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ANALYSIS OF OPERATIONAL AND MAINTENANCE PERFORMANCE OF CIMEDANG - CIPUTRAPINGGAN SERVICE UNIT (SUP) MERJAN IRRIGATION AREA PANGANDARAN REGENCY

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ABSTRACT
Water is a natural resource that is very important for the continuity of human life. Human needs for water include drinking, cooking, farming, washing, and so on. The Cimedang-Ciputrapangan service unit (SUP) has a very strategic role because this officer has the authority to regulate and distribute water to agricultural land. While the amount of water supply from upstream sometimes does not cover the needs of the work area, the ability to process and operate the irrigation network is very important to ensure that irrigation water can be distributed. The purpose of the Merjan DI Operation and Maintenance Performance Analysis is to provide useful input or information and provide an overview and solutions to problems that occur at the irrigation network level. The method utilized is qualitative, focusing on in-depth communication; however, it lacks specific details regarding data collection and analysis techniques. The analysis reveals that, despite an effective irrigation network, there is an 84% staffing shortage among the management personnel, indicating a significant need for improvement in operational capacity. The research findings are clearly stated, outlining the condition of the irrigation network and its ability to meet rainfall and irrigation needs.

Keywords: AKNOP; cropping pattern; dam; discharge; irrigation management; maintenance performance

INTRODUCTION

Water is a natural resource that is very important for life and is very important for the continuity of human life (Bozkir et al., 2024; Ferro et al., 2024; Licznar-Fajardo et al., 2024; López-Martínez et al., 2023; Manyepa et al., 2024). Human needs for water include drinking, cooking, farming, washing, and so on. Thus, water must be available in sufficient quantities, good quality, and satisfactory (Chen et al., 2025; Eryiğit et al., 2023; Zulhilmi et al., 2019). The availability of water in sufficient quantity and quality is crucial for societal well-being and economic development. Optimal water resource management, particularly in irrigation networks, is vital to ensure efficient and equitable water distribution (Al-Jawad et al., 2019; Ren et al., 2021; Yazdian et al., 2021; Zhang et al., 2023; Zhou et al., 2015). The Cimedang-Ciputrapangan service unit (SUP) plays a strategic role in this context, as it regulates and distributes water to agricultural lands. However, the challenge lies in instances where the water supply from upstream sources is insufficient to meet the demands within the service area. Therefore, a strong ability to operate and maintain the irrigation network is paramount to ensure that irrigation water is distributed professionally, fairly, and efficiently based on crop requirements (Farzaneh et al., 2021; Fovargue et al., 2021; Rosinger, 2020; Wutich et al., 2020).

Addressing the identified challenges in the Merjan irrigation area is crucial for ensuring sustainable agricultural production and improving the livelihoods of local farmers. This study's findings will provide valuable insights and recommendations to the Cimedang-Ciputrapangan SUP and relevant stakeholders for optimizing irrigation management practices, enhancing water use efficiency, and strengthening the resilience of the agricultural sector in the face of increasing water scarcity and climate change.

Several studies have examined irrigation performance in Indonesia (Ariyanto, 2019; Priatama & Kania Kurniawati, 2023). Ariyanto (2019) focused on the performance of irrigation networks at secondary canal gates in Lampung Tengah Regency. Priatama & Kania Kurniawati (2023) analyzed the real needs figures for the operation and maintenance of the Cimuncang irrigation network. While these studies provide valuable insights, a gap remains in the literature regarding the specific operational and maintenance performance of irrigation systems within the Pangandaran Regency, particularly concerning the Cimedang-Ciputrapangan SUP and the Merjan irrigation area.

Furthermore, existing research often examines individual components of irrigation management, such as infrastructure conditions or water availability, in isolation. There is a need for a more holistic approach that integrates the assessment of infrastructure, water resources, institutional capacity, and financial considerations to provide a comprehensive understanding of irrigation system performance. Finally, a deeper understanding of the challenges experienced by irrigation managers and staff is needed. While quantitative data is valuable, qualitative insights are essential for uncovering the underlying causes of operational inefficiencies and identifying effective solutions that are tailored to the local context.

