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THE CONTRIBUTION OF IRRIGATION SYSTEMS TO HOUSEHOLD FOOD SECURITY IN RUFIJI DISTRICT, TANZANIA

Angela M. Jesse
Department of Development and Strategic Studies
College of Social Science and Humanities
Sokoine University of Agriculture
Email: nyahiriangel@gmail.com/angela.jesse@sua.ac.tz

ABSTRACT
Irrigation is considered a major means of increasing productivity to ensure food security all over the world due to rainfall variability caused by climate change. Different countries, including Tanzania, have been advised to engage in irrigation systems, and various regulatory frameworks have been developed to support this. However, different studies reveal both positive and negative results regarding the contribution of irrigation systems to food security, which has raised concerns and prompted the need for further investigation. This study aimed to determine the awareness on the contribution of irrigation systems to food security, types of crops cultivated through irrigation systems, the number of meals consumed by households practicing irrigation, and the challenges facing smallholder farmers in adopting irrigation systems. The Entitlement to Food Theory guided the conduct of this study, which employed a cross-sectional research design involving surveys, interviews, and documentary reviews. A total of 60 households were selected for the study, and the data were analysed descriptively using the Statistical Package for the Social Sciences (SPSS) and content analysis. The study revealed that farmers had an understanding of the contribution of irrigation systems to food security, although they encountered some challenges including lack of inputs and funds for extensive farming. It was further found that 80% of farmers preferred planting maize over other food crops due to its cost-effectiveness in terms of the required inputs. Additionally, majority of the community members had an understanding of food security in terms of access and availability, rather than utilisation. The study recommends that farmers be educated on the importance of planting other nutrient-rich crops. Furthermore, they should be informed about alternative means of obtaining funds, such as entrepreneurial activities, and using their farms as collateral to access the required agricultural inputs.

Keywords: Climate change, Food crops, Food security, Household food security, Irrigation system, Nutrient-rich crops
Paper type: Research paper
Type of Review: Peer Review

1. Introduction and Background to the Study

Irrigation systems have emerged as a pivotal means of increasing agricultural productivity and ensuring food security on a global scale (Bazin et al., 2017; Jambo et al., 2021). As a viable alternative to rainfall-dependent agriculture, which is susceptible to climate change-induced water scarcity (Gohar et al., 2015; Muluneh et al., 2017). Irrigation plays a crucial role in addressing food security challenges, particularly in developing countries where smallholder farmers heavily rely on rain-fed practices to ensure food availability at the household and national levels. Various studies have underscored the adverse impact of rainfall variability on food security (Kinda and Badolo, 2019; Naheed, 2023). Food security, as defined by the FAO, IFAD, UNICEF, WFP, and WHO (2019), refers to a situation where food is available, accessible, safe, and nutritionally adequate, meeting the dietary needs and preferences for a healthy and active life.

Recognising the significance of irrigation systems in mitigating the impact of rainfall variability on food security, different countries have been advised to adopt irrigation practices to ensure food availability and alleviate the problem of food insecurity (Fanadzo, 2012; URT, 2013; Hanson, 2013; Bazin et al., 2017; Christian et al., 2019). In Ethiopia, farmers were encouraged to adopt irrigation systems to bolster food production, reduce poverty, and enhance the country's GDP (Bacha et al., 2011; Beshir, 2018; Jambo et al., 2021). In Tanzania, the government has implemented various regulatory frameworks to promote irrigation as a means of enhancing productivity and ensuring food security, including the National Irrigation Policy of 2010, the National Agriculture Policy of 2013, and the Agricultural Sector Development Strategy – II 2015/2016–2024/2025. Consequently, public irrigation schemes, such as the Rufiji River Basin Irrigation Scheme, have been established in Tanzania with the assumption that practicing irrigation can effectively address food insecurity at both the household and national levels.

Rufiji District is one such region where irrigation systems are being practiced, thanks to the presence of the Rufiji River Basin. With water abstraction estimated at 12,788 million m^3 for existing and planned irrigation and hydropower developments, constituting 45% of the total available 28,382 million m^3 of water in the basin (Shughude, 2016), Rufiji District holds the potential to achieve food security through irrigation activities. The availability of water enables the cultivation of diverse food crops, including cereals like maize and paddy, as well as fruits and vegetables. Therefore, water resources within the Rufiji River Basin empower local community members to produce sufficient food for both consumption and commercial purposes. Studies conducted by Oni et al. (2011) and Jambo et al. (2021) have demonstrated that farmers involved in irrigation projects are more likely to achieve food security compared to dryland farmers.

