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ECONOMIC VALUATION ESTIMATION OF SUPPLEMENTARY IRRIGATION WATER IN CROP FARMING ENTERPRISES IN BANTUL REGENCY

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ABSTRACT

Hydrological droughts in Bantul Regency significantly reduce crop productivity to an average of 59.97 kw/ha, thereby affecting farmers' income due to land conversion and water scarcity. This study evaluates the economic implications of supplementary irrigation in high, moderate, and low drought-prone zones. Farmers in low (Sabdodadi) and moderate (Guwosari) drought-prone areas can cultivate rice twice a year, whereas those in high drought-prone areas (Wukirsari) can do so only once. The methods employed include literature review, field survey, field data collection, and data analysis using RIA (Residual Imputation Approach) and ArcGIS 10.8. Cash costs for the third planting season in Sabdodadi, Guwosari, and Wukirsari amounted to Rp 11,590,451, Rp 11,698,165, and Rp 10,671,432 per hectare, respectively. Non-cash costs were Rp 2,600,260, Rp 3,331,483, and Rp 4,229,162 per hectare. Total production costs fluctuated, particularly in Sabdodadi, totaling Rp 14,190,711 per hectare. Sabdodadi exhibited the highest income at Rp 15,518,964 per hectare, while Guwosari and Wukirsari reached Rp 15,778,358 and Rp 14,778,346 per hectare. Supplementary irrigation significantly enhances the economic value of food crops, ranging from 20% to 29.15%, with Wukirsari making the highest contribution. The strategy of implementing flexible water tariffs and developing irrigation infrastructure can be applied to promote economic growth in drought-prone areas. Empowering farmers through economic incentives and access to adequate irrigation water is expected to create conditions conducive to sustainable agriculture.

Keywords: *agricultural economics, cropping patterns, food crop production, supplementary water value*

BACKGROUND

Competition among sectors to meet the increasing water demand has led to a change in the proportion of water allocation from the agricultural sector to the industrial and domestic sectors (raw water usage by regional water companies for processing into drinking water) (Huang et al., 2020; Mekonnen & Hoekstra, 2016). In 2022, the irrigated land spans 7.1 million hectares, and the anticipated demand for irrigation water is projected to reach 177.1 billion m3/year Approximately 46% of the irrigation infrastructure, totaling around 3.3 million hectares, is in a state of disrepair (Alaerts, 2020). These damaged areas are distributed with 7.5% under central authority, 8.26% under provincial authority, and 30.4% under the jurisdiction of district/city governments. Water consumption for industrial and domestic purposes stands at 4.06 and 13.19 billion m3, respectively

(Suhardiman & Giordano, 2014). The reliability of irrigation water is notably low, with only 76,542 hectares (10.7%) of surface irrigation area assured by reservoirs, leaving the remaining 6,383,626 hectares (89.3%) dependent on river flown(Ma'Mun et al., 2021; PUPR., 2019). Currently, the agricultural sector is the largest water user, accounting for 70%, compared to the industrial sector at 20% and households at 10%. Food crops absorb significantly more water on average than human needs for daily life (Harefa et al., 2022; Wang et al., 2019).

The food production system is influenced by several factors, such as human resources, technological advancements, and environmental conditions such as water, soil, and climate (Fanzo et al., 2021). However, in recent years, extreme climate events have been occurring more frequently with an increasing frequency, resulting in climate change phenomena (Miyamoto et al., 2021; von Braun et al., 2023). These phenomena include climate anomalies such as changes in rainfall intensity and patterns, droughts, floods, rising air temperatures, as well as increased pest and disease attacks, which are symptoms of climate change that could potentially reduce agricultural productivity, especially food crops (Furtak & Wolińska, 2023). Climate change poses a serious challenge to food security and food supply in Indonesia (Mulyasari et al., 2023). One of the factors affecting food productivity is the El Nino Southern Oscillation (ENSO) phenomenon, which triggers increased drought disasters in Southeast Asia and has a negative impact on food productivity (Y. Li et al., 2019; Kuznetsova et al., 2017). This phenomenon causes meteorological anomalies, especially in temperature, caused by global warming due to human-induced climate change (Rifai et al., 2019). Variability in rainfall and shifts in planting seasons due to ENSO also have adverse effects on the agricultural sector, particularly food crops. The correlation between El Nino phenomena and decreased rainfall significantly affects the productivity of food crops such as corn and rice, leading to a decline in farmers' income (Malau et al., 2023).

Despite the current relatively low water demand to meet the needs of the domestic and industrial sectors in Indonesia, ranging from 16% to 19%, both the rate and pace of water demand continue to rise in tandem with population growth and economic expansion (Li et al., 2021;Panuju et al., 2013; Kumar Lalit, 2020). Sustainable growth in the rate of water demand for industrial and urban areas is expected to impact the availability of water for the agricultural sector by 2025 (Andini et al., 2020:Das et al., 2015). The escalation of this water demand may exacerbate the situation of agricultural land drought disasters, especially considering that approximately 46% of irrigation infrastructure, or about 3.3 million hectares, is currently in a state of disrepair (Alaerts, 2020). These damaged areas are distributed with 7.5% under central authority, 8.26% under provincial authority, and 30.4% under the jurisdiction of district/city governments. In this context, limited water availability and the deterioration of irrigation infrastructure can increase the risk of drought disasters, with significant impacts on agricultural production and rural economies. It is estimated that the agricultural sector will experience a loss of food production amounting to 350 million tons per year if there are no serious efforts to address the continuous changes in water demand patterns (Shurson et al., 2023; Giordano et al., 2017). The agricultural sector, as a cornerstone of rural economies, requires special protection and attention to address these challenges and continue to contribute positively to food security and the national economy (Aznar-Sánchez et al., 2019; Song et al., 2022).

The surface water demand projections for the major islands in Indonesia in 1990, 2000, 2015, and 2020 indicate an increasing trend in demand across all water user sectors. Java and Bali, contributing 62% of the country's population, exhibit the highest water demand for agricultural, urban, and industrial purposes (Maliva & Missimer, 2012). Meanwhile, the groundwater potential in

Indonesia has become a limited resource capable of supporting only a portion of the water supply needs for urban and rural areas, along with providing irrigation water for highly restricted areas (Fulazzaky, 2014). Apart from the issues related to inter-sectoral water allocation mentioned earlier, a substantial portion of the irrigation systems is also damaged, reaching 46% or approximately 3.3 hectares, contributing to the scarcity of groundwater resources due to drought (Suhardiman, 2018 ; PUPR, 2019). Drought is considered to have a dual and more significant impact compared to other natural disasters, affecting the agricultural sector, water supply and demand, food production, as well as overall social and economic consequences (Nasrudin & Kurniasih, 2021;Zhang et al., 2019). Constraints in water resources, including hydrological aspects, lack of capital, and labor shortages, pose obstacles to adopting additional water usage in agriculture (Santosa et al., 2022). The key to addressing water scarcity lies in improving water productivity in the agricultural production process. This effort involves ensuring that each water droplet can generate higher output to support food security while still providing a water supply for the environment, industrial sector, and urban areas (Clement, 2013; (Syaukat & Siwi, 2009). In addition to the development of more efficient irrigation technologies, solving the issue of water scarcity also requires the economical addition of water for all users of water resources (Cousins, 2013; Levidow et al., 2014).

