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Women's Local Knowledge and Engagement in Groundwater Irrigation: Impacts on Household Food Security in the Upper East Region of Ghana

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ABSTRACT

Groundwater irrigation in Ghana is a major livelihood activity that secures food through the cultivation of vegetables for households, particularly in the dry season. This activity is largely driven by the application of local knowledge. However, the existing studies that examined local knowledge of groundwater irrigation focused mostly on male irrigation farmers. Women's local knowledge is often ignored or remains undocumented. In instances where it is studied, women's local knowledge is lumped with males' local knowledge thus ignoring its uniqueness. Furthermore, the studies about women's local knowledge in this activity present this knowledge as one that permits women to perform only supplementary roles. Also, irrigation generally has an impact on food security. Yet, few studies have examined how women's engagement in this activity secures food for their households. Therefore, the study discusses the following: the source of women's local knowledge of groundwater irrigation, the value and application of women's local knowledge of groundwater irrigation and the contributions of groundwater irrigation undertaken by women to household food security. Local knowledge is special knowledge; thus, a qualitative study approach was employed to explore it. Five rural communities in the Upper East Region of Ghana were studied. Interviews were used to generate the primary data while ATLAS.ti and GraphPad software were used in organising, analysing and presenting the data. The results showed that women farmers possessed local knowledge which was traced to different sources. The knowledge extended to include their negotiation power for access to land/wells, resources of which they have been marginalised. The application of this knowledge in groundwater irrigation promoted household food security, in the dimensions of access, utilisation, affordability, and agency. However, climate change may threaten groundwater irrigation's contribution to food security unless artificial groundwater recharge is promoted.

INTRODUCTION

Local knowledge of women has been critical in the exploitation and protection as well as adaptation to environmental changes. By local knowledge, Dei (2000) referred it to as knowledge that is personal and transmitted orally, it is experientially based, tied to people's economic, cultural, political, spiritual, ecological and material forces and conditions. This knowledge relates to the cosmos and beliefs of the people and is expressive and narrative through proverbs, fables and tales and at the centre of this knowledge are people, place and history. Considering its significance, Shiva (1992) presented that women's local knowledge in India has influenced seed development, the indigenous dairy industry, fertiliser use and feed value of different fodder species in agriculture and biodiversity conservation and utilisation. In Mexico, Kernecker *et al.* (2017) showed that women's local knowledge helps them adapt to water crises by using indicators such as vegetation/trees to identify springs of water. "In Bafoulabé region in Mali, women would take care of the field individually or in groups. Their

knowledge of landraces was vast. They could identify 30 different varieties by growth cycle, plant growth habit, plant height, number of stems, grain yield, grain size, form, colour, preparation quality, utilization and taste of the end product. Women are often involved in the selection, improvement and adaptation of plant varieties. They often have more specialized knowledge of wild plants used for food, fodder and medicine than men" (Food and Agriculture Organisation, 2005).

In Ghana, women possess local knowledge which enables them to engage in various livelihood activities including groundwater irrigation. Considered an agelong activity, groundwater dry season farming in the country is largely driven by the application of local knowledge of farmers (Derbile, 2010: Kwoyiga & Stefan, 2018, 2019: Laube *et al.*, 2017). Both men and women engage in it. However, women apart from cultivating crops, negotiate for land and other resources since by patriarchal arrangements they own less or no land. They make independent decisions throughout the production or irrigation chain including packaging and marketing of their produce. This, the women do because of their local knowledge. Noteworthy, however, the existing studies that examined local knowledge of groundwater irrigation in the country focus largely on male farmers (Kwoyiga & Stefan, 2018: Laube *et al*., 2012, 2017). Women's local knowledge is often ignored, less appreciated and remains undocumented. In a few instances where it is studied, women's local knowledge is lumped with men's local knowledge rather than independently studied, considering its uniqueness. Informed by such situations, Oedl-Wieser (2017) posited that, though women are contributing significantly to agriculture, they remain underestimated and weakly appreciated. Similarly, Shiva (1992) asserted that "women have remained invisible as farmers despite their contributions to farming as people fail to see their work in agriculture". The BRIDGE (2014) added that women make vital contributions to farming but they usually do not get the credit for much of their efforts.

Furthermore, the few studies about women's local knowledge within the context of dry season farming in Ghana present their local knowledge as one that permits them to perform only supplementary rather than complementary roles. For instance, Nchanji (2017) discussion of women vegetable cultivation in the Northern Region of Ghana highlighted them as those who lack knowledge and technical expertise in groundwater irrigation. Hence, their local knowledge only permits them to sell vegetables at farm gates from male farmers, source vegetable accompaniments to staples provided by men, assist to fence, irrigate and carry water for watering plants. Contrary, in the Upper East Region of Ghana, Apusigah (2009) highlighted that women drawing from their knowledge play complementary roles that secure food for their households. The research gap in documenting the significance of women's local knowledge which enables them to undertake groundwater irrigation and its related major decisions is, therefore, of appeal in this study.

