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Aksyun Danum: The Development of an Assessment Tool to Evaluate the Performance of Porac-Gumain River Irrigation System in Pampanga, Philippines as Basis for Action Proposal

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Abstract:
This research focuses on the crucial role of effective irrigation systems in improving agricultural productivity and economic growth, especially in the Philippines, where agriculture plays a vital role in the economy and the livelihoods of many depend on farming. To address the need for reliable assessment tools to evaluate irrigation system effectiveness, the study created a comprehensive tool based on key factors like water allocation, environmental impact, economic feasibility, and infrastructure quality. The objectives included tool development, data analysis, and recommendations for enhancement, concentrating on irrigation facilities in Barangay Pulungmasle, Guagua, Pampanga, and Barangay Concepcion, Lubao, Pampanga. Using a mixed-methods approach, the research combined qualitative and quantitative perspectives to ensure a thorough understanding. Essential performance indicators were identified, with parameters rated on a scale of one to five to assess consistency. Validation and reliability testing involved input from stakeholders and rigorous evaluation by irrigation system experts to ensure the tool's reliability and accuracy. Pilot testing of the assessment tool engaged engineers specializing in managing the Porac-Gumain River Irrigation System, with sample sizes determined using established methods and software for optimal representation. Data analysis techniques, such as factor analysis and ANOVA, were utilized to assess performance across indicators and extract actionable insights. The study's results highlighted varying efficiency levels across parameters, with tailored recommendations to address shortcomings and enhance system performance. By creating a robust assessment tool, the research aims to equip stakeholders, particularly the National Irrigation Administration, with practical insights to inform decision-making and foster improvements in irrigation system management and sustainability.

Keywords ***— Irrigation System, Performance Assessment Tool, Agricultural Productivity, Economic Growth, Key Performance Indicators***

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I. INTRODUCTION

An irrigation dam is a type of dam that is established to store water for irrigation purposes. It is constructed across rivers or water streams to create a path for water to flow into canals or channels that distribute water to crops and vegetation. Irrigation systems mainly provide water for human consumption and industrial processes.

The increasing aridity caused by climate warming is expected to intensify the need for irrigation water, which is crucial for agricultural development and directly impacts food security. However, the ability to enhance water management in agriculture is typically constrained by ineffective regulations, underperformance of major institutions, and financial constraints. Private and public institutions (including basin authorities, water and agricultural ministries, irrigation agencies, water users' and farmer groups) generally need more essential conducive conditions and capacities to effectively carry out their functions [1].

In the Philippines, agriculture is a central component of the economy. The majority of Filipino laborers are farmers who grow rice, sugarcane, maize, tobacco, and lumber. According to a report by the International Fund for Agricultural Development, more than 36% of Filipinos depend solely on agriculture to sustain their families [2]. However, as reported by the Philippine Institute for Development Studies (PIDS) in

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2014, the irrigation sector has been underperforming due to several factors, including inadequate hydrologic data, site-specific design criteria, and insufficient watershed and aquifer protection [1]. Despite receiving substantial public investments annually, national irrigation systems have consistently underperformed due to overly optimistic technical and economic assumptions, inadequate water supply, inappropriate designs, and difficulties in operation and maintenance.

Irrigation systems contribute significantly to crop production, especially in water-deficit areas. Plants need water to grow; therefore, applying the exact water measure at the right time will maximize crop yield. Therefore, an irrigation system assessment can improve farm productivity, enhance environmental protection, conserve water, and prevent nutrient losses from crops.

II. METHODOLOGY

The data gathering procedure was done in three phases:

A. *Phase 1 – Formulation of Multi-criteria Assessment Tool*

A performance assessment tool was developed and structured around four parameters: water allocation and distribution, infrastructure, economic aspects, and environmental impact. Each parameter was drawn from relevant literature and incorporated specific criteria for evaluating irrigation performance indicators. This tool aims to comprehensively evaluate the effectiveness of the irrigation system.

To examine the vital elements of the irrigation system, researchers conducted on-site inspections for the infrastructure aspect. For the remaining parameters, National Irrigation Administration engineers are not required to go on-site due to time constraints and conflicts of schedule, information was gathered from available documents from Guagua Municipality, Lubao Municipality, and the office of the National Irrigation Administration.

The researchers adhered to the Data Privacy Act of 2012, ensuring that the gathered data were treated with utmost confidentiality and will be used for the sake of this study only. Furthermore, the researchers ensured that no one was harmed physically or emotionally just by answering the questionnaire of this study, and the data collected will not be used in the future without respondents' consent.

Each determining factor, parameter, and overall performance were rated from one (1) to five (5) depending on how much they met the indicated threshold value. In order to determine how to handle every component during analysis, the scores of all the items were evaluated.

TABLE I
Interpretation of Grading of Determining Factors, Parameters, and Overall Performance

Rating	Interpretation
5.00	Highly Efficient
4.00-4.99	More Efficient
3.00-3.99	Efficient
2.00-2.99	Less Efficient
1.00-1.99	Inefficient

B. *Phase 2 – Validity and Reliability Test of Assessment Tool*

The assessment tool was validated by engineers with relevant expertise residing outside the study area. This approach aimed to capture diverse perspectives and maintain the integrity of the study's outcomes.

The reliability of the assessment tool was tested using Cronbach's Alpha, which measures how closely all test items measure the same concept or notion, internal consistency may be considered a measure of how closely test items are related to each other. [3]

To identify the sample size for the assessment tool's reliability test, Boateng's study was adapted, suggesting that a sample size of ten is sufficient to assess the internal consistency and reliability of an assessment tool. [4]

C. *Phase 3 – Pilot Testing of Assessment Tool*

The respondents selected for this study are engineers specializing in managing the Porac-Gumain River Irrigation System, particularly those associated with the National Irrigation Administration (NIA). This focused choice aimed to ensure a thorough grasp of the system's functions and issues.

Conchran's formula was employed with a 95% of confidence level to select the final sample size for the pilot testing of the assessment tool. This formula aids in determining an ideal sample size by considering the expected proportion of the attribute in the population, the desired level of confidence, and the desired level of accuracy [5]. The study also assessed the potential suitability of the Raosoft software for determining the sample size, as it is efficient and easy to use on various technological devices. [6]

To obtain representative samples, convenience sampling was adapted to ensure that the samples represented the population or system under study. Convenience sampling, also known as haphazard or accidental sampling, selects participants based on practical criteria such as easy access, geographical proximity, availability, or willingness to participate [7].

