Mixed Farming System and Key Agricultural Water Management Practices in Ghana

A Review Report

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The Sustainable Intensification of Mixed Farming Systems Initiative aims to provide equitable, transformative pathways for improved livelihoods of actors in mixed farming systems through sustainable intensification within target agroecologies and socio-economic settings.

Through action research and development partnerships, the Initiative will improve smallholder farmers' resilience to weather-induced shocks, provide a more stable income and significant benefits in welfare, and enhance social justice and inclusion for 13 million people by 2030.

Activities will be implemented in six focus countries globally representing diverse mixed farming systems as follows: Ghana (cereal–root crop mixed), Ethiopia (highland mixed), Malawi: (maize mixed), Bangladesh (rice mixed), Nepal (highland mixed), and Lao People's Democratic Republic (upland intensive mixed/ highland extensive mixed).

1. Background

Agricultural water management has been at the core of sustainable agricultural production, seeking to provide crops and animals with the requisite amount of water for growth and development whilst conserving the unproductive farm and landscape water for other productive downstream use and ecosystem services. Crop and fodder production in Ghana is predominantly rainfed. Managing water under this production system requires efficient capture of the available precipitation as well as effective moisture distribution and storage within the crop's productive rootzone. In cases of supplementary irrigation, efficient capture and on-farm storage is required. Thus, managing the captured and available water becomes critical for sustainable production.

Irrigated agriculture in Ghana has been spearheaded by government and multi-lateral interventions in developing large and medium scale irrigation schemes across the country. In recent times, farmers are investing in small-scale irrigation systems to improve the resilience of their production systems. As part of the Sustainable Intensification of Mixed Farming System (SI-MFS) Project, Ghana has focused on cereal-root crops mixed farming system. This is justified in the current trend of rice increasingly replacing major staples in Ghana. In Ghana, increasing rice production to meet the domestic demand is an important step to achieving food self-sufficiency, but this must occur with more efficient water and nutrient use.

Rice production is a heavy consumer of agricultural water worldwide. Rice production in Ghana can be grouped under three production ecologies: upland, irrigated and lowland. In Ghana, its production under lowland and irrigated agroecologies consume about half of the available water resources for irrigation and crop production. In an era of water scarcity and unreliable rainfall, it becomes increasingly important to identify production systems that are efficient users of water and other resources such as labor and nutrients. Rice straw is a source of forage for animal feeding. It can meet the dry matter requirements for livestock when offered in combination with legumes, molasses, and other concentrates to improve the protein content. Since irrigated rice production can occur year-round, rice straw remains a practical fodder source particularly in critical periods when fresh sources of animal feed are not available.

Enhancing rice production is a national priority and has been captured in national agricultural development strategies and projects such as the Shared Growth and Development Agenda, Ghana Commercial Agriculture Project (GCAP), Modernising Agriculture in Ghana (MAG), etc. Improving rice production systems would improve yield and incomes of farmers. This improvement, however, needs to be sustainably implemented by improving on the water and nutrient use efficiencies of the production systems.

Appropriate water and nutrient management are necessary to maximise yields while limiting the wasteful losses of scarce nitrogen as nitrous oxide (a potent greenhouse gas) emissions and water. Alternate wetting and drying (AWD) technology has been identified to boost rice yields and reduce greenhouse gases emanating from rice fields. The Lancaster Environment Centre, Lancaster University and the CSIR-Crops Research Institute have for the past 5 years evaluated the alternate wetting and drying technology for rice production in Ghana. The technology uses a simple water table cylinder, made from PVC pipe to measure the water level in a rice field. Results indicate that the technology can reduce water consumption for rice production by about 30% without compromising on yield (Suwanmaneepong, 2023). Farmers across rice growing areas in Northern Ghana have welcomed the technology and are of the view that its mass dissemination would boost rice production in the country. To aid in the implementation and mass adoption of the AWD technology, a proof of concept for automation of the water table cylinder would be done with evaluations of prototype carried out in farmers field using demonstrations and field days.

The alternate wetting and drying technology is predominantly practiced under the irrigated and lowland rice agro-ecologies. Irrigated and lowland ecologies allow for cultivation during the dry seasons. Biomass from harvested rice fields during these periods are dried and used as fodder to feed livestock, an integral component for livestock integration. In rare cases, the dried fodder is left on the fields to be grazed by livestock. For sustainable water management, tailwater from the AWD and farmer irrigated rice fields would be harvested, treated, and reused for supplementary irrigation and livestock watering in the integrated crop livestock system. In very rare cases, fish is reared in the impounded tailwater for household consumption as well as for extra farm income. Tailwater has been used in various forms (treated and untreated) for irrigation of both vegetables and cereals. Tailwater systems consists of ditches that collect drained and runoff water from irrigated fields into storage reservoir for reuse.