Additionally, in Tanzania, some farmers have adopted irrigation systems in their agricultural practices, leading to improved productivity (Theis et al., 2018; Mgendi, 2022; Bagambilana and Rugumamu, 2023). This improvement is partly attributed to the utilisation of technological advancements, such as water pumps and irrigation services, where people pay for access to water resources (Caretta et al., 2015). However, the studies by Oates et al. (2017) and Kansal and Nyamsha (2021) also highlights that small-scale farmers practicing irrigation in sub-Saharan Africa face challenges, including limited access to technology and insufficient funds to purchase agricultural inputs, perpetuating food insecurity. Given the varied outcomes observed in previous studies regarding irrigation systems' impact on food security, this study was conducted to ascertain the contributions of irrigation systems at the household level in Rufiji District, where the Rufiji River Basin exists. Specifically, the study aimed to determine the awareness on the contribution of irrigation systems to food security, the types of crops cultivated through irrigation systems, and the number of meals consumed by households practicing irrigation in the study area. Additionally, the study sought to identify the challenges faced by smallholder farmers in adopting irrigation systems in the study area. The findings from this study provides valuable insights and strategies for effectively implementing regulatory frameworks, such as the National Irrigation Policy of 2010 and the National Agriculture Policy of 2013, and align with the pursuit of Sustainable Development Goal (SDG) number 2 which is about "Zero Hunger"

2. Theoretical Framework

The Entitlement to Food Theory, developed by Sen (1980), serves as the guiding framework for this study. Sen's theory posits that the issue of food security is not solely about food supply failure but primarily about food access (Kurniawan, 2016). The focus of the Entitlement to Food Theory lies in the possession of wealth and resources that can be exchanged for food or used to acquire it through other means. According to the theory, individuals can access food if they have the financial means to purchase it, access to land for agricultural cultivation, technological knowledge for farming practices, and agricultural inputs to ensure successful harvests. Sen (1980) categorised four types of entitlements or legal ways of acquiring food. The first is trade-based entitlement, which refers to the ability to buy or sell food. The second is produced-based entitlement, which involves the capability to grow and produce food through agricultural practices. The third is own labour-based entitlement, which relates to the ability to sell one's skills or labour power to procure or produce food. The last is inheritance and transfer-based entitlement, which involves obtaining food from the government, organisations, including Civil Society Organisations (CSOs), or other

individuals in the society, such as remittances. This study primarily focuses on the second category, the produced-based entitlement, as it pertains to the ability to grow and produce sufficient food through agricultural practices. This choice is driven by the study's examination of irrigation systems and their impact on food security in the study area. The Entitlement approach concentrates on each individual's access to resources, including water, and views hunger as a result of the failure to access a bundle of resources sufficient to produce enough food for all people at all times (Mende et al., 2015).

The theory is highly applicable to this study as it assesses whether the entitlement to technology (irrigation) could play a significant role in contributing to food security in the study area. Specifically, the study aims to determine whether the water resources available in the Rufiji River Basin, which entitle the community to irrigate their farms, can effectively address food insecurity in the region. Previous research by Mende (2015) indicated that entitlements to food security, such as the number of cattle owned, membership in farmers' groups, and engagement in non-agricultural activities, were critical factors in enhancing food security. Building on this finding, it is reasonable to suggest that providing entitlement to irrigation technology (both traditional and modern) to community members in the study area could alleviate the problem of food insecurity.

3. Methodology

This study was conducted in Rufiji District, due to the presence of the Rufiji River Basin, which enables irrigation systems. This district is known for its significant engagement in irrigation practices among many households involved in agricultural activities. The research design employed for this study was cross-sectional research design which was selected based on the study's objectives. The study aimed at determining community awareness of the contribution of irrigation systems to food security, the types of crops cultivated through irrigation systems in the study area, and whether the number of meals consumed by households practicing irrigation includes all essential food groups (vitamins, carbohydrates, protein, fats, and oils) required by the body. The study also sought to identify the challenges facing farmers practicing irrigation in the Ikwiriri Ward, Rufiji District.