To meet current food needs without compromising the future environment, agriculture must adopt sustainable principles and efficiently utilize its resources. This strategy, endorsed by the Food and Agriculture Organization (FAO), aims to address global hunger while ensuring ecosystem functionality (Cheng et al., 2018); Tribouillois et al., 2022). The FAO underscores the importance of prioritizing sustainable agricultural production for food, capable of adapting to climate change and drought, to achieve the Sustainable Development Goals (SDGs) by 2030 (FAO, 2018b; FAO, 2019). Preserving and enhancing water availability during agricultural land drought is pivotal, offering sustainable solutions to global challenges and contributing to various SDGs (Ingrao et al., 2023). The sixth SDG specifically targets improving water quality, increasing water-use efficiency, and reducing global water degradation and scarcity, aligning with the objectives of SDG (2), which emphasizes food security, improved nutrition, and sustainable agriculture (Brusseau et al., 2019; Gleick & Cooley, 2021). The Indonesian government has implemented Climate Smart Agriculture (CSA) by launching the Agro Solution program, which is also included in the Paris Agreement. When related to the four dimensions of food security, mitigation efforts through smart farming and CSA can support the dimension of availability (physical availability of food) because these programs encourage increased agricultural productivity (Yulianti, 2023).

The Wukirsari region, situated in the Imogiri and Guwosari districts of Bantul Regency, Yogyakarta, is one of the areas facing agricultural land drought issues due to hydrological conditions with low aquifer productivity (scarce groundwater) with a discharge of less than 2 liters per second (Utomo et al., 2022; Febriarta & Purnama, 2020). The disaster threat index is categorized as high, with a total affected area in Bantul Regency reaching 99.37%, and the population exposure percentage at a high level reaching 99.96% (Hapsari et al., 2020; BNPB, 2016). The biophysical conditions of the Bantul Regency environment have the potential to cause drought (Adam & Rudiarto, 2017; Susmayadi et al., 2014). A considerable area of agricultural land, covering more than 2000 hectares, is at risk of drought due to limited irrigation supply during the dry season (Dabanli, 2018). This has resulted in observed damage to paddy fields reported by the UPTD BPTPH DIY Agriculture Office starting from May 2019, due to a drastic reduction in water, with some areas even drying up (Utomo et al., 2022).

The Sabdodadi region, with a moderate aquifer productivity condition and proximity to Sleman Regency and the city of Yogyakarta, which are the closest to tertiary irrigation channels, tends to have sufficient irrigation water conditions (Sukmawati & Utomo, 2021). This is in contrast to the Wukirsari area, which has a severely limited aquifer productivity (scarce groundwater), posing a threat to water availability for lower-lying agricultural areas (DIKPLHD, 2022). This condition will affect crop production levels, especially rice, planting patterns, and planting intensity between regions. The impact will be felt on the production of food crops and the welfare of farmers. (Adam & Rudiarto, 2017). The economic contribution value of irrigation water in the agricultural production process needs to be studied as a basis for determining supplementary irrigation water pricing (Syaukat & Siwi, 2009;.D'Odorico et al., 2020). Evaluating the sustainability of irrigation water use has been widely recognized over an extended period, given the importance of creating irrigation patterns that can adapt to climate change and regulate the utilization of irrigation water (Radmehr et al., 2022; Kemeze, 2020).

This research focuses on the primary research issues related to supplemental irrigation water, its implications for economic contribution and the value of irrigation water, as well as irrigation water management strategies. The first question investigates the relationship between landform, cropping patterns, planting intensity, and the income levels of farmers in areas characterized by high drought risk (Wukirsari), moderate drought conditions (Guwosari), and regions with water surplus (Sabdodadi). The second question explores the economic contribution value of supplemental irrigation water in influencing the production costs of crop farming enterprises across these three distinct areas and irrigation water management strategy. The third question provides a solution for irrigation water management strategies in drought-prone agricultural lands.

RESEARCH METHODS

This research was conducted in the water surplus agricultural land of Sabdodadi Village, Imogiri Subdistrict, the moderately drought-prone land in Guwosari Village, Pajangan Subdistrict, and the high drought-prone land in Wukirsari Village, Bantul Regency, Special Region of Yogyakarta, Indonesia (Sukmawati & Utomo, 2021; Guo, 2016). The selection of these locations was intentional (purposive) and based on map of drought disasters (DIKPLHD Bantul, 2022) and the more active institutional farming groups. The field research spanned four months, commencing from May 1 to August 27, 2023.

