The status and challenges of irrigation infrastructure performance in supporting the agricultural sector: a case study of Kediri Regency, Indonesia

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Abstract. The increase in population in rural and urban areas has an impact on food availability and security. Agriculture, as a major contributor to food security, faces increasing challenges, such as the decline in the area planted for agricultural commodities, the availability of labor, and the water provision for crops. Climate change will affect water availability, planting patterns, and agricultural production. The government has provided irrigation infrastructure services to increase agricultural production. Limited budget, authority, irrigation water sources, and irrigation service areas have not been able to meet farmers' needs for irrigation water. This study aims to assess the performance of irrigation infrastructure services based on farmers' perceptions of these services. Measuring irrigation infrastructure services is based on indicators of physical availability, physical quality, appropriateness, utility, and contribution to the economy. The level of satisfaction with irrigation infrastructure services was measured using a Likert scale. The data are used to compare expected values and perceived values. This measurement obtains service gaps, as mentioned in the IPA (Importance Performance Analysis) method. The respondents to this research are farmers or farmer groups who receive irrigation infrastructure services. The results show significant gaps in several indicators, namely the reliability of the irrigation system, application of irrigation technology, regular irrigation infrastructure checks (O&M), and resilience to climate change.

1 Introduction

The increase of population in rural and urban areas has an impact on food availability and security. More pressure on food demand will experience a rapid increase as the population projection in 2050 will reach around 9 billion [1]. To ensure the food security, irrigation becomes a fundamental aspect. Increasing irrigation could lead to increasing agricultural production [2].

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There are some barriers hinders this agricultural sector in producing the , among others are climate change, increased water scarcity, droughts, land degradation and poor management of resources which some factors are intertwined [3]. Furthermore. There are also several problems faced related to irrigation, such as inefficiencies in irrigation projects and delays in completion of projects, losses in operating irrigation projects, increasing cost of irrigation, regional disparities in irrigation development, decline in water table, and water logging and salinity [4]. Another problem may arise, for instance little attention is given to the monitoring and evaluation of the established irrigation performance, whereas numerous irrigation systems are undergoing deterioration in physical infrastructure, operational aspect, and management [2].

As the main purpose of irrigation provision is to support optimum crop production, therefore measuring performance is crucial to spot the shortcomings of the system and provide feedback to improve the performance [5][6]. Service delivery is the most common measurement used in term of performance evaluation approach [7]. Some studies have assessed irrigation performance using service delivery approach that included physical performance and operational as well as maintenance aspects employing the indicators as follows: routine checking, preventive maintenance, repairs to canal banks, outlet checking [5], irrigation ratio (the ratio of annual irrigated cropped area and command area) [8], irrigation water quality including salinity [9], technology advancement [10], and adaptation to changing climate [11]. On the other hand, irrigation has been largely built in low and middle income countries in the wish of boosting the agricultural economy and economic development by increasing the agricultural productivity which eventually can improve aggregate welfare [12].

East Java is one of the biggest food contributors in Indonesia. Kediri Regency becomes one of the regencies in the East Java that has higher rice productivity (5,7 ton/ha) in 2022 compared to the average of the East Java Province (5,6 ton/ha). To pursue optimum agricultural productivity, it is necessary to investigate the current status and some factors hindering the performance of irrigation service.

This paper assesses the performance of irrigation infrastructure in supporting the agricultural sector of the Kediri Regency in Indonesia from the perspective of farmer groups who utilize irrigation infrastructure services. From the adoption of the former discussion regarding aspects related to service delivery performance, this study evaluates the farmer's perception pertaining the following dimensions: physical availability, physical quality, appropriateness, utility, and contribution to the economy.[13]

2 Method

This study employs a purposive sampling method, targeting farmers and landowners in Kediri Regency. The selection of respondents is based on geographical considerations, with the eastern part of the Brantas River having more agricultural land than the western part. Therefore, the research focuses on the eastern region as it is considered more representative in terms of agricultural land area. A total of 140 respondents were involved in this study. Pagu, Papar, Ngadiluwih, Purwoasri, and Gurah sub-districts are agricultural centers on the east side of the Brantas River, while Grogol and Banyakan sub-districts are agricultural centers on the west side of the Brantas River. The distribution of the questionnaires is explained in **Figure 1**. The majority of respondents were concentrated in Pagu District, followed by Gurah District and Purwoasri District. Additionally, significant attention was directed toward areas on the east side of the Brantas River. On the other hand, Grogol and Gurah Districts were particularly emphasized for their role in representing agricultural conditions in the West Brantas River region.