The gathered data from the responses were statistically treated using Factor Analysis and One-way ANOVA. Factor Analysis aims to extract the maximum common variance shared among all variables and encapsulate this shared variance into a common factor score. The ANOVA model provided an indication of whether the mean test scores for the irrigation's performance were statistically different based on the four indicators: water allocation and distribution, environmental impact, economic aspects, and infrastructure. [8], [9]

To evaluate the overall performance of the irrigation system, each parameter has their corresponding percentage according to the weight they hold.

- Water Allocation and distribution contains (35%) - Efficient water allocation and distribution are essential for sustainable water management in irrigation systems, ensuring crops receive adequate water while minimizing wastage and ensuring equitable access for all users. [10]
- Infrastructure (25%) - Infrastructure is the backbone of an irrigation system, including pipelines, canals, pumps, and other components. High-quality infrastructure is essential for the reliable and efficient delivery of water to agricultural fields. [11]
- Economic (20%) - Economic factors play a significant role in the sustainability and viability of an irrigation system. Efficient water uses and cost-effective maintenance practices help minimize operational expenses and maximize the economic benefits of agricultural production. [12]
- Environment (20%) - Environmental sustainability is essential for ensuring the health and integrity of ecosystems affected by irrigation activities. An environmentally responsible irrigation system incorporates practices that minimize negative impacts on soil, water, and biodiversity. [13]

The researchers utilized problem tree analysis to discern the root causes and ramifications of issues influencing the irrigation facility located in Barangay Pulungmasle, Guagua, Pampanga, and Barangay Concepcion, Lubao, Pampanga. Problem tree analysis offers a systematic method for pinpointing problems and their underlying causes, ensuring attention is directed towards genuine issues, a crucial feature for the relevance of this study.

The identified irrigation problems were given corrective measures, with claims and suggestions justified by related literature, studies, and theories to assure their applicability and efficiency in the irrigation facility.

D. Phase 4 – Turnover of the Assessment Tool and Guidelines

The developed assessment tool and guidelines were turned over to the NIA. The aforementioned agency possesses the expertise to evaluate the efficiency of irrigation systems and identify areas requiring improvement, therefore, laying the groundwork for future development or restoration initiatives.

III. RESULT AND DISCUSSION

The data gathering procedure was done in three phases: The Aksyun Danum framework sought to evaluate the performance as well as to identify irrigation problems in 4 components namely: Water Allocation and Distribution, Infrastructural, Economic, and Environmental. The study responses have garnered a total of twenty (20) respondents are the National Irrigation Administration engineers and personnel.

A. Water Allocation and Distribution

The assessment tool comprises four parameters, one of these is the irrigation's water allocation and distribution sector. This parameter emphasizes the irrigation dam's total irrigable area, runoff, length, height, volume of water, flow rotations, water discharge, and its real carrying capacity for each segment of the irrigation system. Hence, figure 1 and figure 2 demonstrate the summary of data gathered from all the respondents suggesting the current performance and state of Porac-Gumain River Irrigation System (PGRIS) particular in Barangay Pulungmasle, Guagua, Pampanga and Barangay Concepcion, Lubao, Pampanga, respectively in terms of Water Allocation and Distribution. Also, the interpretation of the

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results for each determining factor are stated and determined based on the criteria they fall on Table 2. [17]

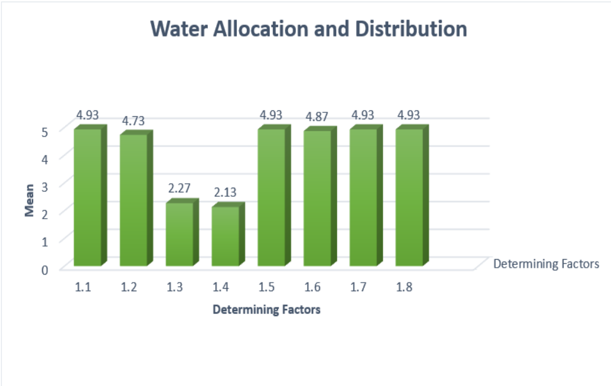

Fig. 1 Water Allocation and Distribution (Barangay Pulungmasle)

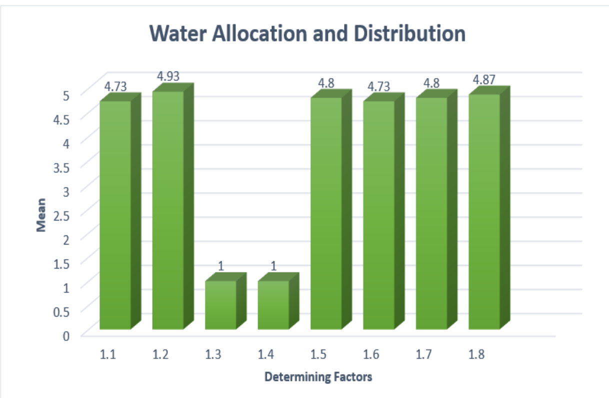

Fig. 2 Water Allocation and Distribution (Barangay Concepcion)

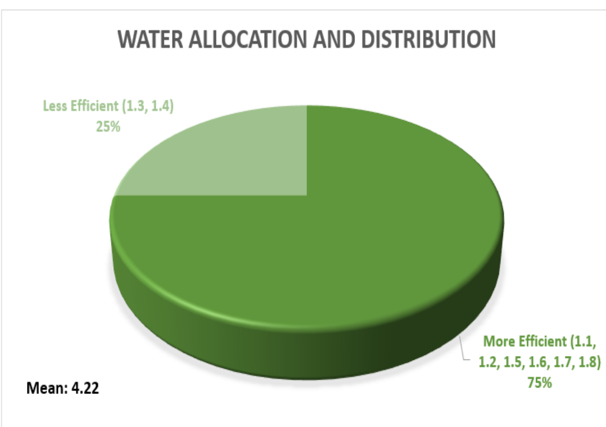

Fig. 3 Overall Water Allocation and Distribution Performance (Barangay Pulungmasle)

