

Modern Technology as an Approach to Enhancing Water and Food Security (Leading International Experiences)

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Abstract:

This study aims, first, to shed light on what is meant by water security, food security, and modern technology; and second, to examine the applications of modern technology and the resulting rational and sustainable management of water by presenting several leading international experiences in this field drawn from real-world practice, thereby fostering agricultural development, or more precisely, food security.

The most important result reached through this presentation is that modern technology plays an effective role in water sustainability, such as weather control, combating drought, treating wastewater, and preventing the evaporation of drinking water, among other measures. As an appropriate recommendation, it is necessary to adopt modern technology in developing countries, including those in North Africa, as a mechanism to achieve both water and food security simultaneously.

Keywords: Water security; Food security; Modern technology; Weather control; Wastewater treatment.

1. INTRODUCTION:

One of the most important modern terms today by which we describe a country as economically advanced is the attainment of water security and food security. However, it should be noted that many studies and research works—especially economic ones—have been conducted in this field. One of the points agreed upon is that traditional tools are no longer effective in achieving this objective; rather, it has become necessary to adopt modern technology to modify and control weather conditions, and to treat wastewater by transforming polluted water into pure water suitable for drinking and irrigation, thereby seeking to reduce drought, confront water scarcity, and limit the impacts of natural disasters. Modern technology also contributes by developing chemicals or modern techniques that enhance plants' ability to retain water or prevent its evaporation in storage facilities. We should not forget one of the most significant contributions of technology: seawater desalination, as well as the development of techniques to reduce the use of water, or what is known as rationalizing water consumption.

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The same applies to developing countries: in order to catch up with advanced countries, they must make it a priority to adopt a comprehensive policy that activates modern technology across all economic sectors without exception, especially the agricultural, irrigation, and industrial sectors, with the aim of enhancing both water and food security together.

From this standpoint, we propose the research problem of this paper as follows:

Does modern technology play an effective role in strengthening water and food security?

We will also break down this main question into sub-questions to be addressed within the content of this paper, as follows:

- What is meant by water security, food security, and modern technology?
- How does modern technology contribute to strengthening water and food security?
- What lessons can be learned from leading international experiences in adopting modern technology as an effective tool for enhancing water and food security?

To answer the proposed problem, we will support its content by adopting the following hypothesis: One of the most important mechanisms relied upon in advanced countries around the world for the rational and sustainable management of water is modern technology.

1.1 Objectives and Importance of the Study:

At present, many advanced countries have demonstrated that the real reason behind their progress lies in achieving both water security and food security. These countries have also affirmed that modern technology is an effective mechanism that enabled them to achieve these two goals.

On this basis, in this modest paper we have sought to cover the essential concepts in order to clarify what is meant by modern technology, water security, and food security. We did not stop there; rather, we also address how modern technology contributes to achieving and sustaining both water and food security simultaneously.

1.2 Methodology and Structure of the Study:

In line with the nature of the topic, we adopted the descriptive approach in the first section, entitled “The Foundational and Conceptual Framework of Modern Technology, Water Security, and Food Security,” in order to precisely define what is meant by water security, food security, and modern technology. We also adopted the descriptive and analytical approach in the second section, entitled “Achieving Water and Food Security through Modern Technology (Leading Experiences),” so that we can identify the tools of modern technology and present them as proposals for developing countries in particular, enabling them to sustain water resources first and achieve food security second.

2. The Foundational and Conceptual Framework of Modern Technology and Water and Food Security

2.1 Modern Technology:

Technology is defined as a way of thinking, a tool, and a set of solutions to problems, before being merely the acquisition of equipment. It is also a human activity that includes both the scientific and the applied dimensions².

It is a human effort and a method of thinking about how to use information, skills, experience, and human and non-human elements, and how to apply them to discover means for solving problems, satisfying needs, and increasing capabilities.

2.2 Characteristics of Technology:

Technology is distinguished by many characteristics and features that are difficult to list in full, as its characteristics are continually renewed due to its ongoing and continuous development. Among these are:

- Speed: Speed is one of its most prominent characteristics, especially with regard to performing tasks at a very high pace; what humans may find difficult to do over weeks, technology can accomplish in a few minutes or seconds.
- Continuous development: This is clearly seen through the stages this element has gone through; it has continued to advance and develop and does not recognize stillness or stability at all.
- Ease of use: It is simple and easy to handle and does not require excessive effort or great exertion to learn.

2- Zineb Farajallah and Lylia Ben Soueilh, Modern Technology and Its Role in Achieving Quality Performance of Human Resources, Al-Muqaddima Journal for Human and Social Studies, Volume 6, Issue 2, 2021, p. 323.

