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The Role of Dry-Season Vegetable Irrigation Farming in Enhancing Food Security in the Nanumba South District

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Abstract

This study examined the role of dry-season vegetable irrigation farming in enhancing food security in the Nanumba South District, using the Wulensi community as a case study. Guided by a qualitative research design, the study employed a case study approach and collected data from 15 purposively selected respondents, including dry-season farmers and agricultural officers. Data were gathered through in-depth interviews and focus group discussions, and were analysed thematically. The findings reveal that dry-season irrigation farming is widely practised in Wulensi and contributes significantly to household food security by improving food availability, generating income, and supporting livelihood diversification during the dry season. Despite these benefits, the study identified multiple constraints that undermine the sustainability of irrigation farming. These include water scarcity, limited access to modern irrigation technologies, high input costs, pest and disease infestations, market challenges, inadequate agricultural extension support, and financial barriers. Respondents proposed several feasible strategies to address these constraints, such as rehabilitating water infrastructure, improving access to irrigation technologies, strengthening extension services, expanding credit facilities, forming farmer cooperatives, and improving market access mechanisms. The study concludes that implementing these strategies could substantially improve the productivity and sustainability of dry-season irrigation farming, thereby contributing to long-term food security in the Wulensi community.

Keywords: *Dry-Season Vegetable, Irrigation Farming, Food Security*

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1.0 INTRODUCTION

The role of dry-season irrigation farming in promoting community food security cannot be underestimated. It serves as a crucial pillar for enhancing household nutrition, income stability, and year-round food availability, particularly in farming communities (Tshwene & Oladele, 2016). About 53% of South African farmers reported being involved in irrigation farming, as the existing irrigation schemes are their only source of income (Balarane & Oladele, 2014). Despite the importance of dry-season irrigation farming, many households continue to face challenges in accessing reliable irrigation facilities and in maximising the benefits of dry-season vegetable production. Farmers in rural areas often rely heavily on rain-fed agriculture, which limits their ability to produce food year-round. However, empirical research on how dry-season vegetable irrigation farming contributes to local food security remains limited, particularly within the Wulensi community of the Nanumba South District. As a result, there is a need to examine the role this farming practice plays in sustaining household food access.

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The Wulensi community vegetable irrigation farming system project was used as a case study; this investigation provided evidence on the current contribution of dry-season irrigation farming to food security. The findings would offer valuable insights for agricultural development planning and inform interventions to improve irrigation practices. Ultimately, this study will support stakeholders in enhancing food production systems and ensuring that households are better positioned to achieve year-round stable food security.

1.1 Background to the study

Agriculture remains central to global economic stability and human survival. It provides food, raw materials, and employment to billions of people worldwide. According to the Food and Agriculture Organisation (FAO, 2022), global food production must increase by about 60% by 2050 to meet the nutritional needs of an estimated 9.7 billion people. However, this goal is threatened by climate variability, limited arable land, and freshwater scarcity. Irrigation farming, which involves the artificial application of water to support crop production, is one of the most sustainable approaches to increasing agricultural productivity and ensuring food security. Globally, irrigated lands account for about 20% of cultivated land yet produce 40% of total food (World Bank, 2022).

Research findings in Africa continue to reveal that agriculture employs about 60% of the labour force and contributes nearly 23% of the continent's Gross Domestic Product (GDP) (AfDB, 2020). However, only 6% of cultivated land is irrigated, making Africa the least irrigated region in the world (World Bank, 2021). This means dry-season irrigation farming is not as encouraging as in the western hemisphere. This limited adoption of irrigation in most African countries contributes to persistent food shortages and low agricultural productivity. Studies show that small-scale irrigation can increase crop yields by 100-300%, promote year-round cultivation, and enhance resilience to climate shocks (Burney & Naylor, 2019; Hussain & Hanjra, 2016). In countries such as Kenya, Ethiopia, and Mali, community systems have substantially improved food security and household income when combined with strong local participation and institutional support (Inocencio et al., 2017).

Agriculture continues to serve as the backbone of Ghana's economy, employing over half of the labour force and contributing 19.7% to the national GDP (GSS, 2021). Despite this crucial role, agricultural production in Ghana remains largely rain-fed and seasonal, creating periods of high vulnerability. This challenge is most pronounced in the northern ecological zones, where the dry season spans from November to April. During this period, vast farmlands lie idle, resulting in reduced food availability, limited income-generating opportunities, and heightened rural poverty. National statistics confirm the severity of this issue. The Ministry of Food and Agriculture (MoFA, 2022) estimates that about 1.2 million Ghanaians face chronic food insecurity each year, with the Northern, Upper East, and Upper West Regions most affected. In response to these challenges, initiatives such as dry-season vegetable irrigation farming have been introduced to ensure year-round food production and livelihood sustainability.

One such intervention is the Dry Season Vegetable Irrigation Farming Project in the Nanumba South District, specifically targeting communities like Wulensi. While the project is intended to boost food security and improve livelihoods through off-season farming, little is known about its actual impact at the community level. Although irrigation farming has been widely promoted as a dry-season livelihood strategy in northern Ghana, there is limited empirical evidence on how these interventions influence food security and household resilience in specific local contexts, such as Wulensi. Existing studies tend to focus on the general benefits of irrigation without examining community-level outcomes, farmer experiences, or the sustainability of such projects in rural districts like Nanumba South (Giordano et al, 2019; Jambo et al, 2021).

This study, therefore, seeks to explore the role and impact of the Dry Season Vegetable Irrigation Farming Project in enhancing food security in the Wulensi community, addressing a critical gap in localised knowledge and informing future agricultural policy and interventions.
In agricultural development, vegetable irrigation farming is unquestionably indispensable. The need for reliable and efficient dry-season irrigation practices among farming households is no less than that of the wider community. Nothing is conceivable in sustaining the food supply during extended dry periods without a firm grasp and application of irrigation farming

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techniques. Many other aspects of rural livelihoods rely heavily on dry-season vegetable production, including income generation, nutrition, and household resilience. Therefore, we cannot imagine modern rural life without vegetable irrigation farming. For the future success of individual farmers and the food security of communities, vegetable irrigation farming is also essential (Namara et al., 2011)

1.2 Statement of the problem

Food security remains a pressing concern in many rural districts of Northern Ghana, especially in communities such as Wulensi in the Nanumba South District. These areas are characterised by highly seasonal rainfall and a long dry season, during which rainfed agricultural production sharply declines. In response, dry-season vegetable irrigation has emerged as a promising livelihood strategy, but the extent to which it contributes to food security in Wulensi has not been systematically documented. Dry-season vegetable irrigation in northern Ghana typically relies on small-scale, informal systems developed by individual farmers using groundwater from shallow wells or simple pumps (Kwoyiga & Stefan, 2018). These systems often draw on deep reservoirs of local and indigenous knowledge. Farmers use environmental indicators, such as specific plant species or soil texture, to locate groundwater, and traditional timing wisdom (e.g., when to dig wells) to optimise recharge and well construction (Kwoyiga & Stefan, 2018). Despite minimal formal infrastructure, dry-season irrigation has significant socio-economic benefits. It provides income-generating opportunities, creates full- or part-time employment for vulnerable households, and contributes to the cultivation of nutrient-rich vegetables (Kwoyiga & Stefan, 2018).

In Nanumba South District, local government and development partners (such as SIGRA) have recognised the potential of expanding irrigated vegetable farming. For example, Wulensi and Nakpayili have been identified as pilot communities for establishing irrigation systems to support year-round vegetable production, with the goals of boosting local food production, creating jobs, and improving resilience to climate variability (Ghana Districts, 2025; SIGRA, n.d.). The Nanumba South District Assembly, in collaboration with SIGRA, is therefore actively promoting dry-season vegetable farming as part of a climate-adaptation strategy (SIGRA, n.d.; Ghana Districts, 2025). However, despite this policy and planning momentum, rigorous empirical studies of the real impacts of these irrigation interventions, especially on household food security, are scarce. There is limited published research on how dry-season vegetable irrigation translates into concrete improvements in food availability in Nanumba South, particularly in Wulensi.