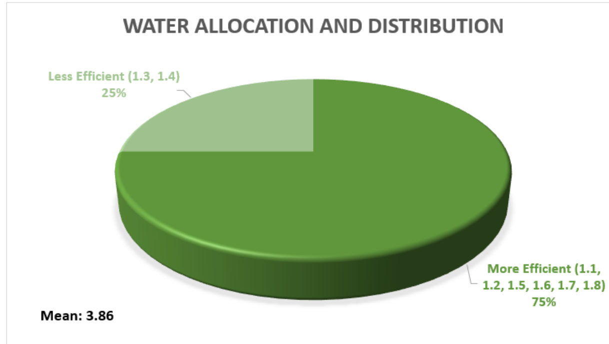

Fig. 4 Overall Water Allocation and Distribution Performance (Barangay Concepcion)

Based from the given data and responses of the professionals on the assessment tool (refer to Figurs 3 and 4), it has been determined that the total average score of this parameter is 4.22 for Barangay Pulungmasle and 3.86 for Barangay Concepcion. This indicates that majority of the parameter's determining factors exceeded the expectations in Barangay Pulungmasle and in Barangay Concepcion.

B. *Infrastructure*

The infrastructure parameter of the performance assessment tool evaluated several factors, such as the condition of canals, channels, and ditches, operational status and condition of valves, pipeline system, pumps, filtration system, steel gates, fuel source, level of technology, and maintenance and history. The assessment results of this parameter are shown in Figures 5 and 6, which comprises of two areas used for pilot testing of the performance assessment tool, the Barangay Pulungmasle, Guagua, Pampanga and Barangay Concepcion, Lubao, Pampanga, respectively. Also, the interpretation of the results for each determining factor are stated and determined based on the criteria they fall on Table 2.

Fig. 5 Infrastructure (Barangay Pulungmasle)

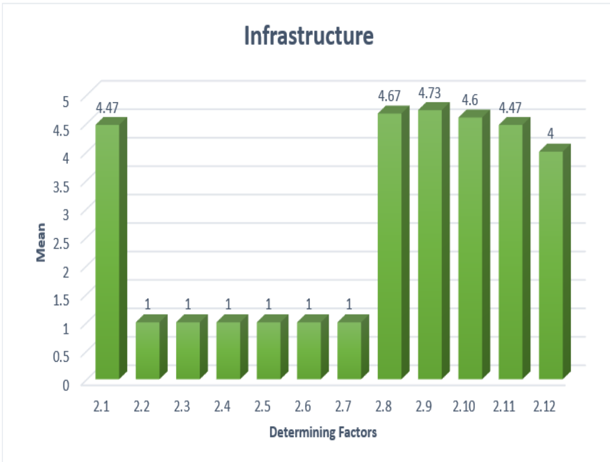

Fig. 6 Infrastructure (Barangay Concepcion)

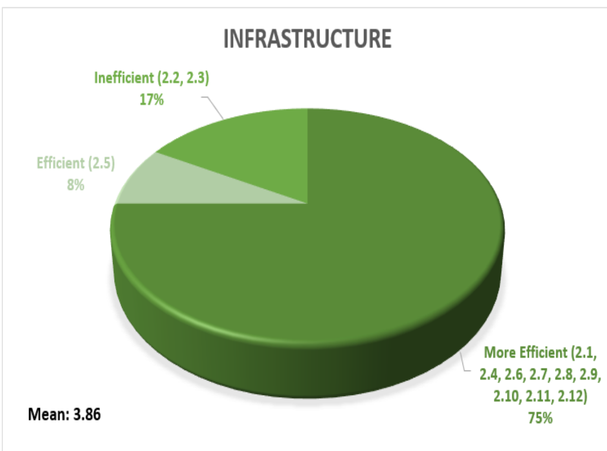

Fig. 7 Overall Infrastructure Performance (Barangay Pulungmasle)

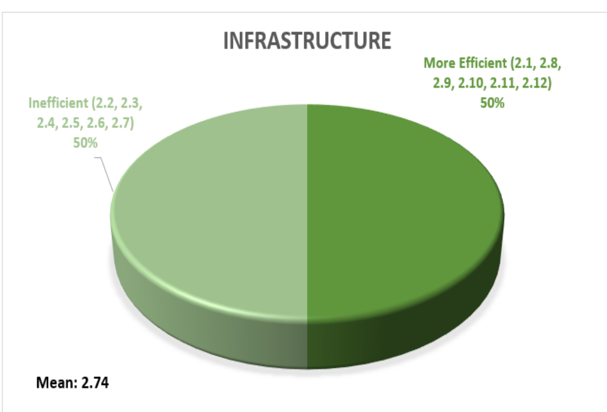

Fig. 8Overall Infrastructure Performance (Barangay Concepcion)

Based from the given data and responses of the professionals on the assessment tool, the results have been tabulated (refer to Figures7 and 8). This resulted to a total average mean score of 3.86 for Barangay Pulungmasle while on the other hand, for Barangay Concepcion, it is 2.74. This indicates that the parameter's determining factors fully met the established expectations and may have periodically exceeded expectations in Barangay Pulungmasle and it indicates that is its less efficient in Barangay Concepcion since the parameter's determining factors met some of the expectations but did not fully meet the established measures. [18]

C. Economic

The economic parameter of the performance assessment tool evaluated several factors, such as the irrigation system's economic performance were consistency, effectiveness, budget allocation, cost-effectiveness, and profitability. The results of this parameter are stated and illustrated below in the figures 9 and 10, which comprises of two areas used for pilot testing of the performance assessment tool, the Barangay Pulungmasle, Guagua, Pampanga and Barangay Concepcion, Lubao, Pampanga, respectively.