On the other hand, irrigation generally has an impact on food security. Food security as defined by the Food and Agriculture Organisation of the United Nations (2002) refers to when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. Though this definition has been commonly adopted, Clapp *et al.* (2021) argued for the inclusion of *agency* and s*ustainability* as independent pillars. A*gency* they refer "to the capacity of individuals and groups to exercise a degree of control over their circumstances and to provide meaningful input into governance processes" while *sustainability* "refers to 'food system practices that contribute to long-term regeneration of natural, social, and economic systems, ensuring the food needs of the present generations are met without compromising the food needs of the future generations'"(Clapp *et al*., 2021). Dillon (2008) indicated that in northern Mali households that engage in irrigation experience an increase in household consumption and caloric and protein as such households also tend to save and share more with their fellow rural folks; a kind of informal social insurance. Specifically about women's engagement in irrigation and the relationship with food security, Namara *et al*. (2005) citing Nepal indicated that

"household nutritional intake has significantly improved as the families have started eating green vegetables regularly as women small cultivators were involved directly in market transactions, they had access to and control over the revenue generated from the sale of vegetables. This access and control over income had a positive impact on overall household food security, as the majority of these women, spent most of the revenue on household food items". In East Shoa, Ethiopia, irrigation contributes significantly to enhancing household food security with households headed by women being less likely to be food insecure compared to male-headed households (Tesfaye *et al*., 2008). Upadhyay *et al.* (2005) study of drip irrigation technology by women in Nepal showed that farmers' households experienced improved dietary changes as vegetables were included in every meal. In fact, all farmers and their households consumed vegetables with their meals. In addition to the consumption of vegetables, savings from the sales of vegetables were used to purchase milking cows resulting in the inclusion of milk and its products in households' meals. Cash from the sales of surplus milk is used to purchase other essential household foodstuff.

In Ghana, groundwater irrigation has evolved to become a major livelihood strategy for most people, especially in the dry season. According to Kyei-Baffour and Ofori (2006), groundwater irrigation augments rain-fed agriculture to meet the food needs of the country's ever-growing population and secures food for consumption in the lean season as is the case of northern Ghana where there is unimodal rainfall pattern. Moreover, crop yields from irrigated farming are better than rain-fed farming. In the Atankwidi catchment in northern Ghana, groundwater irrigation is contributing to tackling food insecurity and poverty (Namara *et al.*, 2011). In their study of irrigation impacts in Ghana, Akudugu *et al*. (2021) established that farmers "now have an extended period of supply of fresh farm produce for household consumption and sale for income to buy other consumable goods not produced by farm households. The extended supply of fresh food according to them leads to a reduction in food prices and improvement in food security". Notwithstanding the general contributions of irrigation to food security in Ghana, research specifically focusing on the contributions of irrigation undertaken by women is almost absent in the country. It is a fact that Theis *et al*. (2018) assessed women dry season farmers about technology adoption. However, a sift through the existing literature indicates that little has been documented about women farmers and their household food security. Thus, the study further assesses the women's engagement in groundwater irrigation through the application of local knowledge and its impacts on food security in their homes.

This study thus, contributes to highlighting the critical role and value of women's local knowledge of groundwater irrigation. The study is considered among the first to discuss the local knowledge of women of groundwater irrigation as a vital factor in the process of irrigation development in Ghana. The goal of this study was, therefore, to examine the context and contributions of women's local knowledge of male-dominating groundwater irrigation. Specifically, it focused on the following: the source of women's local knowledge of groundwater irrigation, the value and application of women's local knowledge of groundwater irrigation and the contributions of groundwater irrigation undertaken by women to household food security.

MATERIALS AND METHODS

Study Area

The study was conducted in the Upper East region of Ghana. The study communities included; Bawiu, Nimbasenia, Telania, Nyangua and Navio. Bawiu, Nimbasenia, Telania and Nyangua are all located in Pungu, a large rural community in the Kasena/Nankana Municipality with Navrongo as the district's capital. Navio is located in the Kasena/Nankana West District with Paga as the district's capital. Lying within the Guinea Savannah Woodlands vegetative zone of northern Ghana, the study communities have shared relief, climate and soil conditions. The climate is characterised by dry and wet seasons. The wet season of only four months occurs from May to September and is getting shorter over the years. The average annual rainfall is 950mm (Ghana

Statistical Service, 2014). The landscape is undulating with isolated hills. The vegetation cover is made up of the savannah grassland with short trees and stomps. The Savannah ochrosols and groundwater laterite are the main types of soils found in the area.

Until recently, the study communities belonged to one local government area. Hence, they have shared governance systems, formally and traditionally. Apart from the formal system, they both practice the twin traditional government system of chiefs and priests. While chiefs are political heads, priests are spiritual heads. With natural resources such as land and water, critical to irrigation activities, both chiefs and priests share in its governance. Land titles, household headship and inheritance regimes rest with men.