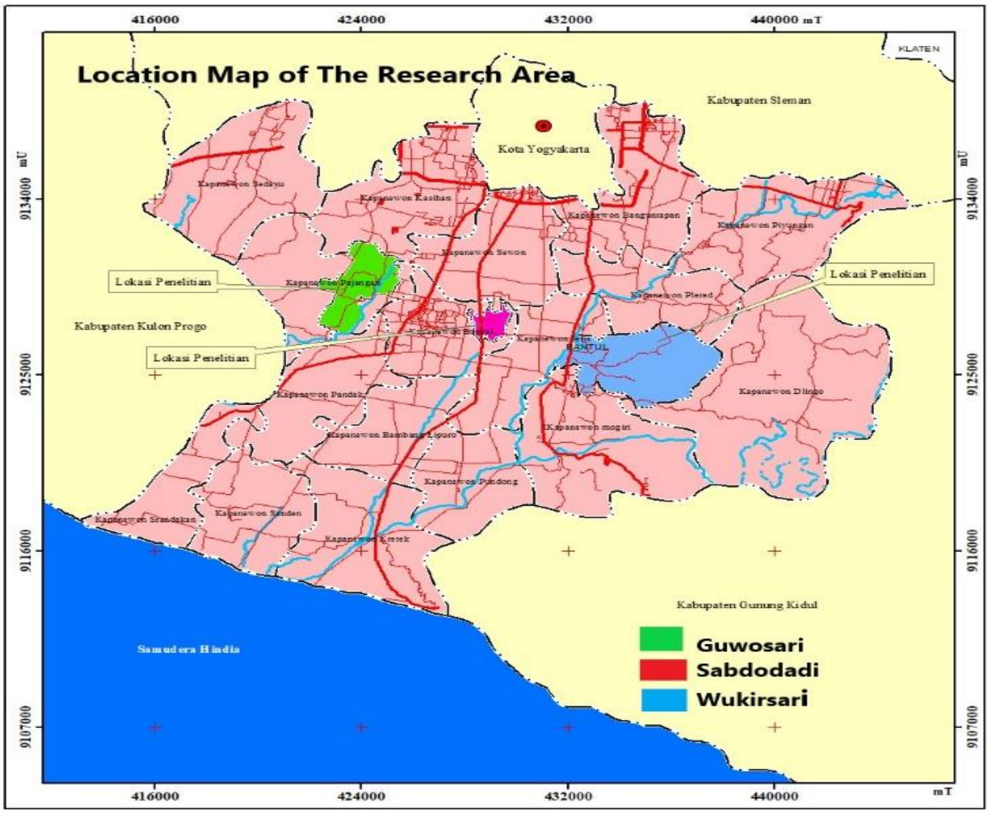

Figure 1. Location Map of the Research Area
Source: Data Analysis (2023)

The farmer sampling framework was purposively determined based on the land location related to drought-prone areas, while the selection of sample farmers was randomly determined (simple random sampling) in these three regions. The selection of sample farmers was carried out using purposive sampling within the group of farmers with more than 10 years of experience in three regions, with a total of 30 sample farmers per village in each drought category (high, moderate, and water surplus), resulting in a total of 90 sample farmers (Qian & Service, 2010). The data used in this research encompass both primary and secondary data. Primary data include population characteristics, farming operation cost data, and interview data from informants. Meanwhile, secondary data include Drought Shapefile Data (Bantul Regional Disaster Management Agency), geological maps, soil types, and Indonesia Basic Topographic Map (RBI). Primary data were obtained through direct interviews with respondents and other informants using a prepared questionnaire. Secondary data were collected from the Department of Agriculture and Food Security of Bantul Regency, the Environmental Department of Bantul Regency, the Agriculture Department of DIY Province, the offices of Sabdodadi, Guwosari, and Wukirsari Villages.

The initial steps involve collecting administrative maps and soil maps in shapefile format (shp). The soil map at a scale of 1:223,454 includes information on soil permeability, soil texture, and landforms. Subsequently, an identification of attributes or columns in the SHP data reflecting various types of information is conducted (B. Chen et al., 2015). The data processing is carried out using GIS (Geographic Information System) software such as ArcGIS v8 (Schmidt et al., 2018). To obtain these maps, a "clip" process is performed on the shp data, resulting in the soil map of Bantul

Regency at a scale of 1:20,000 (Khan et al., 2022). This data is obtained from the Agricultural Technology Assessment and Development Agency (BPTP) Yogyakarta Province.

The cropping pattern undertaken by farmers in each drought-prone area pertains to the types of crops planted during the observation period (Nugroho & Nuraini, 2016; Clarke, 1989). Planting intensity is measured based on how many times the land is cultivated in one year calculated by the formula:

$$\mathrm{IT}=\frac{\sum_{i=1}^{n} Pi}{T}\ x\ 100\%$$

Where IT is the Planting Intensity, Pi is the cultivated area in the i-th planting season, T is the total land area, and i is the planting season index, where i=1,2,3 (rainy season I, rainy season II, and dry season)(Fan et al., 2022; Bharathkumar & Mohammed-Aslam, 2015). The method used to assess the economic value of supplementary irrigation water in the agricultural cultivation of food crops on various types of drought-prone lands employs the Residual Imputation Approach (RIA) framework (Syaukat & Siwi, 2009), which refers to the concept of the Product Exhaustion Theorem (Young & Loomis, 2014; Meyerhoff et al., 2014). In the production process of food crop farming, which involves four primary inputs capital (K), labor (L), natural resources (R), and supplementary irrigation water (W) the production function is as follows.

$$\mathrm{Y = f(K, L, R,W)}$$

Assuming perfect competition in input and output markets, with constant prices, the total product value (TV P_Y) can be calculated as the sum of the marginal product values (VMP) of each input multiplied by the corresponding input quantities:

$$Y\ P_Y = VMP_K\ X_K + VMP_L X_L + VMP_R X_R + VMP_W\ X_W$$

Here, Yis the total product, PY is the price per unit of the product, XiXi represents the quantity of input, and VMPi denotes the marginal product value of input i. With the objective of maximizing revenue (R) while considering budget constraints (C), the first-order condition states that the price of input ii must equal the marginal product value derived from using that input (Pi=VMPi) (Saepudin & Amalia, 2022; Yang et al., 2020). Utilizing this equation, the economic value contribution of irrigation water (PW·XW) can be computed as the difference between the total product value and the costs associated with other input usages:

$$P_W\ X_X = Y\ P_Y - (P_K X_L + P_L X_L + P_R\ X_R)$$

In essence, the economic value of water is determined by the disparity between the total product value and the costs of utilizing other inputs (Marchant, 2006). If the cost of supplementary irrigation water usage (XW) for a specific crop season is known, the shadow price of supplementary irrigation water (PW∗) can be estimated using the formula:

$$P^{*}{}_W = Y\ P_Y - (P_K X_L + P_L X_L + P_R\ X_{R)}$$

RESULT AND DISCUSSION

Landforms in Agricultural Areas

The landforms in the water surplus research area (Sabdodadi) as a whole consist of volcanic plains. These volcanic plains exhibit relatively good drainage and gentle slope gradients. Flat landforms are essential for controlling the permeation of both surface and subsurface water within a specific region. The even terrain of flat slopes has a tendency to channel water towards the lower areas, resulting in a direct downward flow and the pooling of water in those regions (Fan et al., 2019). This process may lead to the development of hydrostatic pressure, wherein the accumulated water applies pressure to the layers beneath the soil surface. On flat slopes, the efficiency of water infiltration may not be as pronounced compared to steeper slopes. As a consequence, flat slopes can give rise to circumstances where surface water is more prone to concentration rather than seeping into the soil (Yang et al., 2020; Hokanson et al., 2019). This characteristic enables flat slopes to receive water supply from upstream areas, enhancing water retention in the soil (J. Zhang et al., 2017).