Purposive sampling was utilised to select households practicing irrigation systems in the study area. Subsequently, a simple random sampling technique was employed to select 60 households for the study. This sample size was chosen due to the homogeneity of the collected data, as the population exhibited uniform geographical positions, culture, and practices. Purposive sampling was also employed to select participants for two Focus Group Discussions (FGDs). The first focus group consisted of community development officers, village chairpersons, executive village officers, ward executive officers, extension officers, and hamlet leaders. The second focus group comprised farmers, with 4 to 5 female participants planting different crops through irrigation systems in the study area. Each focus group had 8 and 10 participants, respectively. Triangulation of data was ensured through various sources, including household surveys using questionnaires with closed and open-ended questions for households practicing irrigation, interviews with the FGDs, and documentary review of secondary information from existing literature (Talakvadze, 2013).

The documentary review method involved examining different research works related to crops planted in other irrigation schemes. This information was used to assess whether the crops planted by farmers enable them to achieve food security, either through consumption or through the sale of produce to acquire other necessary food substances or not. Additionally, the review of literature aimed to determine the number of meals per day in societies practicing irrigation systems and the challenges faced by farmers in irrigation schemes. The relevant literature was sourced through platforms like Google and Google Scholar, using search terms such as "irrigation system and food security," "number of meals per day for farmers practicing irrigation agriculture," "food consumed by smallholder farmers in irrigation schemes," and "challenges facing farmers in irrigation schemes." The information collected through household surveys was descriptively analysed using the Statistical Package for Social Sciences (SPSS) to obtain frequencies and percentages. The qualitative data collected from the FGDs were thematically analysed through content

analysis. Transcribed information from the FGDs was coded based on the points agreed upon during the discussions, and these coded points were used to develop themes for the discussion in this paper.

4. Findings and Discussion

This section highlights the ways in which the irrigation system contributed to food security in the study area. It addresses various aspects, including the awareness of small-scale farmers regarding the contribution of irrigation systems to food security, the types of food crops cultivated through irrigation, the number of meals consumed per day to assess the adequacy of essential nutrients, and the challenges faced by farmers practicing irrigation systems in the study area. Data presented in this section were subjected to both descriptive and thematic analyses.

Firstly, the study explored the level of awareness among small-scale farmers about how irrigation systems contribute to food security. The descriptive analysis of the data revealed the extent to which farmers were informed about the benefits of irrigation in ensuring food availability and accessibility. Secondly, the study examined the kinds of food crops that were cultivated through irrigation systems in the study area. Through both descriptive and thematic analyses, the study elucidated the variety of crops grown using irrigation practices, contributing to food diversity and potential nutritional benefits. Thirdly, the number of meals and the types of food consumed per day by households practicing irrigation were assessed to determine whether the food provided essential nutrients or not. Descriptive analysis allowed an understanding of the dietary patterns and potential nutrition gaps among the farming communities. Lastly, the study identified and explored the challenges faced by farmers who practiced irrigation systems in the study area. Thematic analysis was employed to categorise and analyse the common obstacles encountered, and shedding light on the factors hindering the optimal utilisation of irrigation for food security. The combination of descriptive and thematic analyses facilitated a comprehensive understanding of how the irrigation system impacts food security in the study area. The findings contribute to enhancing knowledge and devising strategies to further improve the effectiveness of irrigation practices in ensuring food availability, access, and nutritional adequacy for the local communities.

