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Analysis of Modernization Readiness of Irrigation in The Downstream Brantas River Basin Under the Authority of The Central Government

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ABSTRACT

In carrying out the management of the irrigation system has obstacles are inadequate infrastructure conditions caused, the irrigation infrastructure has exhausted its technical age which causes the decline in the performance function of the irrigation network. Government to farmers has not been carried out intensively. In an effort to overcome these obstacles, in addition to the operation, maintenance and rehabilitation required a renewal thoroughly, both institutional, technical, managerial, and human resources. Modernization irrigation is an effort to realize a participant irrigation management system that is oriented toward fulfilling irrigation service levels in an effective, efficient, and sustainable. Limited time, cost and human resources are obstacles in the implementation of irrigation modernization, so an assessment is needed to measure the level of readiness of an irrigation area in carrying out irrigation modernization activities. This result of analyze the readiness of irrigation modernization show that Mrican Kanan area is ready for irrigation modernization with IKMI value 81,69%. Meanwhile DI. Mrican Kiri, DI. Siman, DI. Menturus, DI, Delta Brantas needs maintenance around 1- 2 years. DI. Mrican Kanan can start from the Peterongan Secondary Channel. SI. Pare Peterongan, SI. Tunggorono, SS. Melik dan SS. Sentul.

1. Introduction

East Java is the second most populous province in Indonesia, with a population of 41.149 million people in 2022 and a population growth rate of 5.34% [1]. The increasing population each year is directly proportional to the growing demand for food. However, the reduction of agricultural land due to industrial areas, settlements, toll roads, and other factors poses a challenge in managing the irrigation system. In the National Medium-Term Development Plan (RPJMN) 2020-2024, one of the strategies for basic infrastructure

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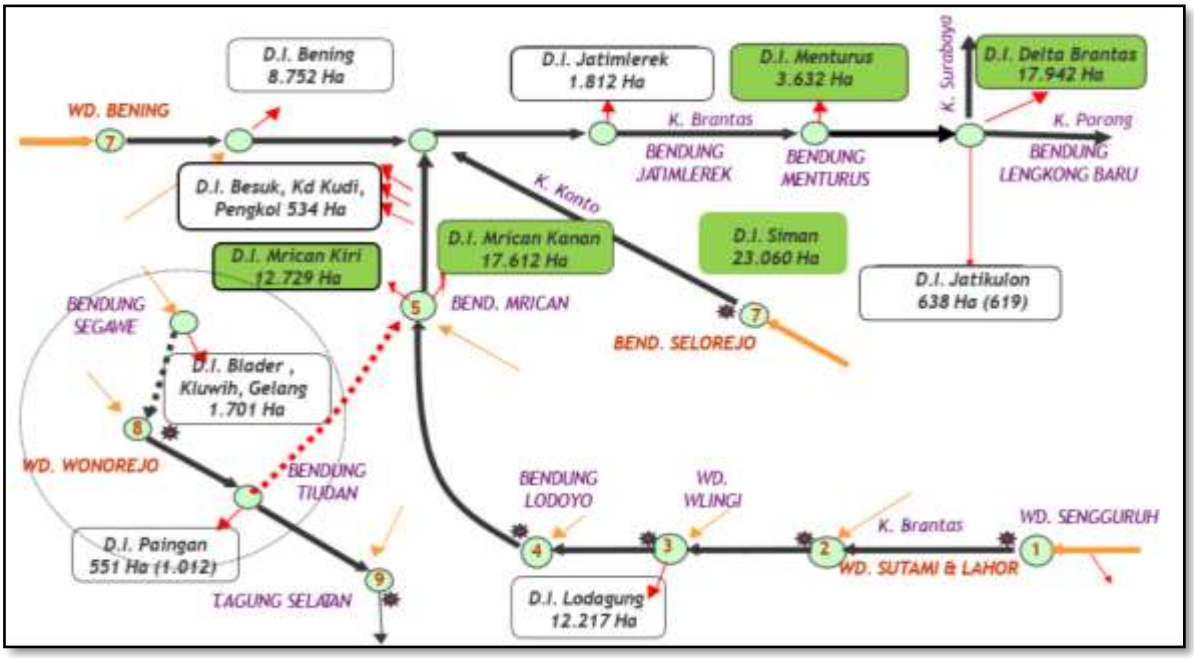
development is the improvement of irrigation services through the construction of multipurpose reservoirs and the establishment of irrigation managers at the irrigation district level, known as irrigation modernization [2]. Irrigation modernization differs from conventional irrigation, as it focuses not only on physical improvements but also on enhancing institutional management and human resources. This approach aims to achieve more accurate, efficient, and effective irrigation system management [3].