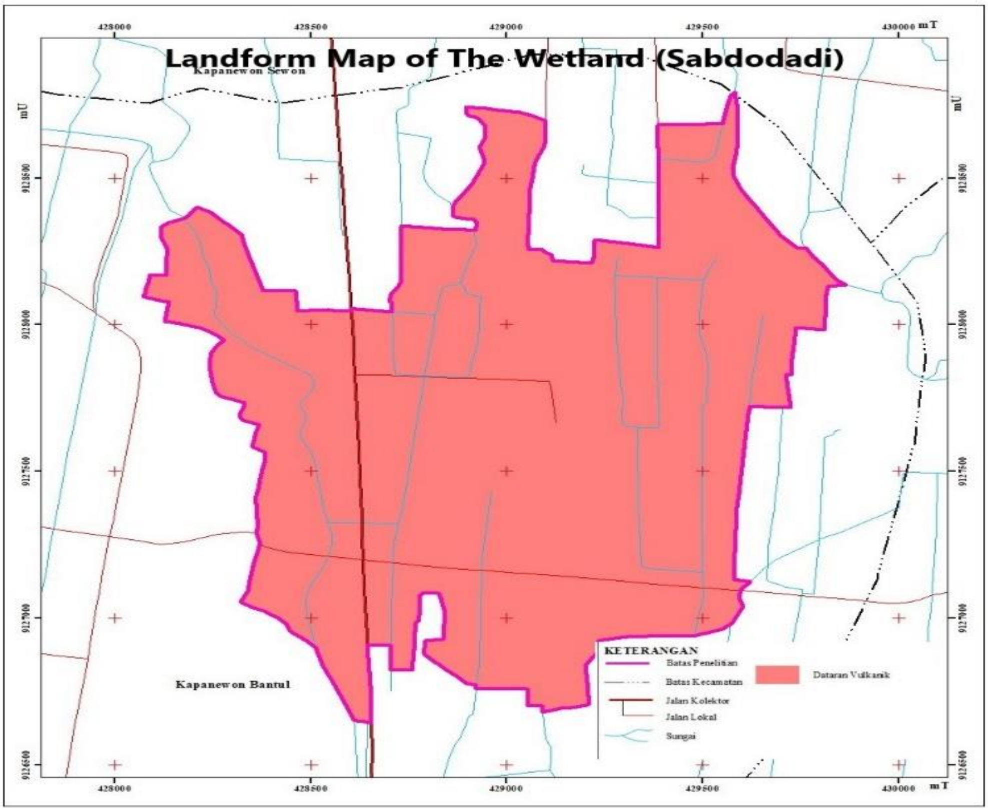

Figure 2. Landform Map of the Wetland (Sabdodadi)
Source: Data Analysis (2023)

The landforms in the moderate fringe area (Guwosari) encompass plains extending to ploso with varying slopes ranging from undulating to moderately steep. These diverse landforms tend to have a slightly lower level of drought. Meanwhile, high drought lands (Wukirsari) are dominated by mountainous and folded hilly terrains, including folded mountains, folded hills, uplifted hills, monoclinal hills, fault gorges, alluvial plains, and inter-hill valleys. The slope gradient is closely related to the ability of rainwater to infiltrate into the soil. The availability of water is generally influenced by geomorphological factors. (Y. Chen et al., 2016).

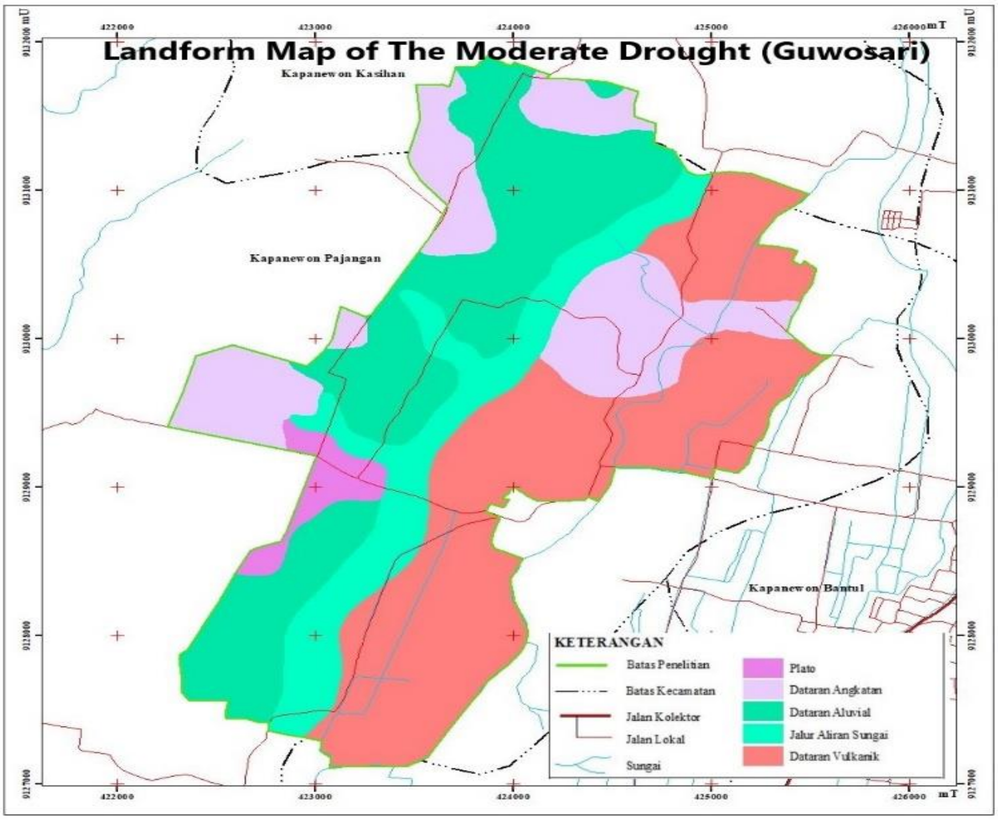

Figure 3. Landform Map of the Moderate Drought (Guwosari)
Source: Data Analysis (2023)

The volcanic plains fall into the category of low drought vulnerability, often characterized by clayey textures and clumped to rounded clump structures in the soil (Istadi & Gernowo, 2023). The hydrogeology of the Sabdodadi and Guwosari regions falls within the category of moderate productivity aquifer zones, with water discharge ranging from less than 5 liters per second. In contrast, the hydrogeology of the Wukirsari area is classified as a region with scarce groundwater resources, characterized by severely limited aquifer capacity, water discharge of less than 2 liters per second, and relatively deep groundwater levels (DIKPLHD, 2022). Research findings by Purnomo (2016) indicate that water on flat terrain has a greater capacity to infiltrate the soil compared to steep terrain. The influence of steep slopes is highly significant in the context of water availability and drought potential. With steep inclinations, rainwater tends to rapidly flow downward without proper infiltration, leading to potential water loss through surface runoff and an increased risk of drought (Factors et al., 1982). Moreover, steep slopes are susceptible to surface erosion as strong water flow can transport soil along with water, reducing the fertility of the soil layer capable of retaining water. Consequently, the availability of groundwater may be hindered, affecting the soil's ability to support plant growth or meet domestic water needs (Wu et al., 2021).

