

Integrated water resources management through linking sustainable irrigation and drainage systems and achieving food security

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Abstract

Integrated Water Resources Management (IWRM) is a modern approach aimed at using water sustainably and efficiently, taking into account the integration between various sectors such as agriculture, industry, environment, and society. In the agricultural sector, improving water use efficiency through the integration of sustainable irrigation systems and efficient drainage and drainage is the cornerstone of achieving food security, especially in areas suffering from water scarcity or land degradation. Integrated management relies on comprehensive planning that considers all aspects of water use, including the quantity of water available, the timing of its use, and the appropriate distribution methods for each crop. The most prominent sustainable irrigation systems that contribute to this management include drip irrigation, which delivers water directly to the root zone while reducing waste; sprinkler irrigation, which simulates rainfall and provides uniform distribution; and improved surface irrigation, which reduces waste and optimizes the use of heavy soils. Sustainable drainage and drainage systems aim to remove excess water and prevent soil salinization, thus maintaining soil fertility and increasing crop productivity. Integrating sustainable irrigation and drainage is the basis for achieving water use efficiency and improving agricultural production. By implementing these systems, water loss can be reduced, soil moisture levels improved, salt accumulation prevented, and agricultural productivity increased sustainably. Reusing treated wastewater also provides an additional opportunity to save water and reduce pressure on freshwater resources, enhancing sustainable food production. This management is closely linked to achieving food security, which encompasses four dimensions: food availability, food access, food stability, and

proper food utilization. Improved water management leads to increased food production, sufficient food supply for the population, and equitable distribution, while preserving the sustainability of natural resources. Linking sustainable irrigation and drainage systems within the framework of integrated water resources management represents an effective strategy for addressing water scarcity and achieving food security. It ensures optimal use of resources, protects the agricultural environment, and improves crop productivity, contributing to the sustainability of agriculture and the provision of food for current and future generations. This approach provides an integrated model that can be applied in multiple regions facing similar challenges, making it one of the key solutions for achieving sustainable food security in light of increasing pressure on water resources.

Keywords: Integrated Water Resources Management, Sustainable Irrigation Systems, Agricultural Drainage, Water Use Efficiency, Food Security

Chapter One

Introduction

1.1 Introduction

Water resources are the cornerstone of achieving sustainable development across various economic and social sectors, most notably the agricultural sector, which represents the largest consumer of water globally. With increasing population pressures, expanding agricultural and industrial activity, and the intensifying effects of climate change, there is an urgent need to adopt integrated water resources management (IWRM). IWRM is a scientific and systematic approach aimed at optimal water use and achieving a balance between meeting current needs and protecting this vital resource for future generations. IWRM is based on the principle of viewing water as a single, interconnected system, integrating its various surface and groundwater sources and various uses within a comprehensive strategic framework that achieves both efficiency and sustainability. In this context, linking irrigation and drainage systems represents one of the most important practical aspects of IWRM. IWRM aims to achieve a balance between efficient water use

in irrigation and the removal of excess water to maintain soil fertility and prevent soil degradation. Irrigation is the primary means of supplying agricultural crops with water, but its overuse or mismanagement leads to serious problems such as soil salinization and rising groundwater levels. Hence, the importance of drainage systems, which work to dispose of excess water and remove harmful salts, thus maintaining agricultural productivity and extending the life of arable land. The integration of these two systems enables the recycling of drained water and its use for irrigation purposes after treatment, which increases the efficiency of water resource utilization and reduces waste. Achieving food security is the ultimate goal of this approach, as food security is linked to a society's ability to provide sufficient, safe, and sustainable food in the face of rapid population growth, climate change, and resource fluctuations. Integrated water resource management, through improving irrigation systems and developing sustainable drainage technologies, contributes to increasing unit water productivity (i.e., the amount of crop produced per cubic meter of water) and enables the cultivation of strategic crops such as grains and vegetables in limited water conditions. This management also enables adaptation to climate change through water harvesting techniques, the use of drought-resistant agricultural varieties, and the reuse of treated water, ensuring stable agricultural production and long-term food availability. Adopting this integrated approach is not limited to the technical aspect alone. It also requires supportive government policies, close cooperation between various sectors, and active community participation. Successful integrated water resources management requires the development of comprehensive strategic plans, the development of irrigation and drainage infrastructure, and the implementation of modern methods such as smart irrigation and digital monitoring of water distribution. Through these efforts, it becomes possible to achieve rational water use, preserve soil fertility, reduce pollution, and ensure sustainable food production that achieves self-sufficiency and enhances national and regional food security. Thus, integrated water resources management, based on the integration of sustainable irrigation and drainage systems, represents a practical and

strategic approach to addressing the challenges of water scarcity and the pressures of increasing demand. It is the cornerstone of building a resilient agricultural system capable of continuing to meet present and future needs.