METHOD

The method used in this study is qualitative. According to Maleong, the qualitative method is a scientific study that aims to naturally understand a phenomenon in social contact by prioritizing the process of deep communication interaction between researchers and the phenomenon to be discussed (Ummah, 2019). This method is well-suited to this research because it allows for a nuanced exploration of the complexities inherent in irrigation management, which involves various stakeholders, institutional structures, and environmental factors.

The purpose of this analysis of the operation and maintenance performance of the Cimedang - Ciputrapinggan SUP in DI Merjan is to provide useful input or information and an overview of and solutions to problems that occur at the irrigation network level. Specifically, the analysis aimed to analyze the irrigation network of the Merjan Irrigation Area, analyze the cropping patterns of the Merjan Irrigation Area, analyze debit availability and needs, analyze the institutional structure of the Cimedang – Ciputrapinggan Service Unit (SUP), and analyze the Actual Operation and Maintenance Needs Figures (AKNOP).

Data collection involved both primary and secondary sources. Primary data was gathered through semi-structured interviews with key informants, including the SUP head, technicians, field operators, and farmers. A purposeful sampling technique was used to select these informants. Direct observations of the irrigation network were also conducted to assess the physical condition of canals and related structures. Secondary data on rainfall, river discharge, cropping patterns, and operational budgets was collected from the UPTD PSDA WS Ciwulan-Cilaki, the Cimedang-Ciputrapangan SUP, and the Pangandaran Regency Agriculture Office. A literature review of relevant books, articles, and regulations provided a theoretical foundation for the study.

Qualitative data from interviews and observations were analyzed using thematic analysis involving transcription, coding, and interpretation. Quantitative data on rainfall and discharge were analyzed using descriptive statistics. The findings were then synthesized into a structured report with conclusions and recommendations. This analysis aims to provide input and information that will give an overview and solutions to problems that occur at the irrigation network level. These include analyzing the Irrigation Network, Cropping Patterns, Debit Availability and Needs, and the Institutional Structure of the Cimedang – Ciputrapinggan Service Unit (SUP), as well as analyzing the Actual Operation and Maintenance Needs Figures (AKNOP).

RESULTS AND DISCUSSION

Analysis of the Algebraic Average Method

The Algebraic Average is the most practical and easy-to-use method for searching for missing rainfall data. Measurements are taken at several rainfall stations in the same period and then added up and divided by the number of stations; the stations used in the calculation are usually adjacent stations. In the Merjan dam irrigation area research, the rainfall was from Cimerak Station, Parigi Station, and Cikembulan Station. The calculation of the algebraic average method is as follows:

$$Rave = \frac{R1 + R2 + R3 + Rn}{n}$$

Description:

Rave : Average Rainfall

R1.....Rn : Amount of Rainfall at Each Station

n : Number of Rain Measurement Stations

The following are the results of the average rainfall calculation using the algebraic average method:

Table 1. Average Rainfall

YEAR	MONTH												Max
	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sep	Oct	Nov	Dec	Year

2009	45.7	36.3	59.2	47.3	57.8	112.0	77.5	35.4	40.7	127.0	81.7	83.0	127.0
2010	49.0	64.0	32.5	38.3	93.0	86.3	106.7	61.5	78.4	77.7	50.4	40.8	106.7
2011	34.7	34.2	37.2	52.0	59.7	91.2	54.7	54.2	49.3	66.7	90.0	46.3	91.2
2012	68.3	48.7	40.3	61.7	68.3	20.3	15.3	6.3	10.0	10.4	107.0	82.6	107.0
2013	39.7	42.3	45.7	35.3	33.7	90.0	131.7	37.0	22.0	49.3	46.3	78.7	131.7
2014	55.3	65.7	31.0	35.3	40.0	77.7	139.0	74.7	46.7	49.3	78.3	139.3	139.3
2015	44.7	97.3	79.0	59.0	69.3	42.0	35.7	19.0	17.0	13.3	105.0	116.3	116.3
2016	44.7	84.0	104.3	140.3	146.3	98.0	193.0	128.7	96.7	167.3	88.7	35.7	193.0
2017	60.3	130.7	100.7	75.0	107.7	96.7	38.0	58.3	83.3	172.3	74.3	34.7	172.3
2018	53.7	40.3	52.3	50.7	23.7	63.0	35.3	32.7	53.7	32.7	225.7	142.0	225.7
Amount	496.0	643.5	582.2	595.0	699.5	777.2	826.8	507.7	497.7	766.1	947.4	799.4	
Average	49.6	64.4	58.2	59.5	70.0	77.7	82.7	50.8	49.8	76.6	94.7	79.9	