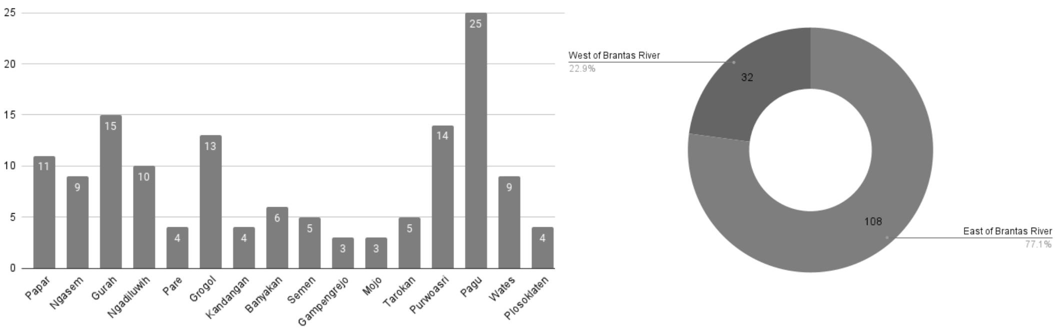

Fig. 1. Distribution of Questionnaires

All respondents represent a single household that owns and manages agricultural land. Consequently, even though their primary occupations may not be farming, they possess a thorough understanding of the environmental conditions and agricultural infrastructure associated with their properties. The age distribution of respondents predominantly falls within the 46 to 50-year range. This trend indicates a declining involvement of younger individuals in productive agricultural work. The decline of young farmers in Indonesia, particularly in East Java, including Kediri, is a growing concern. Research has identified that younger generations are becoming less interested in pursuing careers in agriculture due to several factors. One of the primary reasons is the perception of agriculture as a less prestigious and financially rewarding sector compared to other job opportunities. As a result, many young people choose urban employment, leaving the agricultural sector predominantly managed by older farmers, which threatens the sustainability of agriculture and food security in the region. Enumeration of the 2023 Agricultural Census in Kediri Regency, it is revealed that the number of farmers aged 19-39 years is only 14,232 individuals, accounting for 16.8% of the total farmers in the region. In contrast, the majority of farmers are aged 39 years and above, totaling 70,592 individuals, or 83.2% of the total [14]. For instance, a study on the agribusiness of pineapple farming in Kediri highlights that fewer young people are engaging in farming, with most agricultural work being carried out by older generations [15]. This trend is not only seen in Kediri but across many regions in Indonesia, where the declining interest of younger workers in agriculture threatens future agricultural productivity and rural economic capacity [16].

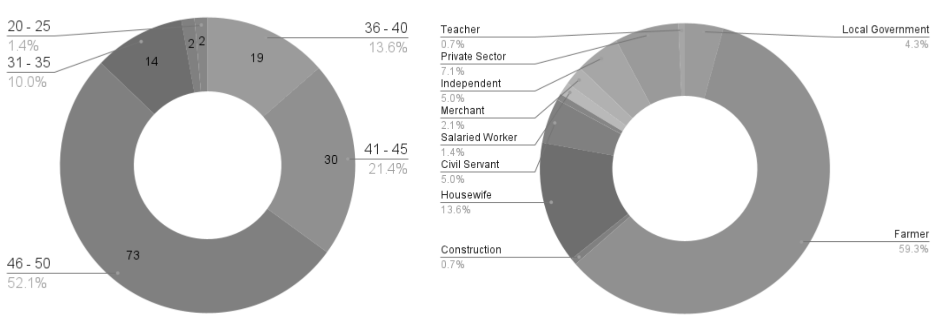

Fig. 2. Demographic Characteristics of Respondents: Age Group (Left) and Type of Employment (Right)

