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The human resource model of field officers for irrigation modernization in Indonesia: A case study of the rentang irrigation area

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Abstract: The government of Indonesia has undertaken the modernization of irrigation systems as one of its key initiatives to achieve food security. This modernization is supported by five main pillars: water availability, irrigation infrastructure, irrigation management, irrigation institutions, and human resources, which serve as the key actors in irrigation management. To assess the readiness for irrigation modernization, Indonesia employs the Irrigation Modernization Readiness Index (IKMI). Among the five pillars, the human resource component consistently scores lower than the others. However, human resources are arguably the most critical factor in the successful implementation of irrigation modernization. This study explores a model for enhancing the human resource component, specifically focusing on field officers such as irrigation technicians (mantri/juru), dam operation officers, and water gate officers. A mixed-method approach was employed, combining quantitative surveys, qualitative interviews, and focus group discussions with 100 field officers in the Rentang Irrigation Area. The findings reveal that the IKMI score for Rentang is 66.9, categorized as "sufficient," with socio-economic conditions being the weakest aspect. To address this, a conceptual framework is proposed, outlining three progressive stages of readiness: sufficient, adequate (early, mid, and advanced), tailored to the specific needs of the region. The study concludes that structured capacity-building interventions, particularly targeted training programs, are essential to elevate human resource readiness and support the broader goals of irrigation modernization and national food security.

Keywords: *Field officers, Human resources, Irrigation modernization, Model, Rentang irrigation area.*

1. Introduction

In FAO [1] in Bangkok defined irrigation system modernization as a combined process of institutional, managerial, and technological transformation strategies aimed at shifting the operational paradigm from supply-oriented to service-oriented management [2-6]. This definition was refined by the International Commission on Irrigation and Drainage (ICID) [7] which described modernization as the process of upgrading infrastructure, operations, and management of irrigation and drainage systems to sustain water delivery services for farmers and to optimize both production and productivity [7].

Irrigation modernization is often associated with high-end technologies or costly automation; however, this is not always the case. Effective modernization can be achieved by addressing current needs through the optimal use of available resources and technologies, while also anticipating future demand scenarios [8]. These future needs vary significantly across nations, depending on their unique contexts and priorities.

Indonesia initiated its irrigation modernization efforts in 2015 [9] based on five key pillars: water availability, irrigation infrastructure, irrigation management, irrigation institutions, and human resources, which serve as key actors in irrigation governance. This initiative is part of the Indonesian government's broader strategy to enhance and safeguard national food security [10, 11]. Food security

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is defined as a condition in which food is sufficiently available both in quantity and quality ensuring safe, diverse, nutritious, equitable, and affordable food access that aligns with religious, cultural, and societal values, enabling individuals to live healthy, active, and productive lives sustainably [12].

To support food security, Indonesia is maximizing the implementation of irrigation modernization. This effort requires a high level of preparedness, which is assessed using the Irrigation Modernization Readiness Index (IKMI), based on the five modernization pillars. Among these pillars, the human resources component consistently scores lower than the others, despite its critical role in the successful implementation of irrigation modernization [13].

This study explores a human resource model for irrigation modernization in Indonesia, focusing on field officers in the Rentang Irrigation Area, including dam operation officers, water gate officers, and other field personnel. The proposed model is a conceptual framework aimed at enhancing human resource capacity to meet the criteria for sufficient, and adequate modernization at early, mid, and advanced stages thereby ensuring the effective implementation of irrigation modernization and the realization of national food security goals.

2. Literature Review

Irrigation modernization varies across countries, depending on each nation's goals and priorities. Many countries have already begun implementing irrigation modernization programs, including China [14], Turkey [15], the United States [6] and Indonesia [16]. In Indonesia, irrigation modernization is an effort to establish a participatory irrigation management system that is service-oriented, effective, efficient, and sustainable. This initiative supports both food and water security by improving the reliability of water supply, infrastructure, irrigation management, institutional capacity, and human resources.