- Wide spread: It has penetrated all fields and has even become the primary driver of most of them, to the point that it is difficult to imagine their functioning without it.
- A basic and effective element: Technology is no longer a matter of choice; it has become an absolute necessity. Its absence would be a reason for paralyzing the work of all sectors and fields. It has come to occupy a central place within them and has become a fundamental means for their operation.
- A two-sided element: Technology carries two sides within it: at times it is a blessing and brings benefit to its user if employed properly, and it can be a curse if used shrewdly for purposes other than those for which it was created, such as using it to develop smart weapons of mass destruction.

2.3 Types and Importance of Technology:

Technology has many types and extends across all sectors and different activities, which makes classifying its types a somewhat difficult task.

2.3.1 Industrial Technology:

It is used in the industrial sector through the use of leading techniques to facilitate production processes. This type is widely used by major industrial companies, such as automobile and equipment manufacturers. Adopting this type within large companies greatly facilitates industrial production, reducing time and costs, which has significantly contributed to the success of these giant industrial firms.

2.3.2 Commercial and Strategic Technology:

Commercial technology is the type whose movement, transfer, and use are subject to specific conditions, and it is often legally protected by registering it with specialized offices. No one other than the rights holder may dispose of it, as in the case of patents and trademarks. Countries rely on it and invest in it to develop their domestic industries because it is based on exploiting new innovations.

Strategic technology, on the other hand, is of a confidential nature. It is not published in journals and is not registered in specialized offices; rather, it is monopolized by certain bodies and institutions. It includes the latest discoveries and innovations, such as space research, nuclear energy, military technologies, and others. Research and development in this area are carried out by specific institutions. It is among the most important manifestations of the scientific and technological revolution, because it enables the countries that possess it to exercise broad control and makes it a pressure instrument across various fields.

2.3.3 Information Technology:

It includes a set of devices, software, and communications, as well as everything related to the transfer of information and systems that facilitate communication. It works to provide information suited to the user, enabling access to data and its processing. It is used in various sectors, which is clearly reflected in digitalization processes in many developed countries.

2.3.4 Financial Technology:

These are financial innovations that use technology, enabling the creation of business models, applications, processes, and new products that have a tangible material impact on markets and financial institutions. Accordingly, financial technology consists of products and services that rely on modern techniques and are used to improve the quality of financial services. It has a direct impact on the financial and banking sector and includes all electronic payment services and their applications, as well as digital currencies³.

2.4 Concept and Importance of Food Security:

Food security is the condition in which self-sufficiency in food is achieved locally, according to the state's ability to provide the needs of all individuals in terms of food goods and commodities through domestic production.

Food security also lies in the state's ability to provide the foreign currency necessary to meet its needs for food imports.

As a comprehensive definition, it refers to the state's ability to provide an attainable level of food for individuals according to their available incomes, while guaranteeing a subsistence level of food for individuals who cannot obtain it, through domestic production as well as imports.

By the attainable level, we mean the level of food that enables members of society to carry out their productive activities in the best possible manner. This level is the result of the interaction between the supply of food through production and trade and the demand for food through the individual's available income. Food security is thus

3- Tetteh Khaled, Ben Daoud Ibrahim, and Shtouh Anfal Hebatallah, The Concept of Technology and the Role of Commercial Companies in Its Transfer, Qadaya Ma'rifiyya Journal, Volume 2, Issue 3, September 2022, pp. 120–122.

considered part of social security, economic security, and political stability for any country, and it falls within economic and social development in its various dimensions.

The level of food security depends on several factors, as follows:

2.4.1 Internal factors:

These are directly linked to the state's internal conditions and include:

- Population size and the level of their needs.
- Domestic food production capacity.
- Real income in society and how it is distributed among individuals.

2.4.2 External factors:

These are linked to the conditions surrounding the country's economy and include:

- Foreign currency resources that can be obtained through exports.
- The extent of food availability in the global market and the degree of price stability.
- The extent to which food aid and facilities provided by international organizations are available.

Food, in addition to being an economic commodity, is—within the perspective of the concept of food security—considered a strategic commodity governed by considerations other than supply and demand, since it is a product that cannot be dispensed with. Therefore, the state must provide it to consumers, whether or not they are able to pay its economic price. In such cases, the state budget bears the difference between economic prices and social prices, or the state may resort to granting financial subsidies or tax exemptions to food producers on the condition that they sell it to consumers at low prices commensurate with their purchasing power. Because food is a strategic commodity, it may also have a political price when the state cannot provide it through domestic production and relies heavily on importing it from abroad; in this context, it may be sold at prices far exceeding its economic prices.

Accordingly, the concept of food security includes the following elements:

- A large proportion of food should rely on domestic production rather than external sources.
- Everyone should be able to access sufficient food at any time.
- It should be affordable for all segments of the population⁴.

