Indonesia Rice Irrigation System

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Indonesia is likely to face a water crisis due to mismanagement of water resources, inefficient water systems, and weak institutions and regulatory organizations. In 2020, most of the fresh water in Indonesia was used for irrigation (74%) to support the agricultural sector, which occupies 30% of the total land area in Indonesia. Of all agricultural commodities, rice is one of the major and essential commodities, as it is the basic staple food for almost every Indonesian. However, in 2018, the Ministry of Public Works and Housing (MoPWH) reported that 46% of Indonesian irrigation infrastructure is moderately to heavily damaged. Aside from how climate change influences water availability for irrigation, rice production with a constant water ponding system has been found to contribute to climate change, as it emits methane (CH4) and other greenhouse gases from agricultural fields of Indonesia. Therefore, the required modernization of irrigation systems in Indonesia needs to consider several factors, such as food demands for the increasing population and the impact of irrigated agriculture on global warming. Multi-stakeholders, such as the government, farmers, water user associations (WUA), and local research institutions, need to work together on the modernization of irrigation systems in Indonesia to meet the increasing food demands of the growing population and to minimize the impacts of agriculture on climate change.

Keywords: Indonesian irrigation systems ; rice production ; food security

1. Introduction

Water has always been an important source for any society to survive on this planet, and it is also vital for the survival of animals and plants. In recent years, water has become a precious source for food and energy production. At the same time, readily available water for agriculture and energy has become more and more scarce. The threat of a water crisis for drinking and sanitation has been long known as a global sustainability problem, and, thus, each of us needs to use and manage water mindfully and sustainably. Despite being one of the ten water-rich countries in the world, Indonesia is not exempted from these threats [1]. Indonesia is likely to face a water crisis due to water mismanagement, as evidenced by high levels of water pollution, inefficient water usage, and weak institutions and regulatory systems [2][3].

Based on the Food and Agricultural Organization (FAO) data, Indonesia was responsible for up to 8.4% of the total world's water usage in 2019 [4]. Out of the total water usage, agriculture is one of the most essential and important sectors, and consumes most of the available fresh water in Indonesia. In 2020, fresh water in Indonesia was mostly allocated for irrigation (74%), with the rest going to household, urban, and industrial uses (11%), rivers (12%), reservoirs, and ponds (3%) [5][6]. A World Bank report mentioned that the agricultural sector contributed about 13.3% of the total GDP of Indonesia in 2021 [7]. The agricultural sector employs 38 million people [8] and covers almost 30% of the total agricultural area in Indonesia [9]. It also has become the primary source of income for rural areas, where 13% of Indonesia's poor lives [10]. Water management and irrigation are critical inputs to agriculture that significantly impact food output and could also help reduce greenhouse gas emissions from agriculture if managed judiciously. Many developing countries in the world are facing a water crisis due to their heavy reliance on water use for agricultural production [11].

Rice has been placed as one of the most important agricultural products among many agricultural commodities, as it has become the primary staple food for most Indonesians. Indonesia is the third-largest rice producing country in the world, following China and India [12]. The increase in rice production in Indonesia grew simultaneously with the development of irrigation infrastructure. Indonesia achieved its first self-sufficient rice production in 1984 after a massive land shift to agriculture and the successful construction of irrigation systems between 1969 and 1989 [13]. In 2004 and 2008, Indonesia achieved its second and third periods of self-sufficient rice production. Indonesia's infrastructure, including research and development (R&D) and governmental policies, have played an important part in supporting the dynamics of rice production [14]. Indeed, the FAO reported that 6.7 million hectares of paddy fields rely on the irrigation system [12]. Indonesia is now included in the list of rice importers [15].

Substantial irrigation infrastructures in Indonesia have been damaged in the last two decades, leading to inefficient water delivery and water use by crops. According to Azdan [16], 22% of the overall irrigation system in Indonesia was found to be moderate to heavily damaged in 1999. This number increased at a rate of 20% in 11 years, while, in 2010, the percentage of moderately and heavily damaged irrigation infrastructure reached 52%. As of 2018, according to the Ministry of Public Works and Public Housing (MoPWH), Indonesia has a total of 7.1 million ha of under surface irrigation networks, with 46% of the irrigation systems being damaged. Ministerial Regulation of MoPWH No. 12/PRT/2015 defines a moderately

damaged irrigation system as one where 21–40% of the infrastructure and channel conditions are damaged from their initial state, whereas a heavily damaged system is when more than 40% of them are damaged.

2. History of Irrigation System and Irrigation Infrastructure Development in Indonesia

The development of rice farming is believed to have existed in Indonesia since 1600 BC [17]. Irrigation systems in the form of basic canals are estimated to have existed on the island of Java during the first century. These canal systems were initially tiny in size, but were within the capacity of local populations to sustain themselves for generations. Dutch colonialism in Indonesia began in 1602, when a Dutch trading partnership was formed called *Vereenigde Oostindiche Compagnie* (VOC). The VOC focused on agricultural development to obtain the highest benefits from Indonesian agricultural products, especially spices. Trials of large-scale irrigation development with longer-lasting construction began in the mid-nineteenth century on Java Island in an effort to alleviate the starvation caused by the prolonged drought in the Demak district in 1849 [18]. Around 280,000 people died from the famine that year. Since then, weirs have been built in various locations, including Gelapan, Tuntang, and Sidoarjo, to support irrigation systems and infrastructure [19][20][21].

