

Managing Paddy Agricultural Irrigation System: A review on Challenges and Strategies

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Abstract — Ensuring enough food supply to meet demand is one of the challenges that the country needs to address. This food security issue is explored in this review article by looking at the challenges and strategies for ensuring a sustainable agricultural irrigation system for paddy farming, with a focus on Indonesia. The review identified five main challenges and four strategies for the management of agricultural irrigation paddy systems. The aim of the discussion in this paper is to help manage irrigation facilities. It is expected to contribute to the sustainability of paddy agriculture for those involved in the management of agricultural water management. Further studies on community participation factors and performance measurement indicators are proposed.

Keywords— paddy farming, irrigation, challenges, strategies, sustainable

I. INTRODUCTION

Agriculture forms the bedrock of Indonesian national stability and sustains the country's economic and cultural development. Agricultural growth is also a key feature of other developing countries in Asia, particularly Indonesia, Malaysia, and Thailand [1]. Food crop agriculture strongly supports Indonesia's economic development and achieves food security, regional development, poverty reduction, employment, and foreign exchange income [2].

Unstable rice production and unsustainable cultivation areas are one of the main problems and attention to the development of Indonesian rice sustainability and resulting in declining rice production. Rice production is multidimensional covering economic, social, political, and environmental aspects. It is estimated that in Indonesia in 2025 there will be a national rice availability deficit of 7.15 million tons per year. This situation is due to population growth so that rice demand is faster than the growth of its supply [3]. This situation demands that creativity increase rice production for domestic needs in production stability can sustain national food [4].

Agricultural development in Indonesia is geared towards sustainable agriculture as part of the

implementation of sustainable development [5]. But the approach to sustainable development in the agricultural sector is determined by agricultural, social, ecological, institutional, and technological economic indicators. Globally, nationally, and locally, advances in agricultural research and innovation offer significant opportunities to improve performance across the value chain of agricultural products. [6].

Indonesia remains committed to a sustainable approach to agriculture to strike a balance between development and environmental needs [5]. In 2017, the Government implemented a three-million-hectare irrigation infrastructure rehabilitation program, procurement of 180,000 units of agricultural system equipment, construction of 3771 units, provision of seed and fertilizer assistance for 77 million hectares of paddy fields. However, this does not result in significant value; because of there being a drop in rice production. The maintenance of irrigation facilities and infrastructure is minimal. The lack of active participation of farmers in maintenance of irrigation canals can be found and maintenance of grass and sediment storage of irrigation channels is not done frequently.

Therefore, without effective control over these activities, economic development and food security will be hindered. Indonesia is a nation with a large population put to work in the agricultural sector. Correspondingly, irrigation development is important for this country. Over the years rice production has decreased in Indonesia [10].

There is a challenge to the sustainability of rice production in many countries and to find a balance between development and nature. Thus, this paper presents the challenges and strategies to address the issue of the agricultural irrigation system. The next topic discussed the challenges faced and following subtopic will be the strategies to overcome these challenges.

II. CHALLENGES

A. Agricultural Water Management

Agricultural water management throughout irrigation networks is a key part of the efficient use of agricultural water in irrigation areas, providing basic

assurance and supporting decisions to improve water efficiency [11]. Reliability of irrigation water, including the condition of available irrigation water, time, location, quality, and structure of water to support maximum agricultural productivity, is a prerequisite for effective and efficient irrigation management. Community behavior in irrigation management needs to be investigated for this purpose.

B. Water Supply

Irrigation water is required by the plant and depends on the plant, the availability of the irrigation canal, but the reality in the field of irrigation water is affected by the physical condition and behavior of the irrigation canal in the field. The state of the irrigation network infrastructure in Indonesia, submitted by the Director General of the Ministry of Water Resources for Public Works for 2.2 million hectares of audited land, 1.3 million hectares suffered minor to moderate damage; 117,900 hectares were severely damaged, 786,600 hectares were moderately damaged, and 331,600 hectares were slightly damaged, as reported by Tempo Magazine in May 2011. Indonesia has the second largest agricultural land after China. In China, more than 98% of their agricultural area is irrigated. This is followed by Bangladesh, with 89% of its agricultural area irrigated. Although Thailand is an exporting country for agricultural products, only 39% of its agricultural land is irrigated.

The centralist approach often ignores local participation and wisdom. This led to the budget of the government for calculating the needs and distribution of flowing water does not meet the budgetary needs of farmers [12]. In the field, frequent conflicts over land use and irrigation water have led to a growing problem of conflict between land users and water users [13]. This needs to be addressed in areas which are at risk of failure of rice farming due to a lack of water supply in the agricultural system [14].

Often, irrigation water needs peak during the dry season, but the availability of irrigation water is low. This results in damaged irrigation facilities due to community behavior in meeting irrigation water needs [9],[15]. Community action by taking irrigation water outside the system has also led to paddy fields being less likely to meet irrigation water needs [16]. Some areas in Indonesia often experience crop failure due to environmental degradation, crop failure by farmers, and irrigation water does not reach paddy fields due to damaged tissues and poor upstream water use. Community action by taking irrigation water outside the system has also led to paddy fields being less likely to meet irrigation water needs [16].