The Algerian legislator also defined food security, pursuant to Law No. 08/16 concerning agricultural guidance, in Article 3, paragraph 1, as follows: "Food security is the acquisition and access of every person, easily and on a regular basis, to safe and sufficient food that enables them to enjoy an active life⁵."

2.5 Dimensions of Food Security:

Food security includes the following four main dimensions:

- Physical availability of food: This includes the availability of food on the supply side of food security, which is determined by the level of food production, stock levels, and net trade in food.
- Physical and economic access to food: Here, local and international policies and programs must take into account and pay attention to aspects of income, expenditure, markets, and prices as they relate to achieving food security.
- Utilization of food: This contributes to enabling the body to obtain the necessary nutrients and energy and improves the nutritional status of individuals in society.
- Stability, continuity, and the ability to access food on a regular basis, away from any factors that may undermine this, such as climate changes and political, economic, or social disturbances that negatively affect and threaten the state of food security⁶.

2.6 The Relationship Between Food Security and Other Security Concepts:

Food security is linked to a set of other security concepts that together contribute to providing security for the individual, including:

2.6.1 Social security:

4- Nasser Mourad, Policies for Achieving Food Security in Developing Countries: The Case of Algeria, *Jadid Al-Iqtisad Journal*, Volume 5, Issue 1, December 2010, National Association of Algerian Economists, pp. 45–48.

5- Abdullah Ashouri, Food Security in Algeria and the Challenges of Achieving It, *Journal of Law, Society and Authority*, Volume 13, Issue 1, 2024, p. 332.

6- Abdullah Ashouri, Op. Cit, p. 334.

Food security is closely connected to social security; each can be a cause of the other, and the absence of one leads to the absence of the other.

2.6.2 Political security:

Food security is considered one of the main components of strategic security. Powerful countries use food as a tool to pressure developing countries in order to influence their political decisions, especially since the latter are net importers of food. A clear example is that during the Tripartite Aggression in 1956, food supplies to Egypt were completely halted; import activity was paralyzed, and the aim was to stop the import of Soviet Union weapons, which were widely present in the Arab Republic of Egypt.

2.6.3 Economic security:

In today's world, many countries suffer from a rising food import bill, as a large proportion of their foreign currency reserves is directed to paying for food imports. This negatively affects their balances of payments, making them dependent on major powers with regard to food. In return, the food dependency experienced by developing countries leads to higher food prices in their domestic markets as an inevitable result of price increases in global markets. Consequently, the value of the local currency deteriorates and loses purchasing power, in addition to the persistent deficit in those countries' balances of payments and the erosion of purchasing power. Moreover, this exposes them to obstacles in the path of development and progress, arising from countries' tendency to abandon projects in exchange for securing the food needed for members of society.

2.6.4 Environmental security:

Studies have shown that there is a strong relationship between food insecurity and environmental degradation. Those who suffer from food insecurity resort to environmentally unfriendly activities, which leads to environmental deterioration at all levels⁷.

2.7 Concept of Water Security:

One of the most focused and straightforward definitions of water security is the one presented by Patrick Webb and Maria Iskandarani, which states that water security is the ability of all individuals to obtain safe and sufficient water at all times in order to live a healthy and productive life.

2.8 Dimensions of Water Security:

Societies that enjoy water security have integrated resource management and are able to meet their needs across the following five dimensions:

- **Environmental water security:** The ability to conserve and restore water within ecosystems, including rivers, lakes, reservoirs, and groundwater aquifers.
- **Economic water security:** Ensuring sufficient supplies to support economic activities such as agriculture, industry, and energy.
- **Water security related to climate change:** Climate change puts water security at risk. Its impact does not only reduce water availability; it also makes it more volatile and unpredictable in many parts of the planet, which worsens supply problems. Droughts and floods have become more frequent as a result of extreme weather events, with severe consequences for both rich and poor countries alike.
- **Household water security:** Providing all people with reliable and safe water and sanitation services.
- **Urban water security:** Establishing better water management and services to support vibrant, water-sensitive cities⁸.

Achieving a Water-Secure World Requires the Following:

- Water-related policies and plans must be integrated into national and international development processes. World leaders and financing agencies should recognize that investing in water, in the long term, is an opportunity and a solution rather than a problem.
- Partnerships for action and innovation at all levels—among communities and nations, across river basins, and globally.
- Moving beyond what is commonly considered “water trade,” which will entail major changes in how sectors such as water supply, sanitation utilities, agriculture, energy, industry, people, and household management can be managed.

7- Ben Nourine Zine Eddine and Dan Bou Abdellah, Sustainable Food Security and Ways to Achieve It in Algeria, *Dafer Bouadex Journal*, Volume 10, Issue 2, December 2021, University of Mostaganem, Faculty of Economic, Commercial and Management Sciences, pp. 209–210.