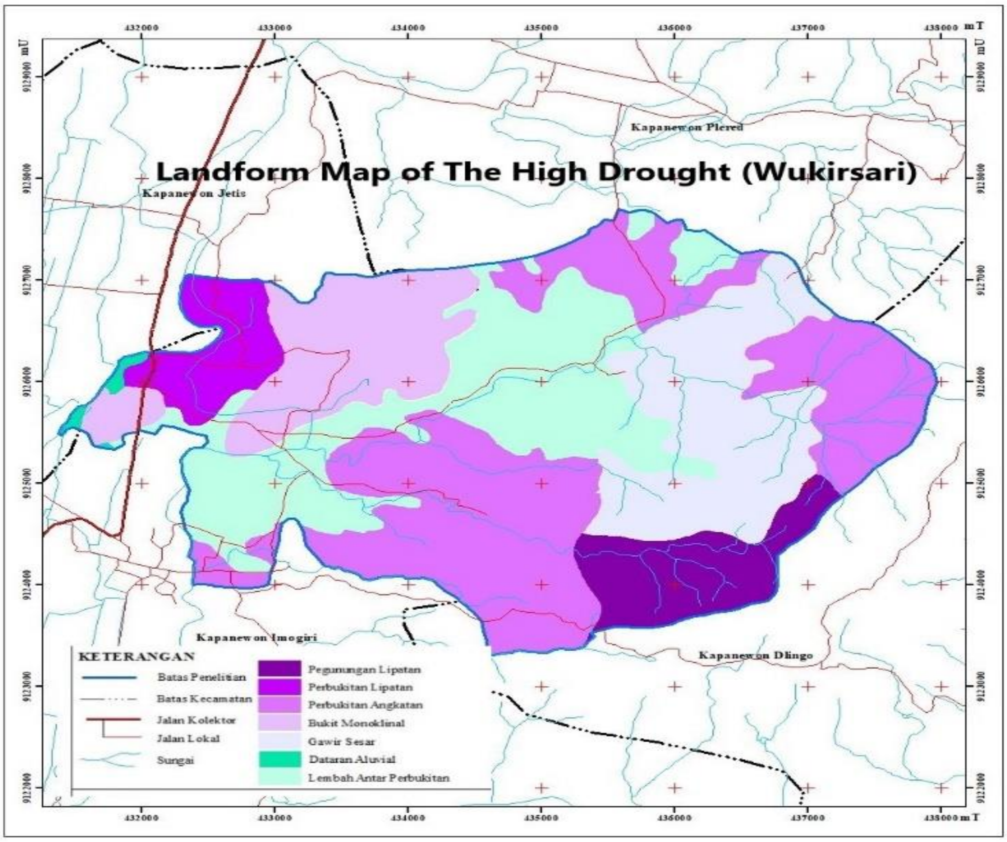

Figure 4. Landform Map of the High Drought (Wukirsari)
Source: Data Analysis (2023)

Cropping Patterns and Planting Intensity

The cropping patterns for staple crops in wetlands (Sabdodadi), areas with moderate drought (Guwosari), and areas with high drought (Wukirsari) exhibit significant variations influenced by seasons and rainfall patterns (Paat et al., 2021). Farmers in Sabdodadi and Guwosari tend to cultivate rice during the first and second seasons, shifting to corn during the third season (Mishra et al., 2021). This is due to the availability of sufficient irrigation water in Sabdodadi to cultivate rice twice a year, requiring an adequate supply of irrigation water. On the other hand, farmers in the highly drought-prone Wukirsari region only cultivate rice during the first season, completely transitioning to other crops in the second and third seasons due to inadequate water supply (Urfels et al., 2020). The adaptation strategy of Wukirsari farmers to insufficient irrigation water supply is implemented by changing the cropping pattern. In the second and third planting seasons, there is a shift from (corn, peanuts, and green beans) to (corn and peanuts) as these crops tend to be more resistant to limited water supply (Anshori & Suswatiningsih, 2022). Variations in planting schedules are influenced by factors such as the availability of additional irrigation water and the characteristics of agricultural land. Essentially, agricultural lands in Sabdodadi and Guwosari have sufficiently abundant water supplies, allowing for rice cultivation twice a year (Ruslanjari et al., 2017). On the contrary, Wukirsari faces challenges in accessing additional irrigation water, and land characteristics limit them to cultivating rice only in the first season. The implications of differences in cropping patterns and the availability of water resources have an impact on the income disparities among farmers in these three regions.

Table 1. Cropping Pattern Conditions in Area

Description	Planting Session		
	Session I	**Session II**	**Session III**
Planting Time	**December 2022 - March 2023**	**April - July 2023**	**August 2022 - November 2022**
Wetland (Sabdodadi)	Rice	Rice	Corn, Peanuts
Moderate Drought (Guwosari)	Rice	Rice	Corn Peanuts
Hight Drought (Wukirsari)	Rice	Corn, Peanuts, Mung Beans	Corn Peanuts

Source: Data Analysis (2023)

Demographic analysis of farmers in wetland areas (Sabdodadi), moderately drought lands (Guwosari), and highly drought lands (Wukirsari) reveal significant differences in characteristics. Generally, the age distribution of farmers in Sabdodadi indicates a majority below 50 years old, comprising 34% of the total population. Conversely, farmers in Guwosari and Wukirsari tend to fall within the 50-65 age group, reaching 63% and 47%, respectively. There is also variation in educational levels, where the majority of farmers have elementary school education (Berni et al., 2021; Tatis Diaz et al., 2022). Meanwhile, concerning family dependents, most farmers have 2-3 dependents, with a significant proportion in all three regions. The analysis also highlights that the majority of farmers have farming experience ranging from 20-35 years, indicating sustainability and extensive knowledge in agricultural activities.

