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IRRIGATION WATER MANAGEMENT AND FOOD SECURITY IN NIGERIA

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ABSTRACT: *Food security remains a persistent challenge in Nigeria, a country with a rapidly growing population and a heavy reliance on rain-fed agriculture. Effective irrigation water management is crucial to improving agricultural productivity and addressing this critical issue, particularly in the face of climate change and increasing water scarcity. This study investigates the current state of irrigation water management and its impact on food security in Nigeria. The research employs a mixed-methods approach, combining an extensive literature review with field surveys, interviews, and focus group discussions with key stakeholders, including farmers, water resource managers, policymakers, and subject matter experts. The findings reveal significant gaps in Nigeria's existing irrigation water management system, including outdated infrastructure, inefficient water distribution, limited access to irrigation technology, and poor coordination among relevant government agencies and agricultural extension services. The study explores the multifaceted relationship between irrigation water management and food security, highlighting the impact of water availability, quality, and accessibility on crop yields, livestock production, and overall agricultural output. The analysis also examines the socioeconomic and environmental implications of poor irrigation water management, such as reduced farm incomes, food price volatility, and environmental degradation. Based on the research findings, the study proposes a comprehensive framework for sustainable irrigation water management in Nigeria. This framework emphasizes the integration of technological innovations, policy reforms, institutional strengthening, and community-based approaches to enhance the efficiency, equity, and resilience of the irrigation system. Key elements of the framework include modernizing irrigation infrastructure, promoting precision agriculture techniques, improving water governance and stakeholder coordination, and enhancing the capacity of farmers and water user associations. The implications of this study are far-reaching, as it provides policymakers, development agencies, and agricultural practitioners with a thorough understanding of the critical role of irrigation water management in achieving food security in Nigeria. The proposed framework offers a roadmap for the implementation of sustainable irrigation practices, which can contribute to increased agricultural productivity, improved rural livelihoods, and enhanced national food security. The findings of this research also offer valuable insights for other developing countries facing similar challenges in the realm of irrigation water management and food security.*

KEYWORDS: Irrigation food security, Water management, Agriculture, Nigeria.

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INTRODUCTION

Water is a critical input for agricultural production and plays an important role in food security. Irrigated agriculture represents 20 per cent of the total cultivated land and contributes 40 per cent of the total food produced worldwide. Irrigated agriculture is on average, at least twice as productive. Irrigation is the artificial application of water to the soil through various systems of tubes, pumps, and sprays. Irrigation is usually used in areas where rainfall is irregular or dry times or drought is expected (Centers for Disease Control and Prevention CDC, 2016). Irrigation management involves fulfilling the water requirement of crops through the management of time and water application without wasting any water, soil, plant nutrients or energy (Neeru et al., 2022). Due to population growth, urbanization, and climate change, competition for water resources is expected to increase, with a particular impact on agriculture. The population is expected to rise to over 10 billion by 2050, and whether urban or rural, this population will need food and fibre to meet its basic needs. Combined with the increased consumption of calories and more complex foods, which accompanies income growth in the developing world, it is estimated that agricultural production will need to expand by approximately 70% by 2050 (World Bank, 2022).

However, future demand for water by all sectors will require as much as 25 to 40% of water to be reallocated from lower to higher productivity and employment activities, particularly in water-stressed regions. In most cases, such reallocation is expected to come from agriculture due to its high share of water use. According to the World Bank (2022), over 70 per cent of the water in the world is used in agriculture, most of it for irrigation and there are many irrigation methods.