8- Takouasht Imad, Water Security Policies as a Strategy to Achieve Food Security: Algeria as a Model, *Journal of Economic and Financial Research*, Volume 11, Issue 1, June 2024, University of Oum El Bouaghi, Faculty of Economic, Commercial and Management Sciences, pp. 398–399.

– Balancing social, environmental, and economic priorities, as well as balancing soft (institutional) and hard (infrastructure) solutions—such as small- and large-scale investments in storage and water transfer and in protecting the resource itself. Water management and investment are cost-effective, providing immediate benefits and long-term social, economic, and environmental resilience. Accordingly, today's investments in water should be viewed as part of a strategy to build a climate-adaptive world, mitigate floods, droughts, and other threats, and contribute to poverty reduction and sustainable development⁹.

2.9 Water Security and Food Security:

The issue of water security cannot be separated from the issue of food security. Rising competition over limited water resources has placed the capacity of developing countries to provide food for their growing populations under severe challenges. Attempts—often desperate—to achieve food self-sufficiency have led to excessive use of water in agricultural activity.

The importance of food security has become an inevitable necessity in a world where the population has increased significantly, resulting in famine and the spread of diseases. Consequently, food security has become dependent on the extent to which individuals can secure food for themselves.

The problem of food security becomes clear because the relationship between water and food is a causal one. In particular, the inability to reach a stage of self-sufficiency has become one of the most prominent threats faced by underdeveloped countries in general, and Arab countries in particular. This is due to their subjection to the will of food-exporting countries that seek to shape their domestic and foreign policies according to their own interests.

The concept of water for food security and nutrition refers to the direct and indirect contributions that water makes to food security and nutrition across its four dimensions. It includes safe drinking water and sanitation, as well as sustainable water for food production and processing. It also encompasses ensuring water sustainability for all sectors in terms of securing livelihoods and incomes and providing food. The concept further covers the goal of sustainable management and conservation of water resources and the ecosystems that host them, which are necessary to guarantee food security and nutrition for present and future generations. Water security is considered one of the most important determinants of food security, and drought and water scarcity are the main threats to global food security in general. The role of water as a determinant of food security is now greater than ever, due to the mismatch between available water quantities and the growing consumption of water by the agricultural sector in all countries. Globally, agriculture accounts for about 71 percent of available water, and about 86 percent in the Arab world.

Providing water suitable for irrigation is one of the most important factors determining food security worldwide. Since most agricultural land is rain-fed, food production fluctuates from year to year according to fluctuations in rainfall. Drought plays a fundamental role in determining the volume of food commodities available in many parts of the world. There is a principle that some people cite and that can no longer realistically be doubted: there is no military security for any nation outside its economic security; the peak of economic security is food security; and the backbone and source of food security is water¹⁰.

3. Achieving Water and Food Security Through Modern Technology (Leading Experiences)

3.1 First Experience: Weather Control Technology in China

China uses weather modification technology (including cloud seeding) to induce rainfall during periods of drought and to reduce hail, as well as to control weather conditions ahead of prominent international events such as the Olympic Games held in Beijing in 2008. A report published at the beginning of last year explains that China's main objective in using weather-control techniques is to achieve additional, higher percentages in the rainfall rate by the year 2020.

Shanghai Province is considered one of the largest provinces and among the driest in the western region of central China, and it contains many rivers, such as the Yangtze, the Yellow River, and the Mekong. Therefore, China allocated an amount of 30 million dollars to be spent on its weather-control program, as part of efforts to combat drought and limit the effects of natural disasters.

It is also mentioned that a team of scientists in the state of Nevada used a drone to control weather. Engineers and meteorology experts stated that they created the first artificial cloud platform that can increase rainfall rates by 15 percent. There is currently an agreement between drone engineers and scientists from the Desert Research Institute

9- Mazouni Mohamed, Water Security on Algerian Public Television: An Analytical Study of a Program Entitled "Water Security... The Bet of the Future" on Algerian Channel 3, Ma'alim Journal for Media and Communication Studies, Volume 6, Issue 2, December 2024, Communication and Food Security Laboratory, Faculty of Media and Communication Sciences, University of Algiers 3, p. 128.

10- Al-Yazid Boussaïq and Mohamed Majdan, Water Security: A Study of the Development of the Concept and Its Importance, Journal of Rights and Political Sciences, Volume 9, Issue 2, 2022, University of Khenchela, p. 1134.

and the AVI SIGHT team, in addition to the American drone team, to build a drone equipped with cloud-seeding equipment.

Researchers conducted successful tests on the DAX8 drone in late January 2016. Experts explained that this developed drone, capable of flying over northern Nevada, aims to verify that the United States is able to deal with different climatic conditions.