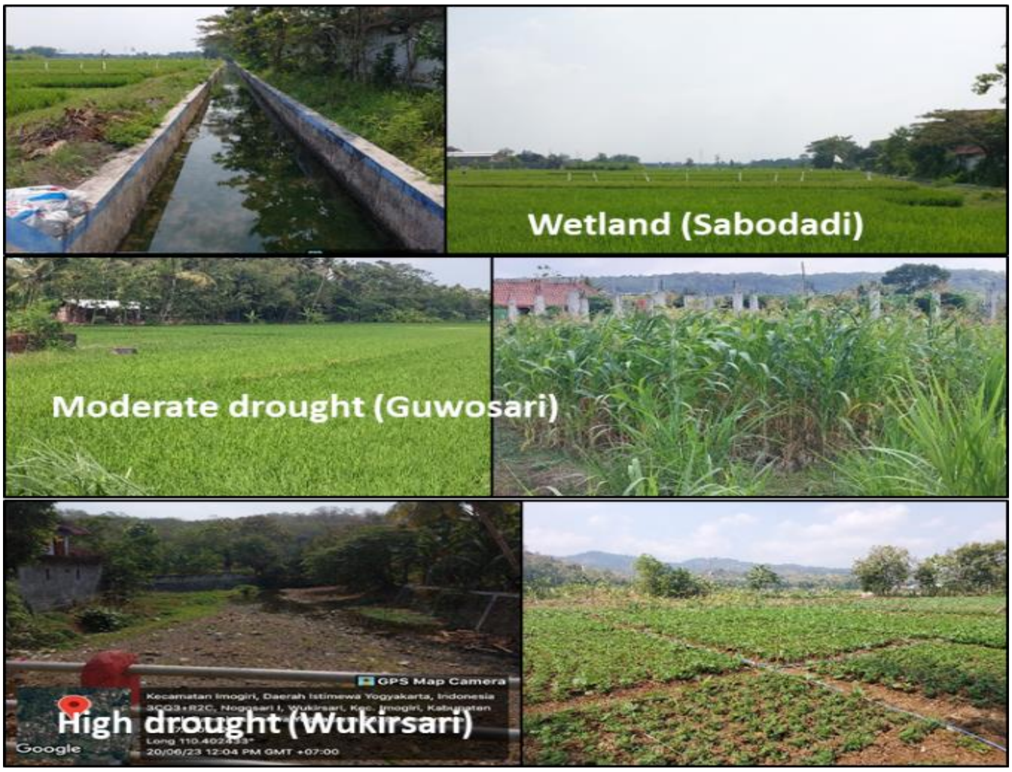

Figure 5. The Existing Agriculture
Source: Data Analysis (2023)

Distribution of younger farmers in Sabdodadi, especially those under 50 years old, may reflect an inclination towards adopting more modern and sustainable farming methods. Conversely, in Guwosari and Wukirsari, where the majority of farmers are aged 50-65, longer farming experience might be a key factor in determining agricultural strategies. Education levels also play a crucial role in agricultural management, as farmers with elementary education may require different approaches and training to implement sustainable farming practices. Extensive farming experience, particularly in Sabdodadi, reflects knowledge and skills passed down through generations, supporting adaptation to fluctuating agricultural conditions due to climate change, such as prolonged dry seasons.

Table 2. The Characteristics of Farmers

Characteristics of Farmers	Sabdodadi		Guwosari		Wukirsari	
	People	%	People	%	People	%
Age						
<50 years	10	34	5	17	14	47
50 - 65 years	19	63	14	47	14	47
>65 years	1	3	11	36	2	6
Education						
Elementary	19	64	18	60	20	67
Junior High	9	30	5	17	7	23
Senior High	2	6	7	23	3	10
Family Dependents						
<2 people	8	27	8	27	10	33
2 - 3 people	21	70	19	63	20	67
>3 people	1	3	3	10	0	0
Farming Experience						
<20 years	7	23	4	13	8	27
20-35 years	17	57	21	70	20	67
>35 years	6	20	5	17	2	6
Land Area						
>0,25 Ha	19	63	17	57	20	67
0,25 - 0,5 Ha	6	20	13	43	7	23
>0,5 Ha	5	17	0	0	3	10
Land Ownership Status						
Owner	27	90	28	93	25	83
Tenant	3	10	2	7	5	17

Source: Data Analysis (2023)

The planting intensity per year in the Sabdodadi region reaches 294.36%. This reflects the reality that during the first and second planting seasons, all the land is available for rice cultivation. Only during the third planting season is there a decrease in cultivated land by 0.470 hectares, with a planting intensity of 94.36%. In the Guwosari region, the total planting intensity reaches 284.67% because around 1.01 hectares of land are provided by its owners during the third planting season. On the other hand, in the Wukirsari region, the planting intensity per year only reaches 247.89%. This is due to the presence of 1.50 hectares of land (19%) and 2.58 hectares of land (33%) that are unused or provided during the third planting season. The difference in planting intensity is mainly caused by issues of insufficient availability of additional irrigation water supply (Gharsallah et al., 2023). This condition arises from accessibility constraints faced by farmers in the Wukirsari region in obtaining water supply. It is triggered by the drying conditions of the paddy irrigation system and the shallow groundwater conditions, necessitating the use of bore wells as an alternative solution to access water resources (Gopalakrishnan & Kumar, 2020; Gilardi et al., 2023).

Table 3. Raw Area, Cultivated Area, and Planting Intensity of the Research Area

Description	Planting Session		
	Session I	Session II	Session III
Sabdodadi			
Standard Area (Ha)	8.33	8.33	8.33
Cultivated Area (Ha)	8.33	8.33	7.86
Intensity (%)	100%	100%	94.36%
Guwosari			
Standard Area (Ha)	6.58	6.588	6.58
Cultivated Area (Ha)	6.58	6.588	5.58
Intensity (%)	100%	100%	84.70%
Wukirsari			
Standard Area (Ha)	7.83	7.83	7.83
Cultivated Area (Ha)	7.83	6.33	5.25
Intensity (%)	100%	80.84%	67.05%

Source: Data Analysis (2023)

Revenue From the Business of Food Crop Farming

The average income of rice farming enterprises per hectare exhibits variation across regions and seasons. Table 4 illustrates significant variability in production and income among seasons and regions at different drought levels. Generally, farmers in the irrigation water surplus area (Sabdodadi) experience the highest total annual income due to (1) elevated planting patterns and planting intensity, (2) greater production per hectare (productivity), and (3) reduced irrigation costs. The income levels of farmers in the moderately drought-prone area (Guwosari) are relatively similar to those of farmers in the Sabdodadi area (Partridge et al., 2023). However, the income levels of farmers in the highly drought-prone area (Wukirsari) are the lowest, attributed to additional supplementary irrigation costs and reduced planting areas caused by drought (Fleming-Muñoz et al., 2023). This can be observed from the amount of expenditure on supplementary irrigation costs in Wukirsari, reaching 29%, or approximately Rp 1,220,190 per hectare. Income variations across regions and seasons, coupled with the dependence on supplementary irrigation as a response to drought affecting soil health, are intricately linked to endeavors in climate change mitigation and adaptation, as well as sustainable terrestrial life as mandated by SDG 13 (Climate Action) and SDG 15 (Life on Land) (Telo da Gama, 2023).