This gap constrains effective planning and resource allocation, as well as the design of support interventions (e.g., training, input provision, market linkages) tailored to local needs. While dry-season vegetable irrigation holds promise for strengthening food security in Nanumba South, there is currently insufficient evidence on the magnitude and pathways of its benefits in Wulensi. Without such evidence, the District Assembly, development partners, and the farmers themselves lack a clear understanding of which irrigation practices are most effective, what constraints undermine their potential, and how to scale successful models equitably across the community. Consequently, investments in irrigation infrastructure and capacity-building may fall short of maximising the benefits for food security. Despite general acknowledgement of the potential benefits of irrigation, peer-reviewed literature documenting the specific food security impacts at the community and household levels in Wulensi (Nanumba South) is very limited. By filling this gap, the study contributes to both academic knowledge and practical planning.

1.4 Significance of the study

This study is significant for several reasons. It contributes to a deeper understanding of how dry-season vegetable irrigation farming supports household and community food security in rural settings, particularly in the Wulensi community of the Nanumba South District. By focusing on a period traditionally characterised by food shortages, the study highlights how irrigation practices help bridge seasonal food gaps, thereby improving year-round access to nutritious vegetables.

Moreover, the research provides empirical evidence on how irrigation-based vegetable farming enhances livelihoods. Specifically, it explores key dimensions, including income

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diversification, employment, and food security. These insights are therefore crucial for policymakers, development practitioners, NGOs, and agricultural extension officers working to strengthen rural agricultural resilience in Northern Ghana. In addition, the study identifies constraints faced by smallholder farmers engaged in dry-season vegetable cultivation, including challenges related to water access, financing, inputs, and market linkages. By understanding these barriers, stakeholders are provided with a basis for more informed and targeted interventions aimed at strengthening local food systems. Furthermore, the findings can serve as a valuable resource for future researchers, students, and agricultural institutions investigating climate-smart agriculture, sustainable food systems, and rural development strategies. In doing so, the study advances scholarly discourse by showing how localised irrigation initiatives contribute to broader goals such as poverty reduction, food sovereignty, and climate adaptation. Finally, the study holds community-level significance by elevating the voices and experiences of Wulensi farmers. Through their shared strategies, innovations, and challenges, these insights can inform community-driven solutions and help shape policies that align with local realities, thereby supporting equitable and sustainable development in the Nanumba South District.

2.0 MATERIALS AND METHODS

2.1 Introduction

This chapter reviews the existing literature on the role of dry-season vegetable irrigation farming in enhancing food security in the Wulensi community. It synthesises theoretical foundations, empirical evidence, and thematic discussions aligned with the four research objectives. The review highlights what is already known, identifies scholarly gaps, and situates the current study within broader academic discourse. The organisation of the review reflects the study's objectives and the concepts underpinning it. The concept of food security, the extent of dry-season irrigation farming, its contribution to household food security and income, the challenges farmers face, and strategies to enhance sustainability.

2.2 Concept of Food Security

Food security is widely defined as a condition in which all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food to meet their dietary needs and preferences (Bahtiyarovna, 2019). It rests on four key pillars: availability, access, utilisation, and stability. In rural contexts, especially in sub-Saharan Africa, food security is closely tied to agriculture and seasonal variations in rainfall patterns (FAO, 2019). This definition extends beyond food availability to encompass economic access, dietary utilisation, and resilience to shocks. Recent scholarship expands this definition to include sustainability, resilience, and the functioning of food systems (Tendall et al., 2015). Food security indicators, therefore, increasingly focus on both quantitative measures (e.g., caloric intake, household food consumption scores) and qualitative indicators (e.g., dietary diversity, coping strategies). However, several studies have revealed that irrigation has contributed to national food security (Balance et al., 2020; MoFA, 2025), suggesting that these findings generalise. Therefore, localising the role of dry-season vegetable irrigation farming in food security would offer more insight into the study gap.

2.3 Dry Season Irrigation Farming

Dry-season irrigation farming refers to the intentional application of water to crops during periods of little or no rainfall, enabling agricultural production to continue throughout the dry months. The practice is widely adopted in regions with highly seasonal rainfall and serves as a strategy for overcoming the limitations of rain-fed agriculture. According to the Food and Agriculture Organisation (FAO, 2017), irrigation provides a means of supplementing natural water deficits, thereby stabilising crop production, increasing yields, and enhancing farmers' resilience to climatic variability. In Ghana and across sub-Saharan Africa, dry-season irrigation has become particularly important for smallholder farmers who cultivate high-value vegetables such as tomatoes, onions, peppers, garden eggs, and leafy greens during the dry months.

Studies from northern Ghana confirm that dry-season vegetable irrigation farming contributes substantially to household incomes, supports nutrition, and improves community-level food supply during the lean season (Donkoh, 2016). However, sustainability challenges

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persist, including high pumping costs, inadequate water sources, weak extension support, and environmental issues such as soil salinity. Despite these limitations, dry-season irrigation farming remains a critical pathway for achieving food security and building climate-resilient agricultural systems in semi-arid regions such as Nanumba South.

2.2 Extent of Dry-Season Irrigation Farming

Dry-season irrigation farming has expanded significantly across northern Ghana, where rainfall is highly seasonal and unreliable for year-round crop production. Regional agricultural studies indicate that farmers increasingly adopt shallow wells, motor pumps, and simple gravity-fed systems to continue vegetable cultivation beyond the rainy season (Akolgo, 2020). In many Northern Region communities, irrigation is practised near rivers, streams, low-lying areas, and hand-dug wells, enabling farmers to cultivate tomatoes, onions, peppers, and leafy vegetables during dry months (Donkoh, 2016). District-level planning documents also show that local governments actively promote dry-season vegetable farming. The Nanumba South District Agricultural Department identifies off-season vegetable production as a key livelihood activity supported by extension services and farmer-based organisations (Nanumba South District Assembly, 2023). Hydrological assessments in northern Ghana further confirm the availability of groundwater suitable for small-scale irrigation, prompting the broader adoption of dry-season farming across communities similar to Wulensi (Yidana, 2023). While peer-reviewed studies on Wulensi specifically are limited, evidence from the surrounding district strongly suggests that dry-season irrigation farming is widely practised, supported by local institutions, and increasingly central to household livelihood diversification. However, this study seeks to uncover the extent to which dry-season irrigation farming is practised among the people of the Wulensi community.

2.3 Contribution of Irrigation Farming to Household Food Security and Income

A large body of literature demonstrates that small-scale irrigation has significant positive effects on food security, nutrition, and income. Irrigation enables households to produce food year-round, reducing dependence on rainfed agriculture and mitigating lean-season food shortages (Wahab, 2015). Studies from northern Ghana show that dry-season vegetable farmers benefit from improved dietary diversity because vegetables—rich in vitamins—are available even during the dry season (Mupaso, 2024). Further studies also highlight substantial improvements in household income associated with irrigation adoption. Balana et al. (2020) found that small-scale irrigation has dramatically increased net farm profits, providing farmers with regular cash flow from vegetable sales. This additional income allows households to purchase staple foods, invest in education, acquire farm inputs, and enhance general livelihood stability. Donkoh (2016) similarly reported that off-season vegetable cultivation significantly contributes to farmers' income because market prices for vegetables are higher during the dry season. Moreso, irrigation enhances household resilience by diversifying income sources, reducing vulnerability to rainfall variability, and enabling households to accumulate assets (Akolgo, 2020). Together, these studies emphasise that irrigation farming plays a critical role in strengthening both food availability and economic access—key pillars of food security.

2.4 Challenges Facing Dry-Season Irrigation Farmers

Despite its contributions, dry-season irrigation farming faces multiple constraints that limit its full potential. One major challenge is water scarcity and sustainability. Over-extraction of groundwater due to increasing demand can deplete aquifers, mainly where multiple farmers depend on the same sources (Yidana, 2023). Competition for water is common in areas with limited surface water bodies. Another significant constraint is the high cost of irrigation equipment. Motor pumps, fuel, hoses, and watering cans require substantial investment, which many smallholder farmers cannot afford (Balana et al., 2020). High fuel prices further increase irrigation costs, reducing profitability.