CONSERVATION MANAGEMENT SYSTEMS

Irrigation water management is generally one of several components of a resource management system used to manage water supplied to a crop through an irrigation system that is part of an overall resource management plan for the irrigated cropland. Irrigation water management planning components of the conservation plan will contain the following information:

- Field map(s) and soil survey information
- Crop rotation or sequence
- Recommended irrigation water application rates, timing, and method of application
- Locations of designated sensitive areas
- Guidelines for irrigation system operation and maintenance

Irrigation water management is most effective when used in conjunction with other conservation practices such as irrigation system design, cover crop, residue management, conservation buffers, nutrient management, pest management, and conservation crop rotation. Irrigation water management requires knowledge, skills, and desire to determine when irrigation water should be applied. The main factors influencing irrigation water management are irrigation interval (time between irrigations), irrigation set time (time water is applied), and application rate (rate at which water is applied). These parameters define the timing and

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duration of irrigation and the amount of water applied. System design and maintenance are also important factors influencing irrigation water management.

IRRIGATION WATER MANAGEMENT

Irrigation water management is the process of determining and controlling the volume, frequency, and application rate of irrigation water in a planned efficient manner. Irrigation management aims at increasing food production, contributing to economic development and reducing poverty through improvements in performance, productivity and sustainability of irrigated agriculture and irrigation systems.

Purpose of Irrigation Water Management: This is applied as part of a conservation management system to support one or more of the following:

1. Manage soil moisture to promote desired crop response

2. Optimize the use of available water supplies

3. Minimize irrigation-induced soil erosion

4. Decrease nonpoint source pollution of surface and groundwater resources

5. Manage salts in the crop root zone

6. Manage air, soil, or plant microclimate where used. This practice applies to all irrigated lands.

IRRIGATION METHODS

There are many methods of applying water (irrigation) to the field. The simplest one consists of bringing water from the source of supply, such as a well, to each plant with a bucket or a water-can. This is a very time-consuming method and it involves quite heavy work. However, it can be used successfully to irrigate small plots of land such as vegetable gardens that are in the neighborhood of a water source.

More sophisticated methods of water application are used in larger irrigation systems. There are three basic methods: surface irrigation, sprinkler irrigation and drip irrigation.

(a). **Surface irrigation**: Surface irrigation is the application of water to the fields at ground level. Either the entire field is flooded or the water is directed into furrows or borders.

i. Furrow irrigation

Furrows are narrow ditches dug on the field between the rows of crops. The water runs along them as it moves down the slope of the field. The water flows from the field ditch into the furrows by opening up the bank or dyke of the ditch or using siphons or spiles. Siphons are small curved pipes that deliver water over the ditch bank. Spiles are small pipes buried in the ditch bank

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ii. Border irrigation

In border irrigation, the field to be irrigated is divided into strips (also called borders or border strips) by parallel dykes or border ridges. The water is released from the field ditch onto the border through gate structures called outlets. The water can also be released by means of siphons or spiles. The sheet of flowing water moves down the slope of the border, guided by the border ridges.

iii. Basin irrigation

Basins are horizontal, flat plots of land, surrounded by small dykes or bunds. The banks prevent the water from flowing to the surrounding fields. Basin irrigation is commonly used for rice grown on flat lands or in terraces on hillsides. Trees can also be grown in basins, where one tree usually is located in the centre of a small basin.

(b) Sprinkler Irrigation

With sprinkler irrigation, artificial rainfall is created. The water is led to the field through a pipe system in which the water is under pressure. The spraying is accomplished by using several rotating sprinkler heads, spray nozzles or a single gun-type sprinkler.

(c) Drip Irrigation

In drip irrigation, also called trickle irrigation, the water is led to the field through a pipe system. On the field, next to the row of plants or trees, a tube is installed. At regular intervals, near the plants or trees, a hole is made in the tube and equipped with an emitter. The water is supplied slowly, drop by drop, to the plants through these emitters.

