Indonesian Journal of Agriculture and Environmental Analytics (IJAEA)
Vol. 5, No. 1, 2026: 39-48

Water Accounting in Improving Irrigation Efficiency and Farmers' Income Amid Limited Water Access in North Gorontalo City

Zulkifli Bokiu[1*], Eduart Wolok[2], Hasyim[3], Sahmin Noholo[4]
Gorontalo State University, Indonesia

ABSTRACT: This study aims to analyze the application of water accounting in supporting agricultural sustainability in North Gorontalo City, focusing on the issue of limited access to irrigation water faced by farmers. The scope of the research includes difficulties in obtaining water from irrigation channels due to sub optimal infrastructure, forcing farmers to rely on groundwater pumped at high cost. This condition directly increases production expenses and reduces farmers' income. The study employs a descriptive qualitative approach, with data collected through field observations and in-depth interviews with farmers, irrigation managers, and relevant government officials. The collected data were analyzed thematically to identify the root causes and potential solutions for more efficient water management. The findings indicate that farmers urgently need a stable supply of water from irrigation channels to maintain crop productivity, particularly rice. The operational costs of groundwater pumping were proven to reduce farmers' profit margins. Furthermore, there has been insufficient attention and no concrete steps from the local government to repair irrigation channels or provide alternative solutions. This study highlights the need for implementing a water accounting system as a basis for planning efficient water management, as well as encouraging active collaboration between the government and farmers to achieve sustainable agriculture.

Keywords: Water Accounting, Irrigation, Groundwater, Production Costs, Sustainable Agriculture

Submitted: 24-11-2025; Revised: 30-12-2025; Accepted: 26-01-2026

*Corresponding Author: zulkiflibokiu@ung.ac.id
DOI: https://doi.org/10.55927/ijaea.v5i1.15773
https://journal.formosapublisher.org/index.php/ijaea

INTRODUCTION

Food security is one of the crucial issues that has consistently become a main priority in Indonesia's national development agenda. In efforts to achieve food security, the agricultural sector plays a vital role, especially in meeting the needs of a growing population through increased food production. Farmers' support is essential to ensure the success of government programs aimed at boosting food production, as they are the frontline actors in producing agricultural commodities, particularly staple crops such as rice, corn, and vegetables. However, to achieve these goals, farmers face various challenges in obtaining water as a vital natural resource for crop cultivation (Renaldo et al., 2024).

In many regions, the main problem faced by farmers is difficulty accessing water from existing irrigation channels. Water is an inseparable component of agricultural activities, especially for irrigating rice crops, which require a continuous and adequate supply of water (Pratama et al., 2024). However, irrigation channels do not always function properly, and water distribution issues have become one of the leading causes of declining agricultural production. The problem is not only limited to the poor quality and insufficient quantity of available water, but also involves the disrupted continuity of water distribution. Irregular inflow and outflow of water in irrigation channels make it difficult for farmers to regulate water needs in a timely manner for their crops (K. Jonathan E. et al., 2022).

On the other hand, although many farmers have begun relying on groundwater as an alternative source for irrigation, extracting groundwater through pumping leads to significantly higher operational costs (Anshori et al., 2025), compared to using water from irrigation channels, which is cheaper and more accessible. Pumping groundwater requires electricity costs, pump maintenance, and other operational expenses that directly burden farmers. As a result, farmers often find themselves in a dilemma between the high cost of pumping and the urgent need to ensure their crops' survival (Susrusa et al., 2023).

However, the issue does not stop at limited and costly water access. The rapid development of residential areas and infrastructure around agricultural land has also caused negative impacts on the quality of irrigation water. Poorly managed household waste often flows into irrigation canals or directly contaminates agricultural land (Koul et al., 2022), thereby degrading the quality of water used by farmers (Singh, 2021). The impacts of household waste, aside from contaminating water, also disrupt plant growth because chemical substances and other pollutants can damage soil structure and reduce soil fertility.

This phenomenon further exacerbates the condition of agricultural production, particularly rice cultivation, which heavily depends on sufficient water quality and quantity. Ideally, existing irrigation channels should serve as the primary solution in ensuring smooth water distribution and minimizing farmers' reliance on expensive groundwater (Khafid et al., 2024). However, the lack of attention and concrete efforts from the government to address these issues has left farmers increasingly struggling to meet adequate water needs to support sustainable agricultural production.