Source: Calculation

Hydrological Analysis

Table 2. Average Annual Rainfall of 3 STA

YEAR	Rainfall Station (mm)		
	Cimerak	**Parigi**	**Cikembulan**
2009	96.00	185.00	148.00
2010	120.00	122.00	211.00
2011	85.00	139.00	114.00
2012	114.00	90.00	173.50
2013	92.00	200.00	123.00
2014	137.00	120.00	202.00
2015	93.00	185.00	122.00
2016	125.00	286.00	208.00
2017	89.00	274.00	154.00
2018	201.00	218.00	258.00
Amount	1152.00	1819.00	1713.50
Average	115.20	181.90	171.35

Source: Calculation

Debit Analysis Mainstay

The calculation of the mainstay discharge is intended to find the amount of discharge available for irrigation water needs with a calculated risk of failure. (Saragi et al., 2023) Here is the mainstay debit formula and the calculated results.

$$Q = 80\% \times n$$

Description:
Q : Mainstay Debit
n : Total Observation Duration

Table 3. 80% Semi-Monthly Mainstay Debit

Month		Order									
		1	2	3	4	5	6	7	8	9	10
January	I	22.3	19.7	18.1	17.5	16.0	14.9	14.6	14.6	13.0	11.3
	II	22.3	19.7	18.1	17.5	16.0	14.9	14.6	14.6	13.0	11.3
February	I	42.7	31.8	27.4	21.5	20.9	15.9	13.2	11.9	11.2	13.8
	II	42.7	31.8	27.4	21.5	20.9	15.9	13.2	11.9	11.2	13.8
March	I	34.1	32.9	25.8	19.3	17.1	14.9	13.2	12.1	10.6	10.1
	II	34.1	32.9	25.8	19.3	17.1	14.9	13.2	12.1	10.6	10.1
April	I	45.8	24.5	20.1	19.3	17.0	16.6	15.5	12.5	11.5	11.5
	II	45.8	24.5	20.1	19.3	17.0	16.6	15.5	12.5	11.5	11.5
May	I	47.8	35.2	30.4	22.7	22.3	19.5	18.9	13.1	11.0	7.7
	II	47.8	35.2	30.4	22.7	22.3	19.5	18.9	13.1	11.0	7.7
June	I	36.6	32.0	31.6	29.8	29.4	28.2	25.4	20.6	13.7	6.6
	II	36.6	32.0	31.6	29.8	29.4	28.2	25.4	20.6	13.7	6.6
July	I	63.1	45.4	43.0	34.8	25.3	17.9	12.4	11.7	11.5	5.0
	II	63.1	45.4	43.0	34.8	25.3	17.9	12.4	11.7	11.5	5.0
August	I	42.0	24.4	20.1	12.1	17.7	11.6	19.1	10.7	6.2	2.1
	II	42.0	24.4	20.1	12.1	17.7	11.6	19.1	10.7	6.2	2.1
September	I	31.6	27.2	25.6	17.5	13.3	7.2	3.3	16.1	15.2	5.6
	II	31.6	27.2	25.6	17.5	13.3	7.2	3.3	16.1	15.2	5.6
October	I	56.3	54.7	41.5	25.4	21.8	16.1	16.1	10.7	3.4	4.4
	II	56.3	54.7	41.5	25.4	21.8	16.1	16.1	10.7	3.4	4.4
November	I	73.7	35.0	34.3	29.4	29.0	26.7	25.6	24.3	16.5	15.1
	II	73.7	35.0	34.3	29.4	29.0	26.7	25.6	24.3	16.5	15.1
December	I	46.4	45.5	38.0	27.1	27.0	25.7	15.1	13.3	11.7	11.3
	II	46.4	45.5	38.0	27.1	27.0	25.7	15.1	13.3	11.7	11.3