IRRIGATION DRAINAGE SYSTEMS

A drainage system is necessary to remove excess water from the irrigated land. This excess water may be wastewater from irrigation or surface runoff from rainfall. It may also include leakage or seepage of water from the distribution system. Excess surface water is removed through shallow open drains. Excess groundwater is removed through deep open drains or underground pipes. The collection and disposal of drainage flows from irrigation and precipitation is an important management consideration in many irrigated areas, both in terms of farm profitability and offsite water quality. Irrigation drainage includes surface runoff and deep percolation from applied water to meet crop consumptive needs. In some areas, periodic pre-season flooding of fields may also be required to leach soil salts from the crop-root zone, often increasing the need for drainage systems. Irrigation drainage is often collected and re-used in irrigated production. In some cases, drainage systems may be used to drain excess water during wet periods as well as sub-irrigate during dry periods by regulating underlying water tables. In many cases, drainage flows of poor quality become a disposal issue. Primary disposal methods include on-farm evaporation ponds, direct discharge to off-farm surface water through drainage canals, and reuse in salt-tolerant crop and tree production.

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PROBLEMS ASSOCIATED WITH IRRIGATION IN NIGERIA

Following are some reasons and factors which affect the selection of an irrigation system for a specific area:

1. Compatibility of the irrigation system
2. Topographical characteristics of the area
3. Economics and cost of the irrigation method
4. Soils
5. Water supply
6. Crops to be irrigated
7. Social influences on the selection of irrigation method
8. External influences

1. Compatibility of the Irrigation System

The irrigation system for a field or a farm must be compatible with the other existing farm operations, such as land preparation, cultivation, and harvest.

- Level of Mechanization
- Size of Fields
- Cultivation
- Pest Control

The use of large mechanized equipment requires longer and wider fields. The irrigation systems must not interfere with these operations and may need to be portable or function primarily outside the crop boundaries (i.e., surface irrigation systems). Smaller equipment or animal-powered cultivating equipment is more suitable for small fields and more permanent irrigation facilities.

2. Topographical Characteristics of the Area

Topography is a major factor affecting irrigation, particularly surface irrigation. The general concerns are the location and elevation of the water supply relative to the field boundaries, the area and configuration of the fields, access by roads, utility lines (gas, electricity, water, etc.), and migrating herds whether wild or domestic.

Restrictions on irrigation system selection due to topography include:

- Groundwater levels
- The location and relative elevation of the water source

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- Field boundaries
- Acreage in each field
- The location of roads
- Power and water lines and other obstructions
- The shape and slope of the field

3. Economics and Cost of the Irrigation Method

The type of irrigation system selected is an important economic decision. Some types of pressurized systems have high capital and operating costs but may utilize minimal labour and conserve water. Their use tends toward high-value cropping patterns. Other systems are relatively less expensive to construct and operate but have high labour requirements. Some systems are limited by the type of soil or the topography found on a field. The costs of maintenance and the expected life of the rehabilitation along with an array of annual costs like energy, water, depreciation, land preparation, maintenance, labour and taxes should be included in the selection of an irrigation system.

Main costs include:

- Energy
- Water
- Land Preparation
- Maintenance
- Labour
- Taxes

4. Soils

The soil's moisture-holding capacity, intake rate and depth are the principal criteria affecting the type of system selected. Sandy soils typically have high intake rates and low soil moisture storage capacities and may require an entirely different irrigation strategy than the deep clay soil with low infiltration rates but high moisture-storage capacities. Sandy soil requires more frequent, smaller applications of water whereas clay soils can be irrigated less frequently and to a larger depth. Other important soil properties influence the type of irrigation system to use.

The physical, biological and chemical interactions of soil and water influence the hydraulic characteristics and filth. The mix of silt in soil influences crusting and erodibility and should be considered in each design. The distribution of soils may vary widely over a field and may be an important limitation on some methods of applying irrigation water.