1.2 The Research Problem

Most countries, particularly in arid and semi-arid regions, face a growing water crisis due to increasing demand for water caused by rapid population growth, agricultural expansion, and climate change, which is leading to the decline of surface and groundwater resources. The agricultural sector is the largest consumer of water, as inefficient traditional irrigation practices waste large quantities of water, raise groundwater levels, and lead to soil salinization. The lack of integration between irrigation and drainage systems also leads to decreased agricultural land productivity and declining food security. Hence, the research problem arises from the absence of integrated water resource management that effectively links sustainable irrigation and drainage systems to ensure optimal water use, soil conservation, and food security.

1.3 The Importance of the Research

The importance of this research stems from its addressing one of the most pressing strategic challenges of our time: water scarcity and its impact on food security. The research provides a scientific framework for adopting policies and strategies that enable integrated water resource management, ensuring increased water use efficiency, reducing waste, preserving agricultural land fertility, and achieving sustainable food production. The study also gains importance from the potential application of its findings in developing countries that suffer from limited water resources and high rates of desertification.

1.4 Research Objectives

The research aims to:

- 1 -Analyze the reality of water resource management in light of environmental and economic challenges.

2 -Clarifying the role of integrated irrigation and drainage systems in improving water use efficiency.

3 -Reviewing sustainable drainage techniques and methods and their role in reducing soil salinization.

4 -Highlighting the impact of integrated water management on enhancing food security and achieving agricultural sustainability.

1.5 Research Methodology

The research relies on a descriptive and analytical approach, collecting data from previous studies, international reports, and agricultural statistics, and analyzing them to uncover shortcomings in water resource management and evaluate the role of sustainable irrigation and drainage systems in improving agricultural production. A comparative approach is also used to compare the experiences of different countries in implementing integrated water management.

1.6 Research Hypothesis

Main Hypothesis: Implementing integrated water resource management based on linking sustainable irrigation and drainage systems leads to increased water use efficiency and achieving food security.

Sub-Hypotheses:

1 -Improving drainage techniques reduces soil salinization and increases productivity.

2 -Modern irrigation systems contribute to reducing water loss and improving water quality.

1.7 Previous Studies

1-GWP (Global Water Partnership), 2010

- o Title: Integrated Water Resources Management in Practice

- o The study addressed the concept of integrated water resources management as a tool for achieving water sustainability through coordinating surface and groundwater management and integrating the agriculture and energy sectors.

- o It focused on the importance of involving farmers and stakeholders in water management to achieve higher irrigation efficiency.

2-Abdelaziz, M. (2018). "Integrated Water Resources Management in the Arab World"

- o A case study of several Arab countries (Egypt, Morocco, Jordan).

- o It highlighted the need to integrate irrigation policies with drainage policies to reduce soil salinization and maintain the fertility of agricultural land.

3-Hassan, S. (2020). "Integrating Irrigation and Drainage Systems to Achieve Agricultural Sustainability in the Nile Delta"

- o An Egyptian study focused on the use of covered drainage in conjunction with improved field irrigation systems.

- o Results: A 25% reduction in soil salinity and an increase in wheat and rice productivity.

Chapter Two

Integrated Water Resources Management

Integrated water resources management (IWRM) is a strategic approach aimed at achieving optimal water use through comprehensive planning and coordination among various sectors related to water resources, such as agriculture, industry, environment, and society. This concept is based on the principle that water is a limited and vital resource that requires balanced management to ensure meeting present needs without compromising the rights of future generations. With increasing global challenges such as rapid population growth, climate change, and the expansion of agricultural and industrial activity, the implementation of integrated management has become an urgent necessity to ensure resource sustainability and achieve comprehensive development. IWRM focuses on rationalizing consumption, protecting surface and groundwater resources, and improving water use efficiency in various sectors, particularly in the agricultural sector, which is the largest consumer of water. IWRM also aims to reduce pollution, minimize waste, and enhance local community participation in decision-making, contributing to achieving water equity between regions and users. By integrating modern irrigation methods and

sustainable drainage technologies, IWRM provides an effective framework for maintaining soil fertility and increasing agricultural production, thereby contributing to enhancing food security. This comprehensive approach represents the cornerstone for achieving sustainable development, as it combines economic efficiency, environmental conservation, and ensuring the availability of water for future generations (FAO, 2017: 65).