Technical inefficiency also affects productivity. Akolgo (2020) found that farmers with limited extension contact, inadequate agronomic knowledge, or poor irrigation scheduling experience lower yields. Pest infestation, poor soil fertility, and post-harvest losses further constrain production. Farmers also face market-related challenges, including price fluctuations,

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perishability of vegetables, limited storage facilities, and poor transport networks. These factors increase financial risk, especially in remote communities like Wulensi (Donkoh, 2016). Environmental concerns, including soil degradation and potential salinisation, have also been noted in some irrigation sites (Mupaso, 2024). These challenges highlight the need for improved management, technology, and institutional support to ensure sustainable irrigation farming.

2.5 Strategies for Enhancing the Sustainability of Irrigation Farming

The literature proposes a range of strategies to strengthen the sustainability of small-scale irrigation farming. A critical starting point is the practical assessment and management of water resources. Yidana (2023) recommends routine groundwater monitoring and community-based water governance systems to prevent depletion. Researchers recommend promoting affordable, efficient irrigation technologies, such as solar-powered pumps and water-harvesting structures. These reduce fuel costs and improve water-use efficiency (Balana et al., 2020). Providing subsidies or micro-credit for irrigation equipment can also enhance adoption, especially among low-income farmers.

Strengthening agricultural extension services is another proven strategy. Studies show that extension contact significantly increases farmers' technical efficiency, improves irrigation scheduling, and enhances yields (Akolgo, 2020). Capacity-building programs on climate-smart agriculture, pest control, and post-harvest management are essential. Enhancing market linkages through farmer cooperatives, aggregation centres, and improved transport would also help reduce losses and increase profitability (Donkoh, 2016). Cold-chain facilities and storage units would also help stabilise prices and reduce spoilage.

Finally, institutional support from local government agencies, NGOs, and MoFA can create an enabling environment by improving infrastructure, promoting farmer-based organisations, and providing training on sustainable resource use. Such integrated strategies are necessary to ensure the long-term viability of dry-season irrigation farming in communities such as Wulensi.

Although substantial literature exists on irrigation farming in northern Ghana, several gaps remain. First, empirical data on the extent of irrigation farming in Wulensi specifically are limited. Second, while regional studies document the socio-economic benefits of irrigation, community-level variations in outcomes remain understudied. Third, little research focuses on farmer-specific challenges in Wulensi, particularly those related to groundwater sustainability and market access. This study, therefore, fills these gaps by providing community-specific empirical insights.

2.6 Theoretical Framework of the Study

This study is grounded in the Sustainable Livelihoods Framework (SLF) and the Food Security Framework. The SLF, widely applied in empirical research, emphasises key components such as livelihood assets, the vulnerability context, transforming structures and processes, livelihood strategies, and livelihood outcomes (Scoones, 1998). Together with the Food Security Framework, it provides a comprehensive analytical lens for examining how dry-season vegetable irrigation farming shapes household food security in the Wulensi community of Nanumba South. The SLF offers insights into the resources and conditions that shape farmers' livelihood strategies. At the same time, the Food Security Framework explains the outcomes of these strategies in terms of the availability, access, utilisation, and stability of food.

The Sustainable Livelihoods Framework posits that households draw on five categories to pursue livelihood strategies that enhance their welfare (Declaration, 1996). In the context of Wulensi, access to natural capital, such as water sources, physical capital, such as pumps and irrigation tools, and financial capital for purchasing inputs, determines the extent to which farmers can engage in dry-season irrigation. Human capital, in the form of skills and experience, as well as social capital, including cooperative networks and community support, further shape the adoption and intensity of irrigation practices. By examining these assets, the SLF helps explain the extent of dry-season irrigation farming in the Wulensi community and also reveals the constraints that limit its sustainability.

Complementing this, the Food Security Framework enables a structured assessment of how irrigation farming contributes to household food security outcomes. Dry-season vegetable

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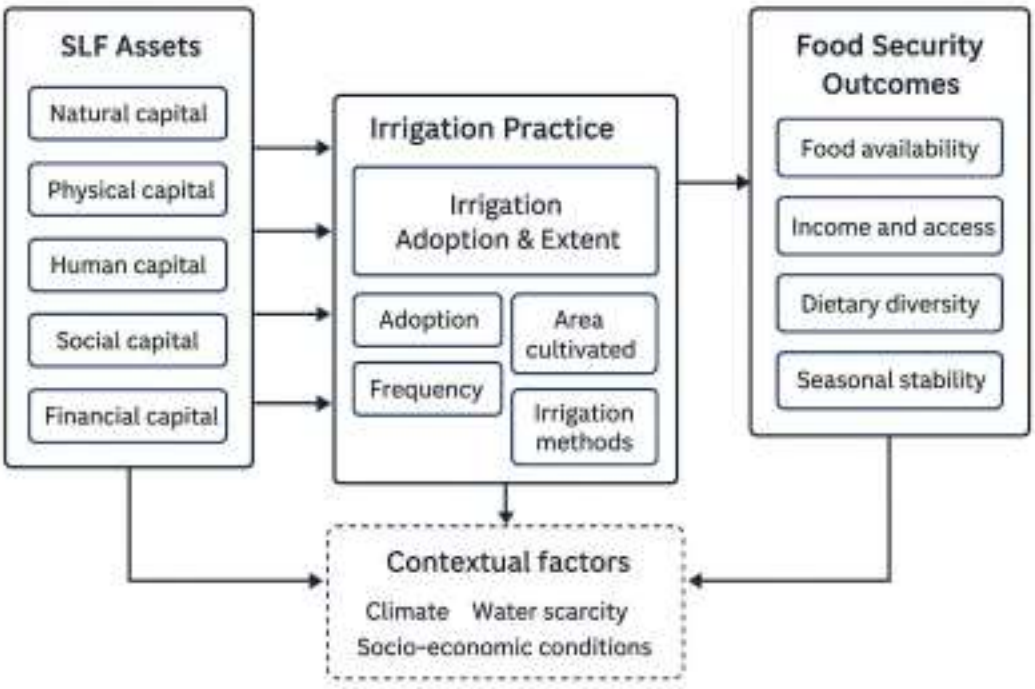
production directly enhances food availability by increasing household-level supply during periods of scarcity. It improves economic access by generating income from vegetable sales, enabling families to purchase other food items. Irrigated vegetable production can also improve utilisation by increasing dietary diversity and nutritional intake. Furthermore, by reducing seasonal food shortages, irrigation supports the stability dimension of food security. These linkages address Objectives 2 and 4, which focus on understanding the contribution of irrigation to food availability and income, and on identifying strategies to promote food security and sustainability.

Together, the SLF and Food Security Framework guide the analysis by linking farmers' resource endowments and livelihood strategies to measurable food security outcomes. This integrated theoretical foundation enables the study to comprehensively evaluate dry-season irrigation farming as both a livelihood activity and a pathway to improved food security in the Wulensi community.

2.7 Sustainable livelihoods framework and food security framework



3.0 METHODOLOGY

This chapter presents information on the proposed research approach, research methods, research paradigms, study population design, sample size, sampling procedure, data collection instruments, data analysis, and ethical considerations.

3.1 Research paradigms

Research scholars hold different beliefs about nature and how the world should be explored. These beliefs and ideas give rise to what are called research paradigms. The philosophical worldview of researchers plays an essential role in every research endeavour. However, these worldviews are not always visible; they still influence the outcome of every study and therefore need to be identified (Slife & Williams, 1995). Moreover, Ulz (2023) defined the research paradigm as a perspective or philosophical framework that governs the research process and encompasses ideas, beliefs, and prejudices. It concerns the researchers' perspectives on what to examine and how to conduct a study to attain a specified goal. Emile Durkheim, August Comte, and John Stuart Mill were some of the Proponents of positivism. Positivists believe that there is a single reality that can be examined and comprehended. As a result, these scholars are inclined to apply quantitative methodologies in their investigations. The research procedure in

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positivist paradigm studies often begins with the formulation of an empirical hypothesis, which is subsequently supported or rejected through data collection and analysis. According to the positivist paradigm, the primary goal of scientific inquiry is to explain the cause-and-effect relationships between variables. Given this, the researcher approached the study without pre-determined beliefs or opinions about the variables, which results in objectivity, the ultimate aim of positivism (Creswell, 2014; Ulz, 2023).