Source: Calculation

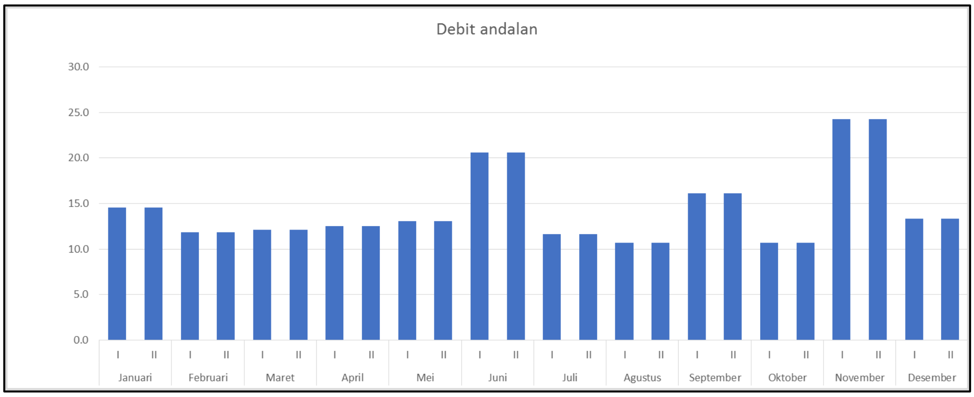

Figure 2. 80% Debit Debit Graph

Potential Evaporation (ETO)

ETO is usually calculated using several methods, such as the most commonly used method in this study, namely the Penman-Monteith FAQ method. The data needed are Climatology data such as Solar Radiation, Air Temperature, Relative Humidity, Wind Speed, and Geographical Location that we can get from BMKG (Meteorology, Climatology and Geophysics Agency). The Eto value is used as a reference to estimate plant water needs and can be calculated as follows:

$$
\begin{aligned}
\text{Eto (mm/day)} &= \text{c x Eto} \\
&= 1.10 \times 3.51 \\
&= 3.86 \text{ mm/day}
\end{aligned}
$$

For other calculation results, please see the table below.

Table 4. Potential Evaporation (Eto) mm/day

Month	Eto (mm/day)
January	3.86
February	3.53
March	3.67
April	2.84
May	2.82
June	2.76
July	3.02
August	3.78
September	4.18
October	4.15
November	3.73
December	3.65

Source: Calculation

Rice Field Water Needs Analysis

Land preparation for rice begins in October. The first step in calculating the water needs of the rice fields is to determine the NFR value of each planting season. Here is the calculation.

Irrigation water requirements (NFR) for rice can be calculated as follows:

$$
\begin{aligned}
\text{NFR} &= \text{Etc} + \text{P} + \text{WLR} + \text{Re} \\
&= 4.15 + 2 + 0 + 0.50 \\
&= 6.64 \text{ mm/day}
\end{aligned}
$$

Irrigation water requirements (NFR) for secondary crops can be calculated:

$$\begin{aligned} NFR &= Etc - Re \\ &= 1.38 - 0.69 \\ &= 0.69 \text{ mm/day} \end{aligned}$$

After calculating the NFR for each planting season, the NFR Max value for each planting season is obtained. For the next step, the irrigation water requirement uses a total irrigation efficiency of 0.65, and the calculation is as follows:

$$\begin{aligned} \text{Irrigation water requirement} &= NFR / (\text{Efficiency} \times 8.64) \\ &= 9.45 / (0.65 \times 8.64) \\ &= 1.29 \text{ l/sec/ha} \end{aligned}$$

Table 5. Irrigation Water Requirements

GROUPS	Paddy	0.65
I	9.45	1.29
II	9.10	1.24
III	9.10	1.24
GROUPS	Secondary crops	0.65
I	3.43	0.47