Thus, to achieve optimal food security, it is crucial for the government to address the water access problems faced by farmers. Food security programs cannot run effectively without adequate and well-managed water availability. Therefore, this study aims to explore and analyze the challenges faced by farmers regarding irrigation water access and the impacts of household waste on agriculture, as well as to identify more efficient solutions for water resource management to support sustainable agricultural production (Ferreira et al., 2023).

THEORETICAL REVIEW

Limited access to irrigation water is one of the major problems faced by farmers. Several factors contribute to this issue, including inefficient irrigation systems, damaged irrigation infrastructure, and uneven water distribution across agricultural areas. The decline in water quality can also occur due to pollution from industrial activities and the rapid urbanization surrounding agricultural regions (Pondaag et al., 2023).

The sustainability of agricultural production can be disrupted if farmers are forced to rely on groundwater as a substitute for irrigation, which ultimately increases operational costs (Anshori et al., 2025). The use of groundwater pumps requires additional expenses for maintenance and high energy consumption (Khafid et al., 2024), while these high operational costs are often unaffordable for most farmers, particularly smallholder farmers.

Water accounting is an approach used to monitor and manage the use of water resources in agricultural production. In this context, proper water accounting can help farmers manage water use more efficiently, reduce waste, and enhance agricultural sustainability. This approach can lead to cost savings and more efficient utilization of water resources (Ferreira et al., 2023).

Rapid urbanization in areas surrounding agricultural land has a negative impact on the quality of water used for irrigation (Patimah et al., 2022). As population growth and housing developments expand, household waste—such as chemicals, detergents, plastics, and organic waste—is often discharged into water channels that are also used for irrigation. This waste can contaminate the water used by farmers, deteriorating water quality and disrupting soil ecosystem balance, which in turn affects plant growth. Water pollution caused by household waste can decrease irrigation water quality and damage agricultural productivity.

Addressing these issues requires a comprehensive approach, including the improvement of irrigation infrastructure(FAO, 2020). The government needs to integrate sustainable water management policies into food security programs by prioritizing the maintenance and rehabilitation of existing irrigation channels, as well as introducing new technologies that can increase water-use efficiency (Ferreira et al., 2023). Therefore, it is essential to develop a water accounting system that can assist farmers in managing water use more efficiently (Ferreira et al., 2023). Additionally, government policies that support the improvement of irrigation infrastructure and the management of household waste are crucial to creating a conducive environment for sustainable agriculture. This study is

expected to contribute to the implementation of water accounting as a basis for efficient water management planning and the realization of sustainable agriculture in North Gorontalo City.

METHODOLOGY

The research method used in this study aims to identify and analyze the challenges faced by farmers in North Gorontalo City related to access to irrigation water, the use of groundwater, and the impact of household waste on water quality. By employing an integrated qualitative and quantitative approach, this study is intended to provide a comprehensive solution and effective policy recommendations to enhance agricultural sustainability in the region.

This study employs a qualitative approach with a case study design to obtain an in-depth understanding of agricultural water resource management in North Gorontalo City. The research location was selected purposively because it represents the issues of limited access to irrigation water, farmers' reliance on groundwater (Rejekiningrum et al., 2022) which increases operational costs, and the rising pollution caused by household waste along with urbanization. Primary data were obtained through field observations of irrigation channel conditions, water distribution patterns, indications of leakage and contamination, and water management practices at the farmer level; as well as semi-structured in-depth interviews with farmers, irrigation channel managers/agricultural agencies, environmental experts, and local government officials involved in food security policies and irrigation infrastructure (GIE et al., 2025). Secondary data such as policy documents, agency reports, irrigation network maps, and water quality data were used to complement and verify field findings. Informants were selected using a purposive–snowball technique to reach key actors across the upstream–midstream–downstream segments of the irrigation system.

Data analysis followed an interactive model: first, data reduction through initial coding and thematic categorization (water access, groundwater costs, water quality/pollution, and institutional responses); second, data presentation in narrative and thematic matrix formats to reveal relationships between infrastructure conditions, farmers' practices, and policy frameworks; third, drawing provisional conclusions continuously verified throughout the process through cross-source and cross-time comparisons (Miles et al., 2014). Validity was strengthened through methodological triangulation (interviews–observation–documents), source triangulation (farmers–government), member checking with key informants, and maintaining a documented audit trail of analytical decisions. All participants provided informed consent, their identities were kept confidential, and the data were used solely for academic purposes. This approach is expected to produce a comprehensive contextual understanding and a solid foundation for formulating efficient and sustainable agricultural water management solutions (Smith et al., 2023) in North Gorontalo City.