Interpretivism is the opposite of positivism. According to interpretivists, there is not a single reality; instead, there are several realities. The bulk of qualitative investigations in the social sciences employ this research paradigm (Ulz, 2023). Alfred Schutz and Max Weber were among the advocates of the interpretivist paradigm. Because human behaviour is so complex, interpretivism holds that statistical models, such as those used in positivist paradigms, cannot be applied to it. Only by analysing the meanings people place on behaviours and occurrences can knowledge be generated. As a result, investigations using this paradigm are inevitably subjective and heavily influenced by the investigator's viewpoint (Creswell, 2014; Ulz, 2023). Given the subjective nature of interpretivist studies, their findings are often limited to the specific circumstances of the investigation, making generalisations almost impossible.

Pragmatism is another research paradigm. A pragmatist combined the ideologies of positivism and interpretivism. John Dewey is one of the prominent figures of this paradigm. Pragmatists believe that reality constantly evolves amid ever-changing conditions. As a result, instead of employing a single research paradigm, practitioners apply the model best suited to the research topic under consideration. As positivist and interpretivist approaches are integrated, both qualitative and quantitative methodologies are frequently used (Creswell, 2003, 2014; Ulz, 2023). This particular study adopted the constructivist paradigm. Though this paradigm does not support the idea of objective reality as a social phenomenon, reality is instead constructed from participants' subjective views (Creswell, 2009). This means that individuals develop subjective meaning from their experiences, often through interaction with others.

The choice of this paradigm is consistent with qualitative research, which is the process of inquiry that seeks to understand a social problem through people's views, using open-ended interviews (Abdulai & Owusu-Ansah, 2014). It is important to note that the topic under study has a greater influence on the chosen design. According to Morse (1991), if the research problem seeks to identify factors that influence an outcome, use an intervention, or, better yet, determine the predictors of outcomes, then a quantitative approach is the best option. However, if the social problem under study is new or requires further clarification due to limited research, a qualitative design would be more appropriate. The study examines the role of Dry Season Vegetable Irrigation Farming in enhancing food security in the Wulensi community of Nunumba South and highlights the need for further exploration.

3.2 Research approach

Research is driven by a desire to solve a real-world problem, which cannot be achieved without strategic pathways and approaches. Therefore, scholars have sought to define and categorise various research approaches. According to Creswell (2014), research tradition refers to the strategies employed by researchers from the beginning of the study to its end to realise the study's objectives. The three main traditions or research approaches identified by Creswell (2014) are qualitative, quantitative, and mixed approaches. The choice of either of the above methodologies of inquiry depends on numerous factors, including the phenomenon, topic, and objectives to be achieved (Morse, 1991). Based on this, the study adopted a qualitative approach.

3.3 Qualitative research approach

Qualitative research is an approach that emphasises understanding human experience and social phenomena through descriptive and analytical methods. This approach is inherently descriptive, focusing on the richness of human experience rather than numerical data (Sa'adah et al., 2023). There are different strategies of inquiry under the qualitative approach. According to Creswell (2014), the qualitative research approach includes strategies such as narratives, phenomenology, ethnography, case studies, and grounded theory. However, the choice between those strategies depends on the topic or issue under study. Therefore, the study utilised a

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qualitative case study design to uncover the views and experiences of the Vegetable Irrigation Farming and other stakeholders as the target population.

3.4 Research design

The general approach or proposal that clearly outlines the research methodology is known as the research design. According to Creswell (2009), a research design can be qualitative, quantitative, or mixed, depending on the specific paradigm, strategies of inquiry, and overall methods chosen by the researcher. However, every research design is influenced by the phenomenon under study. According to Morse (1991), a qualitative approach is essential when little research has been conducted on the identified problem, and it warrants further exploration. Though there are many designs within a qualitative research approach, the choice of one is influenced by the research problem under investigation (Creswell, 2003). However, this study employed a qualitative case study design. It was selected for its ability to understand and accentuate the views, ideas, and experiences of the research respondents regarding the phenomenon under study (Alase, 2017).

This means that the design's concern is to explore in order to comprehend and interpret what these ideas, views, and experiences mean to them. However, respondents' experiences do not make sense when the researcher lacks a better understanding of the target respondents (Alase, 2017). Therefore, it is an added advantage for the researcher to have a thorough understanding of his research participants to achieve the objectives of his study. The study, therefore, seeks to understand how Vegetable Irrigation Farming translate into food security in the Wulensi of the Nanumba South. The ultimate goal of the research is to rely heavily on participants' perspectives of the situation under investigation (Creswell, 2009). This suggests that the research respondents are important to achieving the study's objectives.

3.5 Population

A population is an entire group that a researcher wants to study. According to Cofie (2020), a population is a “well-defined collection of individuals and objects possessing similar characteristics or binding traits” (p. 46). In research, the population refers to the subjects the investigator intends to study. Levin added that population refers to the entire group of individuals or items that meet the criteria for inclusion in a study (Levin, 2006). The target population of this study focused on Vegetable Irrigation farmers in Wulensi and the Stakeholders of the dry-season vegetable irrigation farming project in the community.

3.6 Sampling and sampling techniques

A sample is a subset of the population, allowing the researcher to infer about the entire population. According to Alvi (2016), “a sample can be defined as a group of a relatively smaller number of people selected from a population for investigation purposes” (p. 11). This means that results from the sample can be generalised to the target population or the sample pool. However, there is an ongoing debate on how to determine an appropriate sample size for a qualitative approach. As noted earlier, the primary focus of qualitative researchers is to rely as much as possible on the views of the participants to be able to achieve the research objectives, as literature review in qualitative studies plays a less essential role in the direction of how the research questions should be answered (Creswell, 2012). The study focused on Vegetable Irrigation farmers and the stakeholders of the dry-season vegetable irrigation project, both men and women. A purposive sampling technique was employed to select farmers who have been engaged in Vegetable Irrigation Farming for the past 3 years, as well as project stakeholders directly involved in monitoring and evaluating the project's success. This technique was chosen because not every Irrigation farmer has experience, as most farmers are still learning how to practice dry-season vegetable irrigation farming. Therefore, the study settled on the above target population to draw meaningful conclusions.

3.7 Sample size

According to Creswell (2013), after identifying the research target population, it is important to determine the study's sample size. Data saturation is one of the determinants of qualitative sample size. Generally, researchers conclude data collection when they believe they

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are no longer generating new information. In qualitative studies, researchers view data saturation as the 'gold standard' for determining sample size (Morse, 2015; Sykes et al., 2018). However, scholars like Fusch and Ness (2015) criticise saturation as problematic, since not all designs are unique or equally applicable to all methods to achieve data saturation. These are examples of sample sizes for some scholars: Creswell (2003) suggests a range of 5 to 25 interviews for the phenomenological strategy of inquiry. Dukes (1984), interviews 3–10; Morse (1994), interviews 6; Smith et al. (2009), interviews 3–10. Therefore, given the above sample size for these scholars, one can conclude that the appropriate sample size for qualitative studies should not exceed 30 participants.

Qualitative research is an inquiry that focuses on the similarities in the lived experiences of participants in a particular group (Creswell, 2013). This study adhered to Alase's (2017) principle, which states that qualitative research requires 2 to 25 participants who have all experienced similar occurrences to achieve uniformity in the life experiences of the research participants regarding a particular phenomenon. Therefore, the sample size for this study is 20 participants, comprising 15 Vegetable Irrigation farmers from the Wulensi community and 5 officers of the Dry Season Vegetable Irrigation project in the Nanumba South. After all, the focus of Qualitative case study design is to conceptualise the quality of information about participants' views and experiences, rather than their quantity (Smith et al., 2009).

Moreover, Alvi (2016) maintained that studies seeking to explore an idea rather than understand the population will employ a non-probability sampling technique. Therefore, purposive sampling, a non-probability sampling technique, was selected for the study, which allows the researcher to select respondents based on their experience with the topic under study. According to Etikan, Musa, and Alkassim (2016), purposive sampling is a technique used by the researcher to select subjects based on their possession of relevant information strategically. The nature of the topic demanded key knowledge holders in Vegetable Irrigation Farming within the Wulensi community.

3.8 Research instruments

Data collection is an essential component of this study and therefore cannot be possible without research instruments. These instruments are tools the researcher uses to facilitate field data collection. The selection of these instruments is influenced by the research design and the study's objectives. Therefore, interviews and focus discussions were deemed appropriate for the study.