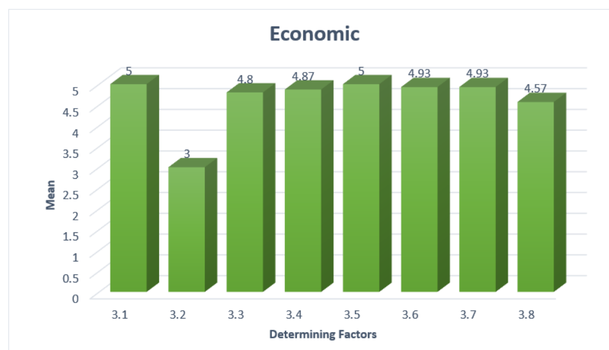

Fig. 9 Economic (Barangay Pulungmasle)

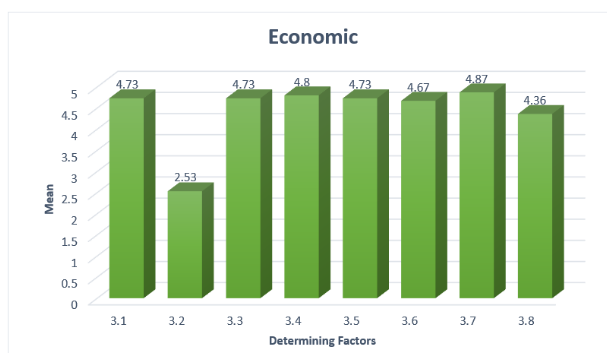

Fig. 10 Economic (Barangay Concepcion)

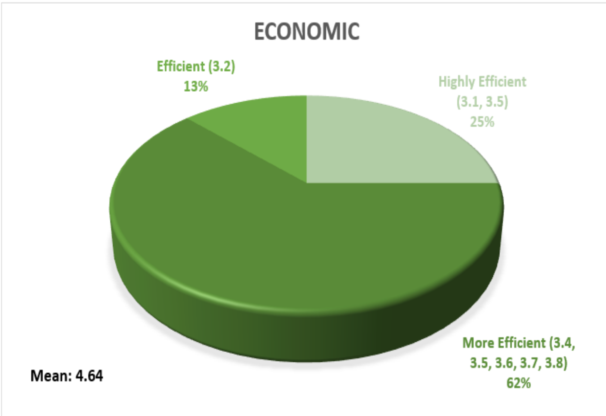

Fig. 11 Overall Economic Performance (Barangay Pulungmasle)

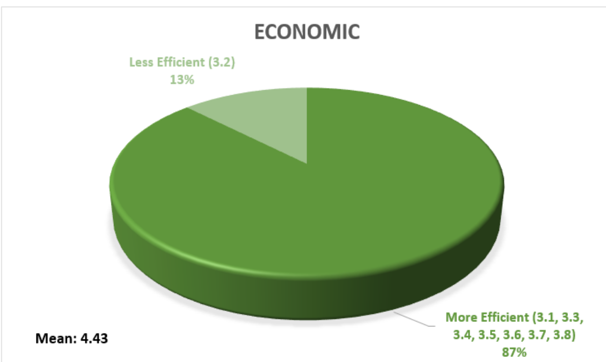

Fig. 12 Overall Economic Performance (Barangay Concepcion)

Based from the given data and responses of the professionals on the assessment tool, the results have been tabulated (refer to Table 11 and 12). This resulted to a total average mean score of 4.64 for Barangay Pulungmasle while on the other hand, for Barangay Concepcion, it is 4.43. This indicates that the performance of the Porac-Gumain River Irrigation System is more efficient in terms of economic since majority of the parameter's determining factors exceeded the expectation.

D. Environment

The environment parameter of the performance assessment tool evaluated several factors, such as water quality, soil composition and efficiency, live vegetation, spatial distribution, rainfall, infiltration rate, temperature, and humidity. The assessment results of this parameter are shown in Figures 13 and 14, which comprises of two areas used for pilot testing of the performance assessment tool, the Barangay Pulungmasle, Guagua, Pampanga and Barangay Concepcion, Lubao, Pampanga, respectively.

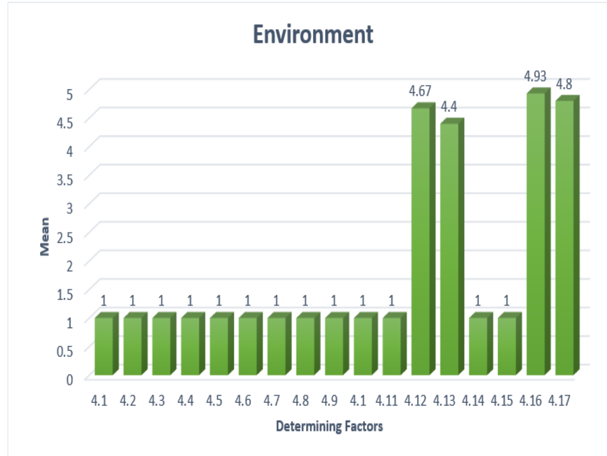

Fig. 14Environment (Barangay Concepcion)

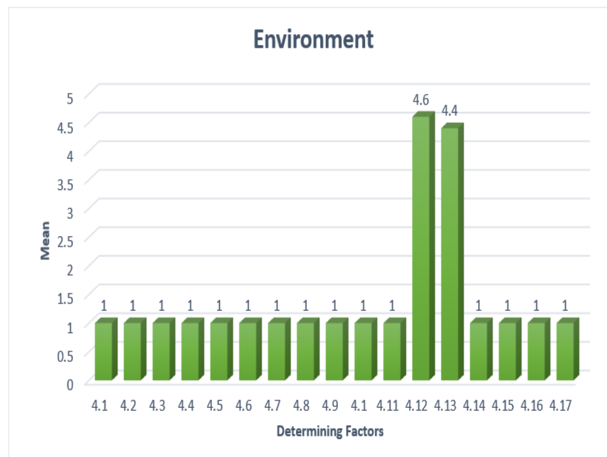

Fig. 15 Overall Environment Performance (Barangay Pulungmasle)

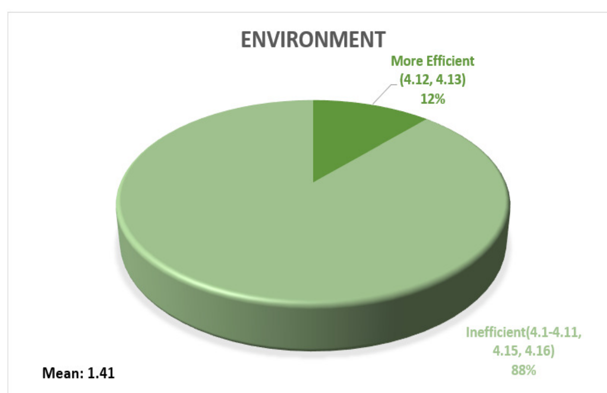

Figure 16: Overall Environment Performance (Barangay Concepcion).