Source: Calculation

The water requirements for each planting season can be calculated as follows:

Rice Field Water Requirements for Land Preparation, Planting, Planting Period, and Cooking.

$$\begin{aligned} KAS &= \text{“a”} \times \text{Planting Area (ha)} \\ &= 1.29 \times 412 \\ &= 530 \text{ lt/sec/ha} \end{aligned}$$

After calculating the water requirements for the rice fields for each planting season, the next step is to add up the water requirements needed and compare it with the available flow rate as follows:

Table 6. Balance of Debit Needs and Debit Availability

P. Season	Month		Flow Requirement (m3/second)	Availability Flow (m3/sec)
MT I	October	I	529.97	1067.25
		II	895.50	1067.25
	November	I	1108.62	2428.54
		II	1108.62	2428.54
	December	I	1108.62	1108.62

		II	1108.62	1108.62
	January	I	1108.62	1459.30
		II	1108.62	1459.30
MT II	February	I	1108.62	1187.04
		II	1108.62	1187.04
	March	I	1108.62	1214.27
		II	1108.62	1214.27
	April	I	1108.62	1252.38
		II	1108.62	1252.38
	May	I	1108.62	1306.84
		II	1108.62	1306.84
MT III	June	I	826.86	2058.27
		II	826.86	2058.27
	July	I	461.32	1165.26
		II	248.20	1165.26
	August	I	248.20	1067.25
		II	248.20	1067.25
	September	I	0.00	1611.76
		II	0.00	1611.76

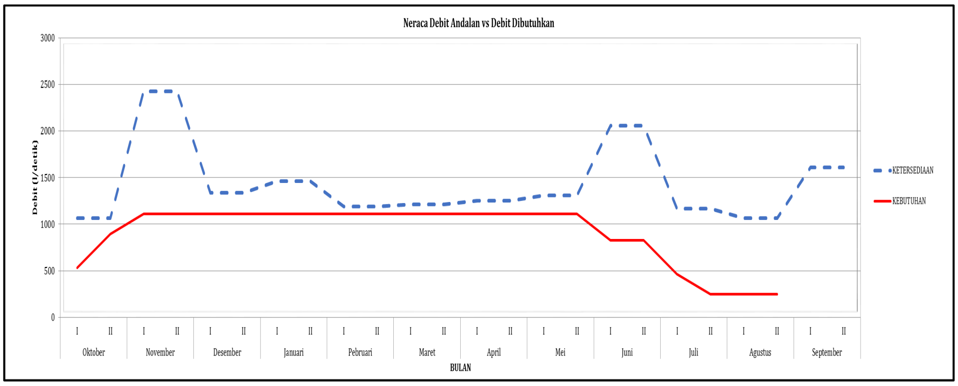

Figure 3. Debit Balance of Demand and Availability

Cropping Pattern Analysis

A planting pattern is a plan for the sequence of planting schedules for types of plants in an irrigation area over a period of one year or more. Once there is a planned planting pattern, the determination of the initial planting time is carried out by trying to shift the initial planting time by a period of 45 days in order to obtain the maximum planting area. The planting pattern used in the Merjan Dam irrigation area analysis is Rice-Rice-Secondary Crops with three groups of planting areas. The first planting season starts at the beginning of October and ends in the third planting season in September.