Around the end of the nineteenth century, irrigation development was closely related to political tools for the colonial government's efforts to produce export commodities associated with "*cultuurstelsel*" or enforced planting of selected commodities, mainly sugarcane, which required irrigation. The Dutch Government made irrigation one of the policy instruments in implementing political ethics (*Ethiesche Politiek*), which Queen Wilhelmina announced in front of the Dutch parliament at the beginning of the twentieth century [22]. Political ethics is another term for the moral justification of political activity that was enforced on the Indonesian people [23]. The establishment of political ethics was a result of concerns by the European aristocracy, who pledged to recompense the Indonesian people for previous political decisions, such as enforced planting [22]. Another goal of irrigation development at that time was to overcome poverty and continue the agricultural surplus on Java Island to benefit the Dutch economy. The political development in irrigation was also influenced by the advancement of hydraulic technology, which enabled the construction of irrigation systems on a larger scale [19].

As a result of the Dutch strategy of adopting political ethics, the first quarter of the twentieth century (1900–1925) was described as an era of large-scale irrigation growth and the establishment of government-based irrigation management organizations. One of the substantial developments was the formation of an irrigation committee. The concept of irrigation management was founded in 1871 by a commission led by R. De Bruyn. As a result of the commission's report, the irrigation brigade was founded in 1885 as a particular unit under the *Burgerlijke Openbare Werken* (BOW) that oversaw the Government's irrigation systems [22]. With the increase in irrigation development, irrigation brigades were considered insufficient. In 1889, the irrigation brigades were replaced with irrigation area units (*irrigatie afdeling*) within a river basin region [24]. In 1906, a commission was constituted to draft levies and monthly payments from the plantations to assist financial authorities in managing water distribution and implementation of policies, which served as the predecessor of the irrigation committee founded in 1920.

The second stage (1925–1950) was a period of intensifying irrigation water management at the tertiary canal level to support the agriculture plan in a small-scale region [17]. To help with water distribution, water intake infrastructures were created to control and regulate irrigation water supplies at the tertiary canal level in irrigated sugarcane fields. Farmers were hired as village-level representatives for the water management organizations [25]. Although this decentralization process in the Java province began in 1926 and irrigation affairs were handed over to the provincial government in accordance with the decentralization process, a law regulating irrigation as a whole (*Algemeen Water Reglement*) was only announced in 1936, which the Provincial Water Regulation policy later followed [24].

To address the issue of food insecurity and in response to the introduction of green revolution technologies in the late 1960s, Indonesia's water resource development went through a series of five-years development programs, which included the restoration of the previous outdated systems as well as the extension of existing irrigation systems to neighboring islands [26][27]. Irrigation investment was made on a large scale in the 1970s and 1980s with the goal of establishing rice production self-sufficiency in Indonesia [28]. The availability of water-responsive green revolution technology necessitated the upgrading of irrigation infrastructure and extending irrigation systems to other regions, particularly outside of Java [25].

These significant investments in irrigation were aided by rising worldwide oil prices, which resulted in efforts to boost support for water management in Indonesia. The Government helped to enhance the tertiary irrigation system with substantial financial aid by introducing standard irrigation system designs throughout Indonesia. This included the improvements of existing irrigation systems in Subak by the Bali Irrigation Project in the 1980s, which restricted Subak's autonomy and promoted Subak's reliance on government control [29][30]. With substantial investment in water resource development during this period, Indonesia attained self-sufficiency in rice production in 1984 through a centralistic and systematic rice intensification strategy in all irrigated areas. However, since the 1986 oil shock, public investment in water resource development has gradually declined. This oil shock was one of the most disappointing performances of Indonesia's 32-year-presidency at the time, as the country was unprepared for an external economic shock of this

magnitude [31]. Since then, despite investments in irrigation infrastructure, the increase in total irrigated area in 2004 was only half of that of the previous years [25].

In 2005, the Indonesian Government developed a new plan called “Long-term Development Plan 2005–2025 (LTDP)”, in which Indonesia stated its focus strategies of development for the next 20 years [32]. This plan was followed by a five-year Medium-term Development Plan (MTDP). The development plans for water management are mainly based on the program for constructing reservoirs and dams to increase the availability of water for irrigation and energy. However, the total rice harvested area and the total area under irrigation have not changed much in the last two decades.