The primary objective of irrigation modernization in Indonesia is to establish a management system capable of delivering the predetermined level of irrigation service effectively, efficiently, and sustainably. The broader goal is to support agricultural productivity, enhance crop yields, and ultimately contribute to national food security and farmer welfare. Key indicators of irrigation modernization in Indonesia include increased water productivity (kilograms of milled dry rice/m^3 of water), improved irrigation service (in terms of adequacy, reliability, equity, and timeliness), enhanced irrigation efficiency, reduced operation and maintenance (O&M) costs, increased cost recovery for O&M, improved financial sustainability, reduced conflicts, and decreased environmental degradation [10].

Before irrigation modernization can be implemented in each irrigation area, two preliminary assessments must be conducted: the Irrigation Asset Management Assessment (PAI) [17, 18] and the Irrigation System Performance Index (IKSI) assessment. Only after an irrigation area passes both assessments can it proceed to the Irrigation Modernization Readiness Index (IKMI) evaluation [18-20]. The following section outlines the IKMI scoring criteria.

Table 1.
Score and Criteria Irrigation Modernization Readiness Index (IKMI).

No	IKMI Score Range	Criteria	Description
1	> 80 (maximum 100)	Adequate	Modernization can be implemented.
2	50 – 80	Sufficient	Modernization is postponed; improvements should be made based on IKMI results within 1–2 years.
3	< 50	Insufficient	Modernization is postponed; irrigation system improvements required within 2–4 years.
4	< 30	Critically Low	Modernization cannot be implemented due to the need for fundamental improvements.

Source: Kementerian Pekerjaan Umum dan Perumahan Rakyat (PUPR) [21].

The Irrigation Modernization Readiness Index (IKMI) serves as a strategic tool for assessing the preparedness of irrigation systems for modernization initiatives. The index categorizes readiness into four distinct levels based on score ranges, each accompanied by specific recommendations for action.

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The human resources aspect of irrigation modernization in Indonesia comprises three key actors: the Irrigation Commission, field officers, and farmers [22]. To date, the human resources pillar consistently receives the lowest scores among the five pillars of irrigation modernization. This pillar encompasses nine key components:

1. Recruitment of non-civil servant human resources
2. Status and position
3. Education, training, and certification
4. Career planning
5. Provision of incentive/remuneration systems
6. Socio-economic conditions of irrigation actors
7. Empowerment of Water User Associations (P3A/GP3A/IP3A)
8. Regeneration
9. Understanding of technology

These components reflect the multifaceted nature of human resource development required to support effective and sustainable irrigation modernization in Indonesia. In addition to government institutions and farmers, field officers play a crucial role in realizing irrigation modernization. Field officers include:

- Observers
- Mantri/Juru
- Dam Operation Officers (POB)
- Water Gate Officers (PPA)
- Canal Workers (PS)

Field officers are responsible for the operation and maintenance of irrigation infrastructure, including canals, weirs, and dams. Their duties also involve engaging with and guiding farmers as well as Water User Associations (P3A/GP3A/IP3A) to actively participate in canal maintenance activities. Field officers play a vital role in the implementation of irrigation modernization in Indonesia, particularly in the operation and maintenance of supporting infrastructure. These personnel are responsible for the day-to-day technical and operational management of irrigation infrastructure, ensuring that water delivery services are carried out effectively and in accordance with modernization objectives.

The challenges of irrigation sustainability and efficiency, particularly the need for a multidisciplinary approach involving human resources, technical training, and institutional management [23] have a significant impact on irrigation modernization. The implementation of training has been shown to significantly improve performance [24]. Thus, training is acritical component of a sustainable irrigation modernization strategy [25]

3. Methods

This study employs a mixed-methods approach, combining both quantitative and qualitative techniques. Data were collected through questionnaires, interviews, and focus group discussions (FGDs) involving field officers in the Rentang Irrigation Area. The participants included observers, mantri/juru, Dam operation officers (POB), water gate officers (PPA), and canal workers (PS), with a total of 100 field officer respondents. The questionnaire and interview questions were structured around the nine key components of the human resources pillar in irrigation modernization, namely Recruitment of non-civil servant personnel, Employment status and position, Education, training, and certification, Career planning, Provision of incentive/remuneration systems, Socio-economic conditions of irrigation actors, Empowerment of Water User Associations (P3A/GP3A/IP3A, Regeneration and Understanding of technology.