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The soil type usually defines:

- Soil moisture-holding capacity
- The intake rate
- Effective soil depth

5. Water Supply

The quality and quantity of the source of water can have a significant impact on irrigation practices. Crop water demands are continuous during the growing season. The soil moisture reservoir transforms this continuous demand into a periodic one which the irrigation system can service. A water supply with a relatively small discharge is best utilized in an irrigation system which incorporates frequent applications. The depths applied per irrigation would tend to be smaller under these systems than under systems having a large discharge which is available less frequently. The quality of water affects decisions similarly. Salinity is generally the most significant problem but other elements like boron or selenium can be important. A poor-quality water supply must be utilized more frequently and in larger amounts than one of good quality.

6. Crops to be Irrigated

The yields of many crops may be as much affected by how water is applied as the quantity delivered. Irrigation systems create different environmental conditions such as humidity, temperature, and soil aeration. They affect the plant differently by wetting different parts of the plant thereby introducing various undesirable consequences like leaf burn, fruit spotting and deformation, crown rot, etc. Rice, on the other hand, thrives under ponded conditions

Crop characteristics that influence the choice of irrigation system are:

- The tolerance of the crop during germination, development and maturation to soil salinity, aeration, and various substances, such as boron
- The magnitude and temporal distribution of water needs for maximum production
- The economic value of the crop

7. Social Influences on the Selection of Irrigation Method

Beyond the confines of the individual field, irrigation is a community enterprise. Individuals, groups of individuals, and often the state must join together to construct, operate and maintain the irrigation system as a whole. Within a typical irrigation system, there are three levels of community organization. There is an individual or small informal group of individuals participating in the system at the field and tertiary level of conveyance and distribution.

Irrigation system designers should be aware that perhaps the most important goal of the irrigation community at all levels is the assurance of equity among its members. Thus the operation, if not always the structure, of the irrigation system will tend to mirror the community view of sharing and allocation.

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Irrigation often means a technological intervention in the agricultural system even if irrigation has been practiced locally for generations. New technologies mean new operation and maintenance practices. If the community is not sufficiently adaptable to change, some irrigation systems will not succeed.

8. External Influences

Conditions outside the sphere of agriculture affect and even dictate the type of system selected. For example, national policies regarding foreign exchange, strengthening specific sectors of the local economy, or sufficiency in particular industries may lead to specific irrigation systems being utilized. Key components in the manufacture or importation of system elements may not be available or cannot be efficiently serviced. Since many irrigation projects are financed by outside donors and lenders, specific system configurations may be precluded because of international policies and attitudes.

SOME IDENTIFIED CONSTRAINTS TO THE ADOPTION OF IRRIGATION BY SMALL-SCALE FARMERS

Farmers lack adequate start-up capital and are frequently faced with irregular fuel supply, frequent pump breakdowns, low stream flow, and well dry-ups. Those using the furrow system also complained of high labour requirements and there is stiff competition for the limited lands around the major perennial streams in the area.

The majority of farmers are illiterate and lack basic knowledge of water requirements, irrigation scheduling, and skills in maintaining and operating the pumps. This affects the yield of crops as the crops are either over- or under-irrigated, leading to wastage of the little available water. Erosion is a serious problem during the rainy season and coupled with continuous use of land, low fertility results.

IRRIGATION POLICIES AND PROJECTS IN NIGERIA

The goal of the National Irrigation and Drainage Policy in Nigeria according to the Food and Agriculture Organization of the United Nations FAO (2023) is to achieve sustainable growth and enhanced performance of irrigation, contributing fully to the goals of the Nigerian agricultural sector. Eight major policy objectives are outlined to address existing constraints and achieve accelerated and sustained irrigation development in Nigeria, these are:

1. Performance, viability and competitiveness;
2. Governance and enhanced services;
3. Socio-economic and cultural inclusion;
4. Funding mechanism and effective private sector participation;
5. Responsible production and sustainable development;
6. Efficient resource utilization and rapid irrigation growth;

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7. Development and uptake of innovation