4.1 Awareness of the contribution of irrigation system to food security

Information on the awareness of the contribution of irrigation systems to food security was collected through Focus Group Discussions (FGDs) with the households practicing irrigation in the study area. The findings revealed that community members indeed understood the significance of irrigation systems for food security in their locality. However, they faced various challenges, primarily related to the lack of essential inputs. During the FGDs, participants expressed their experiences and viewpoints as one stated that:

> "...Irrigation system contributes to food security in this community because most farmers are getting food by irrigating their planted crops. The problem is that they cannot plant large farms because they use canes and buckets to irrigate their farms. Only a few households can buy pumps for irrigating their farms." (Focus Group Discussion 1, Ikwiriri Ward, March 2021)

Furthermore, a respondent added:

> "I am planting different types of vegetables on my farm because it is very close to the river, so it is easier to fetch water by bucket and irrigate my plants mostly in the morning and evening. This activity enables me to earn money, which help me to take care of my family by buying food, paying school fees, and fulfilling other family needs." (Respondent 34, Ikwiriri Ward, March 2021)

These quotes indicate that while the community members are aware of irrigation's role in food security, many farmers lack access to proper equipment, such as pumps, to irrigate larger farms. As a result, most farmers engaged in subsistence farming, while only a few used advanced technology for irrigation, leading to food production for both consumption and commercial purposes. These findings are consistent with the study conducted by Bont et al. (2019) in Kilimanjaro, who identified the emergence of different classes of farmers based on their use of groundwater irrigation technologies, with some engaging in subsistence

farming and others in commercial agriculture. The reliance on poor technology, such as canes and buckets for irrigation, negatively impacted food security as it limited farmers' ability to produce enough food throughout the year. One respondent highlighted this issue, stating:

> "...the food we produce in our farms cannot sustain us until another harvesting season. We use hand hoes for digging and buckets for irrigating, so we can't plant big farms. So, to survive, we are forced to buy food until we harvest again in the next season." (Respondent 16, Ikwiriri Ward, March 2021)

These findings align with the Entitlement to Food Theory, which emphasises the possession of wealth materials as a means to acquire food. The failure to possess essential agricultural inputs, such as water pumps and tractors, hinders farmers from producing enough food throughout the year, leading to food insecurity. To address these challenges, interventions are necessary, such as empowering community members through entrepreneurial activities that provide them with the funds to purchase required equipment, including pumps, fertilisers, and seeds, ultimately leading to increased harvests. Moreover, providing education on effective farming practices is crucial in empowering farmers and reduce the problem of food insecurity in the long term.

4.2 Crops cultivated through the irrigation system and their contribution to food security

The study gathered information on the types of crops grown in the study area through responses from individual respondents and participants in the Focus Group Discussions (FGDs). The respondents were asked to specify the crops they planted using irrigation systems, while the FGD participants were asked to identify the common crops cultivated through irrigation in the study area. The findings regarding the types of crops grown through irrigation systems are presented in Table 1.

Table 1: Types of crops planted in the study area

Types of crops	Per cent
Maize	80
Watermelon	8.3
Paddy	6.7
Okra	3.3
Tomatoes	1.7
Total	100

The Table 1 provides a comprehensive overview of the different crops that are cultivated using irrigation systems in the study area. The data collected from both individual respondents and FGDs participants were analysed and compiled to offer a detailed account of the crop diversity fostered by irrigation practices in the region. The variety of crops grown plays a significant role in enhancing food security by providing a diverse range of food options for consumption and potential commercial purposes. Furthermore, results in Table 1 demonstrate the agricultural richness and potential of the study area, which benefits from the availability of irrigation systems facilitated by the presence of the Rufiji River Basin. The cultivation of various crops, including cereals such as maize and paddy, as well as fruits and vegetables, signifies the utilisation of water resources to enable the production of sufficient food for both household consumption and commercial purposes.

It is worth noting that this crop diversity is made possible due to the proximity of farms to the river, which allows for easier access to water using buckets and other manual irrigation methods. However, the lack of advanced technology, such as water pumps, hampers some farmers' ability to cultivate larger farms and achieve higher levels of food security. The findings further highlight the need for interventions to empower farmers by introducing entrepreneurial activities to generate income for purchasing necessary equipment and inputs, ultimately leading to increased agricultural productivity and food security in the study area. Furthermore, the study findings presented in Table 1 indicate that the majority of farmers in the study area are primarily focused on planting maize as their main crop through irrigation systems. This preference for maize cultivation is attributed to its relative resistance to insect attacks compared to other crops.

Respondents cited that maize cultivation is less expensive than planting other crops like tomatoes, which require significant investments in terms of inputs and care.