2.1: The Concept of Integrated Water Resources Management

Integrated Water Resources Management (IWRM) is a strategic approach aimed at comprehensively and interconnectedly planning, developing, and managing water resources to ensure sustainable water use and achieve a balance between economic, social, and environmental needs. This concept considers water a limited and vital resource affected by natural and human factors, which requires coordinating policies and plans across all sectors (agricultural, industrial, urban, and environmental) to achieve maximum efficiency in its use, while preserving the rights of future generations.

2.2: Principles of Integrated Water Resources Management

Integrated water resources management is based on a set of fundamental principles endorsed by international organizations such as the Global Water Partnership (GWP), most notably:

1-The holistic unity of the water resource: viewing surface water, groundwater, and reused water as a single, interconnected system, integrating environmental, economic, and social aspects.

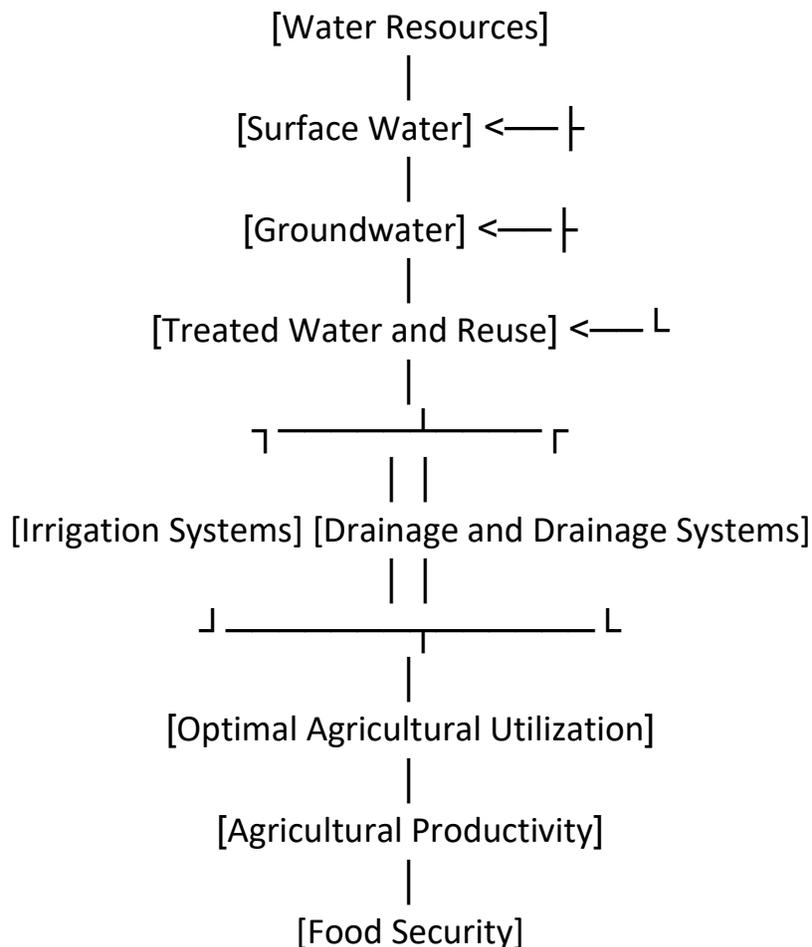
2-Community Participation: involving all stakeholders (governments, farmers, industries, and civil society) in the planning and decision-making process to ensure sustainable solutions.

3-Considering water as an economic and social resource. Recognizing its economic value and the need to price it to encourage rational consumption, while ensuring everyone's right to clean water.

4-Balancing development and environmental conservation. Achieving optimal water use to support agricultural and industrial growth without harming ecosystems or depleting resources.

5-Integrating policies and sectors. Coordinating water plans with energy, agriculture, health, and urban planning policies to ensure coordinated and sustainable management. (FAO, 2017: 65)

6-Equity and efficiency. Distributing water resources equitably among users and regions, while increasing water use efficiency at all stages, from withdrawal to recycling.