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4. Analysis and Discussion

To date, the Government of Indonesia has conducted assessments of the Irrigation Modernization Readiness Index (IKMI) across 16 irrigation areas. The following section presents the IKMI scores for these regions, providing an overview of their readiness levels to implement irrigation modernization.

Table 2.
Score and Criteria Irrigation Modernization Readiness Index (IKMI).

No.	Irrigation Area	IKMI Score
1	Wadaslintang Irrigation Area	77.6
2	Bondoyudo Irrigation Area	81.5
3	Batang Anai Irrigation Area	63.2
4	Rentang Irrigation Area	66.9
5	Jatiluhur Irrigation Area	68.0
6	Saddang Irrigation Area	68.7
7	Colo Irrigation Area	69.0
8	Mrican Irrigation Area	77.9
9	Komering Irrigation Area	66.0
10	Sekampung Irrigation Area	75.0
11	Serayu Irrigation Area	85.8
12	Cikeusik Irrigation Area	66.3
13	Kedung Putri Irrigation Area	68.5
14	Pamukkulu Irrigation Area	67.9
15	Talang Irrigation Area	67.3
16	Jurang Batu Irrigation Area	62.4

Source: Readiness of Human Resources Aspects in the Context of Modernization of Irrigation in Indonesia in the Macan Irrigation Area,2023.

Based on the IKMI assessment, the Rentang Irrigation Area received a score of 66.9, indicating a moderate level of readiness for irrigation modernization. The detailed breakdown of this score is as follows:

Table 3.
Irrigation Modernization Readiness Index (IKMI) Rentang Irrigation Area.

No.	Indicator	Weigh	Score	Predicate	IKMI
1	Water Availability	20	62	Sufficient	12.4
2	Irrigation Infrastructure	25	69	Sufficient	17.25
3	Irrigation Management	20	64	Sufficient	12.0
4	Irrigation Institution	20	73	Sufficient	14.6
5	Human Resources	15	66	Sufficient	13.2
	Total IKMI				66.9

Source: Laporan IKMI DI Rentang Kemen PU&UGM

Based on the IKMI score, value of 66.9 falls into the "sufficient" category, which means that irrigation modernization is delayed, and improvements should be made in accordance with the IKMI results within 1 - 2 years. Therefore, improvement efforts are necessary to elevate the status from "sufficient" to "adequate" to enable the implementation of irrigation modernization in Indonesia.

To measure each stage of irrigation modernization, it needs to be correlated with the IKMI value. Here is the correlation between the IKMI value and the stages of irrigation modernization:

Table 4.
Correlation between the IKMI value and the stages of irrigation modernization.

No	Stage Modernization Irrigation	Assessment Criteria	IKMI
1	Sufficient Modernization Stage	2.0	50 – 80
2	Adequate Stage (early Level)	2.1 – 3.0	81 – 85
3	Adequate Stage (Intermediate Level)	3.1 – 3.5	86 – 90
4	Adequate Stage (Advanced Level)	3.6 – 4.0	91 – 100

Source: Analysis Results

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This table presents the correlation between the Irrigation Modernization Readiness Index (IKMI) scores and the corresponding stages of irrigation modernization.