The study's FGDs participants also echoed the popularity of maize cultivation, highlighting that it is a staple food that can be consumed even before full maturity. This makes maize a versatile crop that can be used for both food and business purposes. However, it was observed that only a few farmers with sufficient financial resources opt to plant watermelons and tomatoes, which are primarily bought by middlemen and transported to other regions for commercial purposes. While maize remains a prominent crop due to its affordability and versatility, the findings suggest that there is potential for cultivating other types of food crops, such as vegetables and fruits, in the study area. Farmers, especially those with access to local technology and assistance from extension officers, can diversify their crops to include watermelon, tomatoes, and other nutritious foods. This diversification can not only improve food security at the household level but also create business opportunities by satisfying the needs of the local and external markets. Regarding the consumed food substances and the number of meals per day, the study reveals that the most common foods in the study area are *ugali* (maize porridge) or rice, often accompanied by beans. The lack of variety in food consumption is attributed to its affordability and accessibility to most households. While maize and beans are staple foods, it is essential for farmers to understand the importance of consuming a balanced diet that includes all the required nutrients for human health.

The study findings emphasises the need for farmer education on balanced diets and the significance of consuming diverse food groups to achieve food security. Proper nutrition is crucial to prevent diseases and ensure the overall well-being of the community. Encouraging farmers to grow a wider range of crops, rich in essential vitamins, proteins, carbohydrates, fats, and oils, can be facilitated through economic empowerment initiatives. To support this, farmers should be educated on accessing credit from financial institutions, using their farmland as collateral, and formalising land ownership to secure funds for agricultural inputs. The findings underscore the importance of implementing the National Irrigation Policy of 2010, which can lead to increased food production and improved livelihoods in the study area and the nation as a whole. Hence, this study highlighted the significance of irrigation systems in contributing to food security in the study area. However, the challenges faced by farmers, such as the lack of modern equipment and limited access to inputs, hinder their ability to maximise crop diversity and achieve higher levels of food security. Implementing strategies to empower farmers economically, diversifying crop cultivation, and promoting nutrition education can pave the way for sustainable food security in the study area.

4.3 The consumed food substances and number of meals per day

The study collected information on the number of meals and the consumed food substances per day from various sources, including respondents, participants in the FGDs, and documentary reviews. The aim was to determine whether the consumed food contained all the required nutrients for a balanced diet, which is essential for food security. According to Dansinger (2019), a balanced diet should include foods rich in protein, such as fish, meat, poultry, dairy products, eggs, nuts, and beans; fats found in dairy products, nuts, and oils; carbohydrates from fruits, vegetables, whole grains, and beans; vitamins, including A, B, C, D, E, and K; essential minerals, and water.

The study findings reveal that in the study area, the most commonly consumed food items are *ugali* or rice, often paired with beans. However, few households consumed vegetables. The preference for *ugali* or rice with beans is attributed to its affordability and accessibility to most families. The FGDs corroborate this information, indicating that the majority of families in the study area opt for *ugali* or rice with either beans or vegetables due to their affordability. The presence of vegetables and other types of food in the market indicates that there are opportunities for farmers to diversify their crops to meet the nutritional needs of the community. However, the limited financial capacity of most farmers hinders them from exploring this potential. The documentary review indicates that in other irrigation schemes like Kinyope and Kitere, paddy, maize, and vegetables are cultivated on a small scale by only a few farmers. This suggests the possibility of cultivating crops that provide essential nutrients while also increasing food availability. The

findings highlight a gap in the understanding of food security in the study area. Many community members viewed food security as merely having enough food, irrespective of its nutritional value. This misconception poses a risk to their health and well-being, as it can lead to malnutrition and related health problems. Addressing this knowledge gap was very crucial for promoting food security in the study area. Educating farmers on the importance of consuming a balanced diet and diversifying their crops to include nutritionally-rich foods can significantly improve food security.

