Achieving food security in light of the development of agricultural technologies

تحقيق الأمن الغذائي في ظل تطور التكنولوجيات الفلاحية

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Abstract:

With the development of industrial technology and the increasing global population, and in pursuit of food security, the excessive use of chemicals has led to a decline in the nutritional value of plants and the environment, as well as the emergence of pests. This has spurred the development of agricultural technologies, which encompass scientific methods, research, and processes used in agricultural and food production. These technologies rely on modern scientific techniques to improve and increase the efficiency of agricultural production. They enable farm monitoring and remote control of operations, reduce crop-related risks, and thus increase productivity. This necessitates the adoption of an agricultural technology policy and strategy to achieve and enhance food security.

key words: Agricultural technology, food security, agricultural scientific research, innovation and development, agricultural development.

ملخص:

بتطور التكنولوجيا الصناعية وارتفاع عدد سكان العالم، وسعيًا لتحقيق الأمن الغذائي، أدى الإفراط استخدام المواد الكيميائية إلى تراجع القيمة الغذائية للنباتات والبيئة، فضلًا عن ظهور الآفات. وقد حفز هذا على ظهور التقنيات الزراعية، التي تشمل الأساليب والبحوث العلمية والعمليات المستخدمة في الإنتاج الزراعي والغذائي. التي تعتمد على استخدم التقنيات العلمية الحديثة، لتحسين كفاءة الإنتاج الزراعي وزيادتها. فهي تُمكّن من مراقبة المزارع والتحكم عن بُعد في العمليات، وتقلل من المخاطر المتعلقة بالمحاصيل، وبالتالي تزيد الإنتاجية. الشيء الذي يتطلب اعتماد سياسة واستراتيجية للتكنولوجيا الزراعية لتحقيق الأمن الغذائي وتعزيزه.

الكلمات المفتاحية :التكنولوجيا الزراعية، الأمن الغذائي، البحث العلمي الزراعي، الابتكار والتطوير، التنمية الزراعية.

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Introduction:

The subject of food is one of the most important topics that has preoccupied humankind throughout history. Agriculture, from the cultivation of plants of various kinds to animal production and aquaculture, constitutes a wealth that meets many essential needs, whether related to food or raw materials such as wood, textiles, and even medicines, etc. The necessity of fulfilling these needs has driven humankind to develop and innovate various methods and means to preserve and intensify plant and animal wealth, which has led to a gradual transition from traditional agriculture to modern agriculture that relies on scientific and experimental research and various modern technological means that save time, effort, and environmental consumption and achieve the goals.

Recent years have been marked by tremendous technological advancements and a surge in innovations in digital devices, artificial intelligence, automation, and biotechnology. The world today is witnessing rapid and massive technological development, innovations, and techniques that are being harnessed across all sectors. Modern technology, along with geographical advantages, abundant arable land, water resources, forests, and diverse livestock, are among the most important elements of food security.

Based on the above introduction, the following problem arises:

"How does the development of technology in the agricultural sector affect the achievement of food security? "

Section one: The role of technology and innovation in developing the agricultural sector

Agricultural technology is defined as the sum of techniques, scientific research, and processes used in agricultural production. It can be considered a branch of agricultural science that relies on the use of scientific tools and techniques, information and communication technologies, genetic engineering, processing, diagnosis, vaccines, and the modification of living organisms such as plants, animals, and microorganisms. In addition, it utilizes modern, innovative machinery to improve and increase the efficiency of agricultural production, enhance the quality of crops and agricultural products, reduce costs, conserve

limited resources such as water and soil, minimize fertilizer use, and improve the management of agricultural holdings.

A: Technological Development in Agriculture

Advanced agricultural methods have been developed to meet human food needs and achieve food security in the face of high population densities and climate and economic changes. Modern agriculture relies on technology to cultivate plants in unconventional ways, reducing dependence on soil and conserving water used in traditional farming. Modern agriculture seeks to leverage advanced technology by utilizing internet technology in agricultural management. This technology improves plant quality and maximizes yields to meet human food needs. According to the United Nations, the world's population will reach 9.7 billion by 2050, and it will be difficult to provide sufficient food for this number using traditional farming methods, especially given climate change, water scarcity, soil degradation, and pollution.[1]

Modern technology enables monitoring of farms and rapid remote control of operations, helping to avoid damage, disease, or spoilage of plants, while predicting any potential hazards. All data is digitized and analyzed using scientific methods. Agricultural machinery now relies on its own sensors to sense the surrounding environment and process various types of environmental data. This makes agricultural production more organized and helps farmers make decisions to improve plant quality, as periodic measurements of different agricultural quality factors are handled and analyzed.[2]

B: Automation and Industrial Development in Agriculture

Recent years have witnessed tremendous technological advancements that have impacted agricultural productivity. These advancements include the discovery of genetic engineering methods and techniques for producing more successful plant varieties adapted to the agricultural environment, as well as more environmentally friendly chemical and biological pesticide technologies.