According to Regulation No. 14/PRT/M/2015 on Criteria and Determination of Irrigation Area Status, the Central Government, through the Brantas River Basin Authority, has jurisdiction over 33 Irrigation Districts (DI) in East Java, covering a total Irrigation Area of 292,830 hectares (criteria for the irrigation area size > 3000 ha). Several irrigation districts under the authority of the Brantas River Basin Authority, receiving water services from the downstream Brantas River, have significant potential for irrigation modernization. These include DI Mrican, consisting of DI Mrican Kanan (17,602 ha), DI Mrican Kiri (13,815 ha), DI Siman (23,060 ha), DI Menturus (3,632 ha), and DI Delta Brantas (17,900 ha).



Source: Brantas River Basin Authority (BBWS Brantas), 2020.
Figure 1. Study Location

In addition to being a priority for irrigation modernization programs, the five irrigation districts mentioned offer various benefits. However, these areas also face challenges that hinder optimal agricultural yields. Some of the issues encountered in DI. Mrican Kanan includes suboptimal planting patterns and yields due to the presence of unirrigated fields and non-cultivated areas during the second dry season planting due to water shortages [4]. The water scarcity is attributed to a high number of fields relying on simple irrigation methods, issues in the irrigation network, including damages, illegal water extraction activities, sediment accumulation in the channels from nearby villages and markets, and channel positions higher than the irrigated fields, causing water seepage that eventually flows into the drainage channel and, ultimately, into the river. Similar to DI. Mrican Kanan, DI. Mrican Kiri faces issues such as reduced irrigation water due to damage to water channels, illegal water extraction activities, and sediment accumulation in the channels.

The Siman Irrigation Area, with a standard rice field area of 23,060 hectares, utilizes water from the Siman Reservoir to meet its irrigation needs [5]. According to the Global Planting Plan in 2019, the cultivated area for rice during the first planting season was 18,824 hectares, 14,817 hectares during the second planting season, and 379 hectares during the second dry season. Challenges in DI. Siman include water scarcity during irrigation leading to suboptimal productivity, conflicts of interest among water users for irrigation and fisheries, high sedimentation causing channel silting, and significant water loss due to illegal water extraction, often involving the destruction of irrigation network assets, such as damaging gates, breaching channels, and using pumps.

DI Menturus draws water from the intake of the Menturus rubber dam, irrigating an area of 3,632 hectares. DI Menturus cultivates rice on 2,067 hectares during the first planting season, 1,079 hectares during the second planting season, and the remaining area is dedicated to crops other than rice [6]. Issues in DI Menturus include water scarcity during the dry season, resulting in many fields being left fallow, significant water loss due to seepage resulting from damage to the floor and walls of the channels, and channels running parallel to the Brantas River with elevations much higher than the river. Prolonged seepage leads to worsening infrastructure damage.

The Delta Brantas Irrigation Area in Sidoarjo Regency has a standard rice field area of 17,942 hectares and receives water supply from the Lengkong Dam in Mojokerto Regency [7]. The main problems in DI. Delta Brantas is the reduction of green land converted into residential and industrial areas, resulting in a decreasing demand for irrigation water and an increasing demand for raw water. Additionally, there is a significant water loss due to porous soil and channel silting caused by high sediment deposits, waste, and water hyacinth.

The Brantas River is estimated to carry more than 8% of plastic waste from the land to the marine environment, leading to sediment accumulation [8]. Operations and maintenance efforts by BBWS Brantas have been undertaken to address the existing issues, but water distribution remains inadequate, even to tertiary and quarter fields. However, with the problems in these five irrigation districts, the expected improvements in irrigation services and agricultural production may not be achieved. Hence, a comprehensive and sustainable renewal (modernization) is needed in terms of technology, management, institutions, and human resources, commonly referred to as irrigation modernization [9].

The implementation procedures for irrigation modernization refer to the Technical Guidelines for Irrigation Modernization published by the Ministry of Public Works and Public Housing. In essence, irrigation modernization involves changes in irrigation management to achieve effective, efficient, and sustainable levels of irrigation services, aiming for better service levels. The concept of irrigation modernization emphasizes five pillars, namely: 1) Improving the reliability of irrigation water supply, 2) Rehabilitating irrigation infrastructure, 3) Refining irrigation management systems, 4) Strengthening irrigation management institutions, and 5) Empowering human resources in irrigation management.

Time constraints, costs, and human resources are obstacles to implementing irrigation modernization, which can be carried out gradually based on the availability of government funds, the readiness of irrigation areas, and the continuous collaboration of relevant agencies and the community in executing irrigation modernization [10]. Therefore, research is needed to provide information about the readiness assessment of an irrigation area for irrigation modernization based on the Irrigation Modernization Readiness Index (IKMI) using the Analytical Hierarchy Process (AHP) decision-making method. Several criteria are necessary in determining the priority order for irrigation modernization. Subsequently, the secondary channel grouping is based on the assessment of irrigation buildings and channels using the k-medoids clustering method with the assistance of Rapid Miner 9.0 software.