8. Improved capacity for sustainable data generation, management and use.

The strategy aims of the policies is to make agriculture more productive and sustainable and to achieve this objective, strategic actions are outlined below:

a. Raise the productivity of water for crops, livestock and aquaculture (promote water-saving techniques, farming systems and incentives among existing irrigators; promote improved water allocation and use efficiency mechanisms among various users at national and basin levels as well as among farming communities and within irrigation schemes; support best practices for the safe use of marginal quality water; promote the efficient conjunctive use of water for irrigation practices).

b. Raise land productivity for crops, livestock and aquaculture (promote soil fertility improvement and management and land conservation practices guided by acceptable standards for different terrains and climates; promote agricultural land drainage techniques).

c. Enhance the production potential of ongoing irrigation activities.

d. Develop new irrigation areas according to demand and feasibility.

e. Increase the level of mechanization of irrigation activities.

f. Enhance the competitiveness of irrigated agriculture.

Policies on water use especially for irrigation must aim at developing water management practices that raise productivity, promote equitable access to water and conserve this precious natural resource. The water ministry noted that the aim of the Federal Government's irrigation programme was to reduce dependency on rain-fed agricultural production.

DAMS (HARVESTED WATER)

According to the Ministry of Water Resources, Nigeria has a total of 250 medium and large-sized dams with a combined storage capacity of about 30 billion cubic meters. The total storage capacity of these dams is more than the projected future demand of Nigeria by the year 2030.

Some of the completed dams in Nigeria include Kashimbila Multipurpose Dam (500 thousand cubic meters) in Taraba; Ogwashi-Uku Multipurpose Dam (4 million cubic meters) in Delta; and Adada Dam (1.4 million cubic meters) in Enugu. Others are Sulma Earth Dam (4 million cubic meters); Gimi Earth Dam (4.5 million cubic meters); Kampe Omi Dam, (250 million cubic meters); Amla-Otukpo Dam, (1.5 million cubic meters; located in Katsina; Kaduna; Kogi and Benue states respectively; Amauzari Earth Dam (25 million cubic meters) in Imo; Ibiono-Ibom Earth Dam (0.3 million cubic meters) in Akwa-Ibom and Kargo Dam, 2.3 (million cubic meters) in Kaduna.

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IRRIGATED LANDS IN NIGERIA

The irrigation land projects in Nigeria include Ejule-Ejebe (50 hectares) in Kogi; Azara-Jere, (1,880ha) in Kaduna; Sabke (879ha) in Katsina and Sepeteri (280ha) in Oyo. All these had been completed. The ongoing irrigation schemes include Bakalori (13,557ha) in Zamfara; Hadejia Valley (6,000ha) in Jigawa; Kano River (15,000ha) in Kano. Others are Dadin Kowa (2,000ha) in Gombe; Middle Rima (4,333ha) in Kano and Gari (2,114ha) in Jigawa.

WATER MANAGEMENT PRACTICES

This determines when and how much irrigation water to apply, it is an important part of the irrigation management process. Over-application of irrigation water relative to crop needs can result in waterlogging, increased soil salinity, erosion, and surface and groundwater quality problems associated with nutrients, pesticides, and pathogens. Deficit water applications at less than full crop-consumptive need, while occasionally implemented as a strategy to extend limited water supplies, can result in an accumulation of salinity in the soil, less efficient use of nutrients and pesticides, and a reduction in yields and economic returns.

Improved water management practices—including irrigation scheduling and water-flow measurement—increase the likelihood that water is applied according to crop needs. While improved management practices are often more cost-effective than structural improvements alone, accompanying structural upgrades may be required to achieve the highest management potential.

CROP WATER NEEDS

Crop water requirements can be indirectly estimated through climate variables. Local weather station data including temperature, humidity, wind speed, and solar radiation are applied in formulas to calculate water needs for a wide range of crops and locales. Plant moisture monitors may be used to detect crop water availability and stress in plant tissue.