The state of Arizona revealed last year plans to create clouds that produce artificial rain by flying aircraft over the Rocky Mountains and dispersing silver iodide in the sky (a compound used in cloud seeding with a crystal structure similar to ice crystals). Water vapor condenses in the upper layers of the atmosphere around the crystallized nuclei of silver iodide; as condensation increases, it soon turns into droplets of water or ice that fall downward under gravity.

Researchers hope that this technology will help alleviate some of the worst effects of climate change. It is also noted that the proposal of cloud seeding first appeared scientifically in the 1940s in General Electric laboratories in New York¹¹.

3.2 Second Experience: Using Technology to Treat Wastewater in Belgium and India

A team of scientists at a Belgian university succeeded in inventing a device that converts wastewater into purified drinking water and fertilizer using solar energy. This is a technology that can be applied in rural areas and developing countries, as it is more energy-efficient and can be implemented in regions that are not connected to electricity grids.

Another method for treating wastewater is biotechnology, which is defined as the science that deals with ways of using biological systems (a living organism or part of it) to produce a useful product or a useful service. Biotechnology provides an important means for farmers in developing countries to address water scarcity by recycling used water and treating it before using it again in agriculture.

There are many biotechnology applications that can play a beneficial role in wastewater treatment, including the use of plants and microbes. Biotechnology can also contribute to improving water treatment and producing biological agents for detecting heavy metals, herbicides, and other contaminants found in used water. It can also develop biological filters to remove pollutants such as heavy metals from water. For example, biological filters have been produced by developing the use of dried materials from floating aquatic ferns known for their ability to absorb heavy metals, such as the Azolla plant. Research is still ongoing on the use of cyanobacteria—also known for their ability to absorb heavy metals—as biological filters.

Indian scientists have successfully developed strains of algae that remove heavy metals, nitrogen, and phosphorus from wastewater to make it safe for reuse in agriculture. Researchers in southeast Nigeria have also developed a simple method of biological treatment for wastewater, providing a suitable source of drinking water for livestock. In addition, researchers in the Indian state of Andhra Pradesh developed a method to purify rainwater for household use by crushing seeds from moringa trees and seeds from *Strychnos potatorum* trees, achieving positive results in this field.

Biotechnology can potentially provide low-cost solutions that consume large amounts of energy and generate biogas that can be used, for example, for heating and cooking. It can also produce sludge used for reinoculation or as fertilizer, as well as treated water that can be used to irrigate crops. Many successes have been achieved in the Netherlands, Germany, and Russia by using biological systems as a means of water treatment, which led to reducing water use by 50 percent. In some cases, such as in Germany, the reduction in water use reached 92 percent. The time has come for many developing countries to benefit from these biotechnologies to confront the challenge of water scarcity.

At the same time, experts warn that if wastewater is not treated properly, it can threaten human health and environmental safety. Water safety through microbial treatment remains a major concern, and experts call for further research on the biology of wastewater and for selecting appropriate treatment techniques that biotechnology tools can provide to eliminate harmful elements and disease-causing agents that wastewater may contain. However, it is certain that biotechnology will play a significant and highly effective role in the management of water resources worldwide in general, and in wastewater treatment in particular. Biotechnology holds a very promising future for managing agricultural water resources and improving the efficiency of their use¹².

3.3 Third Experience: Using Mycorrhiza to Help Plants Overcome Water Scarcity in India

One of the most important and effective biotechnology approaches that can be applied to improve water-use efficiency in agriculture is the use of organisms known as mycorrhiza to help plants cope with water scarcity. These

11- Sara Ben Ghida and Saida Harakat, Employing Modern Technologies to Achieve Water Resource Security: Presentation of Global Experiences, *Journal of Economics, Finance and Business*, Volume 5, Issue 2, December 2020, University of Martyr Hamma Lakhdar, El Oued, Algeria, pp. 555–560.

12- Sara Ben Ghida and Saida Harakat, Op. Cit, pp. 555-560.

microbes can be used as biofertilizers to increase growth and improve a plant's ability to absorb water. The use of microorganisms to enhance plants' water uptake is among the most exciting topics, as it highlights the potential offered by biotechnology and microbiology to reduce the effects of drought on plants. However, there are many technical challenges that hinder the use of these microbes as natural fertilizers in some developing countries.

Results from experiments conducted over several years in India showed that using microbial fertilizers leads to reduced consumption of organic fertilizer, lower amounts of water needed for irrigation, decreased incidence of diseases and pests, improved crop productivity and quality, and enhanced soil water-holding capacity. Research has also demonstrated that the efficiency of water absorption in plants can be strengthened in the presence of other microorganisms. For example, applying mycorrhiza can help increase water-use efficiency, especially when combined with other beneficial organisms such as nodulating bacteria, alongside growth enhancement through the use of low-cost sources such as phosphorus and rock phosphate. Scientists should adopt a simple, low-cost approach that makes it easier for farmers in developing countries to use microbes as organic fertilizers by inoculating crops with microbial strains of fungi and bacteria produced commercially as biological control agents. These can provide a significant increase in the capacity of the roots of many plants and raise their efficiency in absorbing water and other nutrients.