2. Research Method

The study on the readiness for irrigation modernization in the downstream Brantas irrigation area employs a survey method. The survey method is one way to collect data in the

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form of opinions directly related to the research object. The purpose of this method is to understand a general overview of the research object, which, when applied, also relates to the respondents. The results of this method consist of samples that are then interpreted and systematically analyzed. The survey conducted in this research is aimed at understanding the Analysis of Irrigation Modernization Readiness in the downstream Brantas area. After identifying which irrigation areas are ready for modernization, a clustering analysis is performed to determine the grouping of secondary channels based on assessments of the condition of facilities and infrastructure in the secondary channels.

Analytical Hierarchy Process (AHP) is used to describe a structured approach in decision-making [11]. The research method employed is the survey method, which is utilized to gather data through questionnaires and interviews. Respondents in this study include modernization experts, commitment-making officials, and farmer water users. In this research, a total of 25 respondents have been selected from various institutions related to irrigation modernization in the five irrigation areas.

3. Results and Discussions

A. Analytical Hierarchy Process (AHP) Method in IKMI Assessment

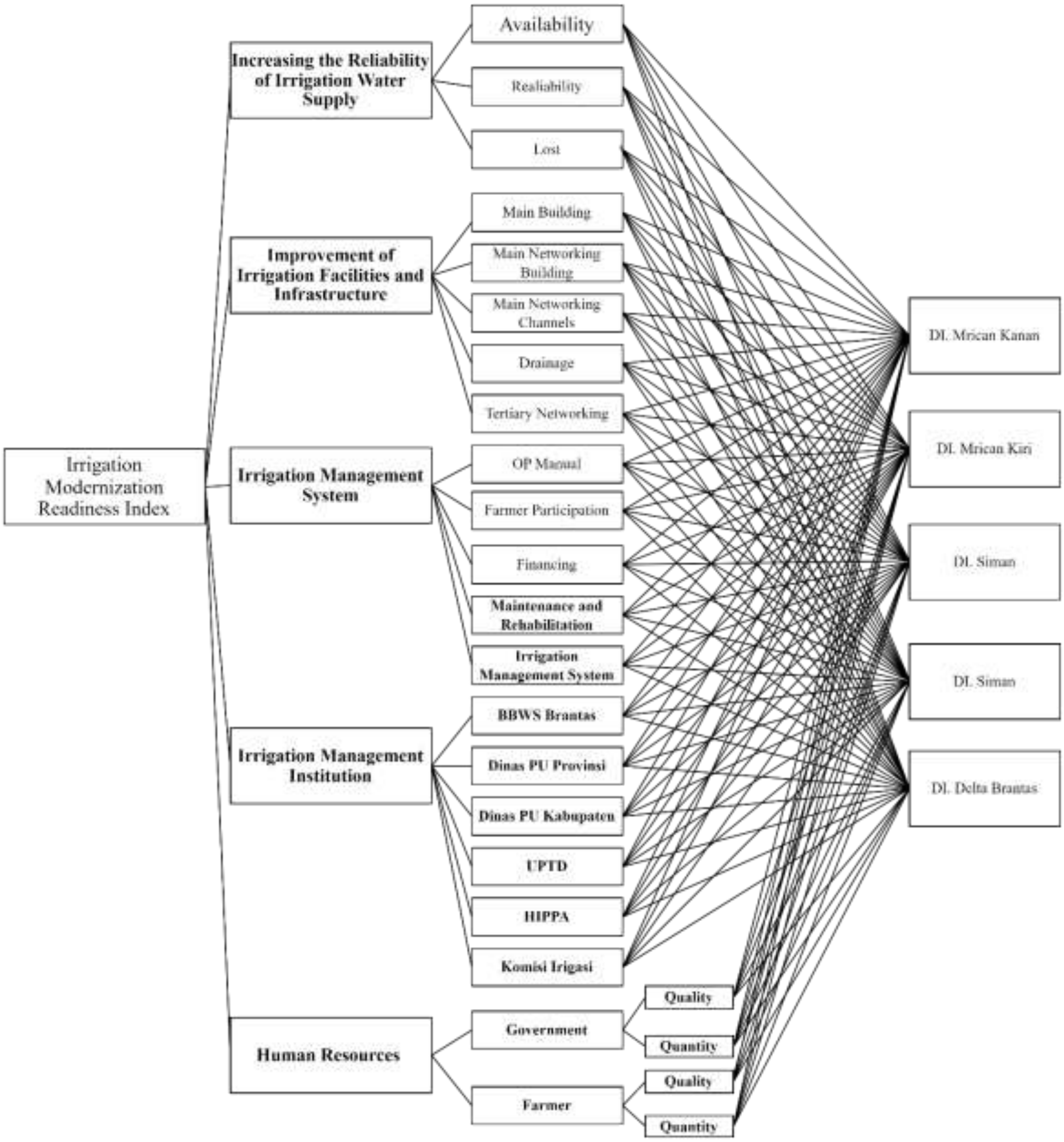
The Analytical Hierarchy Process (AHP) describes a structured approach to decision-making. The research method employed is the survey method, used to gather data through questionnaires and interviews. Respondents in this study include modernization experts, commitment-making officials, and farmer water users. In this research, a total of 25 respondents have been selected from various institutions related to irrigation modernization in the five irrigation areas.