2.3 Planning and Implementation Strategies.

Integrated water resources management requires the development of comprehensive planning and implementation strategies that ensure optimal water use and balance various needs while preserving the sustainability of this vital resource. Effective planning is based on the collection and analysis of accurate data, while implementation focuses on transforming these plans into practical, applicable programs. The following are the most prominent planning and implementation strategies:

1 -Comprehensive Water Resources Assessment. Successful planning begins with a comprehensive field survey to determine the size of available water resources (surface and groundwater), their quality, and consumption patterns in various sectors. This assessment helps identify gaps between supply and demand and set priorities for water management.

2 -Developing Policies and Legislation. Successful integrated management requires the enactment of clear laws and legislation that regulate water rights, define pricing principles, and mandate the use of modern irrigation technologies and reduce waste. Policies must also be adopted that encourage the reuse of treated agricultural and industrial wastewater. (Arab Program, 2015)

3 -Integrating Different Sectors: Integrated management requires coordination between the agricultural, industrial, urban, and environmental sectors, so that integrated plans are developed that avoid conflicts between user interests and achieve a balance between development and resource conservation.

4 -Developing Infrastructure: Actual implementation includes establishing and maintaining sustainable irrigation and drainage networks, building water treatment and recycling plants, and improving storage systems such as dams and reservoirs to ensure water availability during droughts.

5 -Incorporating Modern Technologies: The strategy relies on the application of smart technologies such as drip and sprinkler irrigation systems, digital water level monitoring, and climate prediction models to accurately determine water needs and reduce losses.

6 -Local Community Participation: Involving farmers and local communities in the planning and implementation stages enhances commitment to policy implementation and increases water use efficiency through training and awareness programs on rationalizing consumption and the importance of regular maintenance of irrigation and drainage networks. (Arab Program, 2015)

7 -Continuous Evaluation and Monitoring: Implementation requires establishing monitoring and evaluation mechanisms to regularly measure performance and monitor indicators such as water use efficiency and soil quality, while reviewing and amending plans based on the results. And climatic or economic developments.

2.4 Sustainable Irrigation Systems:

Sustainable irrigation systems are essential elements in water resources management, as they aim to achieve optimal use of agricultural water while preserving soil fertility and reducing waste and negative environmental impacts. These systems are based on the application of modern technologies and methods such as drip irrigation, sprinkler irrigation, and subsurface irrigation, in addition to the use of smart irrigation techniques, which ensures that the needs of agricultural crops are met with high efficiency, enhances agricultural productivity, and ensures water sustainability to meet the challenges of climate change and the increasing demand for food. (Al-Qadi, Ahmed, 2018: 65)

2.4.1 Types of irrigation systems (drip, sprinkler, and surface irrigation).

Sustainable irrigation systems are among the most important means of achieving optimal use of water resources in agriculture. They directly contribute to increasing crop productivity, reducing water loss, and protecting soil from degradation. The most

prominent of these systems are drip irrigation, sprinkler irrigation, and surface irrigation. These systems differ in their method of delivering water to plants and their efficiency, but they all aim to achieve sustainable water resources. (Al-Sayyad, Muhammad, 2016: 56)

1- Drip Irrigation: Drip irrigation is a system that delivers water directly to the plant's root zone via a network of precise pipes and valves. It is considered one of the most water-efficient irrigation systems. This method reduces evaporation and runoff, allowing for the use of smaller amounts of water compared to traditional methods. Drip irrigation also improves nutrient uptake and limits weed growth, thus increasing crop yields. This system is particularly used for horticultural crops, fruit trees, and vegetables. Although its initial cost is higher than traditional methods, the agricultural yield and water efficiency make it an economically and environmentally sustainable option in the long term.



2 -Sprinkler irrigation Sprinkler irrigation relies on distributing water in the form of a spray that simulates rain using sprinklers or rotating pivots, allowing for uniform coverage of the cultivated area. (Al-Sayyad, Muhammad, 2016: 56) This system helps reduce erosion and improves soil aeration around plants. Fertilizers can also be added to the irrigation

water to provide balanced plant nutrition. Sprinkler irrigation is suitable for field crops, pastures, and lands with light or sandy soil. It is less expensive than drip irrigation in terms of initial installation, but it requires careful monitoring to ensure that water is not wasted due to wind or evaporation. (Hussein, Ali, 2014: 45)