Storage reservoirs usually consists of natural or constructed depressions that can drain fields by gravity and harvest excess and runoff water. Tailwater also serves to control soil erosion as well as soil loss from agricultural fields. Tailwater harvesting can be applied in a variety of ways in both urban and rural settings to address environmental, agricultural, and socioeconomic problems such as urban flooding, crop irrigation, and human consumption. Any technique that maximizes the retention and collection of tailwater by minimizing the losses suffered is beneficial to the success of such water resources conservation (Omer et al., 2019). Tailwater

Harvesting should be viewed as a technique for climate adaptation in the early phases of the food system to address these challenges.

Although several irrigation practices have arisen in the last ten years to sustain or improve agricultural production in the face of unfavourable climate change and land competition, tailwater harvesting for irrigation has not yet been a prevalent practice in the country. Even though its adoption has not been widespread despite its many advantages, there are some indications that if promoted widely, it can build the resilience of smallholder farmers in the face of climate change and variability.

2. Mixed Farming Systems (MFS) in Ghana

Agriculture is key to Ghana's economy, providing livelihoods for about 33.5% of the population. The sector is mainly rain-fed making it vulnerable to climate change and variability. Farmers are adopting indigenous and modern methods to mitigate these effects individually or collectively as a community, including mixed farming systems (Guodaar et al., 2021). Four main mixed farming systems dominate agriculture in Ghana - food crop, livestock, mixed food-crop and livestock, and tree-based production systems. The choice of farm type depends on factors including climate, soil, and household characteristics (Etwire, 2018/ 2020). Food crop – aquaculture mixed farming is an emerging system in Ghana.

2.1. Food crop mixed farming system

Cereals, legumes, roots, and tubers dominate Ghana's food crop production systems. The farm diversity depends on factors including farm size, technology adoption, and access to labor and extension support. Maize is the most important cereal crop farmers grow due to its high demand for both humans and animals. Although maize is grown by both male and female farmers, many female farmers perceive the cultivation to be risky due to its sensitivity to drought (Adjei-Nsiah, et al., 2020). Rice is another important cereal crop grown in Ghana. New varieties and improved management practices are supporting farmers to grow rice for local and regional markets. Millet and sorghum are also produced for home consumption or local markets depending on the yields per season (Adams et al, 2022). Cereal cultivation in Ghana has several challenges. These include lack of credit, poor access to inputs, poor soil management, an aging workforce, and low uptake of modern technologies (Anang et al., 2020).

Legumes farmers grow include cowpea, groundnut, common beans, bambara beans, and soya beans, for home consumption and/or market depending on quantities harvested. Common beans, cowpea, bambara beans, and soya beans are sold after minimal processing, but groundnuts may also be processed into oil, paste, and cake for sale in local and regional markets. Common challenges of legume production include pests and diseases, low and declining soil fertility, low access to improved seeds and land preparation equipment, and the high cost of agri-inputs. (Adjei-Nsiah, et al., 2020).

Roots and tubers form an important part of the food crop mixed farming system in Ghana, focusing on crops such as yam, cassava, cocoyam, and potatoes. Farmers allocate a significant portion of farms to roots and tubers because of their ability to adapt to marginal environments, produce reasonable yields, and their flexibility when cultivated with other crops. Roots and tubers are a major source of income for farmers, especially women farmers. Cassava is the most widely cultivated tuber, but yam is also a major crop among farmers for both home consumption and market. Dry spells, floods, and extreme temperatures are resulting in declining yields for roots and tubers in Ghana (Nakasone et al., 2021).

Vegetable production provides a source of livelihood for about 30% of all crop-producing households in Ghana and represents about 32% of the total crop sales for the producing households (Ghana Statistical Service 2012 in Tsiboe et.al, 2019)[1]. Farmers grow vegetables for both home consumption and for the market, with about 2.3% of the total production exported (Tsiboe et.al, 2019). The choice of vegetables to grow is influenced by factors including gender, soil properties, and farmer preferences. Common vegetables include eggplants, peppers, green beans, onions, tomato, okra, cabbage, cucumber, carrot, spring onions, gourds, and green leafy vegetables such as amaranthus, roselle (*braa*) and white jute (*ayoyo*), kenaf, cowpea, and cassava leaves. The variety of crops farmers produce helps to mitigate against crop failure while providing income at different intervals during crop harvests. Incomes from cultivating one crop may also be invested in cultivating other crops (Boateng et.al, 2022). Challenges of vegetable production include low research and policy support, limited access to input and output markets and support services, pests and diseases, and excessive use of pesticides (Issaka et al, 2021).