Table 1. Number of Research Respondents

No.	Correspondent Agency	Amount
1	Irrigation Modernization Expert	3 People
2	BBWS Brantas	6 People
3	Provincial PU SDA Department	5 People
4	District Public Works Department	3 People
5	UPTD	2 People
6	HIPPA	3 People
7	Irrigation Commission	3 People
	Total	25 People

Source: Analysis Results.

The goal of objective is the highest level in the hierarchy of the AHP model. The goal of this research AHP model is the Irrigation Modernization Readiness Index. In the assessment of the Irrigation Modernization Index (IKMI) based on several criteria, there are five pillars of irrigation modernization [12][13]. The first pillar, improving the reliability of irrigation water supply, is divided into 3 Sub-Criteria. The second pillar, rehabilitation of irrigation facilities and infrastructure, is divided into 5 sub-criteria. The third pillar is the irrigation system, which is divided into 6 sub-criteria. The fourth pillar, irrigation management institutions, is divided into 6 sub-criteria. The fifth pillar is human resources, divided into government and farmer components, including quantity and quality. The alternative AHP model in this study consists of five, namely DI. Mrican Kanan, DI. Mrican Kiri, DI. Siman, DI. Menturus, and DI. Delta Brantas. The AHP model in this study can be seen in Figure 1.



Source: Analysis Results.
Figure 2. AHP Hierarchy Model

In the AHP hierarchy diagram above, it can be observed that there is a Goal or objective, which is to determine the Irrigation Modernization Readiness Index. There are three levels: the first level consists of criteria, representing the five pillars of irrigation modernization, such as reliability improvement, facilities and infrastructure, irrigation management system, irrigation management institutions, and human resources. Next is the sub-criteria for each irrigation pillar. These are then connected to the five alternatives. After creating the AHP hierarchy, the next step is Pairwise Comparison.

Pairwise Comparison involves decision-makers comparing two different alternatives using a scale that varies by assigning weights to numerical values from 1 to 9 as a reference in the assessment. These numerical values are based on the pairwise comparison scale developed by Thomas L. Saaty. Based on the data collected through questionnaires, assessment criteria

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and sub-criteria were obtained, and their weights were calculated. Below is the Weight Calculation for the Modernization Criteria.

Table 2. Pairwise Comparison Matrix for Criteria

CRITERIA	Increasing the Reliability of Irrigation Water Supply	Improvement of Irrigation Facilities and Infrastructure	Irrigation Management System	Irrigation Management Institution	Human Resources (HR)
Increasing the Reliability of Irrigation Water Supply	1.00	1.84	2.00	3.07	3.15
Improvement of Irrigation Facilities and Infrastructure	0.54	1.00	3.78	3.59	3.84
Irrigation Management System	0.50	0.26	1.00	3.68	2.99
Irrigation Management Institution	0.33	0.28	0.27	1.00	2.41
Human Resources (HR)	0.32	0.26	0.33	0.42	1.00
Total	2.689	3.645	7.380	11.748	13.381

Source: Analysis Results.

Table 3. Calculation of Criteria Weight Values for 5 Pillars of Irrigation Modernization

CRITERIA	Improved Reliability	Improvement of Irrigation Facilities and Infrastructure	Irrigation Management System	Irrigation Management Institution	(HR)	Amount	Average
Improved Reliability	0.372	0.504	0.271	0.261	0.235	1.643	0.329
Improvement of Irrigation Facilities and Infrastructure	0.202	0.274	0.512	0.305	0.287	1.581	0.316
Irrigation Management System	0.186	0.073	0.135	0.313	0.223	0.931	0.186
Irrigation Management Institution	0.121	0.076	0.037	0.085	0.180	0.500	0.100
Human Resources (HR)	0.118	0.073	0.045	0.035	0.075	0.346	0.069

Source: Analysis Results.