3. Irrigation Community and Policy Reforms in Indonesia’s Irrigation Systems

The concept of the irrigation community started at the beginning of the creation of rainfed rice fields and, subsequently, the discovery of technology to divert water from rivers for irrigation. An irrigation community refers to a group of farmers who use an irrigation system’s water supply, also known as farmer water user associations (WUAs) [33]. Subak irrigation in Bali is one example of communal irrigation that was thought to have existed since the end of the first millennium [29][34]. Although the water diversion technique used free intake flows, these discoveries show community involvement, such as labor division, to ensure that the performance of irrigation systems continued indefinitely and sustainably [17].

There was a phase of cohabitation between the irrigation community and the governmental irrigation agencies between 1848 and 1970 [30]. Despite the fact that the Dutch colonials in Indonesia constructed large-scale irrigation systems in the rice fields, local communities made their own improvements and developed irrigation infrastructure, especially at the tertiary level of the irrigation system. Because some of the irrigation infrastructure built by the communities were short-lived and easily damaged when flooded, these irrigation infrastructures were sometimes seen as unregulated [17]. The Subak irrigation system in Bali and the irrigation systems created in the Solo and Yogyakarta districts were mainly regarded as good, as they were built by Dutch specialists [19][35][36].

The welfare politics of the previous generations persisted until Indonesia gained its independence from Japan in 1945. The phrase “*pengairan*”, refers to water intake for a general purpose, but was frequently used interchangeably with irrigation. It was officially used in the Indonesian constitution about *Pengairan* No. 11/1974, which regulated water resources. This constitution was constructed to replace the 1936 *Algemeen Water Reglement*, which was deemed insufficient in supporting developmental demands. The constitution was then followed by Government Regulation No. 23/1982 which specifically regulated irrigation water in Indonesia. Another significant endeavor at the time was the formation of the water user association (WUA) in the repaired tertiary unit, although WUAs supporting the tertiary irrigation system was not new [30].

In fostering the WUA, the Government issued Presidential Instruction No. 2 of 1984, which provides direction to all relevant agencies for guiding farmer organizations in using the existing irrigation water [17]. The central Government began to formulate a strategy for WUA to help manage the irrigation network that had already been built. The irrigation and water resource management reform phase were typically consistent with decentralization and regional autonomy. This phase was preceded by Presidential Decree No. 3/1999 and Government Regulation No. 77/2001 addressing irrigation, which basically gave the WUA the authority to oversee irrigation systems. There was a conflict of interest in this phase, for example, between continuing irrigation reform, which emphasized efforts to empower farmers through granting greater management authority, and the interest of maintaining the management framework running through an investment approach, as well as allowing opportunities for the private sector in managing water resources [37].

In 2004, the constitution was changed to implement the Water Resource Act No. 7/2004, pulling back the reform movement by making management transfer optional. The enactment of Water Resource Act No. 7/2004 corresponded with the implementation of the regional autonomy policy (Law No. 32/2004). This constitution allowed the central, provincial, and regional governments to manage and develop the irrigation system based on the type of irrigation system. It also provided share authority between the government (for primary and secondary irrigation systems) and the WUA (for tertiary irrigation systems). In this constitution, irrigation systems were generally organized into the following three layers [37]: (1) the central government responsible for the international irrigation systems (trans-national boundary irrigation systems), cross-province irrigation systems, national strategic irrigation systems, and irrigation systems with an area > 3000 ha; (2) the provincial government responsible for cross-regency irrigation systems and irrigation systems with an area 1000 to 3000 ha; (3) regency government responsible for irrigation systems with an area less than 1000 ha.

At least three factors triggered the enactment of Water Resource Act No. 7/2004, namely efforts to recover from the economic crisis after experiencing political shocks, World Bank-proposed efforts to improve the economy, and global pressure to adopt an integrated and sustainable approach. However, no formal service agreements outline the roles, duties, rights, and obligations of the service provider and the service recipient. In the absence of these agreements, providing services to farmers becomes unreliable [5]. According to the regional autonomy policy, the regencies and provinces have their autonomy and are not subject to national authority. The autonomy policy with the lack of integrated coordination between regions resulted in diverse water resource and irrigation management policies, since each regency or province may have its own policy, governmental institution, personnel structure, financing, and so forth [17]. In 2008,

Indonesia released President Decree No. 12/2008, constructing the Water Resources Council (*Dewan Sumber Daya Air*) to coordinate water resources at the regional, provincial, and national levels.

Currently, Indonesia is shifting to a government-supported irrigation system. In the new constitution of Water Resource Act No. 17/2019, the development and management of the irrigation system falls under the Central Government's authority as one united system [37]. Despite the complexity of irrigation management, the new water law has provided a legal foundation for integrated water resource management (IWRM) to be practiced in a river regime unit (RRU), consisting of a single river basin or several interconnected river basins. The new law also acknowledged the role of multi-stakeholders in the decision-making process in water governance. In 2022, Indonesia released President Decree No. 53/2022, in which the new Water Resources Council was established to provide suggestions and technical judgments for the Central Government to further achieve the objectives of Indonesia's water resource management, including irrigation.

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