Data were collected through the distribution of questionnaires that assess the performance of irrigation infrastructure in supporting the agricultural sector. The questionnaire is designed to cover six key dimensions: physical availability, physical quality, appropriateness, utility, job creation, and contribution to the economy as described in **Table 1**. The physical availability dimension evaluates the extent to which irrigation infrastructure is accessible to agricultural land. Physical quality measures the condition and durability of the irrigation facilities, such as canals and dams. Based on previous studies, regular cleaning of irrigation channels and the maintenance of damaged infrastructure represent essential physical interventions required to enhance the sustainability of irrigation systems [17,18]. In addition, the quality of clean water used in agriculture also contributes to the quality and quantity of the harvest [17]. Appropriateness assesses whether the infrastructure is well-suited to the specific needs of the farmers and the characteristics of the land they cultivate. Utility examines how effectively the farmers utilize the irrigation infrastructure in their farming practices. This dimension is related to the sustainability of the agricultural process. Based on previous studies, farmers play a major role in ensuring a sustainable agricultural system, which is the result of farmers' knowledge and expectations [19].

Lastly, contribution to the economy evaluates the impact of irrigation infrastructure on improving agricultural productivity and increasing farmers' income. This indicator is considered as a multiplier effect of the ideal conditions of providing agricultural technology innovation and the implementation of effective management among young farmers. However, in reality the poverty rate among farmers is still high, indicating the need for a more in-depth study of farmer welfare [20].

Table 1. Research Dimensions and Indicators.

Dimension	Indicators
Physical ability	Number of irrigation network
	Irrigation coverage
	Routine checking and inspection
Physical quality	Infrastructure maintenance
	Water quality (salinity, turbidity, etc.)
Appropriateness	Suitability with the demand
	System reliability
	Climate resilience
Utility	Repairment and handling of technical problem
	Technology advancement and implementation
Economic Contribution	Irrigation infrastructure increases local economic development

Once the data were collected, the analysis was carried out using the Importance Performance Analysis (IPA) method, with statistical processing conducted using SPSS software. This approach helps identify the gaps between the actual performance of the irrigation infrastructure and the expectations of the farmers. The IPA method, supported by SPSS, enables precise mapping of which infrastructure elements require more attention, allowing for the efficient allocation of limited resources to improve the performance of irrigation facilities that are considered important but currently underperforming. [21,22]. By employing this method, the study can prioritize areas that are perceived as important but are underperforming, thereby guiding improvements where they are most needed.

3 Results and discussion

3.1 Study area context and characteristics of irrigation infrastructure

3.1.1 Geographical and Administrative Conditions

The geological characteristics of Kediri Regency can be divided into three regions: the western part of the Brantas River, dominated by the hilly slopes of Mount Wilis and Mount Klotok, which are mostly infertile; the central part, a fertile lowland crossed by the Brantas River flowing from south to north; and the eastern part, comprising infertile hills stretching from Mount Argowayang in the north to Mount Kelud in the south [13]. These variations in topography and soil fertility play a significant role in determining the effectiveness of irrigation systems in the region.

Kediri covers an area of 1,386.05 km², with diverse topographical features ranging from 0 to 500 meters above sea level (masl). The northern and southern regions are lowlands with elevations between 0 and 200 masl, while the western and eastern areas are characterized by hilly and rolling terrains. Based on topography, the land is categorized into four altitude zones: 0-100 masl (32.34%), 100-500 masl (53.83%), 500-1,000 masl (9.98%), and above 1,000 masl (3.73%) [13]. The region's slope is generally gentle, with no areas having gradients exceeding 40%, making the landscape conducive for agriculture, despite varied soil types across different areas. Hydrologically, Kediri is rich in natural water resources, with several rivers flowing through the area, such as the Brantas, Konto, Bakung, and Kolokoso rivers, which have significant water flow year-round. Seasonal rivers also contribute to irrigation during the rainy season [23]. These water bodies, alongside groundwater resources, are vital for irrigation in Kediri, supporting agriculture in both fertile and less fertile areas. The region experiences a tropical climate, with temperatures ranging from 23°C to 31°C and an average elevation of 81 meters above sea level, further influencing the irrigation potential across the regency [13]. According to the Kediri Regency Central Bureau of Statistics in 2024, agricultural land accounts for 34% of rice fields, 35% of non-rice agricultural land, and 31% of non-agricultural land [23,24]. This indicates a significant potential for agricultural land in Kediri Regency.