From the above analysis results, it can be observed that of the 5 pillars of irrigation modernization, the highest value is found in reliability improvement, with a value of 0.329.

This is due to the importance of availability, reliability, and water loss in an irrigation area, which is considered crucial as the initial step before moving on to facilities and infrastructure. Following that, facilities and infrastructure have a value of 0.316, as the significant water loss occurs due to the damage of existing facilities and infrastructure, resulting in water not reaching the tertiary plots as planned. Subsequently, management systems have a value of 0.186, followed by institutions with a value of 0.1, and the last is human resources, which is divided into 2 categories – government and farmers – with an AHP value of 0.069. The AHP calculations for sub-criteria in irrigation modernization can be seen in Table 4.

Table 4. Pairwise Comparison Matrix for the Reliability Improvement Pillar

CRITERIA	Availability	Reliability	Lost
Availability	1.00	1.14	1.47
Reliability	0.87	1.00	1.59
Lost	0.68	0.63	1.00

Source: Analysis Results.

Table 5. Calculation of Criteria Weight Values for the pillars of increasing reliability

CRITERIA	Availability	Reliability	Lost	Amount	Average
Availability	0.392	0.413	0.362	1.166	0.389
Reliability	0.342	0.361	0.392	1.095	0.365
Lost	0.267	0.227	0.246	0.739	0.246

Source: Analysis Results.

Availability holds the highest weight in the reliability improvement pillar at 0.389, followed by reliability at 0.365, and water loss at 0.246. Meanwhile, the weighting calculation results for the sub-criteria of the facilities and infrastructure pillar show that the highest value is for the Main Network Buildings at 0.335, followed by main buildings at 0.281, followed by main network channels at 0.167, then drainage at 0.120, and finally tertiary networks at 0.097. Tables 6 and 7 represent the weighting calculations for the facilities and infrastructure pillar.

Table 6. Pairwise Comparison Matrix for the Irrigation Facilities and Infrastructure Pillar

CRITERIA	Main Building	Main Network Building	Main Network Channels	Drainage	Tertiary Network
Main Building	1.000	1.030	1.904	1.933	2.757
Main Network Building	0.971	1.000	2.988	3.078	2.757
Main Network Channels	0.525	0.335	1.000	1.732	2.280
Drainage	0.517	0.363	0.610	1.000	1.246
Tertiary Network	0.363	0.363	0.463	0.803	1.000
Total	3.376	3.090	6.966	8.546	10.040

Source: Analysis Results.

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Table 7. Calculation of Criteria Weight Values for the Irrigation Facilities and Infrastructure pillar

CRITERIA	Main Building	Main Network Building	Main Network Channels	Drainage	Tertiary Network	Amount	Average
Main Building	0.296	0.333	0.273	0.226	0.275	1.404	0.281
Main Network Building	0.288	0.324	0.429	0.360	0.275	1.675	0.335
Main Network Channels	0.156	0.108	0.144	0.203	0.227	0.837	0.167
Drainage	0.153	0.117	0.088	0.117	0.124	0.599	0.120
Tertiary Network	0.107	0.117	0.067	0.094	0.100	0.485	0.097

Source: Analysis Results.

Table 8. Pairwise Comparison Matrix on the Irrigation System pillar

CRITERIA	OP manual	Farmer Participation	Financing	Maintenance and Rehabilitation	Irrigation Management System
OP manual	1.000	1.926	0.330	0.610	1.421
Farmer Participation	0.549	1.000	0.455	0.406	0.577
Financing	3.031	2.197	1.000	1.463	2.262
Maintenance and Rehabilitation	1.639	2.461	0.683	1.000	1.958
Irrigation Management System	0.704	1.732	0.442	0.511	1.000
Total	6.922	9.315	2.911	3.990	7.218

Source: Analysis Results.

Table 9. Calculation of Criteria Weight Values for the Irrigation System pillar

CRITERIA	OP manual	Farmer Participation	Financing	Maintenance and Rehabilitation	Irrigation Management System	Amount	Average
OP manual	0.144	0.207	0.113	0.153	0.197	0.814	0.163
Farmer Participation	0.079	0.107	0.156	0.102	0.080	0.525	0.105
Financing	0.438	0.236	0.344	0.367	0.313	1.697	0.339
Maintenance and Rehabilitation	0.237	0.264	0.235	0.251	0.271	1.258	0.252
Irrigation Management System	0.102	0.186	0.152	0.128	0.139	0.706	0.141

Source: Analysis Results.