3 -Improved surface irrigation Improved surface irrigation is an update to traditional flood irrigation. It involves carefully leveling the land and creating controlled channels to direct water to plants in a systematic manner. This system reduces water loss due to seepage or random runoff, and also reduces operating and maintenance costs compared to older methods. Improved surface irrigation is used to grow cereals, rice, and crops on heavy or low-slope soils. Although less efficient than drip or sprinkler irrigation, it remains an economical option suitable for areas with moderate water availability and suitable terrain. (Hussein, Ali 2014: 45)



4 -Bubble irrigation

Bubble irrigation can be defined as an irrigation system that combines drip irrigation and sprinkler irrigation. This method relies on injecting air into water pipes or tanks, thereby increasing the oxygen content in the water by approximately 150% and, consequently, increasing its content in the soil. This helps eliminate harmful bacteria and improve the soil. This system uses a bubbler device to regulate the flow of air into the water pipes before watering. (Abdullah, Khaled 2014: 23)



2.4.2: Water use efficiency and its impact on production.

Water use efficiency is one of the most important elements in sustainable water resource management, especially in the agricultural sector, which consumes the largest proportion of available water. Water use efficiency refers to the ability of an agricultural system to achieve the highest possible crop yield per unit of water used, whether in irrigation or in drainage and treatment processes. The higher the efficiency, the lower the amount of water wasted and the better the soil fertility, which directly contributes to enhancing agricultural productivity and food security. Water use efficiency impacts production in several ways: First, by improving plant water nutrition, as it ensures proper water distribution reaches plant roots without loss due to evaporation or surface runoff. Second, by reducing soil salinization and degradation resulting from over-irrigation, which maintains soil fertility and prolongs its productive life. Third, implementing sustainable irrigation systems such as drip or sprinkler irrigation allows for a significant reduction in water loss, sometimes by 40–50% compared to conventional irrigation. This means more efficient use of water to increase crop yields without the need to increase the amount of water consumed. (Al-Faris, Sami, 2017: 63) In addition, improving water use efficiency contributes to reducing the operational costs of energy and labor associated with irrigation, and helps alleviate pressure on available water resources, especially in arid and semi-arid regions. This factor is considered vital in facing the challenges of water scarcity and climate change, as it allows agriculture to continue without harming the resource or the surrounding environment.

2.5: Sustainable Drainage Systems

Sustainable drainage systems are an essential part of water resource management, aiming to drain excess water from the soil in a way that preserves its fertility and prevents salinization. Sustainable drainage is an effective tool for maintaining water balance in agricultural lands, contributing to improved crop growth and increased productivity without harming the environment. It also enhances the integration of irrigation and drainage and enables the reuse of drained water, supporting the optimal use of water resources and ensuring the sustainability of agricultural production and food security in the long term. (Al-Shami, Youssef, 2015: 73)

2.5.1 -Types of agricultural drainage and its importance in preventing salinization.

Agricultural drainage, or drainage, is one of the essential elements of sustainable water resource management. It aims to remove excess water from the soil to prevent waterlogging and improve crop growth conditions. Controlling soil water levels is vital to maintaining soil fertility and reducing soil degradation caused by salinity or waterlogging, thus enhancing agricultural production and achieving food security. (Al-Ali, Muhammad, 2018: 74)

1 -Surface drainage. Surface drainage relies on the construction of open channels or drains on the ground to drain excess water away from fields.

Its importance:

- o It prevents water accumulation and reduces waterlogging.
- o It limits salt accumulation on the soil surface and reduces surface salinity.
 - Its advantages: Ease of implementation and maintenance, and relatively low cost.
 - Its limitations: Some nutrients are lost with the drained water, and it performs poorly in heavy soils or areas with high groundwater levels.

2-Subsurface drainage: This type involves installing pipes or drains buried beneath the soil surface to draw water directly from the root zone. (Saleh, Nasser 2016: 55)

Importance:

- o Prevents water accumulation around the roots and reduces soil salinization.
- o Maintains soil moisture at a level suitable for crop growth.
 - Advantages: Reduces evaporation, increases productivity, and protects the soil from cracking or deterioration of its fertility.
 - Limitations: High initial cost and difficulty in maintaining it in some areas.

3-Biological drainage: Relies on the use of deep-rooted plants or vegetation to naturally draw excess water from the soil.

Importance:

- o Contributes to reducing excess water levels and preventing soil salinization. (Al-Masry, Sameh: 2019: 43)
- o Promotes environmental sustainability and reduces the need for expensive infrastructure.
 - ❖ Advantages: Environmentally friendly, maintains soil fertility.
 - ❖ Limitations: Drainage is slower than mechanical methods, and depends on the plant type and climatic conditions.