Measuring each stage of irrigation modernization, cannot be separated from the existing conditions of field officers. In the case of the Rentang Irrigation Area, these conditions are closely tied to the components of the human resources pillar, which include:

- Procurement/recruitment of HR non-PNS
- Status and position
- Education, training and certification
- Career planning
- Provision of incentive/remuneration systems
- Socio-economic of irrigation actors (Farmers, POB etc.)
- Empowerment of P3A/GP3A/IP3A
- Understanding of technology

The following are the existing conditions of field officers in Rentang Irrigation Area

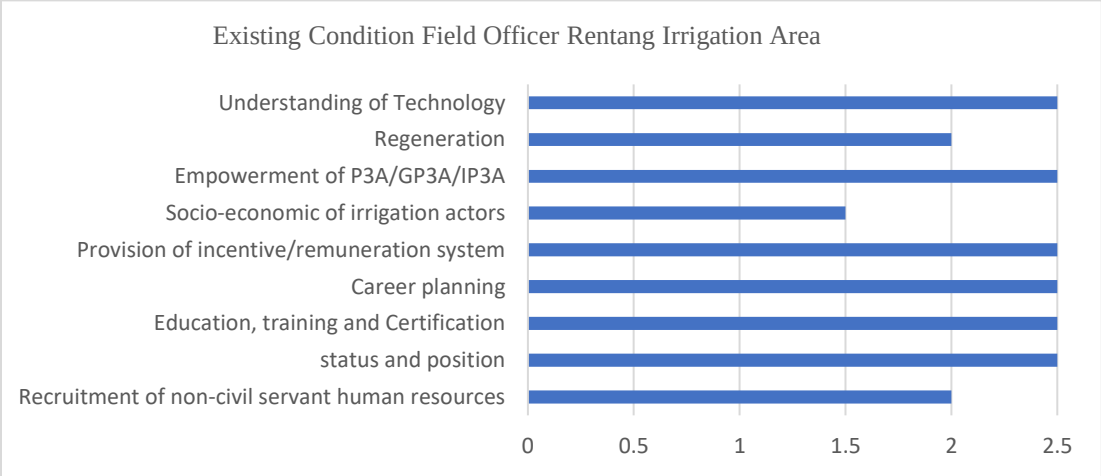

Figure 1.
Existing Condition Field Officer Rentang Irrigation Area.

Based on the existing conditions of field officers in the Rentang Irrigation Area, the components of irrigation modernization that have reached the "sufficient" stage with a score of 2 are:

- Regeneration
- Procurement/recruitment of non-PNS HR

The components of irrigation modernization that have progressed toward the "adequate" stage (minimum/initial stage) with a score of approximately 2.5 are:

- Status and position, Education, training and certification,
- Career planning,
- Provision of incentive/remuneration systems,
- Empowerment of P3A/GP3A/IP3A
- Understanding of Technology

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While for socioeconomics, it has not reached the sufficient irrigation modernization stage with a score of 1.5. Therefore, efforts are needed to improve this component to achieve the sufficient stage of irrigation modernization.

Socio-economic indicators include education, health, housing conditions, income and economic welfare [23-25]. Efforts to improve the socio-economic conditions of field officers in Rentang have been made through training. Training significantly contributes to improving the social and economic welfare of the community [26]. Skills training is closely linked to inclusive socio-economic development [27] and Job skills training can significantly increase income and employment opportunities, especially in developing countries [28].

Training programs conducted to support irrigation modernization in Indonesia include:

- Policies related to Irrigation Modernization
- Irrigation Planning
- Irrigation Operation and Maintenance
- Scope of Irrigation Modernization
- Irrigation Modernization Preparation
- Irrigation Modernization Planning
- Irrigation Modernization Implementation
- Modern Irrigation System Operationalization
  - Monitoring and Evaluation

For field officers, the training focuses primarily on operations and maintenance. The training programs conducted include:

- Dam Operation and Maintenance
- Irrigation Operation and Maintenance
- Irrigation Operation and Maintenance at the Juru Level
- Irrigation Operation and Maintenance at the Observer Level
- Irrigation Operation and Maintenance Management System (SMOPI)
- Real Operation and Maintenance Needs Figures (AKNOP)
- Specialized training on operating Computerized, Telemetry, and Electro Mechanization (KTE) systems

The training concept for field officers in realizing irrigation modernization is described as follows:

Sufficient Stage, Adequate Stage (Early Level) Basics of Irrigation. Provides a basic understanding of irrigation systems and the importance of maintenance

Table 5.
Training Sufficient Stage, Adequate Stage (early Level): Basics of Irrigation.