Maximising the utilisation of the Rufiji River Basin, provides farmers with an opportunity to grow a variety of crops that provide the necessary nutrients for a balanced diet. This approach not only ensures food security for the community but also creates opportunities for income generation through commercial sales of surplus produce. Implementing the National Irrigation Policy of 2010 is key to achieving these goals. By empowering farmers with knowledge, resources, and access to credit, the study area can improve agricultural productivity and enhance food security for its residents. Therefore, addressing food security in the study area required a multi-faceted approach that includes diversifying crop cultivation, promoting nutrition education, and empowering farmers economically. With the proper utilisation of the Rufiji River Basin and the implementation of the National Irrigation Policy, the study area can achieve sustainable food security and improved livelihoods for its residents. Table 2 presents the findings on the number of meals per day in the study area. The majority of households (61.7%) reported having three meals per day, while 38.3% could manage only two meals per day. These findings align with the recommendations of Mattson et al. (2014), who suggest that people should have three meals daily, along with snacks, to meet their nutritional needs. However, the content of the meals is a concern, as many respondents reported consuming primarily *ugali* or rice with beans, indicating a lack of dietary diversity.

Table 2: Number of meals consumed per day

Number of meals	Per cent
Once	0.0
Twice	38.3
Thrice	61.7
Total	100

The documentary review highlights that the number of meals and the kinds of food consumed can vary depending on the availability of food, resources, and the health status of individuals in different regions and countries. This emphasises the importance of promoting a balanced diet that meets nutritional needs for good health. The study reveals that many community members lack awareness of the importance of consuming a balanced diet and fail to access a variety of food items, such as vegetables and other nutrient-rich foods. This knowledge gap presents an opportunity for education and interventions to encourage farmers to diversify their crops and improve dietary diversity for better nutrition.

Moving on to the challenges facing farmers in the irrigation scheme at Ikwiriri Ward, respondents mentioned several significant issues, including lack of capital, crop diseases, limited education in agricultural practices, and crop theft. Lack of access to funds for purchasing agricultural inputs, such as manure, is a common problem, leading to the use of local alternatives like animal dung, which may not provide optimal results. The reliance on traditional tools like cane and buckets for irrigation also limits the scale of farming operations. Education emerges as a key factor in addressing these challenges. Equipping farmers with knowledge and skills in agricultural practices can help them improve productivity and make better use of available resources. Additionally, proper education on the importance of a balanced diet can influence farming choices and promote the cultivation of diverse crops.

The documentary review supports the findings from the FGDs, indicating that issues like inadequate water supply, lack of market access, livestock damaging crops, and shortages of agricultural inputs are common challenges faced by farmers in irrigation schemes. These challenges need to be addressed to maximise the

potential benefits of irrigation systems in reducing food insecurity. Also, this study findings highlighted the need for agricultural and nutritional education in the study area to improve food security. Encouraging farmers to diversify their crops, adopt better irrigation practices, and make use of available water resources effectively can contribute to enhanced productivity and reduced food insecurity. Addressing the challenges facing farmers through supportive policies and interventions aligned with the National Irrigation Policy of 2013 will play a crucial role in achieving sustainable food security in the study area and beyond.

4.4 Challenges facing farmers in the irrigation scheme at Ikwiriri Ward

The challenges facing farmers who practiced irrigation systems in the study area have been clearly identified through data collected from respondents and FGD participants, as well as the information from the documentary review. These challenges include:

(i) Lack of Capital: Many smallholder farmers struggle with limited financial resources to invest in their agricultural activities. This lack of capital hampers their ability to purchase essential inputs like seeds, fertilisers, and pesticides, as well as modern irrigation equipment, such as water pumps.

(ii) Crop Diseases: Farmers face the risk of crop diseases, which can significantly reduce yields and income. Without proper knowledge and access to pest and disease management techniques, farmers may lose a substantial portion of their harvest.

(iii) Lack of Education in Agricultural Practices: Limited knowledge and skills in modern and sustainable agricultural practices can lead to suboptimal farming methods. Proper education and training are essential to improve agricultural productivity and resource management.

(iv) Theft of Crops: Crop theft is a common problem in many rural areas, and it poses a significant threat to farmers' livelihoods. Without adequate protection measures, farmers may suffer losses due to theft of their produce.

(v) Busting of Pipes and Inadequate Water Supply: The irrigation infrastructure may suffer from technical issues such as pipe bursts, leading to water wastage and inefficient water distribution. Inadequate water supply can hinder the success of irrigation systems.

(vi) Lack of Market Access: Access to reliable markets is crucial for farmers to sell their produce at fair prices. Without proper market linkages, farmers may struggle to find buyers for their crops, leading to reduced income.

