceptions of the economic value of the puta spring

No.	Indicator	Answer category	Weight	Frequency (Respondents)	Score	Percentage (%)
1	Income	VG/VSA	5	8	40	9.46
		G/S	4	14	56	20.27
		FG/FA	3	24	72	28.94
		P/D	2	27	54	39.19
		VP/SD	1	3	3	4.05
	Amount			76	225	100
2	Economic benefits	VG/VSA	5	10	50	12.16
		G/S	4	46	184	56.57
		FG/FA	3	15	45	21.62
		P/D	2	5	10	10.81
		VP/SD	1	0	0	0
	Amount			76	289	100
3	Production	VG/VSA	5	9	45	12.16
		G/S	4	12	48	16.22
		FG/FA	3	19	57	25
		P/D	2	32	64	43.24
		VP/SD	1	4	4	5.41
	Amount			76	218	100
4	Assessment	VG/VSA	5	20	100	30.26
		G/S	4	41	164	52.70
		FG/FA	3	10	30	12.16
		P/D	2	5	10	6.76
		VP/SD	1	0	0	0
	Amount			76	304	100
5	Management system	VG/VSA	5	8	40	9.46
		G/S	4	17	68	24.33
		FG/FA	3	39	117	38.15
		P/D	2	9	18	25.66
		VP/SD	1	3	3	4.06
	Amount			74	243	100
	Total				1.279	
	Average				255.8	Good

3.1.5 Overall community perception of the existence of puta springs

The level of community perception regarding the existence of puta springs is presented in Table 8. According to Table 8, the sum of the responses from every responder is 4,864. The average score, according to the evaluation criteria, is 242.47, falling into the good range.

Table 8. Categories of overall community perception regarding the existence of puta springs

No.	Aspect	Score	Category score	Percentage (%)	Description
1	Existence of springs	1,240	248	25.49	Good
2	Management of springs	1,264	252.8	25.98	Good
3	Utilization of springs	1,065	213	21.89	Good
4	Economic value of water	1,279	255.8	26.29	Good
	Amount	4,864	969.9	100	
	Average		242.47		Good

This indicates that the community has a positive opinion on Puta Spring's presence. This is affected by the fact that although the residents of Lakapodo Village are not very educated, they possess sufficient experience, particularly with the increasingly sophisticated social media platform. They have a solid knowledge of Puta Spring's existence as a result of this event. There is a strong correlation between public opinion and educational attainment, claim Darmansah & Yosepha (2020). Experience, age, personality, gender, educational attainment, and other individual characteristics are some of the elements that influence perception. One internal component of a person that is strongly tied to the variety of perspectives and knowledge held by the community is education.

3.2 Water usage volume of the Lakapodo Village community

Water is a fundamental necessity crucial for the survival of humans and other living organisms.It cannot be substituted by any alternative to fulfill people's needs. Water is a vital natural resource that plays a significant role in human existence and enhances the overall welfare of society. It is a key resource for development. Water has many benefits in different areas of life, which makes water resources very valuable. It is a resource that cannot be substituted when it comes to meeting the needs of living things. As the population grows, the demand for water increases in both amount and quality. With ongoing development and a growing population, the need for water also rises, including the amount used for everyday household needs per person (Kılıç, 2020). The amount of water used by the people of Lakapodo Village, Watopute District, Muna Regency, to satisfy their daily water requirements is shown in Table 9.

Table 9. Total volume of water use in the Lakapodo Village community

No.	Type of use	Total water usage (m^3)		
		Per day	Per month	Per year
1	Drink	5.36	160.8	1,929.6
2	Cook	6.46	193.8	2,325.6
3	Bathe	43.24	1,267.2	15,566.4
4	Wash	34.55	1,036.5	12,438
5	Toilet	23.20	696	8,352
6	Water plants	4.47	134.1	1,609.2
Total		117.28	3,518.4	42,220.8

Table 9 shows that the highest water usage is for bathing, amounting to 43.24 m^3/day or 1,267.2 m^3/month, equivalent to 15,566.4 m^3/year, and the lowest water usage is for watering plants, amounting to 4.47 m^3/day or 134.1 m^3/month, equivalent to 1,609.2 m^3/year. Meanwhile, the total water usage of the entire Lakapodo Village community in a year, consisting of 318 households, is 42,220.8 m^3/year. According to Crouch et al. (2021), domestic water use is water used in private residences or houses and so on for drinking, bathing, watering gardens, and other purposes. Water needs are not always the same at all times; they depend on the daily water usage activities of the community. Household water needs are also influenced by consumption patterns, i.e., the more people in an area, the more water is used.

3.3 Current price analysis method (HB)

The study's findings about the economic value of water used by the Lakapodo Village community for various purposes like drinking, cooking, bathing, washing, toilet use, and watering plants are shown in Table 10 of the Appendix. The results were calculated using either the current price method or the hedonic price method.