Marriage is also patri-local. The patriarchal nature of their society has meant that women's interests and rights are subsumed under men's. For instance, access to natural resources is through husbands, brothers and sons. The people of the rural communities are mainly agrarian and engage in food crops and animal production on a subsistence basis. They have traditionally depended on rain-fed agriculture to produce their main staples such as millet, sorghum and maize as well as other complements such as groundnuts, rice, potatoes and vegetables. Regarding household food provisioning, there is a traditional gender division. Men as husbands, fathers and brothers are expected to supply the stable foodstuffs such as millet and corn, which are jointly cultivated from the family farm. Women as wives, daughters and sisters are expected to prepare the stables into food for consumption. Traditionally, once the staples have been supplied, men can choose to provide additional support with processing and soup/sauce ingredients or not. The obligation to process food rests with women. Indeed, women are often left with the challenge of providing the soup/sauce ingredients with or without the support of men.

Methodology

A qualitative research approach was employed to examine women's local knowledge of groundwater irrigation and food security in northern Ghana. According to Atieno (2009), this approach allows for the understanding of phenomena deeply and in detail, because it is associated with methods for discovery of central themes and analysis of core concerns. This approach also enables researchers to learn from participants in a given setting about their experiences, meanings and interpretations of a particular phenomenon. Thus informed, since this study is the first of its kind, detailed information is needed to fully understand women's local knowledge, perceptions and experiences of engaging in male-dominating groundwater irrigation and this activity contributes to household food security. Additionally, in Ghana and most developing countries, local knowledge is specialised knowledge and it is usually and mostly discussed and associated with men. Also, local knowledge is the knowledge that is not universally distributed hence few or some people may possess it. So, a topic such as this that explores women's local knowledge in groundwater irrigation needs to be carefully explored in depth. Groundwater irrigation in northern Ghana originated from the Kasena/Nankana area with the activity more pronounced. Unfortunately, women's engagement compared to men remains limited in the activity. Thus, a case study design as noted by Yin (2014) was employed to study women farmers to understand the "how" and "why" (Baxter & Jack, 2008) of women's involvement in male-dominating groundwater irrigation and the place of their local knowledge.

Data for the study were obtained through in-depth interviews, informal discussions, personal conversations, participant observations and desk reviews resulting in the generation of both primary and secondary data. The in-depth individual interviews involved a total of 154 women farmers (49 farmers from Nyangua, 23 farmers from Nimbasenia, 41 farmers from Navio, 13 farmers from Telania and 28 farmers from Bawiu) The participants were selected on a voluntary basis depending on their willingness to participate. A research assistant, who was familiar with the study area and had interacted with the women in the past conducted the interviews. The interviews took place on the farms, in homes and at the church premises at the convenience of the respondents. The interviews were conducted in the local language of the people and transcribed. The data were collected from January to June 2022. The data

were organised, analysed and presented using ATLAS.ti and Graph Pad software.

RESULTS AND DISCUSSION

Socio Demographics of Women Farmers

Different categories of women engaged in groundwater irrigation in the study communities (Figure 1). From the interview responses, 74% of the women were married and living in the dwelling units of their husbands. However, it emerged that the husbands of some of these women had migrated to southern Ghana in search of greener pastures leaving behind their wives and children. Unfortunately, such migrant husbands had not been able to send remittances regularly and sufficient to sustain their families back home. With such women saddled with the responsibility of taking care of their children, and without any reliable source of income-generating activity, they took over the family land and wells to cultivate crops. Such women were mostly found in Nyangua and Navio communities. The unmarried women (10%) were those who were single and either learning a skill, had completed a Senior High School or had no job but were born into families of farmers, hence tended to engage in groundwater irrigation. The divorced/separated (6%) were those who grew up in families of farmers. Upon returning to their father's house and with no reliable income-generating source but with experiences in groundwater irrigation from childhood and can access the family land/well, they cultivated crops to provide food for their households. The widows (10%) were those whose husbands died and were either advanced in age or young (but unwilling to remarry) and living with their children in their husbands' houses. Guided by their irrigation experiences (from their husbands mostly) and access to their late husband's family land and wells, they also engaged in groundwater irrigation to provide food for their children.

In terms of age, the majority of all women farmers (58%) were between 41 and 60 years old. Such women possessed a wealth of experiences and skills in irrigation and had been involved in it together with their husbands. Due to culture, some of the women here got married early but to men who were far older than them. As such the men grew older and weaker, and their younger wives took over their wells and continued to solely cultivate crops in the dry season. Apart from the young married farmers, there also existed farmers (10%) who were above 61 years old but actively engaged in groundwater irrigation.