Based on the provided data and responses from professionals regarding the assessment tool, it has been established that the total average score for this parameter is 1.87 for Barangay Pulungmasle and 1.41 for Barangay Concepcion (refer to Table 15 and 16). Consequently, it can be inferred that the performance of the Porac-Gumain River Irrigation system in terms of its environmental impact is deemed inefficient. This conclusion indicates a lack of sufficient data concerning the performance of an irrigation dam in this specific area, and it generally falls short of meeting the established or required expectations [18].

E. Overall Interpretation

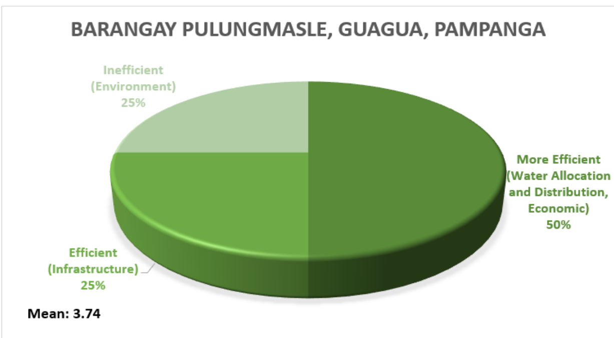

Fig. 17 Overall Performance of Barangay Pulungmasle

To conclude the assessment at Barangay Pulungmasle's irrigation system, each parameter was evaluated through their determining factors. Water allocation and distribution and economic are found to be more efficient, infrastructure is found to be efficient and lastly, environment is found to be inefficient. Along with the application of the weight percentage, this resulted to a mean of 3.74 which indicates that it has an efficient performance since the irrigation system's performance fully met the established amount and expectations a dam can provide and may have periodically exceeded expectations.

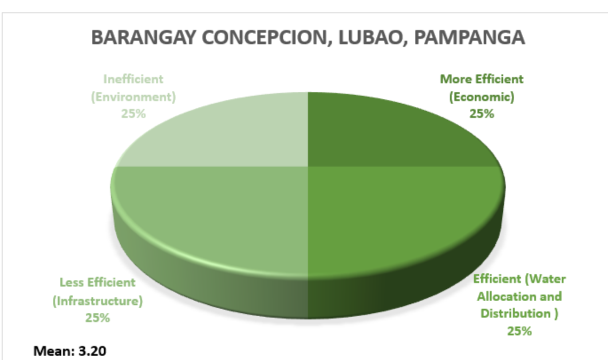

Fig. 18 Overall Performance of Barangay Concepcion

To conclude the assessment at Barangay Concepcion's irrigation system, each parameter was evaluated through their determining factors. Economic is found to be more efficient, water allocation and distribution is found to be efficient, infrastructure is found to be less efficient and lastly, environment is found to be inefficient. Along with the application of the weight percentage, it resulted to a mean of 3.20 which indicates that it has an efficient performance since the irrigation system's performance fully met the established amount and expectations a dam can provide and may have periodically exceeded expectations.

F. Problem Tree Analysis

Problem tree analysis was employed to determine the causes and effects of the low-performing parameters in the Barangay Pulungmasle, Guagua, Pampanga and Barangay Concepcion, Lubao, Pampanga irrigation system. Within this context, the problems are categorized into 'causes' and 'effects,' each being connected by a central or focal concern. Given that the main objective of this study is to create an assessment tool for assessing the performance of an irrigation system to trace back problems where the irrigation system is inefficient, problem tree analysis is a valuable method for comprehending the cause-and-effect relationships of each problem identified in the irrigation system. This analysis is facilitated by the framework developed for the study. The tree is categorized into four parameters, namely: (1) Water Allocation and Distribution, (2) Infrastructure, (3) Economic, and (4) Environment. Most issues inside the tree are concentrated within these components. The primary components were selected based on a comprehensive assessment of the literature on difficulties related to irrigation systems. The next step is to analyze the underlying factors contributing to these issues comprehensively. Once the causes have been articulated, the effects can be readily determined.

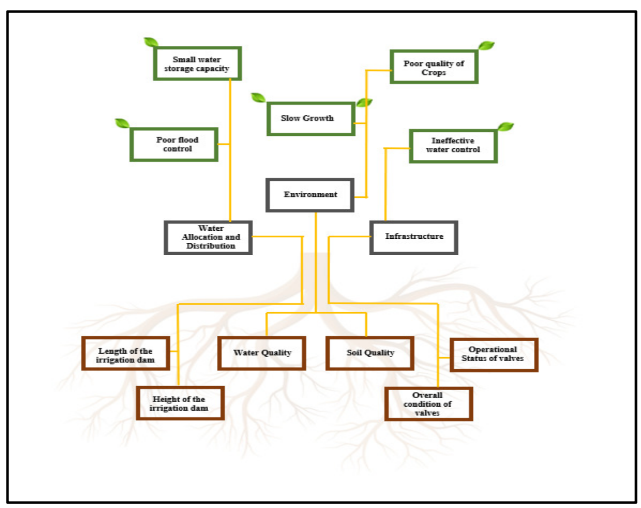

Fig. 19Problem Tree - Pulungmasle, Guagua, Pampanga

Water allocation and distribution are considered parameters in the assessment tool formulated in this study, and they were also considered to be one of the main problems in this analysis method. Due to its inefficiency in the length and height of the irrigation dam, the factors that have been assessed that lead to low tabulated results are considered as the cause of the mainproblem. Small water storage capacity is one of the effects caused by the mentioned factors, especially in regions dependent on irrigation, in which poor storage might not be able to store enough water during the wet season to sustain agricultural needs during the dry season. A dam without standard design capacity can only provide very little flood mitigation when water approaches the full supply level; this limited design storage capacity hinders a short dam's ability to hold back floodwater and rainwater. [19]