2.2. Livestock mixed farming system

Livestock and poultry play important economic and socio-cultural roles in the lives of farming households, especially in northern Ghana where climatic conditions favor livestock farming. Farmers keep chicken, guinea fowls, goats, sheep, pigs, and cattle, using the caging or free-range system. The West African Dwarf breeds of sheep and goats (Djallonké) are the main varieties of livestock that farmers keep in West Africa, including Ghana (Abdul Rahman et.al., 2022). This is because they are hardy, disease resistant, and readily available for purchase. Livestock serves as a source of income, manure, non-cash savings, insurance, and farm portfolio diversification (Adams et al., 2022). Farmers sell livestock and poultry live or dressed in local or district markets through price bargaining. The livestock mixed farming system has multiple constraints. These include limited access to veterinary services, credit, improved breeds, quality pasture, and watering points. Other challenges are theft, pests and diseases, and cultural taboos that ban the rearing of certain animals (Nuvey et al., 2023).

2.3. Food crop-livestock mixed farming systems

The food crop-livestock mixed farming system is a combination of food crops and livestock, excluding commercially planted trees. It is the most common type of farming system in Ghana and helps to improve overall farm productivity, biodiversity, and ecosystem health (Danso-Abbeam et al., 2021). Farm animals provide manure and draft power for crop production while feeding on crop residue from food crop production (Boateng et al., 2022). Demand, supply, and marketing decisions depend on the type of crop or livestock, the variety/ breed, and the level of value addition by the farmer (Adams et al.,2022). Challenges of this farming system

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[1] Ghana has conducted six rounds of living standards surveys since 1987. The second, third, fourth, fifth and sixth rounds, were conducted in 1988, 1991/92, 1998/99, 2005/2006 and 2012/2013 respectively.

include droughts, floods, resource conflicts, and insecurity leading to farm destruction and limited livestock movement.

2.4. Tree-based mixed farming systems

The tree-based mixed farming system is the second most common farm type in Ghana and the most economically valuable. Cash crops such as palm oil, cocoa, coffee, rubber, cashew, and mango are cultivated with other crops and/or livestock. (Ofori et al., 2022). This farming system excludes wild trees or trees planted for non-commercial purposes such as shade and windbreaks (Etwire, 2018). Food crops may be cultivated along with the tree crops for sale or for home consumption. Food crops grown include yam, maize, cassava, cowpea, and groundnut. Food crops serve as a safety net for the farmer as tree crops may take several years to be economically productive. Food crops also help to control weeds and improve soil health. Tree-based mixed farming systems are preferred by farmers with high-quality soils that support plantation or perennial crop production (Etwire, 2020). Constraints of tree-based production systems include land tenure systems, pests and diseases, bushfires, limited access to labor, inputs, information, financial services, and output markets (Osei et al., 2023).

2.5. Food crop – aquaculture production

Food crop-aquaculture production systems are emerging in Ghana. Literature covering this production system specific to Ghana was not readily available for this review.

3. Agricultural Water Management Practices in Northern Ghana

Due to climate change impact resulting in erratic rainfall and unpredictable periods of drought and flooding, a key obstacle to food production in the northern region of Ghana is a recurring water deficit. As a result, the agricultural industry is under pressure and higher levels of technological advancement are needed to ensure the productivity of the land. Although government intervention in this area has seen to the construction and rehabilitation of several medium and large-scale irrigation infrastructure, a considerable amount of the population still farms under constant water stress and deficit. For domestic and irrigation water needs, small scale farmers in these regions depend on surface water and groundwater, specifically wells and boreholes. Due to the area's semi-arid conditions, which cause water scarcity and farmer redundancy during the dry seasons a vast majority of the population is vulnerable to food and nutrition insecurity.

The government of Ghana has made determined efforts to boost agricultural production in the northern regions. These services include giving smallholders access to irrigation, agricultural financing, input subsidies, agricultural extension, and mechanization. All crop farmers are intended customers for these services. These are seen in government programs and interventions such as the Northern Rural Growth Program (NRGP), Ghana Agriculture Sector Investment Program (GASIP), Savannah Agricultural Value Chain Development Programme (SADP), Savannah Investment Programme (SIP). The NRGP which was funded by IFAD, worked with rural poor to diversify their income by developing and introducing to them, income-generating agricultural activities to supplement their farm income. The program also supported the linkages along the value chain to direct local and foreign markets. Despite the pivotal role that access to services play in agricultural productivity and production, many small-scale farmers in Ghana and other developing nations have only sporadic access to these services. Many smallholder farmers are unable to get agricultural services due to poor road infrastructure, long travel times to farms, and provider accessibility issues.