Table 4. The Average Agricultural Crop Enterprise Revenue Per Hectare for Each Planting

Area	Planting Session			Total Income (Rp/Years)
	Session I (Rp/Ha)	Session II (Rp/Ha)	Session III (Rp/Ha)	
Sabdodadi (Wetland)	24,701,543	25,102,013	27,109,415	76,912,971
Guwosari (Moderate Drought)	24,668,928	24,811,422	27,458,602	76,938,952
Guwosari (High Drought)	24,628,065	24,992,180	24,428,190	74,048,435

Source: Data Analysis (2023)

Production Costs and Income from Agricultural Crop Farming

As mentioned above, agricultural inputs are classified as capital (K), labor (L), other resources - such as land (R), and supplementary irrigation water (W). Capital inputs include: tractor rental and the costs of equipment maintenance and depreciation; labor inputs include: costs of family and non-family labor; other resources include: production facilities (seeds, fertilizers, and medicines, land use, as well as cash costs of farming such as land taxes. The cost of using supplementary irrigation water is intentionally not considered, as it is needed to determine the economic contribution of supplementary irrigation water in crop production (supplementary water value) (Kane et al., 2019). Production cost data for rice farming in each irrigation area is generally presented in Table 5. From this table, it is apparent that the average costs incurred by farmers in each planting season in the three areas do not differ significantly. In the cost calculations, land rental and other costs are taken into account each season (Aydogdu & Bilgic, 2016). From Table 5, it is evident that the overall total cost per hectare is slightly higher (8.35%) in the Wukirsari area compared to the Sabdodadi area, while production costs in the Sabdodadi area are 7.8% lower than farming costs in the Guwosari area.

Tabel 5. Agricultural Business Income per Hectare

Description	**Planting Session**			**Total Income (Rp/Ha/ Years)**
	Session I (Rp/Ha)	**Session II (Rp/Ha)**	**Session II (Rp/Ha)**	
Sabdodadi (Wetland)				
Cash Income	14,977,762	15,426,811	15,518,964	45,923,537
Total Income	11,255,068	11,730,288	12,918,704	35,904,060
Guwosari (Moderate Drought)				
Cash Income	13,631,050	12,989,606	15,778,358	42,399,014
Total Income	10,197,376	9,834,317	12,471,248	32,502,941
Guwosari (High Drought)				
Cash Income	13,770,359	15,040,709	14,778,346	43,589,414
Total Income	9,872,747	10,901,436	10,549,184	31,323,367

The data presented in Table 5 illustrates the fluctuations in cash income and total income per hectare across three planting sessions. The wetland area, Sabdodadi, stands out with the highest cash income, reaching Rp 15,518,964 in the second planting session and contributing to a total income of Rp 12,918,704. In contrast, the high-drought region, Guwosari, exhibits the lowest figures, with cash income of Rp 14,778,346 and a total income of Rp 10,549,184 during the same period. These variations are attributed to the challenges faced by farmers in Wukirsari during the third planting season, resulting in increased production costs for supplementary irrigation due to the drought in the primary irrigation system (Okada et al., 2018). Furthermore, income disparity is also influenced by production factors and the prices of food crops. Regions with sufficient water availability are capable of cultivating rice 2-3 times a year, as rice commands higher and relatively stable prices compared to other food crops. The detailed figures underscore the impact of environmental conditions on agricultural income, emphasizing the significance of localized factors in assessing the economic performance of crop farming enterprises (Medellín-Azuara et al., 2022). Farmers need to have the ability to access credit to support capital expenditures and receive agricultural education. This indicates that overcoming constraints to achieving higher profitability is a challenge that is not only related to agronomic aspects but also involves socioeconomic considerations.

Table 6. Production Costs of Agricultural Crop Farming on Various Types of Drought

Description	**Planting Session**		
	Session I	**Session II**	**Session II**

	(Rp/Ha)	**(Rp/Ha)**	**(Rp/Ha)**
Sabdodadi (Wetland)			
Cash Cost	9,723,781	9,675,202	11,590,451
Non-Cash Cost	3,722,694	3,696,523	2,600,260
Total Cost	13,446,475	13,371,725	14,190,711
Guwosari (Moderate Drought)			
Cash Cost	11,037,878	11,821,816	11,698,165
Non-Cash Cost	3,433,673	3,155,289	3,331,483
Total Cost	14,471,552	14,977,105	15,029,648
Wukirsari (High Drought)			
Cash Cost	10,857,706	10,951,471	10,671,432
Non-Cash Cost	3,897,612	4,139,273	4,229,162
Total Cost	14,755,318	15,090,744	14,900,594

Source: Data Analysis (2023)

Economic Contribution of Supplementary Irrigation Water

The detailed analysis of agricultural business data reveals significant variations in revenue, total production costs, and the economic contribution of supplementary irrigation water across different planting sessions and regions. In Sabdodadi the revenue for Session II amounts to Rp 27,109,415, with total production costs at Rp 14,190,711 and supplementary water costs at Rp 1,179,720, contributing 10.18% to the total costs. Guwosari, experiencing a moderate drought, exhibits a similar pattern, with revenue reaching Rp 27,458,602 in Session II. However, the supplementary water costs contribute significantly, ranging from 4.97% to 11.28% of total costs. In Guwosari under high drought conditions, the revenue for Session II is Rp 24,428,190, with supplementary water costs reaching Rp 1,220,190 and contributing 11.43% to total costs. Deducting total costs from total revenue provides the average economic contribution of irrigation water per hectare in each irrigation area, as presented in Table 7.