Isotope hydrology is considered one of the main scientific methods used by experts in Kuwait to trace the impact of freshwater movement and to assess the age of available groundwater. This method relies on the naturally occurring isotopes carried by water, which can be used to determine water sources above and below the earth's surface, as well as the age of the water, its movement, and its interactions. Thanks to the data they obtain and represent as hydrological maps, experts can make evidence-based decisions regarding sustainable resource management.

Kuwait has one of the highest water-use rates in the world: per capita consumption exceeds 400 liters per day, and groundwater abstraction reaches 255 million cubic meters per year. By contrast, the natural inflow of groundwater into aquifers from neighboring countries is estimated at about 67 million cubic meters per year. With limited freshwater resources, Kuwait relies heavily on seawater desalination, which is an expensive process¹³.

3.4 Fourth Experience: The Invention of Opabactin in California

This is an innovation that recently emerged from the University of California. It involves the development of a chemical substance whose function can be described as helping plants capture and retain water, which may help stop the enormous annual crop losses caused by the consequences of drought.

This substance mimics abscisic acid, or ABA, the natural hormone that plants produce in response to drought stress. This hormone slows plant growth so that the plant does not consume more water than is available and therefore does not wilt.

Scientists have long found that using an ABA-mimicking substance to spray plants can improve drought tolerance, but it is an expensive option and may not be available to most farmers. This led researchers to develop a less costly alternative: OPABACTIN.

The ABA-mimicking substance binds to an abscisic acid hormone receptor molecule in a plant cell, forming two tight links—like hands gripping handles—after researchers screened millions of different molecules that mimic hormones.

3.5 Fifth Experience: Using Shade Balls to Prevent the Evaporation of Drinking Water in the United States

Shade balls, as they are called, are effective and low-cost, with the entire project costing no more than 35 million US dollars, whereas covering the reservoir using traditional means would have cost the ministry 300 million US dollars.

The service life of these plastic balls extends to about 10 years, after which they are recycled and used again. The shade-ball technique began in 2008 in Los Angeles to cover the Ivanhoe Reservoir with 400,000 black balls, after the water department discovered high levels of bromate, a carcinogenic substance that forms when bromide and chlorine react with sunlight in reservoir water. Bromide occurs naturally in groundwater, and chlorine is used to kill bacteria, but sunlight is the factor that triggers this mixture.

When the water protection administration realized the seriousness of the problem, it began building a new underground reservoir in Griffith Park while seeking a rapid solution to prevent sunlight from reaching the water. Initial solutions studied by the department included options such as fabrics and metal covers, but they were extremely expensive and took a very long time to install. A biologist working at the department proposed the "bird balls" technique, which is commonly used at airports to prevent birds from gathering in wet areas alongside runways. The Los Angeles department currently uses the shade-ball technique to cover four drinking-water reservoirs.

13- Sara Ben Ghida and Saida Harakat, Op. Cit, pp. 555-560.

This is a smart technique adopted in the United States to prevent the evaporation of drinking water. The Los Angeles Department of Water and Power released 96 million black plastic balls into the Van Norman Reservoir complex for drinking water in the city of Sylmar. The balls covered the surface of the reservoir with a thick layer to protect its water from evaporation. To keep the balls in place, they were filled with water to increase their weight. They cover every inch of the reservoir's surface and protect the water from contamination by dust, rainwater, birds, wildlife, and chemical reactions caused by sunlight. They are also expected to prevent about 300 million gallons of water from evaporating annually—enough to provide drinking water for 8,100 people for an entire year¹⁴.

3.6 Sixth Experience: The Water-Saving Bubble 90 Nozzle Manufactured by DG TAKANO CO., LTD in Japan

Japan is believed to have abundant water because it is surrounded by oceans and enjoys high levels of annual rainfall. Nevertheless, Japan has a very low level of usable freshwater. Per capita water availability in the highly populated Greater Tokyo area is particularly low, comparable to that of North Africa and the Middle East.

Because Japan's mountainous terrain results in short rivers, and because rainfall is concentrated in specific seasons and during typhoons, rainwater flows rapidly into the sea. For this reason, there is a shortage of water in many parts of Japan almost every summer, and people are asked to reduce water use. This has driven the development of many distinctive water-saving products in Japan. One of the recently successful products is the Bubble 90 water-saving nozzle manufactured by DG Takano Co., Ltd. in Higashi-Osaka, Osaka Prefecture. Using it reduces the amount of water used for washing under running water by 80 to 95 percent, while improving washing performance without using electricity.