3.1.2 Social and Economic Conditions

In 2023, the population of Kediri Regency reached 1,684,470, consisting of 849,958 males and 834,496 females, with a population density of 1,215.29 people per km² [13]. Ngasem District had the highest population density, reaching 3,402.19 people per km². In terms of employment, the working-age population increased by 5.21% from 1,258,799 in 2022 to 1,324,474 in 2023 [13]. The labor force amounted to 910,477, with 52,753 classified as unemployed, indicating a need for strategies to address labor market absorption and employment [25]. Economically, Kediri Regency's Gross Regional Domestic Product (GRDP) reflects the area's overall economic health, measured through both current and constant prices. From 2019 to 2023, the GRDP showed fluctuations, with a sharp decline in 2020 due to the COVID-19 pandemic. Economic activities across several sectors saw negative growth during this period. However, the economy began to recover in 2021, with subsequent increases in the GRDP, driven by strong performance in the tertiary sector, which contributed 44.99% to the economy in 2023, largely from wholesale and retail trade, along with motor vehicle repairs [25]. The secondary sector, contributing 31.20%, was bolstered by manufacturing industries, making it the second-largest contributor to the regional economy after the agricultural sector. Though the economy faced a contraction of -2.41% in

2020, it rebounded to 3.06% in 2021 [25]. However, growth slowed to 4.90% in 2022, and by 2023, it experienced a slight decline of 0.37%. Poverty levels also showed a positive trend, with the number of impoverished residents significantly decreasing from 199,380 in 2015 to 163,950 by 2019. Addressing unemployment remains critical, as the open unemployment rate (TPT) reached 6.83% in 2022, above the provincial and national averages, requiring continued workforce development and vocational training programs.

3.1.3 Characteristics of Irrigation Infrastructure

The irrigation infrastructure in Kediri Regency is predominantly characterized by surface irrigation systems. According to the data from the Kediri Agricultural Service, the total irrigated area was 38,317 hectares in 2022, which slightly declined to 38,215 hectares in 2023. Primary irrigation networks serve key agricultural districts such as Badas, Gurah, Kandangan, Kandat, Kras, Ngadiluwih, Ngancar, Ngasem, Pare, Plemahan, and Wates [23]. Secondary irrigation networks extend across an even larger area, covering districts such as Badas, Banyakan, Gampengrejo, Gurah, Kandat, Kepung, Kras, Mojo, and several others, providing essential support for agricultural productivity [24]. In the Regional Government Work Plan (RKPD) of Kediri for 2024, it is noted that 74.19% of irrigation structures in 2022 were in good condition, with 74.68% of the total irrigation network length also classified as being in satisfactory condition [26]. These figures demonstrate the overall effectiveness and maintenance of the irrigation infrastructure, ensuring the steady supply of water to farmlands. Additionally, the region employs a rain-fed system for agricultural activities, with 5,851 hectares of rain-fed land being utilized from 2022 to 2023, supplementing the surface irrigation efforts. The water resources infrastructure in Kediri is further supported by a series of dams and reservoirs. Key facilities include Babadan Dam, Damarwulan Dam, Kacangan Dam, and Siman Dam, alongside major reservoirs such as Karanglo, Sumbersari, Kaliboto Utara, and Sumberagung [23,26]. All these water bodies are reported to be in good condition, ensuring the sustained regulation of water flow and storage capacity, which is critical for both irrigation and flood control within the region. This robust water infrastructure plays a vital role in maintaining the stability of agricultural production and water resource management in Kediri Regency.

3.2 Irrigation infrastructure performance based on farmers' perception

Based on the survey results, it can be observed that overall, average score for all dimensions and indicators showed score gap ranged from 0.73 for economic contribution dimension to 1.33 from utility dimension if compared between performance and expectation score. Performance score for each indicator and dimension always showed lower score compared to the expected one.