In terms of the infrastructure parameter, the inefficiency in the operational status, overall condition, functionality, and structural integrity, such as pipeline systems, pumps, valves, and filtration systems, is identified due to low performance with the use of the assessment tool, which is formulated in this study. These identified causes are assessed as determining factors in the given assessment tool, and the effects are supported by related literature, articles, and studies relating to the given parameter. It was stated that the absence of valves to regulate water flow not only hinders the proper functioning of the system but also leads to uncontrolled water distribution, resulting in potential infrastructure damage. The system lacks the necessary mechanisms for effective water control without these valves, leading to significant inefficiencies [17], [19]. It was also mentioned that without a pipeline system in place, there are no supports or connections to evaluate, leading to a fundamental inefficiency in the irrigation system's infrastructure [20]. Corrosion in pumps cause inefficiency that resulted from the absence of a pipeline system. Without functioning pumps, water transportation to the fields is hindered, leading to disrupted irrigation operations and decreased agricultural productivity [20]. Lastly, the irrigation system lacks the capability to effectively remove debris or contaminants from the water, which can lead to issues such as clogged pipes, compromised water quality, and operational inefficiencies. [21]

Economic factors are considered as one of the parameters in this problem tree analysis; the determining factors stated in the formulated assessment tool will serve as the cause of the low performance of particular factors. The results show that it is low-performing in terms of the consistency of crop yield. One of the significant effects of poor production of crops can lead to food insecurity, especially in developing countries where agriculture is the primary source of food and income. When crops fail, farmers may not have enough food to feed themselves and their families, let alone sell in local markets [22]. Economic loss is also considered an effect of crop loss that can have significant economic consequences for farmers and the broader economy. When crops fail, farmers may lose their source of income, which can lead to financial hardship. Crop loss can also lead to increased food prices, which can affect consumers' purchasing power and lead to inflation [22]. Lastly, the decline of productivity of crop result in consequences such as higher food prices and increased greenhouse gas emissions from agriculture [22].

Environment is the last parameter that will identify its cause and effects as the determining factors that cause the problem due to its inefficiency. Water and soil quality are the primary causes considered in this parameter due to the low performance of selected factors. Irrigation water quality is a critical aspect of greenhouse crop production. A soil test to measure soil quality is essential to optimize crop production, protect the environment from contamination by runoff and leaching of excess fertilizers, aid in the diagnosis of plant culture problems, improve the nutritional balance of the growing media, and save money and conserve energy by applying only the amount of fertilizer needed. Water quality should be tested to ensure it is acceptable for plant growth and to minimize the risk of discharging pollutants to the surface. These causes, such as poor water and soil quality, are responsible for slow growth poor quality of the crop and, in some cases, can result in the gradual death of plants.

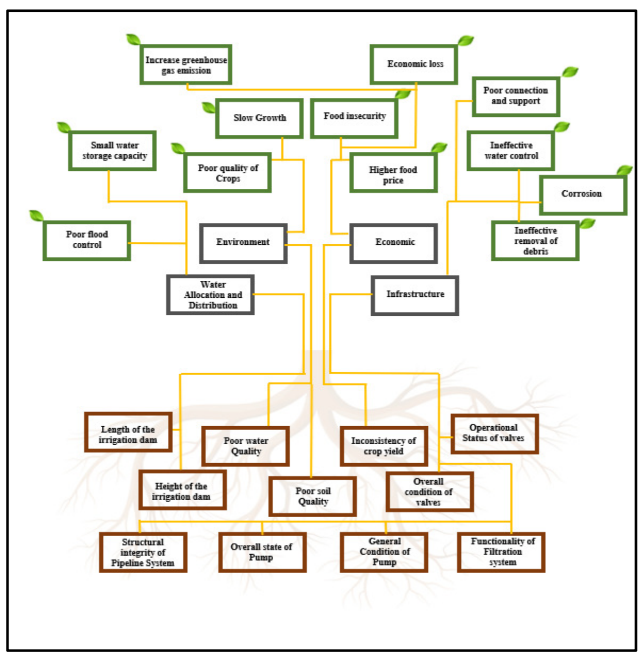

Fig. 20 Problem Tree - Concepcion Lubao, Pampanga

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G. Action Plan Proposal Based on Performance Assessment of Barangay Pulungmasle, Guagua, Pampanga, and Barangay Concepcion, Lubao, Pampanga's River Irrigation System.

To practically implement the assessment tool, presented here is the detailed action plan proposal, which will be submitted to the local government unit for approval. The proposal includes the following contents:

1) *Executive Summary*

This assessment tool evaluates the performance of a river irrigation system by analyzing key indicators such as water allocation and distribution, infrastructure, economics, and environment. Its main objective is to assess the effectiveness and efficiency of the irrigation system across critical aspects including water allocation, distribution, environmental sustainability, economic viability, and infrastructure integrity.

The assessment criteria, supported by maps and datasets, are analyzed using a compliance rating system from very efficient to inefficient. This process results in a comprehensive report that identifies areas of compliance and improvement needs. Consequently, it plays a crucial role in

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determining the effectiveness and efficiency of the system across vital areas including water allocation, distribution, infrastructure, economics, and environment.

The assessment tool provides substantial benefits for farmers and the National Irrigation Administration (NIA) by offering clear insights into areas needing improvement within their local irrigation systems. By evaluating river irrigation system performance, NIA can take necessary actions to enhance system efficiency and effectiveness. This proactive approach promotes equitable and efficient water allocation and distribution, ensures the reliability and resilience of infrastructure, implements cost-effective strategies for irrigation management, and minimizes environmental impacts.

2) ***Goals and Objectives***

To develop an assessment tool that evaluates the performance of a river irrigation system and determines whether a given river irrigation system in a locality needs improvement, thereby aiding in the optimization of irrigation practices.

In order to achieve this, the following must be considered:

- To identify the water allocation and distribution, environment, economics, and infrastructure data required for determining the performance of an irrigation system.
- To design a user-friendly interface for the assessment tool to support the NIA specifically the NIA engineers in evaluating river irrigation system performance in a locality.
- To provide recommendations for improving the performance of the irrigation system.
- To promote fair water distribution, infrastructure reliability, cost-effective irrigation management, and environmental conservation, the assessment of river irrigation system performance enables NIA to take informed actions.