3.9 Interview Guide

An interview guide is simply a list of the topics a researcher plans to cover in an interview, along with the questions to be answered under each topic (Jamshed, 2014). Abdulai and Owusu (2014) categorise interviews into three types: structured, semi-structured, and unstructured. This study employed unstructured interviews to gather data from experts with knowledge of dry-season vegetable Irrigation Farming in the Wulensi community. This is due to the research respondents' level of experience with the topic under study. Even though the interview guide has been criticised for being difficult to administer and time-consuming, and for the tendency of the researcher to influence responses and the study's outcome, it has been considered a very suitable instrument due to the opportunities it offers the researcher and the respondents. For instance, the closed interaction between the researcher and the respondent allows the researcher to ask follow-up questions or probe for clarification to gather the needed information.

Moreover, the researcher had the opportunity to request clarification of questions that were vague or unclear to obtain very relevant information on the topic under discussion. The respondents also had the opportunity to respond to the questions at their convenience. They had the opportunity to clearly express their opinions on the role of Dry Season Vegetable Irrigation Farming in enhancing food security in the Wulensi community. Researchers have demonstrated the effectiveness of administering unstructured interviews to key knowledge holders in the subject matter (Creswell, 2013). Therefore, given the effectiveness and results-oriented nature of this tool, it was utilised face-to-face to facilitate the achievement of the research objectives.

The interview instrument was administered to the respondents at the scheduled time. A total of 15 people were interviewed. The face-to-face interview was suitable for the project officers

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because of their busy schedules, which do not allow the researcher to conduct a focus group discussion with them as organised by the farmers. The researcher determined a suitable day and time for each respondent based on their convenience. On the day of the interview with each respondent, as predetermined, the researcher visited them, some in their homes. The purpose of the research was explained again before the interview began, and each interview lasted approximately 1 hour and 30 minutes. Some respondents could express themselves well in English; therefore, the interview was conducted in English. A few respondents did not speak English; hence, the interview was conducted in the local dialect (Dagbani) so they could express themselves well. This was done to ensure that actual information regarding the topic is obtained.

3.10 Focus group discussion

Qualitative research commonly uses Focus Group Discussion (FGD) as a method to collect data. It involves interactive discussions among participants to generate data. Community development research often uses FGD to achieve a bottom-up, community-driven approach (Adekola et al., 2016). The need to investigate shared experiences and views on a specific phenomenon, such as the role of dry-season vegetable Irrigation in enhancing food security in the Wulensi community, justifies the use of focus group discussions (FGDs) within a qualitative research design. As emphasised by Creswell (2013), qualitative studies aim to comprehend the essence of human experiences, making FGDs an appropriate method for capturing the collective meaning individuals attribute to their lived experiences.

Krueger and Casey (2014) also say that focus groups (FGDs) are great for qualitative research because they allow participants to talk to each other, share different points of view, and help make sense of things, which aligns with phenomenology's interpretive nature. Moreover, Morgan (1997) underscores that FGDs offer a rich context for exploring the complexities of subjective experiences, facilitating a deeper understanding of the phenomenon under investigation. The focus group discussion was conducted with the farmers, excluding the project officers in the Wulensi community, as their presence would have influenced the discussion's outcome.

3.11 Validity and reliability of the instrument

There is an ongoing debate among scholars about the relationship between validity and reliability in qualitative studies. Although Creswell (2014) argued that validity and reliability are associated with quantitative studies, it remains important to ensure that qualitative findings meet these requirements. The instrument's content validity was established by presenting it to the experts in qualitative research. Moreover, pre-testing of the instruments was conducted in a different community in Nanumba South, which was accurate for further administration.

3.12 Analysis of Data

This study has adopted the qualitative data analysis procedure from Punch (2009). Punch (2009) divides this analytical method into three significant components. The section on data reduction focuses on methodically condensing and organising raw data. It includes tasks such as translating recordings made in the local dialect into English. The translations were later transcribed and were further coded and categorised for analysis. The goal was to simplify and make sense of the extensive data or information gathered. The second phase of the analysis helps display and make meaning from the data. This process makes the information more accessible and understandable. The final stage involves interpreting the data and drawing meaningful conclusions. The researcher finally analysed the patterns and themes that had emerged from the data reduction and display phases.

3.13 Ethical considerations

According to White (2005), ethics can be defined as the general consideration of beliefs that are either good or bad, proper or improper, right or wrong. Ethics in research are essential to participant safety and study integrity. Informed Consent: The researcher obtains consent from all participants, explaining the study's purpose and potential risks. It was made clear to

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the participants that they can freely withdraw at any time if they no longer wish to participate, without any consequences whatsoever: anonymity and Confidentiality. The researcher also ensured that participant identities would be kept confidential and used solely for the study. To ensure the highest level of anonymity, letters were used to represent the participants, and any information that might reveal their names was therefore avoided. Moreover, they were assured that any information shared would be kept confidential. Any information that might dent their image or harm them was kept secret. Respect for Autonomy: The researcher respected participants' autonomy and choices, including their decisions to participate or withdraw from the study. In conclusion, Chapter Three presents a rigorous qualitative methodology grounded in the constructivist paradigm. Through purposive sampling, interviews, and focus group discussions, the study captures rich insights from farmers and stakeholders. The use of Punch's (2009) data analysis model, along with strong ethical considerations, ensures credibility and depth in exploring the link between dry-season irrigation farming and food security in Wulensi.

4.0 RESULTS AND DISCUSSIONS

This chapter presents and discusses the empirical findings from the study conducted in the Wulensi community of the Nanumba South District. Data were obtained through in-depth interviews and focus group discussions (FGDs) with dry-season irrigation farmers and agricultural project officers. The analysis followed Punch's (2009) qualitative data reduction approach—comprising data selection, condensation, and interpretive summary—guided by the study's four research objectives. Verbatim quotations are incorporated to strengthen the credibility and authenticity of the findings. The discussion is situated within the Sustainable Livelihoods Framework (SLF) and supported by relevant empirical literature.

4.1 Extent of Dry-Season Irrigation Farming Practices in Wulensi

4.1.1 Prevalence and Participation

The findings reveal that dry-season irrigation farming is a dominant livelihood activity in the Wulensi community. Participation is widespread, cutting across different age groups and involving both men and women. This underscores the importance of irrigation farming as a community-wide livelihood strategy. One farmer explained*: "Once the rains stop, everyone moves to the dam area. It has become a tradition here."* This quotation demonstrates how ingrained irrigation farming has become in the seasonal cycle of community life. The practice is not viewed as optional but as a customary response to rainfall cessation. It reflects a collective adaptation strategy in line with the SLF, in which communities mobilise available natural resources—such as the dam—to sustain their livelihoods during the dry season. Another respondent added*: "Whether you are young or old, you must join, unless you have moved away. It feeds us."* This statement highlights both the inclusiveness and economic necessity of irrigation farming. The phrase "*it feeds us*" emphasises its central role in meeting household food and income needs. The mention of all age groups participating indicates that irrigation farming functions as an essential livelihood asset accessible to nearly the entire community.

4.1.2 Types of Crops Cultivated

Farmers in Wulensi predominantly cultivate short-maturing, high-value vegetables, including tomatoes, peppers, onions, okra, cabbage, and leafy greens. Tomatoes and peppers stood out as the main crops due to their high market demand and profitability.

One participant noted: "*Tomato is our main crop. If you get a good harvest, you earn something meaningful."* This quotation illustrates the economic motivation behind crop selection. Tomatoes, in particular, are associated with financial returns that significantly support household needs. The reference to "earning something meaningful" shows that successful harvests can substantially improve household income, consistent with the SLF's emphasis on enhancing financial capital through livelihood activities.

4.1.3 Farm Sizes and Land Use Patterns

Farm sizes in the study area were relatively small, typically 0.25-1 acres, due to land scarcity and competition for space around the dam. Irrigation land is a limited asset, and farmers adjust by cultivating smaller plots. One respondent reflected*: "My farm is not big, but I manage it*

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well. It is enough to give me vegetables and some income." This comment demonstrates how farmers maximise productivity despite small landholdings. The respondent emphasises efficiency and resourcefulness, suggesting that even small plots can contribute meaningfully to both food supply and income. This aligns with the SLF principle that effective management of limited assets can still generate sustainable livelihood outcomes.