(vii) Livestock Destroying Corps: Conflicts between farmers and livestock can result in damage to crops, affecting agricultural productivity.

(viii) Shortage of Inputs: Farmers may face difficulties in accessing quality seeds, fertilisers, and other agricultural inputs, limiting their ability to achieve higher yields.

Addressing these challenges requires a multi-faceted approach. The government and relevant stakeholders need to invest in agricultural extension services to provide farmers with knowledge and skills in modern agricultural practices. Providing access to credit and financial services can help farmers overcome the capital constraints. Strengthening irrigation infrastructure and water management can enhance water efficiency and address water-related challenges. Furthermore, creating market linkages and value chains can help farmers connect with potential buyers and improve their income. Implementing measures to prevent crop theft and addressing livestock-farmer conflicts can also contribute to improved food security and farmer well-being. Therefore, the findings emphasise the importance of comprehensive interventions to empower smallholder farmers and maximise the potential benefits of irrigation systems in ensuring food security and poverty reduction in the study area and beyond. The National Irrigation Policy of 2013 needs to be effectively implemented with a focus on addressing these challenges to achieve sustainable agricultural development and food security.

5. Conclusion and Recommendations

The conclusions drawn from the study are well-supported by the data and findings presented. It is evident that being aware of the contribution of irrigation systems to food security is crucial, but it is not sufficient on its own. To achieve food security, it is essential to empower smallholder farmers with the knowledge and resources needed to improve agricultural practices and access necessary inputs. The study rightly

emphasises the importance of empowering farmers to adopt good agricultural practices and use improved technologies such as water pumps, fertilisers, and tractors. These interventions can lead to increased productivity, which is a key factor in ensuring food security. By improving productivity, farmers can not only meet their own food needs but also have surplus produce to sell in the market, contributing to food security at both the household and regional levels.

Moreover, the study's emphasis on educating the community about the importance of consuming a balanced diet is crucial. Many farmers in the study area may not be fully aware of the significance of having a diverse and nutritious diet. By understanding the importance of consuming all the required food substances, farmers may be motivated to plant a variety of crops to meet their nutritional needs. This can lead to increased production of fruits, vegetables, and other nutritious crops in the study area, making them potential suppliers to other regions with limited access to such food items. Hence, the study provides valuable insights into the complexities of achieving food security through irrigation systems. It highlights the need for a holistic approach that combines awareness, empowerment, education, and technological support to ensure sustainable agricultural development and food security in the study area and beyond. The study's recommendations can serve as a basis for policymakers and development agencies to design targeted interventions and policies to address the challenges faced by smallholder farmers and promote food security in the region. Hence, it is recommended that:

(i) Existing extension officers at the local government level, farmers can receive essential guidance on good agricultural practices. Such knowledge-sharing initiatives can lead to increased productivity, reduced crop losses, and overall improved agricultural outcomes.

(ii) Empowering farmers to use their assets, particularly land, as collateral for loans from financial institutions is an important step in addressing the challenge of access to agricultural inputs. Many smallholder farmers face financial constraints, and providing them with the means to access credit can enable them to invest in improved technologies and inputs, ultimately leading to enhanced food production.

(iii) Furthermore, streamlining the process for obtaining title deeds from the environmental department is crucial in securing farmers' land rights. Clear land ownership can provide farmers with greater confidence and security, leading to more long-term investments in their farming practices.

(iv) The recommendation to educate the community on the importance of consuming a balanced diet is vital in improving nutrition and overall health. Through various channels, including writings, mass media, and nutritionists, the government and relevant organisations can raise awareness about the significance of diverse and nutritious food consumption. Additionally, utilising community development workers can be an effective way to disseminate this information at the local level.

(v) Lastly, encouraging farmers to plant different types of food, beyond just maize, can diversify their diet and improve food security. By promoting the cultivation of a wide range of crops, including fruits, vegetables, and legumes, the community can have access to a variety of nutrients, contributing to better health and wellbeing.

Implementing these recommendations will require coordinated efforts between various stakeholders, including the government, local authorities, development organisations, and community leaders. By taking these steps, the study area can work towards achieving food security and contributing to the larger national goal of poverty reduction and improved agricultural development as outlined in the National Irrigation Policy.

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