3) ***General Provisions:***

- The tool identifies several determining factors, each with a designated item number. Additionally, the required data and the site of the government agency from which it can be collected are also indicated.
- The following are the general documents that must be initially gathered to effectively utilize this tool:

a.National Irrigation Systems Irrigators Association Profile
b.Delineation of Catchment Area
c.Design Discharge Summary Result from Hydrologic Engineering Center - Hydrologic Modeling System (Specific during wet season)
d.Global Summary Results for Run
e.River Irrigation System Maintenance Plan
f. National Irrigation Systems Irrigators AssociationOperation and Management Seasonal Report Dry and Wet Cropping Season
g.Production Cost
h.Irrigation Water Analysis Report
i.Soil Survey Reports
j.Comprehensive Land Use Plan (CLUP)
k.Soil infiltration rate for soil moisture and temperature based on Irrigation System
l.Irrigation Efficiency and Consumptive Use Program Guidance
m.Daily temperature and humidity readings

- Regarding infrastructure, if there is no available document regarding the overall structure of the irrigation system, consider on-site inspection by capturing the present condition of the irrigation system or by having the respondents assess it personally by going on the irrigation system itself.
- Upon completion of data collection, segregate and organize the required information according to the assigned item in the assessment tool.
- Following the sorting process, utilize the provided rubric below to assess the gathered information based on the criteria outlined in the provided assessment tool.

TABLE II
Interpretation of Grading of Determining Factors

Rating	Interpretation	Description
5.00	**Highly Efficient**	The determining factortotally surpassed the expected threshold value an irrigation system can possess.
4.00-4.99	**More Efficient**	The determining factorexceeded the expected threshold value an irrigation system can possess.
3.00-3.99	**Efficient**	The determining factor fully met the expected threshold value an irrigation system can possess.
2.00-2.99	**Less Efficient**	The determining factorfall behind the expected

		threshold value an irrigation system can possess.
1.00-1.99	**Inefficient**	There is no available data regarding the determining factor and it failed to meet the expected threshold value.

Table 3: Interpretation of Grading of Parameters

Rating	Interpretation	Description
5.00	**Highly Efficient**	The parameter's determining factors consistently exceeded expectations.
4.00-4.99	**More Efficient**	Majority of the parameter's determining factors exceeded expectations.
3.00-3.99	**Efficient**	The parameter's determining factors fully met the established expectations and may have periodically exceeded expectations.
2.00-2.99	**Less Efficient**	The parameter's determining factors met some of the expectations but did not fully meet the established measures.
1.00-1.99	**Inefficient**	There is no available data regarding the parameter and it generally failed to meet the established or required level of expectation.

Table 4: Interpretation of Grading of Overall Performance.

Rating	Interpretation	Description
5.00	**Highly Efficient**	The irrigation system's condition and performance in all four parameters consistently exceeded expectations.
4.00-4.99	**More Efficient**	Majority of the area and parameters based from the data scores in assessment tool exceeded expectations
3.00-3.99	**Efficient**	The irrigation system's performance fully met the established amount and expectations a dam can provide and may have periodically exceeded expectations
2.00-2.99	**Less Efficient**	The performance of an irrigation dam met some of the expectations but did not fully meet the established measures.
1.00-1.99	**Inefficient**	There is no available data regarding the performance of an irrigation dam on a specific area and it generally failed to meet the established or required level of expectation.

- Upon evaluating the gathered information, calculate the mean value for each parameter (Water allocation and distribution, Infrastructure, Economics, and Environment), as well as the overall average for all items.

Formula for computing the average of each score:

$$\bar{X} = \frac{\sum_{i=1}^{n} Xi}{n}$$

Where: $\bar{X}$ = Average of Score
Xi = Value of Score
n = Number of items

Table 5: Average and its Corresponding Interpretation per Parameter.

Parameter	Average	Interpretation
Water allocation and distribution ($\bar{X}_1$)		
Infrastructure ($\bar{X}_2$)		
Economics ($\bar{X}_3$)		
Environment ($\bar{X}_4$)		

Overall Performance $= \bar{X}_1(0.35) + \bar{X}_2(0.25) + \bar{X}_3(0.20) + \bar{X}_4(0.20)$

∴ Interpretation**:** _______________

- Produce an analysis of the computed averages to ascertain the compliance level for each parameter and overall assessment. This analysis enables users to offer

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recommendations for enhancing each sector using the available data within the locality.

- Regarding parameters that have met or exceeded compliance levels, it indicates that the performance of the irrigation dam has consistently met or even occasionally surpassed the established standards and expectations. The data associated with these parameters can offer valuable insights for improving the irrigation system. This highlights the importance of maintaining consistent compliance levels to gather sufficient data for effectively enhancing an irrigation system.
- Parameters with low compliance levels indicate either insufficient available data or failure to fully meet established measures. This is particularly evident in assessing the performance of an irrigation dam in a specific area, where it often falls short of the expected standards. Insufficient data makes it challenging to ascertain the effectiveness and efficiency of the irrigation system's performance. Thus, it is imperative for the locale to take proactive measures to enhance data availability, enlist expert assistance for testing, and ensure compliance across all parameters.
- This study, based on the review of related literature, proposed solutions for identified problems discovered through the assessment tool.
- The validity of the results of this assessment tool is 2–3 years. Therefore, there is a need for reevaluation after those years.
- The developed assessment tool along with its guidelines will be turned over to concerned offices or agencies.