4.1.4 Irrigation Methods and Tools

The study shows that irrigation practices in Wulensi remain predominantly manual. Most farmers rely on watering cans and buckets, while only a few use motor pumps due to their high cost. This reflects limited access to modern agricultural equipment and constrained financial capital. A farmer remarked, *"Using the bucket is stressful, but what can we do? Pumps cost too much."* The farmer's statement highlights the physical burden of manual irrigation and also points to financial barriers that prevent the adoption of modern irrigation technologies. The phrase *"what can we do?"* reflects a sense of resignation and limited options, showing how financial constraints shape livelihood strategies. An agricultural officer corroborated this view*: "The majority depend on manual irrigation. Pumps are scarce and expensive."* This quotation validates the farmers' concerns and confirms that limited access to pumps is not an isolated issue but a systemic challenge. The officer's statement reinforces the argument that economic limitations hinder technological adoption, affecting productivity and labour efficiency.

4.1.5 Labour Dynamics

Dry-season irrigation farming in Wulensi is highly labour-intensive. Households typically rely on family labour, including spouses, children, and extended relatives, to support various farm activities such as watering, weeding, and harvesting. One participant shared: *"I farm with my wife and children. We all help because the work is plenty."* This quotation reflects the communal nature of labour within households. The phrase "the work is plenty" shows that irrigation farming requires collective effort, making family labour a critical livelihood asset. This also demonstrates how social capital, particularly family networks, supports the viability of irrigation farming.

4.2 Contribution of Irrigation Farming to Household Food Security and Income.

Dry-season irrigation farming plays a central role in shaping households' livelihoods in the Wulensi community. Respondents emphasised that, beyond providing food, irrigation farming enhances income, employment, and social relations. The following sections present the major themes that emerged from the interviews and focus group discussions.

4.2.1 Household Food Availability

Respondents consistently emphasised that irrigation farming significantly improves household food availability, especially during the dry season, when most rain-fed farms lie fallow, and food shortages become common. The cultivation of vegetables such as tomatoes, peppers, okra, and leafy greens ensures that households have a steady supply of nutritious produce. One farmer explained: *"During the dry season, vegetables in the market are expensive. Because we farm, we always have food."* Another echoed this sentiment, highlighting the non-monetary value of irrigation farming*: "Even if we do not make a profit, at least we eat fresh vegetables every day."* These responses underscore the role of irrigation farming in enhancing dietary diversity and reducing households' pressure to purchase expensive vegetables during periods of scarcity. The availability of home-grown produce contributes directly to one of the fundamental pillars of food security—household food availability.

4.2.2 Contribution to Household Income

In addition to providing food, irrigation farming serves as an essential source of income for many households in Wulensi. Farmers sell surplus produce both locally and to traders from nearby towns such as Bimbilla and Tamale. Earnings from these sales support a range of household needs, particularly education, farm investment, and basic expenses. One farmer highlighted the importance of this income*: "Last year, I sold my pepper and used the money to pay school fees. Without it, I do not know what I would have done."* Another added*: "It is during dry-season farming that I get money to buy fertiliser for the next rainy season."* These testimonies

Innovations in Engineering and Technology
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reveal that irrigation farming not only supplements household finances but also strengthens farmers' capacity to reinvest in agriculture. Project officers interviewed further confirmed that dry-season irrigation has become a primary livelihood strategy, helping households stay economically afloat during periods when other income sources are limited.

4.2.3 Employment and Livelihood Diversification

Dry-season irrigation farming creates critical employment opportunities, particularly for youth who often face limited work options during non-farming periods. For many young people, engagement in irrigation activities prevents idleness and helps them generate income to meet personal and household needs. A young farmer described this benefit*: "I farm during the dry season so that I do not just sit at home. It keeps me busy and gives me income."* This contribution aligns with the Sustainable Livelihoods Framework (SLF), which emphasises the need for diversified livelihood portfolios to enhance resilience. By providing an alternative source of income outside the rainy season, irrigation farming reduces vulnerability and broadens households' livelihood options.

4.2.4 Social and Community Benefits

Beyond food and income, irrigation farming also generates important social benefits. Respondents reported strong cooperation among farmers, often working in groups, sharing farming knowledge, and supporting each other with labour or resources when needed. Such collaboration strengthens social cohesion within the community. One participant stated, *"We help each other. If someone's pump spoils, we join hands to support."* This sense of mutual support reflects the community's substantial social capital—a key asset within the SLF. Shared learning, collective problem-solving, and cooperation contribute to a more resilient farming community and enhance the sustainability of irrigation activities.

4.3 Challenges Affecting Sustainable Irrigation Farming

The study revealed several interrelated challenges that constrain the productivity and long-term sustainability of dry-season irrigation farming in the Wulensi community. These challenges span environmental, technical, institutional, and economic dimensions. The narratives provided by respondents offer vivid illustrations of farmers' everyday struggles and provide deeper insight into the realities that shape agricultural outcomes. The expanded Explanations below contextualise each quotation within the broader findings of the study.

4.3.1 Water Scarcity

Water scarcity emerged as the most dominant challenge reported by farmers, particularly during the peak of the dry season from February to April. Respondents repeatedly pointed to the drastic reduction in water levels in the community's dams and streams during this period, rendering irrigation extremely difficult. One farmer lamented*: "By February, the dam reduces drastically. We struggle to get water, and some crops die."* This statement highlights not only the physical reduction in water availability but also the emotional and economic toll on farmers who depend entirely on irrigation for dry-season production. The phrase "*struggle to get water*" conveys the daily burden of competing for limited water supplies, while "some crops die" reflects the direct impact on productivity and household income. The scarcity is attributed to environmental factors, including siltation of the dam, high evaporation rates driven by rising temperatures, and overuse resulting from increased farmer participation in dry-season farming.

4.3.2 Limited Access to Irrigation Technology

Another major constraint identified by respondents was limited access to modern irrigation technologies, especially motorised pumps and drip irrigation systems. Most farmers still depend on manual watering methods, which are time-consuming, labour-intensive, and less effective. One participant expressed*: "I want a pump, but where will I get the money? So, I use buckets every day."* This remark underscores how financial constraints prevent farmers from acquiring technologies that could significantly reduce their workload and increase efficiency. The reliance on buckets not only slows down irrigation activities but also restricts the size of plots farmers can cultivate, thereby limiting production potential. Another farmer emphasised the

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challenge further: *"Drip irrigation would help us save water, but it is too expensive."* The respondent further acknowledges the benefits of modern irrigation systems, particularly their capacity to conserve water during periods of scarcity. However, the prohibitive cost makes such technologies inaccessible, reinforcing the technological divide that keeps farmers dependent on traditional, low-yield methods.

4.3.3 High Cost of Agricultural Inputs

Rising prices of essential agricultural inputs—including fertiliser, pesticides, and improved seed varieties—were widely mentioned as barriers to sustainable production. Without access to these inputs, farmers are unable to meet crop nutrient requirements or manage pests effectively. As one respondent noted, "With the price of fertiliser *now, many of us cannot afford it. So, the crops suffer."* This statement illustrates how financial constraints directly translate into reduced crop vigour and lower yields. The phrase "*the crops suffer*" reflects the visible deterioration of plants due to inadequate soil nutrients, demonstrating the strong link between rising input costs and declining productivity. High input prices also discourage farmers from applying recommended quantities, further compromising agricultural output.

4.3.4 Pest and Disease Infestations

Pest and disease outbreaks, particularly affecting tomatoes, peppers, garden eggs, and leafy vegetables, pose a significant threat to dry-season farming. Respondents emphasised that these infestations can be devastating if not controlled promptly. A farmer reported*: "Sometimes the insects finish the whole farm. If you do not spray, you lose everything."* This quotation demonstrates the severity of pest damage, with "*finish the whole farm*" signifying complete crop destruction. It also highlights the vulnerability of farmers who lack access to appropriate pesticides or the knowledge to apply them effectively. Without timely intervention, pest infestations compromise livelihood security, contributing to both financial losses and food shortages.