Highest performance score shown by economic contribution dimension, particularly the indicator of "irrigation infrastructure increases local economic development" whereas the lowest one performed by utility dimension, especially "technology advancement and implementation" indicator. In terms of users' expectation, the irrigation users expect that all dimensions could deliver best performance in the future with the average expectation score of 4.89. Therefore, the average gap score between performance and expectation in all dimensions is 1.01 (scale 1-5) and 20.27 (scale 0-100). The average score of irrigation infrastructure performance based on farmers' perception can be seen in the following Table 2. and Figure 3.

Table 2. Average score of irrigation infrastructure performance based on farmers' perception.

Dimension	Indicator	Average score for each indicator		Average score for each dimension		Dimension gap
		Performance	Expectation	Performance	Expectation	
Physical availability	Number of irrigation network	3.99	4.93	3.86	4.90	-1.04
	Irrigation coverage	4.06	4.93			
	Routine checking and inspection	3.53	4.84			
Physical quality	Infrastructure maintenance	3.89	4.88	4.13	4.92	-0.80
	Water quality (salinity, turbidity, etc.)	4.36	4.98			
Appropriateness	Suitability with the demand	4.13	4.9	3.71	4.88	-1.18
	System reliability	3.21	4.86			
	Climate resilience	3.78	4.89			
Utility	Repairment and handling of technical problem	3.69	4.88	3.52	4.85	-1.33
	Technology advancement and implementation	3.36	4.82			
Economic contribution	Irrigation infrastructure increases local economic development	4.17	4.9	4.17	4.90	-0.73
Average score (scale 1-5)				3.88	4.89	-1.01
Average score (scale 0-100)				77.55	97.81	-20.27

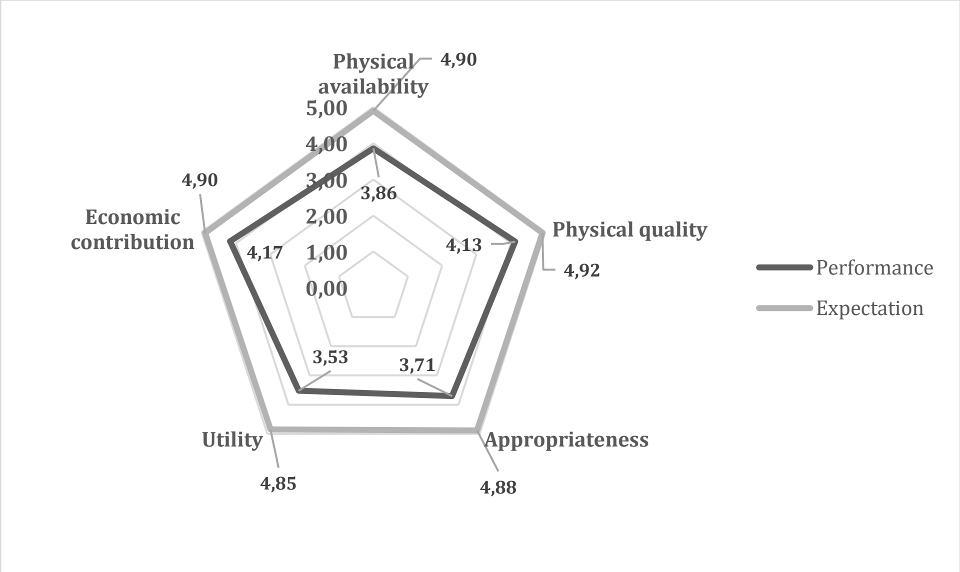

Fig. 3. Spiderweb diagram of the average score of irrigation infrastructure performance based on farmers' perception.

The average scores of irrigation infrastructure performance based on farmers' perception are then plotted into IPA diagram with a little modification made (horizontal axis for performance and vertical axis represents expectation). From the following Figure 4. it can be observed that the three dimensions of physical availability, physical quality, and economic contribution are categorized into quadrant II with high performance as well as high expectation so that the three dimensions should be sustainably maintained to perform their good performance in the future. The three dimensions characterize major strengths in attaining a standardised level of performance with quite high users' satisfaction and users also consider them important.