RESULTS

This study reveals that farmers in North Gorontalo City face serious problems related to the availability of irrigation water, which is essential for the growth and development of their crops, particularly staple crops such as rice. The

irrigation channels that should serve as the primary source of water for crop irrigation are not functioning optimally, forcing farmers to rely on groundwater extracted using water pumps. However, the use of these pumps imposes a very high financial burden. Farmers must incur additional expenses for pump operations, including fuel costs, pump maintenance, and operator fees that continue to rise over time.

The high costs required to obtain groundwater through pumping directly affect farmers' incomes, as production expenses increase and reduce the profit margins they receive. Ideally, inexpensive and easily accessible irrigation water should help farmers lower their operational costs. However, due to the lack of adequate repair or maintenance of existing irrigation channels, farmers are compelled to spend more money to obtain groundwater, the quality of which is often affected by household waste contamination.

This study also found that there has been no meaningful response from the relevant institutions—either the local government or the agricultural office—to address this long-standing issue. Farmers feel that no concrete efforts have been made by authorities to repair damaged irrigation channels or to provide alternative solutions that are more efficient and affordable for obtaining irrigation water. The government appears to be more focused on collecting land taxes from farmers, while offering no form of attention or solutions to help reduce the high production costs caused by water scarcity.

Government involvement in the agricultural sector appears to be limited to distributing fertilizers to farmers, without any direct dialogue between government representatives and farmers to identify solutions to the problems they face. Farmers feel neglected because they have never been invited to meet and discuss their challenges with the government to find measures that could ease their burden.

Adequate and affordable water supply from irrigation channels is crucial for the sustainability of agricultural production, and the use of groundwater pumps only adds to farmers' operational burdens. The lack of attention and solutions from the government has worsened the situation, ultimately affecting farmers' incomes and well-being. The government must improve irrigation infrastructure, reduce dependence on groundwater, and take a more active role in collaborating with farmers to find solutions that can enhance agricultural production efficiency in the region.

DISCUSSION

Based on the research findings that reveal the significant challenges faced by farmers in North Gorontalo City regarding access to irrigation water and dependence on groundwater, this section discusses these findings in relation to theoretical perspectives and previous studies. The main objective of this discussion is to identify the most appropriate and sustainable solutions to address the existing problems and provide policy recommendations that can support agricultural sustainability in the region.

The Importance of Water Availability for Agriculture

Water resources are a key element in agricultural production, especially for crops requiring regular irrigation such as rice. According to the theoretical framework presented by (Molden, 2013) in *"Water for Food, Water for Life,"* efficient irrigation can significantly enhance agricultural yields. In this context, poorly functioning irrigation channels force farmers to depend on groundwater, which in the long term is not only inefficient but also increases production costs.

One of the major challenges faced by farmers in many regions is dependence on limited water resources. Decreasing water quality due to pollution and poorly maintained irrigation infrastructure further aggravates this issue, resulting in increasing expenditures for farmers (Rondhi et al., 2024). Therefore, the need for more stable and affordable water access becomes a priority to support agricultural productivity.

Impact of Groundwater Use on Production Costs

This study found that the high costs incurred by farmers to operate groundwater pumps ultimately reduce the income they should be receiving. Groundwater pumping is expensive, both in terms of operational costs (electricity, fuel, and pump maintenance) and the long-term costs associated with declining groundwater quality. Farmers who depend on natural resources often lack the capacity to bear these high expenses, which ultimately affects their economic sustainability.

A study by (Hoekstra, 2017) on water accounting found that monitoring and managing water use can help farmers reduce waste and increase efficiency. With the integration of a water accounting system, farmers can better understand their water consumption patterns and take more efficient steps in water use, whether from irrigation channels or groundwater sources (FAO, 2018). Water accounting is highly relevant in this context because it allows farmers to calculate the water footprint of each agricultural activity and analyze the true costs associated with water use.