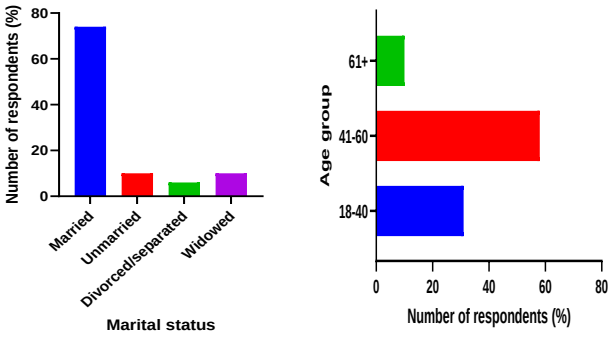

Figure 1: Marital Status and Age of Respondents

Regarding the household size (Figure 2), the majority (75%) of the households comprised 6-10 members. With the communities located in northern Ghana, the extended family system is commonly practised, the reason for some households being made of more than 11 members (16%) were found also in the communities.

Educationally, about 68% of them were without any formal education (Figure 3). The majority of them were women aged 41 years and above and were engaging in groundwater irrigation and other informal income-generating activities. A few of them (7%) had basic education, especially those below age 41. The unmarried respondents (mostly young ladies) though educated but born into irrigation families were also found here. Such respondents were found to be combining irrigation with the learning of a skill (dressmaking or hairdressing) or waiting to further their education. Also within this age bracket were women who after high school could not further their education but got married to irrigator husbands.

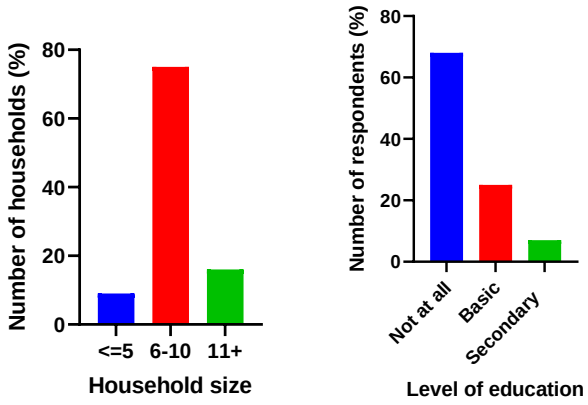

Figure 2: Household and Educational Characteristics of Respondents

Figure 3: Women Irrigation Farmers on their Farms

Nature of Women Groundwater Irrigation

Groundwater irrigation undertaken by women is not different from that of men even though a few differences exist in the study communities. Noteworthy, however, unlike men, women here negotiated for land and wells since patriarchal arrangements denied them ownership of such. The goal of women's engagement in groundwater irrigation was largely to secure and sustain food for the household, especially in the dry season. That is, to augment available household food and avert hunger; a situation which is common in the dry season in northern Ghana. The women farmers' families constructed at least one well. Unlike in some areas where wells for irrigation are temporary and constructed in dry riverbeds during the dry season, the wells in the study areas were permanent with the age of some wells ranging between 1 and 70 years. The wells were locally constructed by the residents. The wells were either unlined or lined with cement/cement blocks (Figure 3). Almost all the wells in the study communities were located near the homesteads of the people. Since the purpose of women's engagement in groundwater irrigation was to secure food for their families, the farmers cultivated mostly vegetables such as tomatoes, pepper, okra, garden eggs, spinach, and other local edible food crops. These were harvested fresh and used to prepare dishes for the household.

Women's Local Knowledge and Groundwater Irrigation

The study findings revealed the importance of local knowledge in groundwater irrigation. Noteworthy, all the respondents (100%) possessed local knowledge about groundwater irrigation. From the interviews, the women farmers traced their knowledge to different sources (Figure 4) with some respondents tracing their local knowledge to more than one source such as parents and a husband. The interviews revealed that 45% of the respondents accumulated their knowledge mostly from their parents while 45% of them traced their knowledge mostly to their husbands. Historically, groundwater irrigation in northern Ghana started in Pungu, where Bawiu, Nyangua, Telania and Nimbasenia communities which are not far from one another are located. Nonetheless, people from such communities inter-marry, it was, therefore, not surprising to find a woman irrigator whose source of knowledge was from both the parents and husband. Women whose husbands were and are still farmers initially supported them on the farms through which they accumulated this knowledge. Then with time, such tended to venture into irrigation independently of their husbands. About 6% of them traced their knowledge to their siblings, especially brothers. As a patriarchal society, males turn to owning farms (particularly when their father dies) at an early age and may receive labour support from their sisters, especially their younger ones. Such sisters while assisting their brothers also accumulated this knowledge. The others (4%) were those who accumulated knowledge from their

fathers-in-law, brothers' in-law and friends through labour services that they rendered to these male farmers.