H. Action Proposal for Barangay Pulungmasle, Guagua, Pampanga and Barangay Concepcion, Lubao, Pampanga

1) *Water Allocation and Distribution*

The dimensions of an irrigation dam, including its length (1.3) and height (1.4), are vital factors that directly influence the efficiency and effectiveness of the water management system. Inadequate dimensions, as indicated by failure to meet average standards or absence of sufficient data in Barangay Pulungmasle, Guagua, and Barangay Concepcion, Lubao, can lead to challenges such as insufficient water storage, uneven water distribution, and potential safety hazards. To address this issue, conducting comprehensive assessments of existing irrigation dams, including detailed surveys and measurements of their dimensions, is essential. ZThis data can then inform the determination of optimal dimensions required to meet the irrigation needs of local communities, considering factors like water demand, catchment area, and potential future expansion. Investing in the improvement or reconstruction of irrigation dams with appropriate length and height can enhance the system's overall efficiency, ensuring a reliable water supply, improved crop yields, and sustainable agricultural practices in the region. [20]

2) *Infrastructure*

Based on the gathered data under the determining factors 4.2 and 4.3, it is shown that the operational status and overall condition of valves in both Barangay, Pulungmasle, Guagua, and Barangay Concepcion, Lubao could be more efficient due to the absence of valves poses a significant challenge to effective water control within the irrigation system. With valves, the ability to regulate and direct water flow is maintained, leading to inefficiencies in water distribution. [24]. To address this issue, installing valves at strategic points along the irrigation system enables precise water flow control, allowing optimal distribution to different areas as needed. [25]

In Baranggay Concepcion, Lubao, Pampanga, the lack of a pipeline system (2.4), filtration system (2.7), and operational pumps (2.5, 2.6) makes the irrigation system inefficient. Addressing these issues requires the installation of pipelines to enhance water delivery efficiency, implementing a filtration system along the canals to remove debris and contaminants, and the installation of functional pumps to automate water transportation. These improvements will enhance water management and increase farming productivity sustainably. [20], [21], [26]

3) *Economic*

Based on the gathered data in Barangay Concepcion, Lubao, Pampanga, the inconsistency of crop yield over time-based on the average (3.2) indicates inefficiency. To address this issue and ensure efficiency, there should be an increase in the average percentage yield over two years, aiming for a minimum of 2.4%. Achieving this target requires analyzing factors affecting crop yield consistency, such as soil quality, water availability, pest management, farming practices, and weather patterns, and implementing targeted interventions accordingly. This approach enables farmers to achieve more predictable income, facilitating better financial planning and reducing the risk of financial losses. [27]

4) *Environment*

Water quality is crucial in irrigation systems, impacting crop health, soil fertility, and overall agricultural

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sustainability. The lack of available data on water quality in Barangay Pulungmasle, Guagua, and Barangay Concepcion, Lubao, suggests efficient water quality (4.1 - 4.9), management, which can result in reduced crop yields, soil, and water. To tackle this issue, prioritizing water quality monitoring and assessment through regular testing is essential to establish baseline data. Comprehensive water quality monitoring programs, educational campaigns to promote proper irrigation practices, and collaboration with local stakeholders to implement corrective measures are necessary to improve water quality in these areas. This approach aims to ensure a healthier environment for agriculture and communities alike. [28]

Soil quality is crucial in irrigation systems as it directly affects crop growth, nutrient availability, and water retention capacity. Inefficient soil quality, as indicated by the lack of available data in Barangay Pulungmasle, Guagua (4.10, 4.11, 4.14, 4.15), and Barangay Concepcion, Lubao (4.10, 4.11, 4.14, 4.15, 4.16, 4.17), can lead to poor crop yields, erosion, and decreased agricultural productivity. To address this issue, prioritizing soil quality assessment through soil testing and analysis to understand key indicators such as nutrient content and soil structure is crucial. By implementing soil quality monitoring programs, promoting sustainable farming practices like crop rotation and organic fertilization, and educating farmers on soil conservation techniques, we can work towards improving soil quality in these areas, fostering healthier soils for sustainable agriculture and environmental stewardship. [29]

IV. CONCLUSION AND RECOMMENDATIONS

A. Conclusion

The researchers formulated an assessment tool that assessed the performance and current state of the Porac-Gumain River Irrigation System (PGRIS). Based on the analyzed data from the assessment tool and using Table 3, it was determined that the PGRIS, particularly in the area of Barangay Pulungmasle, Guagua, Pampanga, the following parameters were evaluated and interpreted: The water allocation and distribution, as well as the economic aspect of the PRGIS are both more efficient and exceeded the threshold amount of service an irrigation dam can provide. The infrastructure or physical state of the PGRIS on the other hand, is generally efficient to function and contribute to the community as it fully met the established amount and expectations for an irrigation dam. However, it was also found out that the dam is inefficient in terms of its environmental facets as it lacks data on majority of its determining factors and may have generally failed to meet the established or required level of performance and expectations for an irrigation.

Using the same assessment tool and river irrigation system, the following parameters were also evaluated and interpreted in the area of Barangay Concepcion, Lubao, Pampanga: The water allocation and distribution component of the PGRIS is efficient; Infrastructural condition as less efficient as the performance of the PGRIS only met some of the expected threshold values but did not fully met the established measures; Economic sector as more efficient; and, environmental aspect as inefficient in providing aid and service in the community.

Through the evaluation of four parameters, it has been found out that both irrigation systems are in efficient condition wherein the irrigation system's performance fully met the established amount and expectations an irrigation system can provide and may have periodically exceeded expectations

.

The researchers were able to develop an assessment tool that will assess the performance and current status of not only the PGRIS but all other irrigation systems using data in these four key parameters such as water allocation and distribution, infrastructure, economic, and environment. Hence, this assessment tool is highly effective in the process of rehabilitation of irrigation systems and can give the professionals in the field, especially to the National irrigation Administration's engineers to provide a logical conclusion regarding the current status and condition of an irrigation dam.

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B. Recommendations

Based on the results of the study, the researchers propose adopting the subsequent measures to improve the developed assessment tool for evaluating an irrigation system:

1. It is recommended to only allow professionals to be the respondent of the performance assessment tool since the formulated tool is highly technical.
2. Despite the technicality of the assessment tool, it is recommended that the irrigation association president of the locality be considered as the respondent to assess his/her view.

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3. It is recommended to utilize the performance assessment tool since it has undergone statistical analysis, including Cronbach's alpha and one-way ANOVA to demonstrate its reliability and consistency. Hence, various irrigation facilities can adopt this assessment tool as a prompt means to examine the efficiency of the irrigation system and then identify the underlying issue.
4. Future researchers can evaluate the efficacy of the performance assessment tool by employing various analytical methods to determine the present condition of an irrigation system.
5. Future researchers may consider balancing the number of determining factors per parameter. Additionally, alternative statistical techniques, such as rating scales, could be modified to further evaluate the components.

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