Table 10. Water value based on total water use for household needs of the Lakapodo Village community

No.	Description	Score
1	Total water usage (m^3/month)	3,518.4
2	Total water usage (m^3/year)	42,220.8
3	Applicable price (IDR/m^3)	5,000.00
4	Water value (IDR/month)	17,592,000.00
5	Water value (IDR/year)	211,104,000.00

Table 10 shows that the water value based on the applicable price is calculated by first determining the actual water value used by the Lakapodo Village community as users of the

Puta Spring, based on the average water usage of m^3/household/month and the water price set by the Lakapodo Village government, together with the manager and the community, which is IDR 5.000.00/m^3 and total water usage of 42.220.8 m^3 /year, then, when calculated using the RT water value equation with a population of 318 households, the water value used for the household needs of the Lakapodo Village community each year is IDR. 211.104.000.00/year or IDR 17.592.000.00/month. According to the Muna Regency Public Works Office, the 2009 clean water tariff for the Muna Regency Regional Water Company is IDR 3,900,00/m^3. If the water value is calculated based on the total water usage volume from the Puta Spring for 318 households using the Muna Regency Regional Water Company water tariff or market price, it is as follows:

$$\begin{aligned} \text{Water value RT} &= \text{Total water usage x applicable price (IDR/m}^3) \\ &= 42{,}220.8(\text{m}^3)/\text{year x IDR } 3{,}900.00/\text{m}^3 \\ &= \text{IDR } 164{,}661{,}120.00/\text{year} \end{aligned} \quad \text{(Eq. 7)}$$

Therefore, the annual water value that the Lakapodo Village community must pay based on the market price is IDR 164,661,120.00/year. The comparison of the value of water based on the applicable price set in Lakapodo Village, which is IDR 5,000.00/m^3, and the value of environmental services based on market prices, which is IDR 3,900.00 is presented in Table 11. Table 11 shows that the applicable price set by the Village Administration, together with the managers and the community, is higher than the market price set by the Muna Regency government. The value set by the Village government is IDR 5,000.00/m^3, resulting in the value of water used by the community for household needs each year being IDR 211,104,000.00/year. Meanwhile, the actual market price sets the price of water at IDR 3,900.00/m^3, resulting in the value of water used by the community to meet their domestic needs amounting to IDR 164,661,120.00/year.

Table 11. Water valuation value based on community agreement and Muna Regency regional water company tariffs

No.	Description	(IDR/m^3)	Total water usage (m^3/year)	Water value (IDR/year)
1	Current price	5,000.00	42,220.8	211,104,000.00
2	Market price	3,900.00	42,220.8	164,661,120.00

Water resources are one of the most valuable natural resources, so their existence must be preserved and maintained. Lack of public awareness in conservation will result in the destruction of water catchment areas, where the largest water catchment area is the forest. Water availability will decrease if the hydrological system is disrupted due to forest degradation. Lakapodo Village has excellent forest vegetation, so the water catchment area is not disturbed. This indicates that the Lakapodo community has a good perception of the importance of vegetation in the spring area. It also shows that no population density exceeds the utilization of natural resources. According to Kandari et al. (2020), natural resource management in an environment will function optimally if it does not face population pressure, or in other words, the population density is balanced with the natural resources available in that environment. The community values water highly, which shows how much benefit they derive from the spring. A spring is groundwater that naturally emerges to the surface without human intervention (Kumar et al., 2023). Therefore, springs must be managed properly so that they can be used by future generations.

3.4. Puta spring discharge

The amount of water that flows across a certain area in a predetermined amount of time is measured by the flow rate. Typically, cubic meters per second (m^3/s) are used to express it. This shows how much water flows through a river's cross section every second (Asdak, 2002). The flow rate for Puta Spring is presented in Table 12. Table 12 indicates that discharge measurements were recorded on two separate occasions, specifically in May and June. The water discharge recorded in May was 0.0102 m^3/second, while the measurement for June was 0.0062 m^3/second. Additionally, the average water discharge at Puta Spring for both May and June was 0,0082 m^3/second. Consequently, it can be concluded that the average daily discharge from Puta Spring amounts to 708.48 m^3/day or 21.254.4 m^3/month, which translates to 255.052.8 m^3/year.

Table 12. Puta spring discharge

No.	Month	Time (t) (seconds)	Volume (liters)	Volume (m^3)	Flow rate (m^3/second)
1	Mei	19.47	20	0.02	0.0102
2	Juni	32.15	20	0.02	0.0062
	Total	51.62	40	0.04	0.0164
	Average	28.81	20	0.02	0.0082

The water from Puta Spring can change how much it flows at any time. The amount of water flowing can be affected by a few things. First, the size of the area the water is moving through – the bigger the area, the more water flows. Second, how fast the water is moving – the faster or stronger the flow, the more water there is. Third, the season – during rainy seasons, there is more water flowing, but during dry seasons, there is less. The availability of water is connected to how much rain there is. More rain and more green spaces mean more water available (Olivadese & Dindo, 2024).