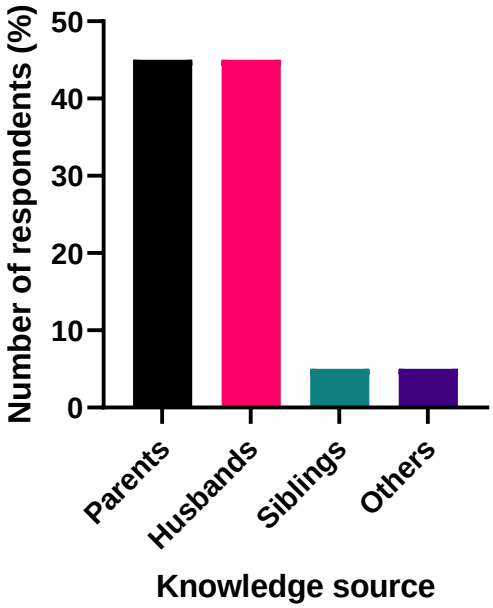

Figure 4: Sourced of Women Farmers' local knowledge

Local Knowledge and Groundwater Development and Abstraction

The results showed that local knowledge of women farmers permeated different aspects of groundwater development and abstraction which included: locating the site for well digging, the physical construction, depth of the water table, water quality and quantity (including monitoring water availability/recharge), conveyance and application (manual irrigation and spray irrigation) and water conservation. All (100%) of the women farmers revealed that water for dry season irrigation was exploited from manually constructed open wells that were at least 8m in depth (Figure 5). Covers/lids made of local materials were used to cover the mouths of the wells. About 40% of them had knowledge of the procedures to follow during well construction, well water quality determination, monitoring and conservation. From the interviews, it was revealed that the women farmers did not usually engage in the physical construction (digging and plastering) of the wells but carried out the rest of the activities relating to water exploitation and application. Regarding how suitable sites for well constructions were identified, the responses showed that some indicators were usually considered. A woman irrigator in Nyangua said this:

"*I know that digging a well and getting water for any purpose is not done haphazardly. From my experiences and observations, it is usually low-lying areas, marshy areas or places near valleys or rivers as well as those surrounded by trees/bushes that have high yielding groundwater tables. For instance, in places where even in the dry season one sees trees and plants growing, when a well is constructed there, there are higher chances of the well supplying water throughout the year. This is evident in my community as most of the wells are located in some of these places*".

The respondents (80%) highlighted that the physical construction of a well started with the creation of a broader/wider open pit after the exact location had been identified. The pit is deepened to the water table zone or water-bearing rock, a depth characterised by bigger water bubbles ejecting water from all directions. At that zone, the bed/floor of the well is decked and plastered. The wall of the well is also plastered using local materials. This is to prevent pollution by mud and other debris. On one side of the wall of the well, holes about the size of a human palm are created. These holes serve two purposes; aid movement in and out of the well especially when there is a need for desilting or removal of unwanted things. Secondly, the holes help determine the availability of water in the wells as the number of them immersed in water defines the available water.

Figure 5: A Well Under Construction and a Completely Developed Well

As noted already, though women do not dig and plaster the well, 90% of them confirmed that their knowledge helped them maintain the physical surroundings of the wells. As pointed out, wells were open and usually located in low-lying areas. Their location thus made their immediate surroundings liable to flooding, erosion and pollution. Therefore, the women fetched sand and other building materials and used them to create an embankment or raise the surrounding landscape of the well. Furthermore, the local knowledge of the women enabled them to determine the water quality in the wall. According to 90% of them, the physical quality of the water was indicated by its clarity, absence of odour and waste or fines. Guided by local knowledge, the women were aware that saline water was unsuitable for some crops. Drawing from local knowledge, the women farmers were able to use other methods to measure the availability of water in wells. A woman in Nimbasenia said this:

"*I use several methods to determine the availability of water in my well. Apart from considering the number of holes on the wall of the well immersed in water, I tie a heavy object to a rope, then lower this object up to the bottom of the well. The length of the rope soaked in the water is then compared with my arms stretched upward to know the volume of water in the well at that moment. Furthermore, when I am fetching water from the well, and the bucket hits the bottom of the well, it is an indication that the water level of the well is almost zero".*

In terms of conveyance, all respondents explained that local knowledge played a critical role in how water was transported and distributed to plants. Citing Telania, Nyangua, Bawiu and Nimbasenia, responses showed that some farmers had diesel-powered pumps that enabled them to draw water from the wells. The water drawn was then applied to crops via spray tubes. However, most farmers in the Navio community were without pumps and hence drew water manually (the commonest practice) from wells using buckets and ropes. The water was then either stored in a small drum before application or directly applied to their crops using watering cans or buckets. Additionally, considering the yields of their wells, the local knowledge of women farmers enabled them to conserve the water in the wells by adopting water application practices that ensured that all crops were watered. For instance, different crops were watered at different times. This made room for groundwater recharge over time.

Local Knowledge and Irrigational/Agronomic Practices

Women drew ideas from local knowledge to cultivate irrigable crops as noted already. Apart from ploughing, their knowledge covered the following aspects or activities of irrigation; land preparation, fencing, sowing, crop water conveyance and application, transplanting, weeding, pest control, harvesting, and marketing. Respondents (99%) were familiar with almost all the activities even though there were instances that compelled them to seek support from other people to perform them. Since irrigation is done in the dry season, immediately after the rainy season harvest, irrigable plots were cleared of stumps and other waste by the women.