CROP WATER CALCULATIONS

Soil moisture available for plant growth can also be measured directly through periodic soil testing. Shovels or soil probes are used to obtain soil samples at various depths for "feel and visual" evaluation. More sophisticated devices including moisture blocks, tension meters, neutron probes, and various electrical conductivity devices can be used to accurately quantify the amount of water removed from the soil profile.

$$V = Ep*Kp*Kc*Sp*Sr*WP$$

whereas,

V = Volume of water required (litre/day/plant)

Ep = Pan evaporation as measured by Class-A pan evaporimeter (mm/day)

Kc = Crop coefficient (coefficient depends on crop growth stage)

Kp = Pan coefficient

Sp = Plant to plant spacing (m)

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Sr = Row to row spacing (m)

Wp = Fractional wetted area, which varies with different growth stages (0.3 to 1.0).

WATER FLOW MEASUREMENT

This is an important component of water management, both on- and off-farm. Measurement of water flows to and through the on-farm conveyance system ensures optimal water deliveries to the field, as determined by irrigation scheduling methods.

IRRIGATION AND AGRICULTURAL PRACTICES

Agricultural production is often interrupted during the dry season when many farmers must rely on food stocks accumulated during the rainy season and/or on food purchases (World Bank, 2022).

The practice of irrigation consists of applying water to the part of the soil profile that serves as the root zone, for the immediate and subsequent use of the crop. Well-managed irrigation systems are those which control the spatial and temporal supply of water so as to promote growth and yield, and to enhance the economic efficiency of crop production. Such systems apply water in amounts and at frequencies calibrated to answer the time-variable crop needs. The aim is not only to optimize growing conditions in a specific plot or season but also to protect the field environment as a whole against degradation in the long term. Only thus can water and land resources be utilized efficiently and sustainably. On the other hand, poorly managed irrigation systems are those which waste water and energy, deplete or pollute water resources, fail to produce good crops and/or pose the danger of soil degradation.

The vital task of increasing and stabilizing food production in drought-prone regions must therefore include a concerted effort to improve on-farm water management. Some traditional irrigation schemes need to be modernized to achieve higher yields as well as better resource utilization. New schemes being planned should likewise be based on sound principles and techniques for efficient water use and for optimizing irrigation in relation to all other essential agricultural inputs and operations.

IRRIGATION APPLICATION IN OTHER COUNTRIES

1. Irrigation Scheduling: Irrigation scheduling involves the application of irrigation water based on a systematic monitoring of crop soil moisture requirements. Scientific irrigation scheduling methods based on sensors, microprocessors, and computer-aided decision tools can be used to determine the optimal timing and depth of irrigation to meet changing crop needs over the production season. Time and again newer methods of irrigation have been introduced to reduce flood irrigation (Dolci, 2017). Currently, drip irrigation with embedded systems is the most prominently used in precision agriculture where water usage is reduced by exploiting parameters such as soil, pest, wind speed, solar radiation, humidity, and plant density among others. Devices such as fertility meters and pH meters are installed in the field

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to evaluate soil fertility via the evaluation of primary ingredients of soil such as potassium, phosphorus, and nitrogen.

Artificial Intelligence in Irrigation Management

Besides, automated farm irrigators and microcontrollers control drip irrigation through irrigator pumps and wireless technology. There is machine-to-machine technology (M2M) which is being developed for communication and data sharing amongst each other via cloud or the main network of agricultural fields. An AI-based robot is developed for the estimation of moisture and temperature with Arduino and raspberry pi3; and an AI-based strategy (Seyedzadeh et al., 2020; Shekhar et al., 2017). Similarly, an automated irrigation system wherein the output of cameras and different sensors are used for the detection of soil moisture, pressure, and temperature are shared over the network for better irrigation management. Approximately $7.4 million was invested in 1998 for computers and related software for improved irrigation water management.

IRRIGATION AND FOOD SECURITY

Based on the 1996 World Food Summit, food security is defined as "when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (Annex 1).