C. Damage to Irrigation Network

Damage to the irrigation network is also found as one of the problems in sustaining rice production. This may be caused by natural disasters, lack of funding for the operation and implementation of irrigation

networks [18]. In addition, the irrigation network may also be affected by the quantity and sustainability of irrigation distribution of water [19]. Other factors include the behavioral factors of irrigation managers and the water user community [20]. In Indonesia, farmers are still minimal in terms of irrigation and infrastructure management and lack of sense of belonging. Meanwhile in Japan, most farmers are in the process of joining cooperative associations which support among themselves to water their fields. According to Soenarno [17] the water resources and irrigation sector is facing increasingly complex and challenging long-term investment and management challenges.

D. Government Control

The implementation of the Basic Irrigation Management (PKPI) Update Program in Indonesia has been implemented selectively, gradually, and democratically, in line with the capabilities of the local Water Consumers Farmers Association (P3A). However, the PKPI program has not reached the level of farmers, so it is still necessary to familiarize the PKPI program at regional and district level to maintain the sustainability of irrigation management. The principles of irrigation management model prioritize the interests of society and place P3A as the decision maker and key actors in irrigation water (Government Regulation 1977).

Mukhlis et al. [21] argued that, at present, the implementation of government regulations and local irrigation regulations is not able to deal properly with irrigation management in the field. This shows that the level of damage and conflict in irrigation water services is still difficult to overcome. As a result, there is a lot of damage and lack of function of buildings and irrigation network facilities that caused water becomes wasteful. Without effective control, these challenges will therefore be an obstacle to economic development and the achievement of national food security.

E. Fund

Water resources and irrigation systems face increasingly complex and challenging long-term investment and management challenges. At the same time, the provision by the Government to support the operation and implementation of irrigation networks is limited. The costs for the operation and implementation of irrigation in Indonesia are allocated to only 40-50 per cent of the real needs [7]. Nurrochmad [22] and Tegal [18] have argued that, due to neglected operation and implementation of irrigation, community service performance is declining.

Five challenges have been identified in the literature from the discussion in this subtopic. The first is the issue of the management of paddy farming. Second, challenges in water supply are also identified. Third, the damage to infrastructure is also reported to be a challenge in rice production. Meanwhile, the last

two challenges are the government's control aspects and the lack of funds for the operation and maintenance of agricultural irrigation systems.

III. STRATEGIES

A. *Agricultural Development Policy*

The Indonesian Government's agricultural development policy is aimed at achieving the self-sufficiency of rice, because rising rice production is particularly important for increasing availability, accessibility, and resilience due to global climate change. However, farmers still face the risk of paddy production and crop failure [23]. Indonesia's population by 2025 is estimated at 275 million people, to meet food security in the form of rice, water is very necessary [24]. According to the Directorate of Irrigation and Swamp, the Ministry of Public Works (2011) water resource policy reform includes key target irrigation to improve national policy and enhance the function of institutions and regulations on irrigation management with the agenda of:

- Empowerment of Water Consumer Farmers Association (P3A)
- Irrigation Management Board (LPI) arrangements
- Sustainability of operational and maintenance and rehabilitation financing

B. *Sustainable Agricultural Practices*

Sustainable agriculture can be defined as capable of maintaining long-term productivity and usefulness for society and must be environmentally friendly. The sustainability of paddy farming is based on five aspects, including the economic, social, ecological, institutional, and technological factors of agriculture [25].

Rainwater harvesting has great potential for productive, sustainable, and efficient agriculture [26][27][28]. Mahmuddin [29] stated in his study that the development of agriculture at present seeks to develop a sustainable agricultural system capable of increasing farmers' resources in support of the system.

C. *Participatory Irrigation Management*

The PIM Strategy (Participatory Irrigation Management) is seen as one of the strategies to address issues related to sustainable paddy production [30][31][32]. Consequently, irrigation management must be coordinated with the socio-cultural conditions of the local community. This means that irrigation management depends on a set of management behaviors based on the participation of local communities. The Irrigation Commission and the P3A community can ensure a good and responsible mentality. Purwantini et al. [33] acknowledged that the

sustainability of irrigation development is supported by effective collective management.

D. *Agricultural water management evaluation system*

Irrigation of agricultural water management is an important component in the practice of managing agricultural irrigation, for efficient use in the promotion of high agricultural products, through sound water distribution management [34][36]. Irrigation is a major need in agricultural activities, particularly in paddy fields [35], thus an evaluation system on its management is a need. Agricultural water management evaluation system for irrigation has been established with the classification of 5 types of second-class indices, namely the Technology Index, the Engineering Index, the Management Index, the Environmental Index, and the Economic Index, and 35 third class indices [36].

From the above discussion, there are four main strategies that can be implemented to address the challenges of water management in rice farming. This can begin with the policy aspect at the level of the government. Secondly, the second strategy is to promote sustainable agricultural practices. Third strategy is Participatory irrigation management, followed by the development of a management evaluation framework.

IV. CONCLUSION

This paper presented the challenges and strategies in the development of a sustainable water management system with a focus on Indonesia. Five main challenges and four solutions have been identified from the literature. The first is the management of paddy farming. Second, water supply challenges are also identified. Third, infrastructure damage is also reported to be a challenge in rice production. The last two challenges are the lack of government control and financing for the operation and maintenance of agricultural irrigation systems. Four main strategies have been presented to address these challenges. The policy aspect can begin at the level of the government or federal level. Second, sustainable farming practices should be given highlight and be supported. Third strategy is participatory irrigation management followed by the development of a management evaluation framework. Challenges and strategies presented here may be used by stakeholders involved in, or intended to participate in, sustainable paddy agriculture. Further studies on community participation factors, performance measurement indicators, strategies presented here are proposed.

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