Harvested local materials such as millet stocks, shrub sticks and dry branches of trees were then used to fence their farms in order to prevent animals' invasion. Pepper seedlings were usually nursed among leafy vegetables such as roselle *(Hibiscus sabdariffa)* before transplanting. This is to promote the efficient use of water and reduce the impacts of diseases on the pepper seedlings. Weeding was done using a hoe. Local knowledge guided in the watering of the crops as in the words of a woman in Bawiu:

"*I water my crops either in the morning or evening and sometimes both. Since I am not privileged to own a diesel pump, I use a bucket tied to a rope to fetch water from my well. The water is then poured into a watering can and transported to the crop area where the water is applied directly to the roots of the crops".*

Local knowledge was also applied during the harvesting of vegetables. For instance, harvesting vegetables such as kenaf *(Hibiscus cannabinus)* was done by hand and with a knife. According to 99 % of the respondents, the stem of the matured crop was cut with the small shoots left on, a deliberate strategy. These small shoots matured and

got harvested later. This strategy allowed for the constant availability of leafy vegetables on the farm. Other times, roselle vegetables were uprooted when matured. Vegetables meant to be sold were then packaged in bundles, put in sacks or baskets, transported to and sold in the nearby markets. A woman explained how her vegetables were prepared and packaged for sale in the market: "*When I intend to sell my vegetables, I harvest them either in the evening or early morning. When I harvest them in the evening, I put them in a corner of the farm which is cool and dry. On the next day, I then put them in bundles depending on the given market price. The bundled vegetables are put in a basin and transported by bicycles, donkey carts or tricycles to Navrongo and Paga markets. Sometimes, I put them in my basin and carry them on my head as I walk to the market. Before getting to the market, some would have been bought by some villagers or commuters. People from Bolgatanga also come to buy plenty of them to resell. Some market women in Navrongo also buy from us and resell. Matrons and cooks from boarding schools in the Upper East Region also come to buy from us and use them to prepare soup/sauce for their students. Caterers of restaurants, chop bars and hotels also patronise our vegetables. Female traders from neighbouring Burkina Faso who trade in Paga and Navrongo markets also buy our vegetables".*

The results of this study demonstrated that like men, women also possess a wealth of local knowledge that enables them to engage in groundwater irrigation. In fact, the local knowledge of the women is unique and special. This is because it transcends the cultivation of crops to include groundwater development, packaging, marketing and culinary issues. It enables women farmers to monitor water levels in wells which is in sync with the findings of Chikodzi *et al*. (2014) study of Zimbabwe and Kwoyiga and Stefan (2018) study of local knowledge (especially male farmers) in the Atankwidi catchment of the White Volta.

According to this study, though women are marginalised especially in terms of access to resources, their local knowledge of groundwater is invaluable and empowering as through this knowledge they are able to navigate through the challenges that confront them in engaging groundwater irrigation. This is seen in their negotiation power to acquire land and wells. The study results further revealed that women's local knowledge is overarching and composite as it is being shaped by several factors including their marital status and geophysical locations which is not the case for male irrigators' knowledge. This is because their knowledge is traced to multiple sources including their husbands and transcended their communities of birth. That is, while Derbile (2010) study of local knowledge (of male farmers largely) in Atankwidi equally showed that male farmers traced their knowledge also to multiple sources, such findings did not show that farmers there traced their knowledge to their spouses (wives) as is the case in this study where wives accumulated knowledge from their husbands also. This makes women's knowledge broader in context. Also, the study showed that the women's local knowledge is largely practically based hence experiential; that is accumulated through participation and observation on the farms of both their husbands and parents/siblings. This makes its application easier. Their knowledge is thus consistent with Dei (2000) assertion of local knowledge as being different from other forms of knowledge.

The study further explored the significance of local knowledge especially of women as being evolving and adaptive. This re-echoes Risiro *et al*. (2013) assertion that such knowledge is creative and incorporates outside influences and inside innovations to meet new conditions. This makes the local knowledge of these women rich and comprehensive considering its integrated nature; as one that encapsulates different irrigational practices of several communities or geographical areas and the diverse/multiple features of local knowledge holders. The nature of the women's knowledge, however, refutes Nchanji (2017) study findings of women in the Northern Region of Ghana, where women here are seen to have limited knowledge about vegetable cultivation. It can thus be said that women farmers in the study areas possessed a wealth of knowledge which plays a

vital role in their livelihood activity, hence needs to be given appreciated.