Utility dimension is included into low performance and low expectation, meaning that it has low priority. This dimension is categorized low performing but do not threaten the whole system. This can be interpreted that if the government has limited budget allocation, this dimension can be put aside first. Appropriateness dimension is indicated to be the primary prioritization as it shows low performance, yet the users demand for high expectation or importance. The consequences are that further budget allocation should be allocated first or higher in this dimension. To further explore the results, the following sub-sections discuss extended investigation for each dimension.

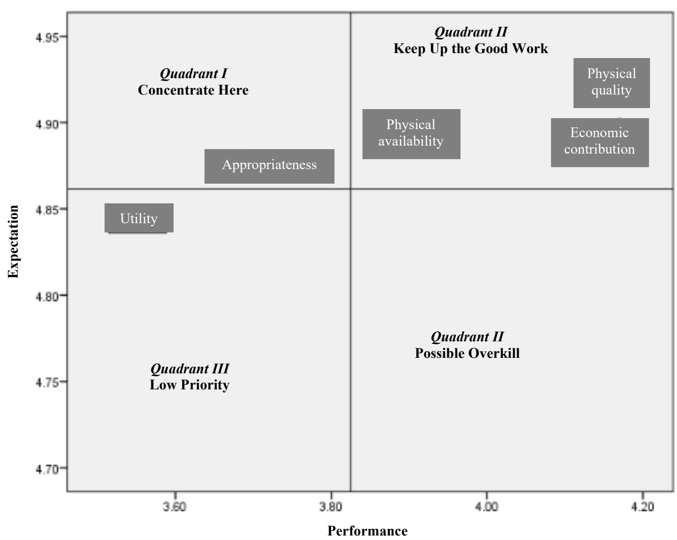

Fig. 4. IPA diagram of the average score of irrigation infrastructure performance based on farmers' perception.

3.2.1 Physical availability

This dimension assesses the availability of irrigation infrastructure, encompassing the number of irrigation channels, the coverage of irrigation services, and routine inspections. The average satisfaction scores for the variables within this dimension, compared to user expectations, reveal a gap. The number of irrigation channels in agricultural areas has an average satisfaction score of 3.99, while the expectation score is 4.93. This creates a gap of -0.94, indicating that although users are relatively satisfied with the existing number of irrigation channels, their expectations for an increase in the number of channels are higher.

The coverage of irrigation services for agriculture has a satisfaction score of 4.06, higher than the previous variable. However, expectations remain high at 4.93, resulting in a gap of -0.87. This suggests that while the service coverage is adequate, there is still room for improvement, particularly in meeting the users' maximum expectations. A previous study highlighted that the number and coverage of irrigation channels were essential in supporting agricultural productivity, yet the satisfaction levels of farmers did not meet their expectations [7][27], The study identified inadequate coverage of irrigation services and a need for better infrastructure maintenance as critical areas for improvement, reflecting the negative gaps seen in the present analysis [17,28].

Additionally, the variable for routine inspection of irrigation channels shows the lowest satisfaction score at 3.53, while expectations reach 4.84. The resulting gap is -1.31, the largest among all variables. This indicates that routine inspections require serious attention, as users feel that this aspect falls significantly short of their expectations. Moreover, another studies found that the quality and frequency of routine inspections of irrigation channels are crucial to sustaining agricultural productivity, particularly in regions dependent on consistent water supply [8,29]. Overall, the average satisfaction score for this dimension is 3.86, while the expectation score is 4.90, producing an average gap of -1.04. This gap reflects a significant level of dissatisfaction among users concerning the availability of irrigation infrastructure, particularly in terms of routine inspections, which are perceived as inadequate.