Furthermore, there are agricultural techniques that are more compatible with environmental protection requirements, in addition to automated irrigation

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[1] UN: https://www.un.org. Retrieved from https://www.un.org: https://www.un.org/ar/desa/world-population-prospects-2019

[2] Liuyan and others, F. (2026). Changsu Xu, Han Tang, Zhongcai Wei, Xiaodong Guan, Jingcheng Xu, Mingjin Yang, Yunwu Li, Application of navigation technology in agricultural machinery: A review and prospects. Artificial Intelligence in Agriculture Journal, 2026, p 99.

systems that reduce water consumption, and other modern agricultural techniques such as protected agriculture and organic farming. Agricultural information technology and artificial intelligence systems, including machine learning techniques and algorithms, sensor networks, data collection methods, and computer infrastructures, are also being utilized, particularly in tasks involving image analysis such as plant disease detection, crop monitoring, and yield estimation [1].

This development was accompanied by other policy trends that encouraged the adoption of more technological applications in the agricultural sector in general. This opened the door to smart technological applications that seek to achieve this developmental balance, including the development of plant varieties that use less of limited agricultural resources, and numerous biological control techniques for agricultural pests. These techniques leverage advanced technologies to improve agricultural production management. This agricultural approach has numerous applications for improving productivity, with a focus on integrating smart technologies for the sustainable control of pests and diseases[2].

This trend has been adopted by agricultural institutions belonging to private sector companies, in addition to public institutions, with the aim of achieving the greatest possible technological development in agricultural fields and related activities, especially agricultural marketing and processing. This agricultural approach has numerous applications for improving productivity, with a focus on integrating smart technologies for the sustainable control of pests and diseases. This trend has been adopted by agricultural enterprises belonging to private sector companies, as well as by public institutions, with the aim of achieving the greatest possible technological development in agricultural fields and related activities, particularly agricultural marketing and processing.[3]

C: Monitoring and measurement technology in the agricultural sector

[1] Sadrul and others, H: Artificial intelligence in agriculture across south Asia Technology adoption, improvements, and sustainability outcomes. Sustainable Futures Journal, V 9, 2026, p 131.

[2] Emogine and others, M. Application of precision agriculture technologies for crop protection and soil health, Smart Agricultural Techn. Smart Agricultural Technology Journal, V 5, 2025, p 39.

[3] Al-Hamza, A. H: The Role of Agricultural Economic Integration in Achieving Sustainable Agricultural Development in the Arab World. Sitif University, 2012, p 119.

Agriculture suffers from many agricultural diseases and pests that negatively affect and cause losses in large quantities of agricultural production, in addition to the negative effects they have on the quality of products, and the resulting decline in agricultural yield. Also, many of the pesticides used and the methods of their use leave significant negative effects on the surrounding environment and on humans and animals. Therefore, monitoring and measurement technologies in the agricultural sector are crucial for protecting plant resources from the risk of pests and diseases and their spread. This is achieved by focusing on preventing the transmission of introduced diseases between agricultural areas through monitoring and ensuring the safety of seeds and plants, confirming they are free from any infections, problems, insects, or damage. It also involves adopting an integrated pest management strategy, prioritizing scientific and technological research on agricultural pests and diseases that threaten major crops such as wheat and cereals, and guiding farmers on how to protect crops from insects and pests and safeguard livestock from common diseases.

In addition to providing farmers with technical information regarding necessary methods and their application, including timing and intensity, the government also provides the necessary technical equipment for pest control through support programs and interventions in the prevention and treatment of major and serious pests affecting key crops. Furthermore, scientific research and comprehensive surveys of agricultural pests and diseases are conducted, particularly in key geographic areas, monitoring their spread and identifying biological, chemical, and mechanical control methods. Continuous monitoring is also implemented to detect diseases and pests in their early stages, thus facilitating their control. Furthermore, programs are implemented to provide chemical and biological pesticides, train farmers in the use of modern pest and insect control technologies, and support programs for crop protection supplies.[1]

The latest development in agricultural prevention and treatment technology is the widespread use of applications for examining plants through their leaves or branches using a digital camera. These programs and applications work through an extensive database to identify the problem, whether it is a lack of minerals, drought, or pests, and then provide solutions directly. The effectiveness of agricultural technology has increased through the digital revolution with the

[1] Aref and Jirjis, A. a: Biological Control of Agricultural Pests, Arab Authority for Agricultural Development and Investment, Sudan Agricultural Investment Journal, 2003, p 36.

advent of the internet, which has developed communication methods and opened wide channels for all societies, individuals, and organizations. Its use has also increased in the field of agricultural scientific research and has been widely adopted in many countries around the world to enhance agricultural improvement.