Women Engagement in Groundwater Irrigation and Household Food Security

In northern Ghana, Apusigah (2009) established that women especially those in rural areas are at the forefront of food production and provisioning. Kwoyiga and Apusigah (2022) averred that despite the barriers that women farmers face as food producers, they are surmounting such barriers by combining home-keeping with irrigation to provide food for their households. As indicated, the women farmers of the study areas engaged in the cultivation of vegetables with this activity significantly contributing to addressing food deficits in an area noted for hunger in the dry season. The contributions of women's engagement in groundwater irrigation to food security are presented along the lines of the pillars of food security by FAO and two additional pillars offered by Clapp *et al*. (2021). It is important to mention that the tenets of the sustainability pillar presented by Clapp *et al*. (2021) are very similar to the stability pillar of FAO, but broader in content as far as food security discourse is concerned, thus, important to also be considered in this chapter.

Groundwater Irrigation and Food Availability

Primarily driven by household food needs, the responses from the studied communities that women engaged in groundwater irrigation by depending on wells to grow mostly vegetables such as tomatoes, pepper, okra, garden eggs, spinach, and other local edible food crops. All the respondents mentioned that between half and three-quarters of the vegetables cultivated were consumed at home. Some of the vegetables were also shared with families, friends and relatives, especially those who offered their free support, thus contributing to the food baskets of other households. The strategic harvesting of the vegetables (in periods/stages) guaranteed a regular and sufficient supply of vegetables to households. The vegetable waste from the farm was used to feed the family animals. Meat from the animals raised by the women supplemented household nutritional needs. Furthermore, these animals served as assets and were usually sold to generate income to meet household food needs and unforeseen situations.

Groundwater Irrigation and Household Access to Food

In this study, the engagement of women in groundwater irrigation accelerated easy access to food (vegetables) and its distribution within households. This was seen in the perceived value of the irrigated crops in providing immediate food to the household, especially in situations where there is no family/social support system as such women have to largely fend for their families. From the responses, divorced women (sometimes with children) who returned to their fathers' houses and would have otherwise been a burden on their brothers were encouraged by their brothers to engage in groundwater irrigation. In the Nyangua community, the results showed a woman who was assisted by her brother to dig a well which is currently 7 months old, close to their house to enable her to undertake groundwater irrigation to provide food for her children. Income from the sales of vegetables also gave farmers the purchasing power to buy other foodstuffs, ingredients and spices for the household. This increased farmers' access to other foodstuffs and items that could not be provided by their households. Farmers as vegetable cultivators also made available their surplus vegetables to their local food markets thereby contributing to food security in the dry season in Ghana.

Groundwater Irrigation and Household Food Utilisation

From the study communities, the responses revealed that the cultivated vegetables were harvested and freshly used to prepare dishes for the household. Fortunately, no health-related problems have been noted with regard to the consumption of such vegetables. It can, therefore, be said that the vegetables grown were safe for consumption. Furthermore, the income generated from the sales of vegetables was used to purchase other nutritional items that boosted household diet quality and diversity. Also, the vegetables were staples and culturally/traditionally accepted by all as they were not associated with any food taboos in the communities. The results confirm Apusigah (2009)

assertion that women in northern Ghana are generally responsible for meeting the nutritional needs of the household as they engage in food processing and extraction.

Groundwater Irrigation and Household Food Stability

Groundwater irrigation is an activity undertaken in every dry season. Men who are owners of land and wells are willing to release these resources to women since the activity lies outside the major farming season. The study areas were politically stable as they were without conflict. Noteworthy, however, land inequalities and marginalisation of women might destabilise irrigation food systems. This is because, as noted already, women did not permanently own the land and wells but acquired them through negotiation. Secondly, sometimes, women farmers' initial capital for irrigation comes from other income generating activities; which are not reliable. They also rely on family members and friends to assist with labour, which is not guaranteed always. Prices of farm inputs are also increasing. These issues may threaten the stability of women's groundwater irrigation. It is important to indicate that these women also cultivate vegetables intercropped on their husbands' farms or on different plots of land in the rainy season as a way of getting vegetables and raising income for the household.

Groundwater Irrigation and Women Farmers' Agency

Women farmers in the study communities exercised agency. From the interviews, the women mentioned that they were able to raise some capital through income earned from trading, wages earned from menial daily jobs, sales of farm produce and animals and borrowing money from local savings called susu. Thus, considering the availability of resources like land and groundwater wells in the study communities, though owned by the men, they negotiated for or took over the family land and groundwater wells to cultivate vegetables for the household.

Focusing on the activities of groundwater irrigation after securing land and wells, agency was exercised by these women in the following areas: desilting wells, nursing seedlings, planting, securing materials for and fencing their farms. Other aspects of decision making involved making vegetable beds, weeding, securing compost manure/fertiliser, farm tools, daily watering, harvesting and others. Agency was also exercised in how the revenue generated from the sales of vegetables should be used. As noted, the dry season which is usually the lean season is associated with hunger, women therefore, make decisions to use income associated with groundwater irrigation to buy other food and non-staple food, ingredients, spices and other items for the kitchen.