In the calculation of weights for the irrigation system, many respondents chose financing as more crucial, with a weight of 0.339. This is because all infrastructure development, operations, and maintenance require funding. The second choice is maintenance and rehabilitation, valued at 0.252. Respondents believe that after the construction of buildings or the improvement of operational channels, rehabilitation is also important to maintain the functionality of the structures. Manual OP is considered crucial to obtain data on the irrigation area, including the completeness of buildings, discharge, and individual plots – this has an AHP value of 0.163. Following that, irrigation management systems weight of 0.141, and the lowest is farmer participation. Some respondents believe that farmers, as beneficiaries, still have a relatively low awareness level to maintain the structures properly, with a value of 0.105. The next step is to calculate the criteria weights for the institution pillar, as shown in Tables 10 and 11 below.

Table 10. Pairwise Comparison Matrix for the Institution Pillar

CRITERIA	BBWS Brantas	Provincial PU SDA Department	District Public Works Department	UPTD	HIPPA	Irrigation Commission
BBWS Brantas	1.000	3.269	3.680	1.926	2.087	1.926
Provincial PU SDA Department	0.306	1.000	2.977	0.664	0.803	0.719
District Public Works Department	0.272	0.336	1.000	0.440	0.440	0.701
UPTD	0.519	1.507	2.271	1.000	3.066	1.432
HIPPA	0.479	1.246	2.271	0.326	1.000	1.246
Irrigation Commission	0.519	1.390	1.426	0.698	0.803	1.000

Source: Analysis Results.

Table 11. Calculation of Criteria Weight Values for the Institution pillar

CRITERIA	BBWS Brantas	Provincial PU SDA Department	District Public Works Department	UPTD	HIPPA	Irrigation Commission	Average
BBWS Brantas	0.323	0.374	0.270	0.381	0.255	0.274	0.313
Provincial PU SDA Department	0.099	0.114	0.218	0.131	0.098	0.102	0.127
District Public Works Department	0.088	0.038	0.073	0.087	0.054	0.100	0.073
UPTD	0.168	0.172	0.167	0.198	0.374	0.204	0.214
HIPPA	0.155	0.142	0.167	0.065	0.122	0.177	0.138
Irrigation Commission	0.168	0.159	0.105	0.138	0.098	0.142	0.135

Source: Analysis Results.

Table 12. Calculation of Criteria Weight Values for the Human Resources pillar (Government)

CRITERIA	Quantity	Quality	Quantity	Quality	Amount	Average
a. Quantity	1.00	2.58	0.721	0.721	1.441	0.721
b. Quality	0.39	1.00	0.279	0.279	0.559	0.279

Source: Analysis Results.

Table 13. Calculation of Criteria Weight Values in the Human Resources pillar (Farmers)

CRITERIA	Quantity	Quality	Quantity	Quality	Amount	Average
a. Quantity	1.00	3.15	0.759	0.759	1.518	0.759
b. Quality	0.32	1.00	0.241	0.241	0.482	0.241

Source: Analysis Results.

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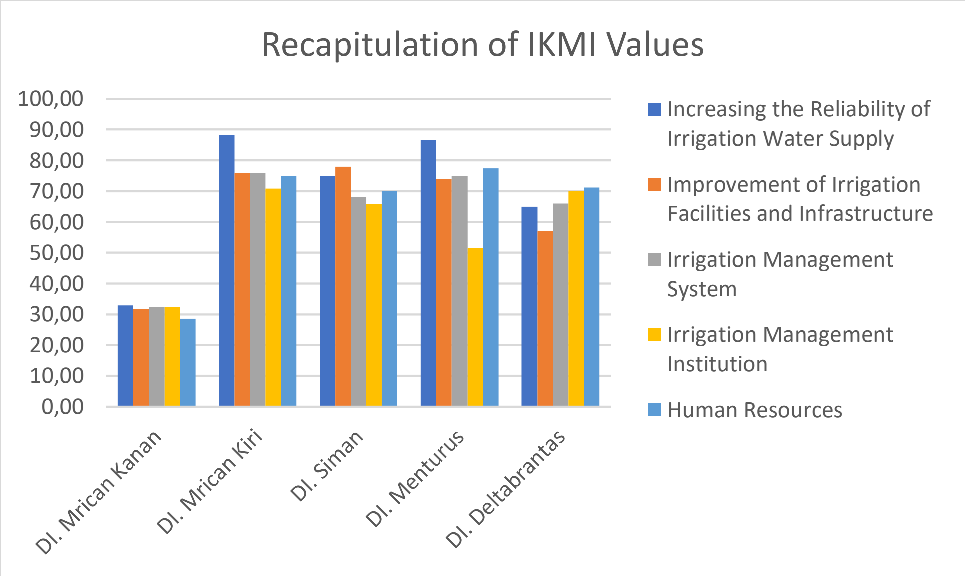
Institutions play a role in irrigation modernization, and in this context, there are six institutions. BBWS Brantas has the highest value at 0.313, considered to have a significant contribution to the management of irrigation modernization. Next is UPTD at 0.214, followed by HIPPA and the Irrigation Commission, which will manage, operate, and maintain irrigation modernization as users, with benefits valued at 0.138 and 0.135, respectively. Then there is the Department of Public Works and Spatial Planning of East Java Province at 0.127, and finally, the District Public Works Department at 0.073. As for the weight values for Human Resources (SDM), there are two aspects: government and farmers, encompassing both quantity (amount) and quality of the human resources. In terms of quantity, the government has the highest value at 0.721 and quality at 0.279, while farmers have a quantity value of 0.759 and quality at 0.241.