It is the means by which users can receive and exchange up-to-date information and the results of global and national agricultural research, thus delivering scientific methods more efficiently and effectively, at lower costs, and making them available anytime, anywhere. This allows for the application of agricultural technological practices from anywhere in the world to improve production levels and ensure sustainability. Smart technology, also known as digital technology, is used in many forms, such as irrigation, spraying, fertilization, and even remote crop monitoring. It also enables the testing of soil and mineral content, water, and plants, either in laboratories or on farms using remotely piloted aircraft.[1]

D: Potential challenges to adopting technology in agriculture

Among the most significant potential challenges to adopting technology in agriculture are the following:

- Climate change that negatively impacts crops, such as frost in some regions during winter, or excessively high temperatures, particularly due to global warming, necessitating the use of greenhouses and increased water consumption.
- High taxes on local production, equivalent to import taxes, leading to a policy of importing to reduce effort and resources.
- The high cost of importing technology, coupled with a lack of conviction regarding the need for technology and a preference for traditional methods due to fears of not understanding it.
- The absence of strategic plans for advancing agricultural technology in many countries, especially in the developing world.
- The lack of a legislative framework and the absence of national institutions, or their lack of visibility.

[1] Ismail, A. Y. (2022). The Impact of Technology on the Development of the Agricultural Sector in the Gaza Strip, Institute of Sustainable Development. Gaza : Faculty of Graduate Studies, Al-Quds University, 2022, p 41.

- The agricultural workforce's inability to absorb technological advancements.
- Insufficient funding, difficulties in obtaining agricultural financing, and high costs of agricultural investments.

E: The impact of technology on increasing productivity and product quality

The use of digital technology in crop management reduces resource consumption, increases productivity, and minimizes the use of pesticides, fertilizers, and irrigation. Digital technology has contributed to the development of indoor agriculture, not just greenhouses, and many varieties have been cultivated thanks to smart digital technology. this technology has helped organize irrigation, fertilization, and pesticide application processes, as well as plant care from inception to harvest. It has also reduced crop risks, thus increasing productivity.

Agricultural technology also helps determine soil moisture, nitrogen, and salinity levels. This information is used to determine the appropriate irrigation and fertilization times, the type of crop suitable for the soil type, and the types of plants and crops that should be grown.[1]Agricultural technology also provides many digital sites and applications specializing in weather and its fluctuations. These sites and applications provide information about the weather around the clock, such as temperature, rainfall, possible frost and floods, so that appropriate measures can be taken to mitigate damage and avoid losses.

The second axis: Employing technology and innovation in the agricultural sector to ensure food security. Agriculture has been a human activity since the dawn of humanity. After humans identified the essential food sources and distinguished them from all other types found around them, they discovered how to utilize and produce them, starting with harvesting and then cultivating the land for their growth and reproduction. It was essential for humans to strive to obtain food, whether from plants or animals. Innovation in developing the agricultural sector to achieve food security is considered an effective integration of methods that achieve optimal results. Furthermore, innovation involves discovering or

[1] Ismail, A. Y. Op.cit. p 30.

utilizing technological means in agriculture, even if these means are primarily intended for other purposes.

Section two: Employing technology and innovation in the agricultural sector to ensure food security

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A: The Importance of Innovation in Improving Agriculture and Ensuring Food Supply

Modern technology has become a means to improve and diversify agricultural production[1], in addition to agricultural chemistry and its contributions through the application of chemical fertilizers, chemical pesticides for agricultural pests and diseases, chemical fungicides, and the treatment of soil chemical composition, among others. However, the true revolution in agriculture remains soilless farming, hybridization, genetic engineering, and the crops produced by these new practices that possess characteristics superior to native plants, such as larger, more disease-resistant produce, genetically modified seeds that grow faster, and plants resistant to chemical pesticides.[2]

As a result of the climate changes that the planet Earth is going through, due to the impact of various pollutants, wastes and industrial gases, new farming systems are being developed, known as climate-smart farming systems. These rely on hybridizing and cultivating plant and animal varieties capable of adapting to all climatic conditions, from high temperatures or drought waves to high rates