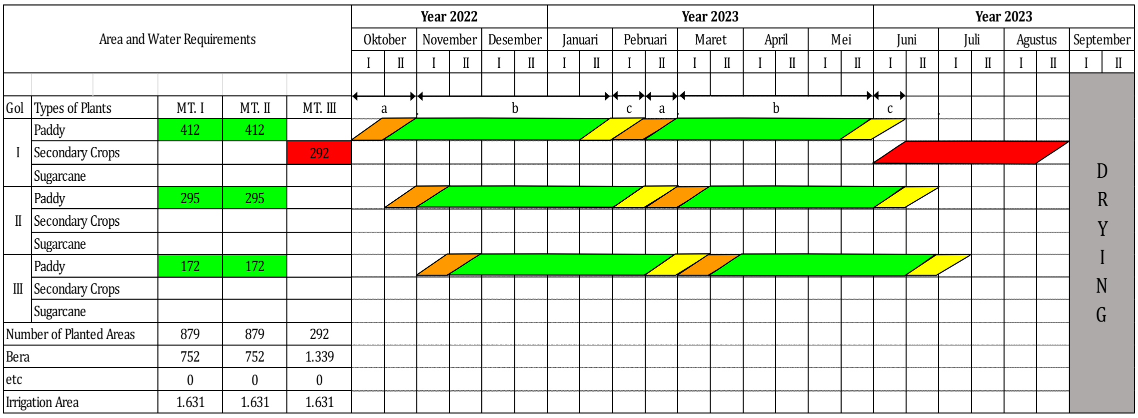

Figure 4. Planting Patterns in the Merjan Dam Irrigation Area

Irrigation Network Condition Analysis

The analysis of network conditions refers to PU Regulation No. 12/PRT/M/2015, which contains the network condition assessment indicator values.

Table 7. Condition of Merjan Dam Irrigation Network

NO	DESCRIPTION	VOLUME	CONDITION			INFORMATION
			GOOD	CURRENTLY	DAMAGED	
1.	**Merjan Dam**					
	Lighthouse	1	90	5	5	GOOD
	Dam Wings	1	92	8	0	GOOD
	Front and Rear Dam Floors	2	90	5	5	GOOD
	Cover Embankment	1	95	5	0	GOOD
	Bridge	1	100	0	0	GOOD
	Measuring Ruler	1	0	75	25	MEDIUM DAMAGED
	Safety Fence	1	100	0	0	GOOD
	Dam Gate	1	95	5	0	GOOD
	Dam Drain Gate	1	95	5	0	GOOD
2.	**Merjan Right Main Channel**					
	Building Share	1	90	5	5	GOOD
	Building for Tapping	5	95	5	0	GOOD
	Measurement Building	1	90	5	5	GOOD
	Gutter Building	5	8	87	5	MEDIUM DAMAGED
	Washing Ladder	8	90	10	0	GOOD
	Drain Building	2	90	5	5	GOOD
3.	**Cikukulu Secondary Channel**					
	Tapping Building	2	15	30	55	HEAVY DAMAGED
	Measurement Building	1	90	10	0	GOOD
	Carrier Gutter	1	90	5	5	GOOD
	Falling Building	1	90	10	0	GOOD
4.	**Barengkok Secondary Channel**					
	Tapping Building	3	5	85	10	MEDIUM DAMAGED

5.	**Merjan Left Main Channel**					
	Tapping Building	10	5	85	10	MEDIUM DAMAGED
	Building for Tapping	1	0	40	60	HEAVY DAMAGED
	Washing Ladder	7	0	40	60	HEAVY DAMAGED
	Measurement Building	1	90	10	0	GOOD
	Falling Building	2	14	86	0	MEDIUM DAMAGED
	Drain Gutter	13	15	85	0	MEDIUM DAMAGED
	Bridge of People	1	15	80	5	MEDIUM DAMAGED
6.	**Babakan Secondary Channel**					
	Tapping Building	21	20	50	30	MEDIUM DAMAGED
	Building for Tapping	2	15	45	40	MEDIUM DAMAGED
7.	**Bojong Malang Secondary Channel**					
	Tapping Building	6	0	30	70	DAMAGED
8.	**Secondary Channel of Coral Object**					
	Tapping Building	3	0	50	50	DAMAGED
	Animal Washing Ladder	2	90	5	5	GOOD
	Falling Building	1	80	20	0	GOOD
	AMOUNT	110	1854	991	455	
	AVERAGE		56.18	30.03	13.79	GOOD

Source: Calculation

Institutional and Human Resource Analysis

This analysis is used to find out more details about the condition of an irrigation management institution through the results of a questionnaire filled out by the Merjan Irrigation Management Institution (Graph & Spectral, 2022). Refer to PU Regulation No. 32/PRT/M/2007 for this institutional analysis.