4.3.5 Market Access and Price Instability

Market-related challenges also emerged as key constraints, including limited access to buyers and unstable vegetable prices during the dry season. Some farmers reported that harvested vegetables could not be sold due to a lack of market linkages. As one respondent explained*: "Sometimes buyers do not come. When vegetables spoil, we lose our efforts."* This statement reflects the frustration and emotional burden farmers endure when their produce goes to waste. The phrase "*we lose our efforts*" encapsulates the loss of labour, time, and financial investment that goes into production. Poor market infrastructure, overreliance on intermediaries, and limited storage facilities collectively contribute to these losses, discouraging farmers from expanding their operations.

4.3.6 Insufficient Extension Support

Institutional support—particularly agricultural extension services—was described by many respondents as inadequate. Farmers noted that they rarely receive guidance on improved agronomic practices, pest control, and irrigation management. One participant stated: *"We hardly see the officers. We need their guidance, especially on pests."* This quotation highlights a significant institutional gap: the lack of regular technical assistance to help farmers adopt improved practices. The specific mention of "*pests*" shows that farmers recognise the importance of expert knowledge in addressing challenges they cannot tackle on their own. The lack of extension support contributes to inefficient farming methods, low yields, and repeated crop losses.

4.3.7 Financial Constraints

Finally, limited access to credit was widely cited as a challenge that restricts farmers' ability to invest in their farms. Without capital, farmers cannot purchase inputs, adopt new technologies, or expand cultivated land. One respondent explained: "*We do not get loans easily.*

Innovations in Engineering and Technology
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Even small support would help." This statement emphasises that even minimal financial assistance could significantly improve farmers' capacity to increase productivity. The difficulty in obtaining loans—often due to lack of collateral or high interest rates—keeps farmers operating at a subsistence level. This financial constraint perpetuates a cycle of low investment and low productivity.

4.4 Strategies for Improving Irrigation Farming and Food Security

Participants and agricultural officers outlined a range of strategies to enhance irrigation farming and ensure sustained food production in the Wulensi community. The following sections expand on their suggestions and explain the meaning and implications of each quotation provided.

4.4.1 Improving Water Infrastructure

Farmers emphasised improving the capacity of existing water sources, especially the community dam, as a top priority for sustainable irrigation. One respondent explained*: "If they remove the silt and deepen the dam, we can farm throughout the dry season."* This quotation reflects farmers' firm belief that dam rehabilitation—particularly desilting and deepening—would significantly enhance water storage. The phrase "farm throughout the dry season" shows that farmers see expanded water capacity as key to year-round cultivation, improved yields, and higher income. Silt accumulation in the dam currently reduces its depth and restricts water availability, making desilting an essential intervention. Furthermore, some farmers suggested drilling boreholes as supplementary sources of irrigation water. This shows that respondents understand the need for diversified water options to reduce pressure on the dam and ensure water security during peak dry months.

4.4.2 Provision of Modern Irrigation Technology

A second primary strategy proposed was the provision of improved irrigation technologies such as motor pumps, drip kits, and water storage tanks. One farmer remarked*, "If the government supports us with pumps, we will produce more. The work will also be easier."* This statement highlights two important aspects: increased productivity and reduced labour intensity. Farmers recognise that motorised pumps would allow them to expand their cultivated areas and irrigate more efficiently than manual watering with buckets. The phrase "the work will also be easier" illustrates the physical strain of current methods and shows how modern equipment could transform smallholder irrigation into a more efficient and sustainable system. By calling for government support, farmers also emphasise that purchasing pumps independently is financially challenging, underscoring the need for subsidisation or direct distribution.

4.4.3 Strengthening Extension Services

Respondents strongly recommended strengthening extension services through regular training on agronomic practices, pest control, irrigation techniques, and water conservation. A participant stated: *"We need more education to improve our practices."* This quotation underscores the importance of improved knowledge and technical guidance for increasing productivity. Farmers acknowledge gaps in their current methods and believe that education from extension officers would help them adopt modern practices, reduce crop losses, and manage water more efficiently. The call for "*more education"* shows that the current extension contact is insufficient and that farmers desire ongoing engagement for long-term improvement.

4.4.4 Improving Access to Credit

Access to affordable loans was another primary concern raised by the farmers. They emphasised that financial support would enable them to purchase essential inputs and adopt better technologies. One farmer noted: "*Even small loans can help us buy fertiliser and seeds."* This statement reveals how limited financial resources constrain agricultural production. The emphasis on "*small loans"* demonstrates that farmers do not necessarily need large amounts of capital—modest, accessible credit could make a significant difference in their ability to acquire inputs such as fertiliser, pesticides, and improved seeds. Without credit, farmers remain trapped in low-input, low-output cycles that hinder productivity and income generation.

Innovations in Engineering and Technology
IETech 2026, Volume 6, Issue 1, Page 74-96
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4.4.5 Enhancing Market Access

Respondents highlighted the need to strengthen market systems to reduce post-harvest losses and improve profitability. Suggestions included improving transportation networks, creating organised buyer linkages, and establishing storage facilities. One participant stressed, *"If there is a storage place and transport to big markets, we will not lose our vegetables."* This quotation reflects farmers' concerns about their inability to store perishable produce or transport it to more profitable markets. The lack of storage leads to spoilage, while inadequate transport limits market reach. The phrase "*we will not lose our vegetables"* emphasises the economic losses farmers incur when produce spoils. Improved market systems would therefore not only reduce waste but also increase income and encourage expanded production.

4.4.6 Promoting Farmer Cooperatives

Collective action through farmer cooperatives was viewed as an effective strategy to improve market access, reduce input costs, and enhance bargaining power. One respondent explained*: "If we form a group, we can buy inputs cheaper and sell together for better prices."* This statement highlights the benefits of cooperation: reduced input costs through bulk purchasing and improved sales through collective marketing. Operating as a group allows farmers to negotiate better deals with suppliers and buyers, strengthening their economic position. The idea of "*selling together"* also suggests unity and shared benefits, demonstrating farmers' awareness that collective organisation can address many of the challenges they face individually.

4.5 Summary of Key Findings

The findings reveal that dry-season irrigation farming is widely practised in Wulensi and plays a crucial role in improving household food availability, providing income, and supporting livelihood diversification. However, several challenges—including water scarcity, limited access to irrigation technologies, high cost of agricultural inputs, pest and disease infestations, market limitations, inadequate extension services, and financial barriers—threaten the sustainability of these farming activities. Farmers proposed several feasible strategies to address these challenges: rehabilitation of water infrastructure, improved access to modern irrigation technologies, strengthening of extension services, expansion of credit facilities, cooperative formation, and improved market access systems. If implemented, these strategies could significantly enhance irrigation farming productivity and contribute to long-term food security in the community.

4.8 Discussion of Findings

This section discusses the study's significant findings in relation to the research objectives, the existing literature, and the theoretical frameworks guiding the study—the Sustainable Livelihoods Framework (SLF) and the Food Security Framework. The discussion reveals how dry-season vegetable irrigation farming contributes to food security in the Wulensi community, while highlighting the constraints and opportunities that influence its sustainability.

4.8.1 Extent of Dry-Season Irrigation Farming Practices

The study found that dry-season irrigation farming is increasingly widespread in the Wulensi community, with farmers cultivating tomatoes, pepper, cabbage, lettuce, and garden eggs using water from dams, wells, and streams. This expansion reflects a shift from reliance on rain-fed agriculture to more intensive year-round production. The findings align with Namara et al. (2011), who argue that smallholder irrigation in northern Ghana has become a key livelihood strategy due to climate variability and the increasing demand for fresh vegetables during the dry season. Additionally, the increasing participation of youth and women in irrigation farming confirms the argument by Dittoh, Akuriba, and Issaka (2013) that dry-season irrigation provides employment and empowerment opportunities for marginalised groups. Under the SLF, this expansion indicates strengthened livelihood strategies, driven by access to natural (water) and social (farmer groups) assets.

4.8.2 Contribution of Irrigation Farming to Household Food Availability and Income

Innovations in Engineering and Technology
IETech 2026, Volume 6, Issue 1, Page 74-96
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The study revealed that irrigation farming significantly improves household food availability by ensuring steady access to vegetables during the dry season. Households that engage in irrigation farming enjoy improved dietary diversity and reduced food expenditure. This finding aligns with FAO (2016), which emphasises irrigation's role in stabilising food supply and enhancing nutrient intake. Economically, farmers reported gains from vegetable sales, which they used to purchase staple foods, pay school fees, and meet healthcare needs. This confirms Namara et al. (2014), who found that dry-season vegetable production is among the most profitable livelihood activities for small-scale farmers in northern Ghana. The income generated strengthens the food access pillar of the Food Security Framework and enhances resilience during the lean season. Under the SLF, these outcomes represent improvements in financial and human assets, leading to positive livelihood outcomes such as poverty reduction, increased consumption, and enhanced well-being.