Groundwater Irrigation and its Sustainability for Household Food supply

The interview responses showed that the sustainability of groundwater irrigation within the context of household food security by women is a daunting one. As noted already, though the activity itself is evolving to become a major livelihood activity, especially in the dry season, marginalisation of women, and limited access to resources as well as climate change and its impacts on water resources may threaten the sustainability of groundwater irrigation as a food security enabler. Further analysis of the results showed that there is an ever-increasing burden of women as providers for the household. This is because groundwater irrigation is an off-farm activity done in the dry season. This is in addition to the women's normal off-farm work in the informal economy and care for their families, which serve to increase their work burdens even as they face further competition in an area, the off-farm alternative, which has originally targeted men. This increasing burden may affect the women's continuous engagement in groundwater irrigation.

This study explored the nexus among local knowledge, groundwater irrigation and food security in the study area. The empirical evidence suggests that women's possession of local knowledge of groundwater irrigation can secure them food for their households. Similar to Zwarteveen (1997) observation of women in neighbouring Burkina Faso where they engage in their own farming in combination with work on their male-controlled farms, women here while supporting their males draw from their local knowledge to engage in groundwater irrigation as

an alternative to securing food without necessarily depending on their husbands and relatives. The findings further imply that not only does women's local knowledge of groundwater irrigation improve their household food security and nutrition, but also serves as an income- generating activity which empowers women economically. According to this study women who are divorced or separated and otherwise would have been a burden on society, draw from local knowledge to engage in irrigation which in the long run contributes to maintaining and or improving the food stability status of their homes. Noteworthy, the study results confirm such studies of Nkhata et al. (2014) of Malawi, Peter (2011) of Swaziland and Jambo et al. (2021) of Ethiopia, that irrigation, generally, when undertaken makes available food and generates income for irrigators.

The study also revealed that women engagement in groundwater irrigation enables them to partly meet their productive demands at the household level as it enabled them to cultivate vegetables to meet their household food and nutritional needs. As Apusigah (2009) noted, women's position in households in northern Ghana includes providing nutrition through direct processing and cooking of meals for families. The women in the study communities are able to fulfil this partly through the cultivation of vegetables of which more than half are consumed at home. Specifically on the pillars of food security, even though, the study did not systematically analyse the caloric intake of the vegetables cultivated, the readily available staple vegetables for household consumption are presumed to contribute to the improvement in the nutrition of households. The women are thus able to fulfil one of their productive roles at the household level, hence supporting the assertion by the FAO that women contribute between 60 and 80 per cent of household food in Sub-Saharan Africa (Karl, 2009).

Nonetheless, situating the four pillars of food security as defined by the Food and Agriculture Organisation of the United Nations (2002) within the study context, it emerged that pillars such as availability, access and utilisation are being met but stability is being threatened by factors such as changes in prices of farm inputs and tenurial arrangements. This implies that for households to be food secured, measures to increase women access to farm inputs need to be given attention. Considering Clapp *et al*. (2021) agency as a pillar of food security, its interrogation in the study area offered insights into the additional skills that women farmers in particular must possess in order to engage in groundwater irrigation. This notwithstanding, the sustainability pillar needs to be given attention as climate change and its impacts on groundwater resources may threaten it. Therefore, measures such as artificial groundwater recharge to boost groundwater availability should be promoted.

CONCLUSION

Rainfed farming in the Kasena/Nankana area has been unable to make available food that meets household food needs throughout the year. To secure food, especially in the dry season, farmers have embraced dry season groundwater irrigation as a food production and provisioning strategy. Central to groundwater irrigation in the study area is the application of local knowledge. Therefore, the study was carried out to examine women's local knowledge of groundwater irrigation and the contribution of their engagement in this activity to household food security which is seldom given attention.

The case of the study communities highlighted women's possession of local knowledge of groundwater irrigation starting from the development of groundwater wells to the cultivation of vegetables. The study provided insights into the sources, nature and application of local knowledge for groundwater irrigation. Being resources disadvantaged, the study brought to bear also the significance of women's local knowledge in negotiating for land and wells which is hardly the case for male farmers, thus making the local knowledge of women a powerful tool in groundwater irrigation as it encompasses several aspects of groundwater irrigation.

The study further demonstrated that through women's application of local knowledge in groundwater irrigation, their irrigational activities are contributing to meeting the four pillars of food security as defined by the Food and Agriculture

Organisation. Agency, an additional pillar of food security proposed by Clapp *et al*. (2021) reflected here in the form of the negotiation power wielded by the women farmers which enables them to access land and wells for irrigation. Their agency was further seen in the independent decisions that they take along the production chain. On the other hand, the stability pillar of FAO could be fully achieved when women's rights to land and other productive resources are promoted. The sustainability pillar of Clapp *et al*. (2021) could also be realised when attention is given to adaptive measures to boost groundwater availability for irrigation.

CONFLICT OF INTEREST

The author declares that there is no conflict of interest regarding the publication of this paper.

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