Table 8. Field Management Personnel

Employee Status	Personnel			Percentage (%)	
	Need	There is	Not enough	There is	Not enough
Irrigation Officer	2	1	1	50%	50%
POB	2	1	1	50%	50%
PPA	23	8	15	35%	65%
PPS	29	0	29	0%	100%
Amount	61	10	51	16%	84%

Source: Calculation

Analysis of Real Operation and Maintenance Needs Figures

This analysis of the actual operational and maintenance needs figures is carried out to obtain the budget value required for the next year, which is calculated using the proposed operating cost budget table and maintenance cost budget table (Priatama & Kania Kurniawati, 2023).

Table 9. Operation and Maintenance Costs of Merjan Dam Irrigation Area

Year		2021	2022	2023
Operation		1,468,511,000	1,646,697,000	2,558,471,000
Self-management	Routine	895,041,000	1,553,974,000	1,810,889,000
	Periodic	2,395,080,801	3,310,721,000	3,310,721,000
Amount		3,290,121,801	4,864,695,000	5,121,610,000
Total O&P Costs		4,758,632,801	6,511,392,000	7,680,081,000
Rehabilitation Costs		35,543,275,677	31,895,944,000	31,944,731,000
Total cost		40,301,908,478	38,407,336,000	39,624,812,000

Source: Calculation

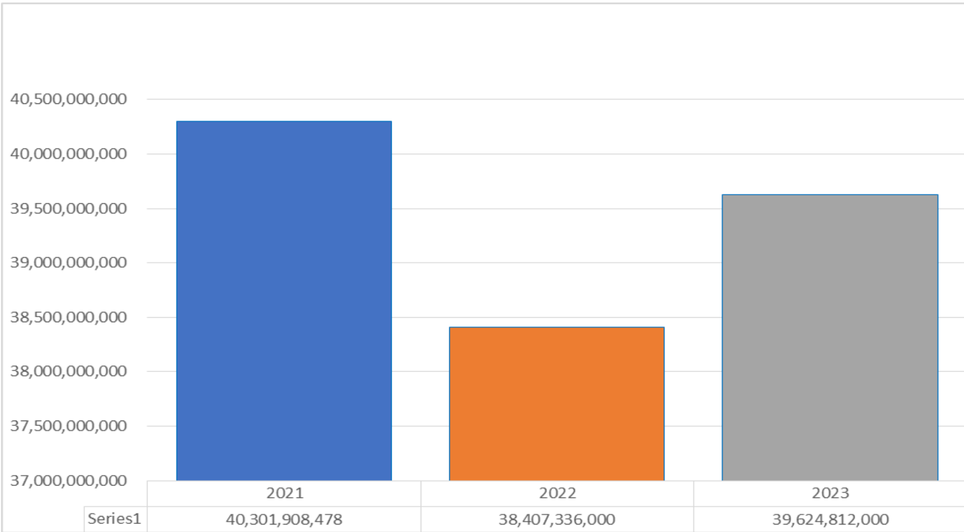

Figure 5. Graph of Real Operation and Maintenance Needs Figures

CONCLUSION

The findings from the rainfall data analysis and the comparison between required and available discharge in the Merjan Irrigation Area indicate that the available water supply exceeds the demand, ensuring the fulfillment of the region's water requirements. The cropping pattern analysis demonstrates the irrigation system's effectiveness, confirming that the Rice-Rice-Secondary Crops pattern aligns with the area's water needs. This suggests that it is a suitable planting pattern for future agricultural cycles. Regarding the irrigation network, the overall condition of the Merjan Dam irrigation infrastructure is generally good, with 56.18% classified as good, 30.03% as moderate, and 13.79% as damaged. However, there is a critical staffing shortage. The current staff of 10 is insufficient to meet the operational needs, leading to poorly maintained infrastructure. This shortage, representing an 84% gap from the required personnel, impacts the overall network performance and calls for urgent staff augmentation.

Finally, the analysis of operational and maintenance costs shows fluctuations in the budget over the years, indicating that the irrigation system's financial management requires improvement to maintain sustainability and efficiency. The research objectives have been successfully met, providing valuable insights into the irrigation area's operational, infrastructural, and financial challenges.

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