3.2.2 Physical quality

Physical quality dimension consists of two indicators of infrastructure maintenance and water quality. These two indicators shown quite high average performance score that are 3.89 and 4.36 for infrastructure maintenance and water quality respectively. Irrigation infrastructure maintenance becomes the authority for two government agencies in Kediri Regency, that are Public Works and Spatial Planning Agency and Agriculture Agency. Each agency has its own role in maintaining irrigation infrastructure with the specification that the secondary network is managed by Public Works and Spatial Planning Agency, whilst tertiary network is the authority of Agriculture Agency. From the strategic plan for each agency in 2021-2026, irrigation maintenance and rehabilitation become one of the program priorities for both agencies [23,24]. Moreover, as the agricultural sector is one of the primary sectors in Kediri Regency, maintenance and rehabilitation of the agricultural infrastructure with the irrigation as the core infrastructure turns out to be the one of the top priorities scheduled in the development agenda of Kediri Regency.

Irrigation water in Kediri Regency is sourced from surface water and ground water with the surface water takes dominant provision to irrigate the agricultural land [13]. In the spatial plan of Kediri Regency, it is stated that the agricultural land is irrigated from Brantas River and its branches that are classified into Brantas River Basin, Waduk Siman (water reservoir) and Embung Joho (water reservoir), as well as Brantas area ground water basin. Consequently, the water quality standards for those sources should achieve the standard set by the Government that refers to the Government Regulation No.22/2021 regarding Implementation of Environmental Protection and Management, particularly in the appendix VI concerning national water quality standard [30]. This water quality standard set in the mentioned regulation stipulates four classes of water usage with the highest standard is for domestic usage (class 1) and lowest standard for agricultural irrigation (class 4). The water quality threshold for the irrigation consists of three large classifications of chemical, physical, and biological standard with the total of 49 parameters such as temperature, total suspended solids, total dissolved solids, color, pH, dissolved oxygen, chemical oxygen dissolved, chloride, faecal coliform, oil and grease, and others.

3.2.3 Appropriateness

This dimension evaluates how well the irrigation system aligns with various factors that affect its effectiveness, such as irrigation needs, the reliability of the irrigation channels, and resilience to weather conditions. The average satisfaction score for this dimension is 3.71, while the expectation score reaches 4.88, resulting in a gap of -1.18. This indicates a significant disparity between user satisfaction and their expectations regarding the system's suitability. The substantial gap in this dimension underscores the need for a thorough review of the irrigation system's suitability, particularly concerning its reliability and resilience in response to external changes. Recent studies on irrigation system performance evaluations using the Importance-Performance Analysis (IPA) framework emphasize the need to consider both environmental factors and operational management for improved outcomes. For instance, the performance of small-scale irrigation systems has been effectively assessed using remote sensing technology [1,31]

The suitability for irrigation needs has a satisfaction score of 4.13 with an expectation score of 4.90, resulting in a gap of -0.77. This shows that while the system's suitability for irrigation needs is relatively adequate, there is still room for improvement to better meet user expectations. Additionally, the reliability of the irrigation channel system for water provision has a satisfaction score of 3.21 with an expectation score of 4.86, resulting in the largest gap of -1.64. This reflects users' concerns that the irrigation system is not yet sufficiently reliable in providing water as expected. Moreover, the resilience of the irrigation system to weather conditions received a satisfaction score of 3.78 with an expectation of 4.89, creating a gap of -1.11. This indicates that the system is not yet robust enough to withstand weather changes, thus requiring further improvements to enhance its resilience. Another relevant study investigated the role of resilience in irrigation infrastructure under changing climatic conditions [3,11]. Their findings indicated that systems lacking sufficient resilience to extreme weather events led to reduced reliability in water distribution, contributing to user dissatisfaction.

3.2.4 Utility

Utility dimension comprises of two indicators of repairment and handling of technical problem and technology advancement and implementation. These two indicators shown quite low average performance score that are respectively 3.69 and 3.36. In terms of expectation, the two indicators have the average scores of 4.88 and 4.82. Compared to average scores of all indicators that is 4.89, the two indicators are categorized as having lower average expectation score in the upper bound position. This makes these indicators are still positioned in the quadrant III of low priority. Despite of that upper bound position, the two indicators can be classified into the lower bound position of the quadrant I "concentrate here". The average score for the utility dimension creates an ambiguity as it locates in the border line between the quadrant I and III. However, this utility dimension becomes the least priority compared to other dimensions, especially when compared to appropriateness dimension.