The president of DG Takano Co., Ltd., Takano Masaki, who developed the nozzle, stated that the secret to achieving high water efficiency without sacrificing washing power is the pulsating flow generated by the Bubble 90 nozzle. Pulsed flows that continuously release water droplets containing air are used in semiconductors employed in washing machines and similar goods, and they are also used in high-quality toilet seats that supply warm water. However, all of these devices rely on electricity. With the Bubble 90 nozzle, the world's first device was developed to generate pulsating flow using only water pressure. This technology was incorporated into a small nozzle that can be easily installed on almost any type of faucet.

3.6 Seventh Experience: Water Desalination Using Electrochemical Technology in Saudi Arabia

The Kingdom of Saudi Arabia is among the earliest countries to take an interest in water desalination. It established its first desalination facility, known as Al-Kandasa, but it did not last long because it relied on coal fuel, which was not available at the time, especially since there was no alternative energy source. Subsequently, it worked on establishing two condensation units for distilling seawater. Among the most promising and tangible benefits of nanotechnology is its contribution to obtaining healthy water free of harmful pollutants and impurities through advanced treatment systems that include nanoscale technological methods.

Electrochemical technology is one of the most prominent modern techniques used in water desalination, and it consumes only a small amount of energy—no more than 3 volts. It is a modern technology that differs from traditional methods in terms of how it works, its size, and its cost. It has been registered as a patent and is currently being developed through a startup called Okeanos Technologies.

This technology involves applying an electric potential to a plastic chip filled with salty seawater. The chip contains a small channel with a size of 50 micrometers, which splits into two branches. At the entrance of this channel, there is an electrode that neutralizes chloride ions present in the salty water, creating an ion-depleted region. As a result, the electric field in this region increases compared to the rest of the channel. This change in the electric field directs salts into the first branch of the channel and freshwater into the other branch¹⁵.

3.8 Eighth Experience: The Indian Case

India is one of the most populous countries in the world, with its population exceeding 1.4 billion in 2023. For decades, it has faced recurring challenges in meeting its food needs, especially during periods of drought and climate volatility. With rising demand for food and shrinking agricultural land, the Indian government adopted a series of technological initiatives to modernize the agricultural sector, increase productivity, and improve resource efficiency.

3.8.1 General Framework of Agricultural Technological Transformation Policies:

India launched several national programs within what is known as the Second Green Revolution, focusing on the following:

14- Sara Ben Ghida and Saida Harakat, Op. Cit, pp. 555-560.

15- Sara Ben Ghida and Saida Harakat, Op. Cit, pp. 555-560.

- **The use of smart irrigation techniques:** By introducing soil-moisture sensing systems and drones to monitor fields—especially in the states of Maharashtra and Gujarat—this contributed to reducing water consumption by more than 30% and increasing wheat and rice yields by 20–25%.
- **Digital transformation through precision agriculture:** A national digital platform was launched that links farmers to markets and provides weather data and agricultural recommendations in real time.
- **Biotechnology and genetically modified seeds:** Improved varieties of cotton and rice resistant to drought and diseases were adopted, which reduced reliance on chemical pesticides and improved farmers' income.

Results and Impacts of the Experience on the Dimensions of Food Security: The program had positive outcomes by increasing agricultural production. Wheat production rose from 98 million tons in 2017 to more than 110 million tons in 2023, according to Food and Agriculture Organization statistics, thanks to precision farming techniques and modern irrigation systems. India also saw improved access to food due to digitalization and shorter value chains, as farmers were able to reach local markets directly through mobile applications, which improved prices and income. Updated climate data via satellites helped reduce annual drought losses by 15%, and early warning systems contributed to adapting local agricultural policies.

3.8.2 Challenges Faced by the Indian Experience:

- Inequality in access to technology between large and small farmers;
- A lack of technical competencies in some poorer states;
- High maintenance costs and dependence on government support;
- Limited digital infrastructure in remote areas¹⁶.

3.9 Ninth Experience: The United Arab Emirates

The United Arab Emirates places great importance on enhancing the use of innovative technology in agriculture, with the aim of improving productivity, expanding arable land, increasing efficiency, preserving natural resources, and strengthening food security. The country's agricultural sector is undergoing a radical transformation thanks to the integration of the latest technologies into traditional farming practices, in order to overcome challenges such as water scarcity, a hot climate, and desert soils.

The UAE follows a number of modern agricultural approaches, such as protected cultivation systems in greenhouses, organic farming, soilless farming, closed-environment farming, and net houses. These technologies aim to produce crops in a closed environment that protects them from external climatic conditions and pests by creating an optimal micro-environment for growth. The main controllable factors include temperature, light and shade levels, irrigation, fertilizers, humidity, and carbon dioxide concentration. This approach is distinguished by year-round food production and optimal use of space.