B. Recapitulation of IKMI Values



Source: Analysis Results.
Figure 3. Recapitulation of IKMI Values

The distribution of IKMI (Irrigation Modernization Index) values for the pillars of irrigation modernization in the 5 irrigation areas is shown in Figure 3. It can be observed that the performance of the irrigation pillars in each Irrigation Area varies.

DI Mrican Kanan: This area excels in 4 pillars - Improvement of the Reliability of Irrigation Water Supply, Improvement of Irrigation Facilities and Infrastructure, Irrigation Management System, and the Institutional Management Pillar. It has the highest IKMI values among the pillars in comparison to other Irrigation Areas, while the Human Resources pillar has the lowest IKMI value.

DI Menturus: This area excels in the Human Resources pillar with the highest IKMI value among the pillars in comparison to other Irrigation Areas. However, the lowest pillar is the Institutional Irrigation Management.

DI Mrican Kiri: This area excels in the Human Resources pillar with the highest IKMI value among the three DI areas, but still lower than DI Mrican Kanan. The lowest pillar is the Institutional Irrigation Management, although it is still superior to DI Siman and DI Menturus.

DI Siman: This area excels in the Improvement of Facilities and Infrastructure pillar, with the highest IKMI value among the three DI areas but still lower than DI Mrican Kanan. The lowest pillar is the Institutional Irrigation Management, although it is still superior to DI Menturus.

DI Delta Brantas: This area is less superior in four pillars compared to the other four DI areas. The lowest pillar is the Institutional Irrigation Management, with the lowest value among the same pillar in other DIs.

C. Readiness for Irrigation

Modernization The readiness for irrigation modernization has been assessed based on the five pillars, covering water availability, irrigation facilities and infrastructure, irrigation management systems, institutional irrigation management, and human resources in the 5 Irrigation Areas - DI Mrican Kanan, DI Mrican Kiri, DI Siman, DI Menturus, and DI Delta Brantas. Based on interviews and field observations, the recapitulation values are shown in Table 14.

Table 14. Distribution of IKMI Values

Irrigation Pillar	DI. Mrican Ka	DI. Mrican Ki	DI. Siman	DI. Menturus	DI. Delta brantas	Bobot Upaya	DI. Mrican Ka	DI. Mrican Ki	DI. Siman	DI. Menturus	DI. Deltabrantas
Increasing the Reliability of Irrigation Water Supply	97.71	96.8	55.81	77.20	62.57	20%	19.54	19.36	11.16	15.44	12.51
Improvement of Irrigation Facilities and Infrastructure	84.40	81.4	77.37	78.97	74.66	25%	21.10	20.36	19.34	19.74	18.66
Irrigation Management System	74.41	75.1	68.18	76.51	65.09	20%	14.88	15.02	13.64	15.30	13.02
Irrigation Management Institution	77.63	72.7	64.56	60.65	69.51	20%	15.53	14.55	12.91	12.13	13.90
Human Resources (HR)	81.25	75.0	70.00	77.50	71.25	15%	12.19	11.25	10.50	11.63	10.69

Source: Analysis Results.

From the processing of IKMI data for the pillars of irrigation modernization in the 5 Irrigation Areas, namely DI Mrican Kanan, DI Mrican Kiri, DI Siman, DI Menturus, and DI Delta Brantas, the IKMI values are obtained as shown in Table 15 below.

Table 15. Distribution of IKMI Values and Predicted Readiness for Irrigation Modernization

Irrigation Pillar	DI. Mrican Kanan	DI. Mrican Kiri	DI. Siman	DI. Menturus	DI. Delta brantas
Increasing the Reliability of Irrigation Water Supply	19.54	19.36	11.16	15.44	12.51
Improvement of Irrigation Facilities and Infrastructure	21.10	20.36	19.34	19.74	18.66
Irrigation Management System	14.88	15.02	13.64	15.30	13.02
Irrigation Management Institution	15.53	14.55	12.91	12.13	13.90
Human Resources (HR)	12.19	11.25	10.50	11.63	10.69
Total	83.24 Good	79.98 Enough	67.5 Enough	74.24 Enough	68.78 Enough

Source: Analysis Results.