The role of drainage in preventing salinization

Salinity is one of the biggest challenges facing agricultural lands, especially in arid and semi-arid regions. Agricultural drainage contributes to:

- ❖ Removing excess salts from the soil And prevent its accumulation on the surface.
- ❖ Improve soil aeration and stimulate root growth.
- ❖ Increase crop productivity by providing a suitable agricultural environment.

1 -Wastewater Reuse Techniques.

Wastewater reuse is an effective solution to address water scarcity and ensure the sustainability of water resources in agriculture, industry, and urban areas. It allows previously consumed water to be reused after treatment and purification, making it suitable for reuse. This reduces pressure on freshwater resources, contributes to environmental conservation, and increases agricultural productivity. This process relies on advanced technologies for treating wastewater and removing impurities and pollutants, ensuring the health and nutritional safety of plants or industrial use. (Saleh, Nasser 2016: 55)

1 -Biological Treatment

This technology relies on microorganisms such as bacteria and algae to decompose organic matter in wastewater.

- Advantages:
 - o Effective in removing organic matter and biological pollutants. (Ibrahim, Mohammed: 8 201: 41)
 - o Relatively low operating costs compared to chemical methods.
- Uses: Irrigation of non-sensitive crops or reuse of water for industrial purposes.

2 -Chemical Treatment

Involves adding chemicals such as chlorine or oxygen to treat wastewater and eliminate germs and pollutants.

- Advantages:
 - ❖ Fast and effective sterilization and elimination of harmful microorganisms.
 - ❖ Suitable for applications requiring high-quality water.
- Limitations: May leave chemical residues that require special management before agricultural use.

3 -Sand Filtration and Filtering

Water is passed through layers of sand or advanced filters to remove solids and suspended matter.

- Advantages:

- ❖ Removal of sediments and fine particles.

- ❖ Improves water quality, making it suitable for drip or sprinkler irrigation.

- Limitations: Requires periodic maintenance and replacement of absorbent materials to ensure effectiveness.

4 -Reverse Osmosis and Advanced Physical Treatment

Relies on semi-permeable membranes to remove salts, heavy metals, and micropollutants.

- Advantages:

- ❖ Produces high-quality water suitable for sensitive irrigation or precise industrial use.

- ❖ Reduces salt accumulation in the soil when used for irrigation.

- Limitations: High cost, energy-intensive, and requires continuous membrane maintenance.

5 -Importance of Reusing Wastewater

- Conservation of freshwater: Reduces pressure on natural resources and enables sustainable agricultural use.

- Improves agricultural productivity: Provides water for irrigation during droughts.

- Environmental protection: Reduces the discharge of polluted water into natural streams.

- Supports food security: By ensuring continued agricultural production without depleting resources.

Chapter Three: Food Security

Food security is one of the most significant challenges facing societies worldwide, ensuring the continuous availability of sufficient and nutritious food for all individuals. This concept relates not only to agricultural production, but also to the management of natural resources, particularly water and soil, to ensure that the nutritional needs of the population are met. Food security also encompasses the ability to access food economically and physically, ensuring its proper use to achieve healthy nutrition, and ensuring long-term stability in food availability. In light of rapid population growth, climate change, water scarcity, and environmental degradation, achieving food security has become a strategic goal closely linked to the management and sustainability of natural resources to ensure societal well-being and stability. (Abdul Rahman 2020: 58)

3.1: The concept and its dimensions (availability, access, stability, and utilization).

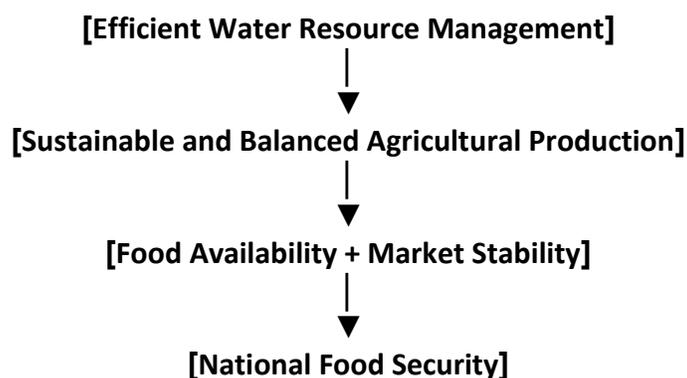
Food security is defined as a state in which all individuals have consistent access to sufficient, safe, and nutritious food that meets their energy and nutrient needs for a healthy and active life. This concept reflects more than just food availability; it also includes individuals' ability to obtain and utilize it properly, in addition to its long-term sustainability. The Food and Agriculture Organization of the United Nations (FAO) has developed a modern definition of food security that includes four main dimensions: availability, access, stability, and food utilization. (Ibrahim, Muhammad: 8 201: 41)