4.8.3 Challenges Affecting Sustainable Irrigation Farming

Although irrigation farming holds significant potential to enhance dry-season vegetable production in Wulensi, farmers continue to face multiple constraints that undermine sustainability. Respondents identified water scarcity during peak dry months, limited access to modern irrigation technology, high input costs, recurring pest and disease outbreaks, poor market access, and irregular extension services as persistent challenges. These findings align with the observations of Barry et al. (2020), who report that water depletion and inadequate access to irrigation pumps remain critical barriers for smallholder irrigation farmers in northern Ghana. Similarly, Sarpong and Anyidoho (2012) emphasise that the high cost of agricultural inputs and limited market infrastructure limit farmers' ability to capitalise on irrigation opportunities fully. Interpreted through the lens of the Sustainable Livelihoods Framework (SLF), these challenges reflect key components of the vulnerability context—environmental stresses, economic pressures, and institutional weaknesses that diminish farmers' capacity to maintain stable, resilient livelihoods. They also point to deficiencies in transforming structures and processes, particularly in relation to extension service delivery, resource governance, and agricultural support systems. Collectively, these constraints weaken farmers' livelihood assets and reduce the effectiveness of irrigation farming as a pathway to sustainable food security in the Wulensi community.

4.8.4 Strategies for Improving Irrigation Farming and Food Security

The strategies proposed by farmers and agricultural officers—including dam rehabilitation, provision of motor pumps, enhanced extension support, increased access to credit, and improved market systems—reflect a strong understanding of the essential components required to ensure sustainable irrigation farming. These recommendations are consistent with the findings of Namara and Sally (2014) and the International Water Management Institute (IWMI, 2018), who emphasise that strengthening water infrastructure and promoting low-cost technologies such as drip irrigation are crucial for expanding profitable smallholder irrigation across Africa. Within the Food Security Framework, the identified strategies contribute to multiple dimensions of food security, including:

- Food availability, through increased agricultural production;
- Food access, supported by higher household income; and
- Food stability, achieved by minimising seasonal fluctuations in food supply.
- Under the Sustainable Livelihoods Framework (SLF), these interventions enhance transforming structures (e.g., institutions and services) and strengthen livelihood assets, thereby supporting more resilient livelihood outcomes.

4.8.5 Integration with Theoretical Frameworks

- Sustainable Livelihoods Framework (SLF).
- The study's findings align strongly with the SLF.
- Livelihood assets: Farmers depend on key capitals such as natural capital (water resources), human capital (skills and experience), and social capital (cooperative networks).

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- Vulnerability context: Farmers remain exposed to shocks arising from water scarcity, pest infestations, and market limitations.
- Transforming structures and processes: The role of extension services, irrigation support mechanisms, and market systems is central to enhancing livelihood opportunities.
- Livelihood strategies and outcomes: Engagement in irrigation farming leads to increased income, improved household food security, and greater seasonal stability.

Food Security Framework
The findings also reinforce the four core pillars of food security:

- Availability: Dry-season irrigation ensures a consistent supply of vegetables throughout the year. Access: Vegetable sales revenue enhances households' purchasing power.
- Utilisation: Households benefit from consuming nutrient-rich vegetables that improve dietary quality.
- Stability: Irrigation minimises dependence on rainfall and reduces vulnerability to lean. The results affirm the framework's position that food production, income generation, and improved dietary practices collectively shape household food security outcomes.

4.8.6 Summary of Discussion

The study demonstrates that dry-season irrigation farming significantly enhances food security and livelihoods within the Wulensi community. The practice contributes to increased food availability, improved incomes, and strengthened household resilience. However, its long-term sustainability is constrained by infrastructural deficiencies, environmental challenges, and limited institutional support. Addressing these issues—particularly through improved water infrastructure, modern irrigation technologies, strengthened extension services, and enhanced market access—would substantially improve livelihood outcomes and secure sustainable food security for farming households.

5.0 CONCLUSIONS

This chapter presents a summary of the study's significant findings, the conclusions drawn from them, and recommendations for improving dry-season vegetable irrigation farming in the Wulensi community. The chapter also outlines suggestions for further research. The summary is organised according to the four research objectives that guided the study.

5.1 Summary of Findings

5.1.1 Extent of Dry-Season Irrigation Farming in Wulensi

The study found that dry-season vegetable irrigation farming is widely practised and has expanded in recent years. Farmers cultivate crops such as tomatoes, peppers, cabbage, lettuce, and okra using water from dams, shallow wells, and streams. The increase in participation is driven by rising awareness of economic benefits, youth unemployment, and household nutritional needs. Women and young people have become particularly active in the practice. Overall, irrigation farming has evolved into a vital livelihood strategy in the community.

5.1.2 Contribution of Irrigation Farming to Household Food Availability and Income

The findings indicate that irrigation farming significantly enhances food availability, food access,
and dietary diversity. Households engaged in irrigation farming have regular access to fresh vegetables during the dry season when rain-fed crops are scarce. Income from vegetable sales is used to purchase staple foods, pay school fees, access healthcare, and support other household needs. This income provides stability during the lean season and contributes positively to household food security. The practice also offers seasonal employment opportunities for youth.

5.1.3 Challenges Affecting Sustainable Irrigation Farming

Several constraints undermine the sustainability of irrigation farming in Wulensi. These include declining water levels during the peak dry months, limited access to modern irrigation technologies, high input costs, frequent pest and disease outbreaks, poor market access,

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inadequate storage facilities, and irregular extension services. These challenges reflect broader environmental stresses, institutional gaps, and economic pressures that limit farmers' capacity to maintain productive, resilient irrigation systems.

5.1.4 Strategies to Improve Irrigation Farming for Sustainable Food Security

Farmers and agricultural officers proposed practical strategies to enhance irrigation farming. These include rehabilitating and desilting the community dam, drilling additional boreholes, providing modern irrigation equipment, strengthening extension services, improving access to credit and subsidies, expanding market infrastructure, and forming farmer cooperatives. These strategies aim to strengthen water availability, improve production efficiency, increase profitability, and promote long-term sustainability.

5.2 Conclusions

Based on the findings, the study concludes that dry-season vegetable irrigation farming plays a crucial role in improving food security and livelihoods in the Wulensi community. The practice enhances food availability, dietary quality, income generation, and resilience during the dry season. It has also become an important strategy for diversifying farmers' livelihoods, especially for women and youth. However, the full potential of irrigation farming is constrained by environmental, technical, and institutional challenges. Limited water resources, inadequate irrigation technologies, high production costs, and weak support systems undermine sustainability. Addressing these constraints is essential to ensuring a stable food supply, improved household income, and long-term food security. Overall, dry-season irrigation farming aligns strongly with the Sustainable Livelihoods Framework and the Food Security Framework, demonstrating its capacity to strengthen livelihood assets, improve food access, and enhance stability. With adequate support, the practice can significantly contribute to rural development in the Nanumba South District.

5.3 Recommendations

Rehabilitate and desilt the Wulensi community dam to increase water storage capacity. Drill additional boreholes and construct water reservoirs to ensure a consistent water supply throughout the dry season. Implement community-based water management structures to regulate and sustain water use. Government and NGOs should subsidise motorised pumps, drip irrigation kits, and water storage systems. Deploy more extension officers to ensure regular farmer support. Provide training on pest control, water management, soil fertility management, and climate-smart agriculture practices. The government should expand input subsidy programs to include seeds, fertilisers, and pesticides used in dry-season production. Encourage public–private partnerships to support irrigation farmers with affordable inputs. Improve market infrastructure to reduce post-harvest losses, including storage and transportation facilities.

5.4 Suggestions for Further Research

The study recommends further research on the following areas:

- Comparative assessment of irrigation efficiency across different technologies in rural Ghana.
- Gender-specific challenges and opportunities in dry-season irrigation farming.
- The long-term economic impact of irrigation farming on household poverty reduction.
- Climate change implications for smallholder irrigation systems in northern Ghana.

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