The IKMI (Index of Irrigation Modernization Readiness) values were calculated for the five areas, with DI. Mrican Kanan scored the highest at 83.24, classified as good readiness.

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Following this, DI. Mrican Kiri scored 79.98, categorized as fair, followed by DI. Siman at 67.5, DI. Menturus with a score of 74.24, and finally, DI. Delta Brantas with a score of 68.78, was deemed fair. This indicates that DI. Delta Brantas is not yet ready for irrigation modernization and requires improvement within 1-2 years. The highest and qualifying readiness for modernization is found in DI. Mrican Kanan with an IKMI score of 83.24, is classified as good, signifying immediate readiness for irrigation modernization.

D. Clustering of Secondary Channels in DI. Mrican Kanan

The analysis of irrigation modernization readiness focused on the five irrigation areas and DI. Mrican Kanan emerged as meeting the criteria for modernization readiness. Subsequently, the analysis delved into the performance of secondary irrigation infrastructure, crucial in transporting water from primary to tertiary channels leading directly to rice fields. DI. Mrican Kanan, with the highest IKMI value in comparison to other irrigation areas, underwent clustering analysis. This facilitates an easier understanding of the actual conditions and provides assessments in the relevant irrigation area. The output of this research is a map plotting the assessment of irrigation infrastructure. The map aims to visualize the distribution of assessments within each cluster, serving as a tool to understand the actual conditions in the irrigation area. The clustering of infrastructure conditions can be used as a basis for improving irrigation management based on supporting pillars [15].

4. Conclusion and Suggestion

4.1 Conclusions

1. The assessment results of the Irrigation Modernization Readiness Index (IKMI) indicate that only the Mrican Irrigation Area, particularly Mrican Kanan, is ready for irrigation modernization, scoring an IKMI value of 81.69%, classified as good. On the other hand, DI. Mrican Kiri, DI. Siman, DI. Menturus, and DI. Delta Brantas requires improvement, development, and refinement of irrigation pillars over the next 1-2 years.
2. Analysis using the Analytical Hierarchy Process (AHP) method reveals that the reliability of irrigation water has the highest level of importance with a score of 0.329, followed by infrastructure and facilities at 0.316. Subsequently, the management system scores 0.186, followed by institutions at 0.1, and finally, human resources, divided into government and farmers, with an AHP value of 0.069.
3. The clustering analysis based on the values of irrigation infrastructure in secondary channels reveals four clusters, with the lowest Davies–Bouldin Index (DBI) in cluster 0-cluster 3. Secondary channels within clusters 2 and 1 exhibit better performance in terms of structure compared to other clusters.
4. Technical recommendations from the clustering analysis are as follows: Secondary channels within cluster 2 can maintain their existing operation and maintenance patterns. Secondary channels within cluster 1 require minor improvements while maintaining the existing operation and maintenance patterns. For cluster 0 and cluster 3, routine maintenance is needed to restore functionality and minimize water loss. Consequently, irrigation modernization in DI. Mrican Kanan can commence at S.I Pare Peterongan, S.I Tunggorono, S.S Melik, and S.S Sentul.

4.1 Suggestion

Based on the analysis results, here are some recommendations to enhance the readiness and effectiveness of irrigation modernization in the Mrican Irrigation Area:

1. Prioritize Modernization in Mrican Kanan Irrigation Area: Considering that the Mrican Kanan Irrigation Area is deemed ready for irrigation modernization, it is advisable to initiate the implementation of modernization projects in this region. Focus on projects that

support the improvement of the reliability of irrigation water supply, enhancement of infrastructure, and the irrigation management system.

2. Improvement and Development in Other Areas: Mrican Kiri, Siman, Menturus, and Delta Brantas Irrigation Areas need special attention in the form of improvement, development, and refinement of irrigation pillars. It is recommended that the government and relevant stakeholders allocate resources and budgets to address identified shortcomings during the next 1-2 years.
3. Focus on Enhancing Irrigation Water Availability: The Analytical Hierarchy Process (AHP) method indicates that improving the reliability of irrigation water supply holds the highest level of importance. Therefore, it is recommended to pay special attention to projects that can efficiently and effectively enhance water availability.
4. Continuous Monitoring and Evaluation: Establish mechanisms for continuous monitoring and evaluation to measure the progress of irrigation modernization projects. Through regular monitoring, relevant parties can promptly respond to changing conditions and identify areas that require further attention.

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