The karst terrain of the Watopute subdistrict, especially Lakapodo Village, makes it challenging to obtain pure water. Water shortages occur during the dry season as a result of the Puta Spring's reduced water flow, despite its plentiful supply. The Lakapodo village authority has put in place rainwater storage devices, like towers or tanks, for every home in order to solve this issue. Residents now have far more access to clean water thanks to this system. A water reserve for the dry season, when water becomes limited, is also guaranteed by collecting rainwater during the wet season. The fluctuations in water discharge and flow consistency experienced by the community are closely tied to variations in annual rainfall and the number of rainy days, which are critical for the Puta Spring's water supply, as illustrated in Figure 2.

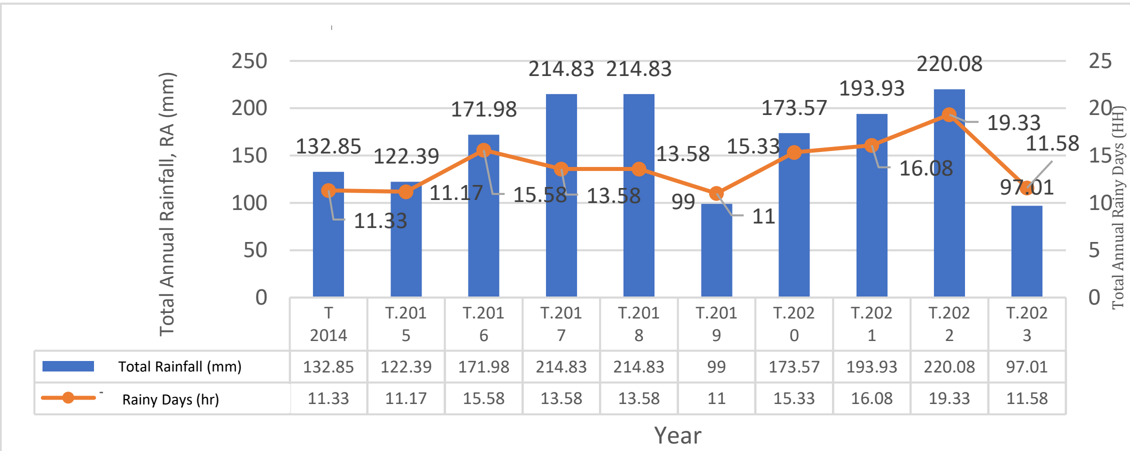

Fig. 2. Graph of average annual rainfall and rainy days for the last 10 years (2014-2023) in Muna Regency

Figure 2 shows that the highest average annual rainfall in Muna Regency occurred in 2022, namely 220,08 mm in 19.33 days, while the lowest rainfall occurred in 2023, namely 97.01 mm in 11.58 days. The highest number of rainy days occurred in 2022, namely 19.33 days with rainfall of 220.08 mm. Meanwhile, the lowest number of rainy days occurred in 2019, namely 11 days with rainfall of 99 mm. This fact indicates that high rainfall is not always caused by a long number of rainy days, and vice versa. Fluctuations in rainfall conditions in the study area indicate global warming and climate change, resulting in unstable water discharge. According to Kandari et al. (2020) and global warming and climate change are closely related and cause unstable climatic conditions in various regions, marked by changes in surface climate parameters, particularly unstable air temperature and rainfall parameters.

4. Conclusions

Based on the results of the research conducted, the following conclusions can be drawn. The study shows that community perception regarding the existence of the Puta Spring in Lakapodo Village is generally positive. Across four assessed aspects—spring existence, management, utilization, and water economic value—the average perception score reached 242.47, which falls into the "good" category. This indicates that local residents recognize both the importance of the spring and its role in supporting daily needs. Furthermore, the economic valuation of environmental services related to the Puta Spring demonstrates significant monetary value. Using the prevailing price approach, the spring contributes an estimated IDR 211,104,000.00, while the market price approach yields an annual value of IDR 164,661,120.00. These values highlight the spring's essential contribution to the community's socio-economic well-being.

The analysis of water availability and usage further supports the importance of the spring. With a total annual water production of 255,052.8 m^3 compared to community usage of only 42,220.8 m^3, the spring provides a substantial surplus. This surplus reflects the spring's strong capacity to meet current water demands. Overall, the findings indicate that the Puta Spring not only holds high perceived value among the community but also provides significant economic benefits and abundant water availability. These results emphasize the need for continuous protection and sustainable management to maintain the spring's ecological and economic functions in the long term.

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