The four main dimensions of food security:

- Physical availability of food: Food availability addresses the "supply side" of food security and is determined by the level of food production, stock levels and net trade.
- Economic and physical access to food: An adequate supply of food at the national or international level does not in itself guarantee household-level food security. Concerns about insufficient food access have resulted in a greater policy focus on incomes, expenditure, markets and prices in achieving food security objectives.
- Food utilization: Utilization is commonly understood as the way the body makes the most of various nutrients in the food. Sufficient energy and nutrient intake by individuals is the result of good care and feeding practices, food preparation, diversity of the diet and intra-household distribution of food. Combined with good biological utilization of food consumed, this determines the nutritional status of individuals.
- Stability of the other three dimensions over time: Even if your food intake is adequate today, you are still considered to be food insecure if you have inadequate access to food periodically, risking a deterioration of your nutritional status. Adverse weather conditions, political instability, or economic factors (unemployment, rising food prices) may have an impact on your food security status.

For food security objectives to be realized, all four dimensions must be fulfilled simultaneously.

Irrigated agriculture can be an important entry point for food security, as water is frequently a limiting factor for crop and livestock production. Irrigation-based agriculture plays an

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essential role in global food security and for the welfare of a large share of the world's population, as it provides about 40% of the global crop production (Frenken & Gillet, 2012)

Furthermore, in sub-Saharan Africa (SSA), the potential for expanding irrigated agriculture is large as only 6% of the total cultivated area is irrigated (You et al., 2011; Xie et al., 2014). Malnutrition rates in Sub-Saharan Africa (SSA) are still high compared to other regions. More than 60% of the population lives in rural areas, and rain-fed agriculture is the main or only source of livelihood for most rural households. Rained cereal crops (for example, maize, sorghum, or millet) and roots and tubers are the main sources of food and income, but have limited nutritional content and low market value and, as a result, have low poverty and malnutrition reduction potential (Burney et al., 2013).

Irrigation can lead to crucial changes in the livelihood and food security of smallholders. The four food security dimensions (food availability, access, utilization, and stability) are likely to change as a result of increased water availability for crop production and other uses. Irrigation can have a direct impact on food availability because of increased productivity and changes in cropping patterns. It was further noted that irrigation had a positive impact on crop production, consumption and revenue generation which all together indicated improvement in food security. These thereby have a positive and significant impact on household food security.

In order to achieve food security, especially in developing countries, regular access to water must be made possible through irrigation.

IMPORTANCE OF IRRIGATION

Irrigation is very important in farming especially when there is no sufficient supply of water. The following are of importance to farmers:

- To grow more pastures and crops.
- To have more flexibility in their systems/operations as the ability to access water at times when it would otherwise be hard to achieve good plant growth (due to a deficit in soil moisture) is imperative. Producers can then achieve higher yields and meet market/seasonal demands especially if rainfall events do not occur.
- To produce higher quality crops/pastures as water stress can dramatically impact the quality of farm produce.
- To lengthen the growing season (or start the season at an earlier time);
- To have 'insurance' against seasonal variability and drought.
- To stock more animals per hectare and practice tighter grazing management due to the reliability of pasture supply throughout the season.
- To maximize benefits of fertilizer applications. Fertilizers need to be 'watered into' the ground in order to best facilitate plant growth.

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- To use areas that would otherwise be 'less productive'. Irrigation can allow farmers to open up areas of their farms where it would otherwise be 'too dry' to grow pasture/crops. This also gives them the capability to carry more stock or to conserve more feed.
- To take advantage of market incentives for unseasonal production.
- Improvements in the levels and security of productivity.
- Employment and incomes for irrigating farm households and farm labour; ii) the linkage and multiplier effects of irrigation development (as part of wider agricultural growth) for the wider economy.
- Increased opportunities for rural livelihood.