Relying on advanced technology supports the achievement of the targets of the national program "Plant the UAE," launched by His Highness Sheikh Mohammed bin Rashid Al Maktoum. The program includes several initiatives that support the UAE's direction toward agricultural development and the enhancement of sustainable national food security rates.

The national program "Plant the UAE" aims to encourage the local community to achieve household self-production of key agricultural products, expand green areas across the country, support environmental protection efforts, and reinforce a positive perception of high-nutritional-value local products. The program also supports the "Year of Sustainability 2024" and strengthens the environmental sustainability system by enabling local products to help reduce the carbon footprint as fresh products. The program includes events that promote technology-based smart farming practices and systems, financing programs for innovative projects—such as those focused on raising crop productivity and product quality while reducing costs and waste—and the launch of partnerships with the private sector. The strategy of the Ministry of Climate Change and Environment focuses on developing the agricultural sector in the UAE, encouraging the adoption of modern farming systems, and expanding their base. This is considered one of the main pillars of the ministry's efforts, in cooperation with its strategic partners and relevant entities nationwide, to ensure the strengthening of national food security on sustainable foundations based on technology and innovation. This aligns with the UAE National Food Security Strategy 2051, which aims to elevate the entire food value chain and build a sustainable future for all.

3.9.1 Innovative and Smart Agriculture in the UAE

Through its innovative agriculture strategies, the UAE aims to achieve several key objectives, including:

- Achieving food security: The UAE seeks to reduce dependence on food imports by strengthening local production.

16- Souhaila Qattaf, Agricultural Technology and Its Role in Solving the Global Food Crisis: International Experiences, Journal of Economic Development, Volume 10, Issue 2, December 2025, University of Martyr Hama Lakhdar, El Oued, Algeria, pp. 93–94.

- Increasing resource-use efficiency: Through smart agriculture techniques, the country aims to improve the use of water and energy, which helps reduce losses.
- Enhancing environmental sustainability: By using sustainable farming techniques, the UAE seeks to protect the environment and reduce negative impacts on ecosystems.
- Stimulating innovation: By encouraging research and development in agriculture through attracting startups and innovators.

3.9.2 Technologies Used to Achieve the Goals of Innovative Agriculture

The UAE uses a set of methods and technologies to achieve its goals in innovative agriculture, including:

- **Vertical farming:** The UAE relies on vertical farming technologies that allow crops to be grown in small spaces, increasing productivity and reducing water consumption.
- **Hydroponics:** Hydroponic systems are used to reduce the use of soil and water, improving production efficiency.
- **Artificial intelligence:** AI techniques are used to analyze agricultural data, helping farmers make informed decisions about cultivation.
- **Robotics:** Robots are used in planting and harvesting operations, increasing efficiency and reducing the need for manual labor¹⁷.

4. CONCLUSION:

This paper addressed the issue of water security and the extent of its contribution to driving sustainable agricultural development, that is, what is known as food security. Based on the preceding presentation of leading international experiences in this field, we were able to conclude that countries that still experience economic and food dependence on economically advanced countries must strive diligently to do the following:

- The necessity of reusing wastewater as an alternative and as a means to preserve natural resources in agriculture, in order to confront pressure on water resources resulting from accelerated population growth, the expansion of the industrial sector, and the deterioration of the quality of water sources—without forgetting climate changes due to the ozone hole. It should be noted that this will not be achieved except by prioritizing the reuse of non-potable water within water policy, while taking into account the health and environmental risks associated with reusing wastewater for irrigation.
- Effective management of water resources based on adopting and developing sound water policies by supporting and developing research systems in the water sector, so that improving and strengthening the performance and capacity of water institutions becomes a priority, with the participation of the private sector, in order to raise the efficiency of water resource management and ensure its sustainability.
- Taking urgent measures to address climate change, including desalinating and conserving ocean and seawater and using it sustainably in a way that ensures water availability for all and sustainable management that guarantees equitable access to safe drinking water at an appropriate cost. This also calls for improving water quality by reducing pollution, as well as protecting and restoring ecosystems related to water resources, such as mountains, forests, and reservoirs of all types of water.
- The necessity of activating and adopting modern technology in developing countries to maximize the benefits of the speed it offers in performance and the reduction of implementation costs. It should be noted that this will not be achieved except by developing human resources capable of adapting to the changes required for effective water management, given that human resources are the primary driver of it.

We emphasize that achieving food security requires decision-makers and active authorities to adopt optimal policies and strategies that enable sound and effective management of water resources and their efficient use to confront climate change.

Declarations

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17- Souhaila Qattaf, Op. Cit, pp. 93-94.

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