The NRGP included small-scale irrigation as part of its infrastructure development strategy. The initiative also targeted a few districts in the south of the nation with regards to small-scale irrigation. The project's goal was to raise money to finish various projects that the African Development Bank had previously sponsored, like the Inland Valley Rice Development Project (IVRDP) and the Small-Scale Irrigation Development Project (SSIDP). IFAD had also supported government grammes such as the Rural enterprises Programme (2011), Ghana Agricultural Sector Investment Programme (2014), Affordable Agricultural Financing for resilient rural development

(2019) and the Emergency Support to Rural Livelihoods and Food Systems Exposed to Covid-19 (2020).

The Savannah Agricultural Value Chain Development Programme with funding support from the AfDB was implemented in the Four Northern Regions to increase the resilience of cereal and poultry value chain. The goal was to create employment and increase the income of smallholder farmers. The project was also expected to contribute to youth andment's industrialization agenda, including One District One Factory (1D1F), support skills development and entrepreneurship for women and youth, and build resilient food systems in the savannah areas of northern and middle belts of Ghana.

Irrigation development is under the control of the Ghana Irrigation Development Authority (GIDA). Nonetheless, the irrigation water user groups at the irrigation sites oversee running the fields and canals on a day-to-day basis under GIDA oversight. In terms of coverage and scope of operations, agricultural extension service is by far the most frequent and widely used agricultural service offered to smallholders in the Northern area. The Municipal, Metropolitan, and District Assemblies currently oversee the Department of Agriculture's Agricultural Extension unit, which employs agricultural extension agents to provide day-to-day extension services (AEAs). Farmer education specialists train farmers in contemporary production techniques and distribute agricultural knowledge to farmers. They also aid in group formation and supply access for farmers.

The International Water Management Institute (IWMI) has been collaborating with farmers, extension agents, and other irrigated agriculture stakeholders in the Northern Regions of Ghana to build capacity of stakeholders in water management methods and technology aimed at boosting water production. In order to increase the accessibility of these technologies and techniques, the team also established alternative scaling pathways. Linking supply and demand for solar irrigation pumps, machinery, and services is one of these avenues. This calls for collaboration with the business sector and all actors and stakeholders along the value chain, from producers to processors and markets, in order to enhance the rules, practices, and other factors that can hasten the adoption of solar irrigation. They include drip irrigation systems, gasoline or diesel pumps, and buckets and watering cans. The amount of land a farmer may cultivate is generally constrained by tools like buckets and watering cans because they require a lot of labor and time. Pumps for gasoline and diesel have reduced the amount of labor and time required for irrigation, but they are expensive to operate and pollute the environment.

IWMI led SI-MFS activities operate in two main irrigation schemes; the Golinga irrigation scheme, and the Botanga irrigation scheme, both located in northern Ghana. Details of each scheme are presented below.

3.1. Golinga Irrigation Scheme

The scheme is in Golinga village in the Tolon district. The Golinga Irrigation system was built by the Government of Ghana in 1976 (Adongo et al., 2015). It is located between longitude 0^{o} 53 and 1^{o} 25W" and latitude 09^{o}15 and 10^{o} 02N (Abagale et al., 2014). It has a potential land area of 100 hectares and a developed area of 40 hectares that is currently used as irrigation land for farming. The crops grown under the project are vegetables (tomato, onion, and okra), which are primarily grown in the dry season (October to April), and rice, which is typically grown both in the rainy and dry seasons. The scheme's source of water is the Kornin River. The Golinga irrigation project serves five communities, namely Gbalahigu, Golinga, Kalinkpegu, Naha, and Tuunayili. The Golinga dam also provides drinking water to nearby towns. The Ghana Irrigation Development Authority (GIDA), a unit of the Ministry of Food and Agriculture (MoFA), oversees the management of the scheme. The scheme was rehabilitated in 2011-2012 under the Millennium Development Authority (MIDA). The irrigation scheme is managed by an agricultural committee which is composed of the technical personnel and representatives from farmers' associations. The farmers' association participates in administration, represents the members in communications with the government and non-governmental organizations (NGOs). The association mediates disputes involving members. The farmers' association elects its chairman through a vote among its members.

3.2. Botanga Irrigation Scheme, Northern Ghana

Botanga Irrigation scheme is a gravity system located in the Kumbungu District of the Northern region. The scheme was rehabilitated in 2011-2012 alongside the Golinga Irrigation Scheme. The dominant crops grown at the scheme are rice, maize, and vegetables. The scheme allows farmers a year-round farming. Due to the nature of the soil, which is highly textured and irrigated by flooding, the upland area is used for the production of vegetables while the lowland area is used for the production of rice (Abdul-Ganiyu et al., 2012). The scheme serves thirteen communities including Tibung, Kumbungu, Kpasogu, Dalun, Wuba, Kukuo, Saakuba, Yiplegu, Voggu, Kushibo, Zangbalwe, and Bagli (Abdul-Ganiyu et al., 2012).

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