No	Training Subject	Description
1	Introduction to Irrigation	History, objectives, and benefits of irrigation in agriculture and water management.
2	Basics of Irrigation Engineering	Types of irrigation systems (surface, sprinkler, drip), main components.
3	Basic Maintenance of Irrigation Systems	How to routinely maintain channels, pumps, and measuring instruments.

At this stage, field officers receive training in irrigation fundamentals, basic irrigation engineering, and essential irrigation system maintenance. This training helps them understand the history, purpose, and benefits of irrigation in agriculture and water management. They will also learn about different types of irrigation systems and the fundamentals of system care and maintenance.

Adequate Stage (Intermediate Level) Technical and Management Strengthening. Enhancing technical skills and managerial capabilities in irrigation management.

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Table 6.
Adequate Stage (Intermediate Level): Technical and Management Strengthening.

No.	Training Subject	Description
1	Advanced Irrigation Techniques	Planning Irrigation network, water use efficiency, and system design
2	Water and Irrigation Management	Water distribution regulation, discharge measurement, and water quality control.
3	Advanced Irrigation System Maintenance Damage	Damage diagnostics, channel repairs and automation systems.

For Adequate stage (Intermediate level) of training for field officers, the emphasis is on strengthening technical and managerial capabilities in irrigation management. This includes advanced irrigation techniques, water and irrigation management training, and training in advanced irrigation systems such as damage diagnostics, channel repair, and automation systems. These efforts build upon the training provided during the Sufficient Stage and the early phase of the Adequate Stage.

Adequate Stage (Advanced Level) Modernization irrigation and technology. Preparing for the implementation of modern technology and managing large-scale irrigation projects. Participants who have advanced experience and want to master the latest advancements in irrigation technology.

Table 7.
Adequate Stage (Advanced Level) Modernization Irrigation and Technology.

No.	Training Subject	Description
1	Modernization of Irrigation Systems	Smart irrigation concept, soil moisture sensors, and IoT-based systems.
2	Latest Technology in Irrigation	Drones for mapping, irrigation management software, and data analysis.
3	Irrigation Project Management	Planning, implementation, and evaluation of irrigation modernization projects.

For the adequate stage (advanced level), training for field officers focuses on irrigation modernization and technology. It aims to enable field officers to adapt to the application of modern technologies, such as drones for mapping, irrigation management software, and data analysis. Training will also include concepts related to irrigation modernization, such as smart irrigation, soil moisture sensors, and IoT-based systems. This is expected to equip field officers with the advanced skills and motivation to master the latest irrigation technologies.

5. Conclusion

Field officers (POB, PPA, Juru, Mantri etc.) play a crucial role in the implementation of irrigation modernization in Indonesia. Based on current conditions, the socio-economic aspect of irrigation modernization among field officers has not yet reached a sufficient stage. Therefore, improvement efforts through training are necessary. Some training programs have been implemented, while others have not. The training concept for programs not yet conducted focuses on the Sufficient Stage and Early Adequate Stage, emphasizing the basics of irrigation providing a foundational understanding of irrigation systems and the importance of maintenance. At the Intermediate Stage, the emphasis is on Strengthening Techniques and Management to improve technical skills and managerial abilities in irrigation management. The advanced stage focuses on modernization and irrigation technology, preparing the application of modern technology and managing large-scale irrigation projects so that field officers are expected to possess advanced experience and demonstrate a strong desire to master the latest irrigation technologies.

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The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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