1 -Food Availability: The availability dimension refers to the amount of food available at the country or community level, whether through local production, imports, or food stocks. Availability depends on several factors, including the size of arable land, the crops produced, water availability, and transportation and storage infrastructure. Without sufficient food availability, achieving Food security is impossible regardless of individuals' economic capacity.

2 -Access to Food: This dimension concerns the ability of individuals and households to obtain food physically and economically. This includes the ability to purchase or produce food, as well as the existence of an effective distribution system that ensures food reaches all areas of society. Factors such as income, prices, agricultural policies, and the equitable distribution of resources play a key role in ensuring access. Even when food is available, lack of economic capacity or logistical problems hinder access, leading to food insecurity at the individual level. (Al-Masry, Sameh: 2019: 43)

3 -Stability: This dimension relates to the ability of the food system to continue to provide food regularly, without sharp fluctuations due to natural disasters or economic and political crises. Threats can include food price fluctuations, floods, drought, armed conflict, or climate change. Food stability ensures that individuals have consistent access to food, rather than intermittent or seasonal access, protecting them from temporary hunger or famine. (Al-Masry, Sameh: 2019:43)

4- Food Utilization: This dimension focuses on how the food consumed is used to ensure healthy nutrition. This includes food quality, safety, nutritional balance, and appropriate preparation methods. It is also linked to nutritional knowledge and public health, as malnutrition or disease can lead to a lack of utilization of available food. Proper food utilization ensures that individuals receive the energy and nutrients needed for growth and overall health.



3.2: The relationship between food security and water management.

Water is one of the most important natural resources needed to achieve food security, as it is an essential component of food production for both plant and animal populations. Without sufficient and quality water, crops cannot be grown or livestock raised sustainably, threatening countries' ability to feed their populations. Hence, the close relationship between water resource management and food security becomes apparent, as food security depends on the availability, efficient use, and sustainability of water.

The Role of Water in Food Security: Water plays a pivotal role in food production, as agricultural irrigation depends on providing sufficient quantities of water at the appropriate time for crop growth. The agricultural sector consumes approximately 70% of the world's freshwater, making it the largest consumer of this vital resource. Food security also depends on water for livestock production, as animal husbandry requires water for drinking, farm cleaning, and fodder production. Any shortage or mismanagement of water resources leads to reduced agricultural production, increased food prices, and threats to food stability, especially in arid and semi-arid regions. (Hamza, Adel: 5 201:50)

Water Management for Food Security Water management involves developing plans and strategies to ensure optimal use of water resources, reduce losses, and maintain water quality. This management includes several elements:

1-Improving irrigation systems: Using drip, sprinkler, or smart irrigation techniques increases water efficiency and reduces losses.

2-Sustainable drainage and agricultural irrigation: Removing excess water and reducing salinization maintains soil fertility and increases crop productivity.

3-Reusing wastewater: Treating used water and reusing it for irrigation contributes to providing additional resources and reduces pressure on freshwater. (Hamza, Adel: 5 201:50)

4-Water storage and harvesting: Building dams and reservoirs to collect rainwater ensures its availability during droughts.

Challenges in the relationship between water and food security This relationship faces several challenges, including water scarcity, climate change, degradation of agricultural land, and increasing population demand for food. Drought and erratic rainfall lead to reduced agricultural production, while over-irrigation and mismanagement of water resources lead to soil salinization and groundwater depletion. Therefore, achieving sustainable food security requires integrated water management that takes into account agricultural, environmental, and economic dimensions. (Ibrahim, Muhammad: 8 201:41)

3.3 Application Framework (Case Study)

To demonstrate the practical application of IWRM concepts, a case study can be selected from a region or country facing water scarcity and its impact on food security. This study aims to analyze how to improve agricultural water use by combining sustainable irrigation systems with efficient drainage and drainage to achieve higher productivity and provide sufficient food for the population.