Lack of Government and Stakeholder Attention

The results also indicate that insufficient government attention toward water access issues and irrigation infrastructure improvements has worsened the situation. In many cases, government efforts focus more on collecting land taxes from farmers rather than providing concrete solutions to address the existing problems. Increasing urbanization and inadequate policies in water resource management contribute to imbalances in water allocation between agricultural areas and residential zones (Rondhi et al., 2024). As a result, the availability of water for agriculture—both in quality and quantity—continues to decline, directly impacting food security and agricultural sustainability.

Limited resources for irrigation infrastructure development and water management require stronger collaboration between the government, farmers, and the private sector. For instance, a study by (FAO United Nation, 2020) showed that multi-stakeholder partnership approaches involving farmers in decision-making and water management planning can produce more accurate and rapidly implementable solutions. The government needs to be more

proactive in engaging with farmers to find joint solutions that can enhance water-use efficiency (Ma'Mun et al., 2021) and reduce dependence on costly water sources.

CONCLUSION AND RECOMMENDATION

Based on the research findings and discussion, it can be concluded that farmers in North Gorontalo City face serious challenges related to limited access to irrigation water and high operational costs resulting from their dependence on pumped groundwater for irrigation needs. The lack of attention from relevant institutions—particularly the local government and the agricultural office—has led to the absence of concrete efforts to repair irrigation infrastructure or to work collaboratively with farmers in addressing water-related issues and mitigating the impacts of urbanization on agricultural water quality.

The findings of this study align with existing research, which emphasizes the importance of stable and affordable water access to support agricultural sustainability, especially for crops that are highly dependent on irrigation, such as rice. The costly and often inefficient use of groundwater places an additional burden on farmers and worsens their economic conditions. The analysis further highlights the need for improving irrigation infrastructure to reduce reliance on groundwater. The implementation of water accounting can serve as an effective solution for managing water resources more efficiently by identifying the true costs associated with water use.

With these measures, it is expected that the water access challenges faced by farmers in North Gorontalo City can be addressed, thereby supporting sustainable agricultural production, strengthening food security, and reducing the economic burden on farmers caused by the high operational costs related to groundwater use.

Based on the research findings and previous theoretical studies, several solutions can be recommended to address the problems faced by farmers in North Gorontalo City:

- **Improvement of Irrigation Infrastructure:**
  The government needs to allocate sufficient funding to repair and maintain existing irrigation channels. Rehabilitating damaged irrigation infrastructure and establishing more efficient irrigation systems can reduce reliance on groundwater and lower high operational costs (Rondhi et al., 2024). This aligns with (Molden, 2013) recommendation regarding the importance of infrastructure improvement to ensure equitable water distribution.
- **Implementation of a Water Accounting System:**
  Integrating a water accounting system into agricultural practices will help farmers use water more efficiently and reduce waste (Rondhi et al., 2024). Through this system, farmers can monitor water consumption in real-time and adjust their irrigation practices according to crop needs. Research conducted by (Hoekstra, 2017) shows that accurate monitoring of water use can reduce costs and enhance agricultural sustainability.
- **Management of Household Waste:**

One of the major impacts of urbanization is water pollution caused by household waste (Nurkholis et al., 2023). Effective waste management solutions—such as treating household wastewater before it is discharged into irrigation channels or agricultural land—need to be implemented to maintain the quality of water used in farming. Environmentally friendly waste treatment technologies can be used to reduce pollution and preserve water quality.

- **Partnership Between Government and Farmers:**
  The government must be more directly involved with farmers in discussions and planning related to water resource management. Collaborative forums that involve farmers, government agencies, and the private sector can yield more adaptive and responsive solutions to field needs. (FAO, 2020) highlights the importance of multi-stakeholder partnerships in supporting sustainable natural resource management policies.

FURTHER STUDY

The limitations that can serve as considerations for future research include:

1. This study did not employ economic models or quantitative simulations (such as cost–benefit analysis, water productivity metrics, or irrigation efficiency indices), so the financial impact of water accounting was analyzed qualitatively.
2. The application of water accounting has not been comprehensively tested because the local government has not implemented a formal water accounting system based on SEEA or Blue Accounting frameworks. Cost analysis of water use was mostly based on actual pump-related expenses and farmers' experiences.

ACKNOWLEDGEMENTS

The author extends appreciation to the rice farmers who provided valuable information regarding water-related challenges experienced over the past five years, as well as to colleagues who contributed to the smooth progress of this research.

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