PRACTICAL CHALLENGES FOR WATER IN AGRICULTURE

The ability to improve water management in agriculture is typically constrained by inadequate policies, major institutional underperformance, and financing limitations. Critical public and private institutions (encompassing agricultural and water ministries, basin authorities, irrigation agencies, water users' and farmer organizations) generally lack the enabling environment and necessary capacities to effectively carry out their functions (World Bank, 2022). For example, basin authorities often hold limited ability to enforce water allocations and to convene stakeholders. Institutions charged with developing irrigation often limit themselves to capital-intensive scale schemes and tend to rely on public sector-based approaches rather than developing opportunities for small-scale private financing and irrigation management. Farmers and their organizations are also often responding to highly distorted incentive frameworks in terms of water pricing and agricultural support policies, which further hinder positive developments in the sector (World Bank, 2022).

Moreover, most governments and water users fail to invest adequately in the maintenance of irrigation and drainage (I&D) systems. While inadequate management and operation may play a part in the poor performance of I&D systems, it is especially the failure to sufficiently maintain systems that results in their declining performance and the subsequent need for rehabilitation. This failure to provide adequate funds for the maintenance of I&D systems has resulted in the "build-neglect-rehabilitate-neglect" cycle commonly observed in the sector (World Bank, 2022).

Given the existing constraints, the agricultural water management sector can work currently on repositioning itself towards modern and sustainable service provision. A singular water approach can be proposed to build resilient water services and sustain water resources, while also managing risks related to broader social and economic water-related impacts. This may transform governance and service provision as well as support watershed management and greening the sector and can be achieved by providing improved incentives for innovation, reforms, and accountability (World Bank, 2022).

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NEXUS AMONG IRRIGATION, AGRICULTURE AND FOOD SECURITY

The Food and Agriculture Organization for the United Nations (FAO) and World Water Council (WWC) predict that the world needs to produce an estimated 60 per cent more food by 2050 to ensure global food security, and it must do so while conserving and enhancing the natural resource base (FAO and WWC, 2015). There is a common understanding that 80-90% of increased food production will have to come from existing cultivated land and the remaining from land reclamation. This poses a significant and complex set of challenges for the agricultural industry, particularly in terms of water management. It is understood that achieving food security through increased food production will require significant improvement in water infrastructure, their operation, maintenance and management (International Commission on Irrigation and Drainage ICID, 2014). The 6th World Water Forum, held in Marseille in 2012, outlined the experience, potential and challenges of agricultural water management's contribution to food security. The principal question is, how to feed 9 billion people in 2050 without additional water. Firstly, there is a need to understand the nature of the challenges faced which go beyond the increased demand for food from a growing population with improved life expectancy. Climate change, extreme weather events, drought, urban development, ever-growing competition for land and water use, reduced supply chain reliability and environmental degradation all contribute to the complexity of this issue (FAO and WWC, 2015). Irrigation is responsible for more water consumption than any other human activity; an estimated 70% of freshwater withdrawals for human use are dedicated to irrigation. Hence the challenge of sustainable water resource management is intrinsically linked to that of increasing food security. Crop productivity has a vital role in achieving both food security and water sustainability which are in ever increasing demand around the world. In order to explore the role of irrigation in food security, there is a need to also consider environmental issues resulting from over-exploitation and poor management of water resources as food production depends on the sustainable use of land and water resources. The need for sustainable food security for our global population and the need for preserving the environment, namely natural and man-made ecosystems and landscapes, have created an increased need for integrated, participative and scalable solutions focusing the various levels of irrigation and natural water management, from the field crop to the catchment and basin scales (Pereira, 2017).

In conclusion, irrigation water management can improve nutritional outcomes through multiple pathways, including increased productivity and availability of food supplies and improved diets (in quantity and quality). The current post-2015 development agenda calls for action to end hunger, achieve food security, improve nutrition and promote sustainable agriculture (Sustainable Development Goal (SDG) 2) as well as promote sustainable water management (SDG 6).

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