1 -Selecting the Region: Semi-arid regions or those experiencing erratic rainfall and high temperatures are suitable for conducting this study. For example:

- The Nile River Basin in Egypt and Sudan: These regions face increasing pressure on water resources due to population growth and climate change, which impacts food security.
- Agricultural lands in Iraq or Morocco: These lands suffer from salinization problems, high groundwater levels in some areas, and scarce water availability for irrigation, which reduces agricultural productivity.

Selecting these regions allows for a realistic analysis of the current situation and an assessment of the impact of IWRM implementation on food production and resource sustainability. (Hamza, Adel: 5 201:50)

2 -Analyzing water use data and irrigation and drainage systems. The analysis includes collecting accurate data on:

- Water sources: the amount of surface and groundwater used, water quality, and its distribution by agricultural season.
- Irrigation systems: identifying the type of irrigation systems used, such as drip irrigation, sprinkler irrigation, and improved surface irrigation, and evaluating their efficiency in delivering water and reducing waste.
- Drainage systems (drainage): analyzing the effectiveness of drainage in removing excess water, reducing salinization, and maintaining soil fertility.
- Agricultural production: evaluating the production levels of different crops, compared to the amount of water used, and identifying gaps resulting from mismanagement of resources. (Ibrahim, Mohammed: 8 201:41)

3 -Evaluating the effectiveness of integrated management

After analyzing the data, the impact of integrated management on food security is evaluated through a set of indicators:

- Water use efficiency: measuring the amount of water used per unit of production and analyzing the improvement of water distribution among crops.
- Soil quality improvement: evaluating the role of drainage and drainage systems in reducing salinity and increasing soil fertility.
- Increased productivity: Monitoring changes in crop productivity after implementing sustainable irrigation and efficient drainage techniques.

- Water reuse: Studying the possibility of using treated wastewater to irrigate crops, reducing pressure on freshwater resources and increasing production sustainability.

Expected outcomes

Expected outcomes from implementing integrated management include:

- Improving water use efficiency and reducing waste, allowing water to be allocated to more crops or other uses.
- Improving soil fertility and reducing salinization, enhancing long-term productivity.
- Increasing agricultural production and food security, ensuring sufficient food for the population.
- Providing a practical model that can be replicated in other regions facing similar challenges.

Conclusions and Recommendations

Integrated water resources management (IWRM) is a vital approach to ensuring optimal water use in agriculture and achieving sustainable food security. Combining sustainable irrigation systems with efficient drainage and drainage improves crop productivity, maintains soil fertility, and rationalizes water consumption amid increasing water scarcity. The study, along with the theoretical and applied frameworks, demonstrates that the integration of these systems represents a practical solution to address water, environmental, and economic challenges and enhances the resilience of agricultural communities to climate variability and population growth.

Conclusions

1 -Water efficiency is a key component of food security: The use of modern irrigation systems such as drip and sprinkler systems, along with sustainable drainage, increases water use efficiency and reduces losses, thus increasing crop productivity.

2-Drainage and drainage maintain soil fertility: Sustainable drainage of excess water prevents salinization and agricultural degradation, ensuring the long-term sustainability of productive lands.

3 -Integrating irrigation and drainage increases sustainability: Combining advanced irrigation technologies with efficient drainage systems enhances the ability to produce sufficient food without depleting water resources.

4 -Reusing wastewater is a sustainable opportunity: Treating and reusing agricultural wastewater provides additional water sources and reduces pressure on freshwater.

5 -Community participation and effective policies are essential: Involving farmers and decision-makers in planning and implementation ensures sustainable and effective policy implementation

Recommendations

1 -Widespread implementation of sustainable irrigation systems: Encourage the use of drip and sprinkler irrigation and smart water control in all agricultural areas.

2 -Developing drainage and drainage infrastructure: Improving drainage networks and treating excess water to ensure water balance and protect soil from salinization.

3 -Reusing wastewater: Investing in water treatment technologies for safe and effective reuse in agricultural irrigation.

4 -Enhancing training and awareness: Disseminating training programs for farmers on integrated water management, irrigation rationalization, and the importance of sustainable drainage.

5 -Integrating agricultural and water policies: Developing integrated national plans that combine water management, agricultural production, and environmental protection to achieve sustainable food security.

6 -Research and Innovation: Supporting studies and research to develop new technologies to increase water efficiency and address the challenges of water scarcity in the face of climate change.

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