Tabel 7. The Average Economic Contribution Value of Water Per Hectare Per Planting Season

Description	**Planting Session**			**Total (Rp/Ha/ Years)**
	Session I (Rp/Ha)	**Session II (Rp/Ha)**	**Session II (Rp/Ha)**	
Sabdodadi (Wetland)				
Revenue	24,701,543	25,102,013	27,109,415	76,912,971
Total Cost Production	13,446,475	13,371,725	14,190,711	41,008,911
Supplementary water	387,107	564,771	1,179,720	2,131,598
Supplementary water (%)	3.98	5.84	10.18	20.00
Guwosari (Moderate Drought)				
Revenue	24,668,928	24,811,422	27,458,602	76,938,952
Total Cost Production	14,471,552	14,977,105	15,029,648	44,478,305
Supplementary water	548,988	1,332,927	1,037,032	2,918,947
Supplementary water (%)	4.97	11.28	8.86	25.11
Wukirsari (High Drought)				
Revenue	24,628,065	24,992,180	24,428,190	74,048,435
Total Cost Production	14,755,318	15,090,744	14,900,594	44,746,656
Supplementary water	721,563	1,212,284	1,220,190	3,154,037
Supplementary water (%)	6.65	11.07	11.43	29.11

Source: Data Analysis (2023)

The data indicates that the average water rent in the high-drought area (Wukirsari) is remarkably high, constituting 29.11% of the total annual production costs for crop farming (Adeoti & Fati, 2022; Liu et al., 2023;.Klein et al., 2012). This observation suggests that the economic contribution of supplementary irrigation water in the high-drought area of Wukirsari surpasses that of Sabdodadi and Guwosari. The substantial supplementary irrigation costs, ranging from Rp 387,107 to Rp 1,220,190 per hectare per planting season, underscore the significant economic impact of supplementary irrigation water in crop production. The results of the valuation of supplementary irrigation water can serve as a reference in the field to determine the maximum tariff/price for irrigation water that farmers should pay, based on their water needs per season (Upadhyaya et al., 2023; Venot et al., 2007). The calculations also reveal that the area with high drought conditions in Wukirsari Village incurs relatively higher supplementary irrigation costs compared to other areas, indicating the potential for higher irrigation fees in comparison to others (Jiang et al., 2022). Farmers in Wukirsari, facing challenges particularly during the onset of the third planting season (dry season), where to meet the water requirements in agricultural production, farmers need to acquire additional irrigation water through purchasing, which is sold at a price of Rp. 110,000 for every 2 m^3.

Irrigation Water Management Strategy

Irrigation water is still frequently regarded as a free resource by farmers, allowing its utilization without constraints. Such a perspective, however, poses challenges for farmers in areas with high levels of drought, particularly those situated farther away from water sources, including in Bantul Regency. Conflicts over the use of irrigation water among farmers in regions with varying levels of land drought vulnerability are often encountered in various Irrigation Areas in Indonesia (Arifah et al., 2022). According to the results of interviews with irrigation water distribution officials, calculations of water requirements based on the irrigated land area have been conducted before the distribution of irrigation water to secondary channels (which will subsequently flow to tertiary and quarter channels) in these three regions. The standard limit for the quantity of water is set at 1.2 liters per second per hectare. Nevertheless, field conditions often experience water shortages, especially in high-drought areas such as Wukirsari.

Farmers in Wukirsari in the past adopted a strategy for the use of irrigation water based on the belief that this water resource could be utilized freely without considering the costs. However, with the increasing awareness of water limitations, especially during the dry season, and worsening drought conditions, this strategy became unsustainable. Farmers then recognized that a deep understanding of the value of additional irrigation water and active participation in water resource management are crucial to ensure the sustainability of agricultural production. The practice of rainwater harvesting, although adopted by some farmers, serves as a tangible example of a shift in awareness regarding the importance of the value of irrigation water, even though it still does not fully meet the water supply needs for agricultural production. Nevertheless, such initiatives indicate positive changes in water management strategies and farmers' awareness of the increasingly complex environmental challenges.

The existence and activities of the Farmers Water Users Association (P3A) are crucial for increasing farmers' awareness that their contributions are highly necessary in maintaining the sustainability of irrigation water distribution to their fields. However, existing P3As seem inactive, serving more as formalities. A majority of respondent farmers (52%) do not comprehend the existence of the Water Usage Fee (IPAIR), resulting in practical non-payment for the water they use. Therefore, efficiency and fairness in the use of irrigation water are unlikely to be achieved without active efforts from local P3A organizations. Several strategic implications can be proposed to address this issue, commencing from now, namely: (1) establishing irrigation water usage tariffs that vary according to the level of drought vulnerability; (2) determining the irrigation water tariff values based on the irrigated land area, applicable throughout each planting season; (3) enhancing infrastructure, including boreholes and supporting facilities (EDB, 2023). The implementation of water tariffs and the development of irrigation infrastructure are anticipated to empower farmers to participate in year-round production, even if they do not necessarily cultivate rice in every planting season (Ahmadov, 2020). To achieve the Sustainable Development Goals (SDGs) by 2030, initiatives that can be undertaken include water and food conservation practices, the development of drought-resistant plant and animal varieties, as well as the implementation of sustainable land and water management practices such as water recycling, reservoir construction, forest engineering, greening, and efficient water use in agriculture, such as drip irrigation (Tabari & Willems, 2023).

CONCLUSION AND SUGGESTION

The landforms in Sabdodadi (Wetland), Guwosari (Moderate Drought), and Wukirsari (High Drought) exhibit diverse characteristics, impacting water availability and drainage. Sabdodadi's volcanic plains with good drainage facilitate water retention, while Guwosari's undulating plains experience a slightly lower level of drought. Wukirsari's mountainous terrain poses challenges, limiting rice cultivation to the first season. This highlights the influence of landforms on water availability and cropping patterns. Cropping patterns vary across wetland, moderate drought, and high drought areas, influenced by water availability. Farmers in Sabdodadi and Guwosari cultivate rice twice a year, shifting to other crops in the third season. Wukirsari, facing water scarcity, only cultivates rice in the first season. Demographic analysis reveals differences in age, education, family dependents, and farming experience among farmers in these regions. Accessibility issues in Wukirsari impact planting intensity and necessitate alternative water sources. Economic variations are observed in revenue, production costs, and the economic contribution of supplementary irrigation water. Sabdodadi achieves the highest income due to favorable conditions, while Wukirsari faces challenges, resulting in lower income. Supplementary irrigation in Wukirsari significantly contributes, reaching 29.11% of total production costs. The shadow price of irrigation water in high drought areas is also higher compared to values in moderate and low drought regions. There is a need for setting irrigation tariff rates according to agricultural land area, enhancing irrigation infrastructure, reactivating the role of farmer groups, and promoting water conservation practices and the development of drought-resistant crop varieties. These steps are expected to improve efficiency and fairness in irrigation water use, support sustainable agriculture, and contribute to achieving the Sustainable Development Goals (SDGs) by 2030.

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