Public Works and Spatial Planning Agency and Agriculture Agency formed an association called as HIPPA (Water Users Association). HIPPA was formed to extend related agencies' authority in the context of daily operation in the field. HIPPA is given an independent authority more in control of irrigation management, water distribution, as well as day-to-day operation including repairment and handling of technical problem in a very local and small scale [32]. All members voluntarily contribute to the retribution for the occurring damage on the network. As HIPPA is only a water users' association and not a professional agency, so that repairment and handling of technical problem is not their priority agenda.

Technology advancement and implementation is important, yet not classified as urgent or priority as the core problem lies on the issues of appropriateness. This indicator becomes the third tier and is not included in the government service standard. In the other words, this indicator is more to an additional provision and advancement. This far, irrigation network in Kediri Regency still utilizes conservative or standardized network and infrastructure. No technological advancement and implementation are founded in the case study. Nonetheless, in the long-term period, considering the threat of climate change, demand for food security and increase of agricultural productivity, as well as requirement to provide more efficient and effective system for the irrigation system, this technological advancement and implementation are necessary, and more priority should be allocated to this aspect. Some examples of the advanced irrigation practices for water savings had been developed, for instance the evapotransporation and soil water balance-based irrigation scheduled developed by Colorado State University, smart irrigation app that facilitate real-time irrigation scheduling developed by the University of Florida, soil sensor-based irrigation scheduling that was developed in Texas, and plant sensor-based that was also developed in Texas [33].

3.2.5 Economic Contribution

Based on the Importance-Performance Analysis (IPA) matrix graph, this indicator can be interpreted that the economic contribution of the irrigation system is running well and meets user expectations, although there is still room for further improvement in its performance. This indicates that although the system meets needs and expectations in this regard, maintaining and possibly improving this feature should remain a priority. The satisfaction score for Economic Contribution is 4.17, while the expectation score is 4.90. This results in a performance gap of -0.73. This gap indicates that although users are relatively satisfied with the economic contribution of the irrigation system, they still have higher expectations, indicating that users believe there is potential for greater economic impact or improvement. Although the current economic contribution of the system is strong and appreciated, users believe there is room for improvement in this area, particularly in aligning performance more closely with their higher expectations. To improve this indicator, various collaborative and social approaches are needed for farmer welfare, that includes enhancing access to modern agricultural technologies, ensuring fair market access, and providing robust government support. Technological innovations, such as efficient irrigation systems and quality seeds, can significantly increase productivity and reduce losses [34,35]. Equally important is connecting farmers to markets and reducing reliance on intermediaries, thereby increasing their income and bargaining power [12,20]. Lastly, infrastructure development, affordable credit, and policies that protect against market volatility can provide the necessary financial stability and sustainability, ensuring long-term welfare for farmers [36].

4 Conclusion

The assessment of the irrigation system, through the application of Importance-Performance Analysis (IPA), reveals substantial gaps between user satisfaction and their expectations across key dimensions, particularly regarding the availability and reliability of the irrigation infrastructure. Users generally express concerns about the insufficient number of irrigation channels, with their expectations for improvement exceeding the current performance. Routine inspections of the system, an essential factor in maintaining functionality, also show a significant shortfall in meeting user expectations, indicating a need for urgent attention.

Additionally, the system's ability to adapt to changing weather conditions and meet irrigation needs presents further challenges. Users feel that the system is not sufficiently reliable, especially in its ability to deliver water consistently. The resilience of the system to external factors, such as weather fluctuations, is also a source of dissatisfaction, highlighting the vulnerability of the infrastructure in the face of climate-related challenges. This calls for a strategic review and enhancement of the system to ensure its reliability and resilience.

In contrast, the economic contribution of the irrigation system appears to fare better, although it still falls short of the desired performance level. While the economic benefits of the system are acknowledged, they are not fully aligned with user expectations. To enhance the overall performance of the system, it is essential to address these key issues related to infrastructure, reliability, and adaptability, with a focus on ensuring that the system can effectively meet the evolving demands of its users and support long-term sustainability.

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