[1] Lherbier, J : Valorisation de l'information géographique en agriculture de précision. France : département de géographie Université Joseph Fourier- Grenoble 1.2005, p 20.
[2] Muhammad, A.-S. A: Food Security for the Arab World. Kuwait: National Council for Culture, Arts and Letters, 1998, p 170.

of toxic emissions, although they require a lot of investment to finance research and development activities in them.[1]

B: Scientific Research and Development in the Agricultural Sector

Research and development in agriculture continues, encompassing a significant advancement in modern agricultural science and biotechnology. This has created favorable conditions for a new agricultural era based on science and technology, primarily dedicated to improving productivity. The biotechnological revolution has encompassed all plant and animal species, with its effects extending to all countries worldwide.

Research and development in agriculture has been based on three fundamental pillars[2]:

- Scientific research and its personnel, comprised of scientists and specialists, who work on the continuous innovation of biotechnology, agricultural technologies, and agricultural production systems.
- Advanced industry that provides agricultural production tools and equipment, and means for manufacturing, transporting, and storing agricultural and food products of suitable quality and at lower costs.
- The public and private sectors working together to improve the overall agricultural development process, organize and fund the agricultural scientific research sector, and create an agricultural economic climate that stimulates research and development in the agricultural field.

C: Financing and Supporting Innovation in the Agricultural Sector

The success and effectiveness of agricultural innovation and sustainable food security depend not only on the practices of the private sector, but also on planning, monitoring, support, and a forward-looking vision from the state, particularly the Ministry of Agriculture, in collaboration with various formal and

[1] FAO. (2010). Climate-Smart Agriculture, report on agriculture, food security and climate change. Rome, Italy, 2010, p 24.
[2] Muhammad, Op cite, p 107.

informal stakeholders, and in coordination with the Food and Agriculture Organization of the United Nations (FAO) and other international agencies[1]

Furthermore, national capacity for conducting scientific research in agriculture must be strengthened, focusing on addressing environmental challenges and promoting agricultural development and innovation, especially given the country's diverse and vast geographical area. Establishing an agricultural information bank as part of a sustainable agricultural information system, and linking it to various international information networks and databases, along with creating platforms for financing agricultural projects, is crucial. Agricultural support should encompass financing and various services, including agricultural insurance, plant protection, weather and climate forecasting, animal health, and other agricultural assistance, while also promoting technological investment in agricultural production[2].

The need arises to establish specialized institutions to reduce the risks of natural and human environmental disasters by monitoring, predicting, and collecting information about them to provide early warning services, in addition to modern means such as satellite sensing. It is also possible to track crops, the development of their production and forecasts, along with counting livestock and their movements.[3]

D: Developing Innovative Agricultural Products and Processes

Urban expansion, coupled with efforts to optimize land use, has led to the development of vertical farming. This involves utilizing discarded structures such as old buildings or abandoned shipping containers. Vertical farming leverages the vertical space to produce crops in a controlled environment. It is essentially mechanized indoor farming, relying on hydroponic systems or pipes with artificially controlled climates and LED lighting. Production can continue year-round, regardless of external weather conditions. However, the setup is costly and requires significant electricity. Although this relatively advanced technology is

[1] Belmadi, S. (2019). The responsibility for ensuring environmental security rests with individuals, states, and international organizations. Algerian Journal of Security and Development, 2019, p 206-215.
[2] Adhikari and others, Collaboration and coordination strategies for a multi-level ai-enabled healthcare supply chain under disaster, International Journal of Production Research, 2025, 504.
[3] Al-Hamza, A. H: Op cite, p 128.

currently only suitable for areas where access to specialized equipment and operating financing is easy.[1]

E: Partnerships and Cooperation to Promote Innovation in Agriculture

Expanding the scope of innovation in agriculture requires coordination among countries to strengthen and enhance research centers equipped with modern technologies and resources. It also necessitates coordinating dialogue among researchers, strengthening communication networks between research centers, and establishing shared servers for data dissemination, distribution, and exchange.

Partnerships and cooperation among a select group of countries play a crucial role in transferring agricultural technologies and fostering innovation in agriculture. Cooperation is a primary driver of research and development in the developed world and operates through key mechanisms, including:

- Trade relations, such as the direct import of technologies, which requires market liberalization and tax reductions.
- Relationships between private sector companies or multinational corporations.
- The migration of skilled human resources from companies and the relocation of research and development projects from developed countries to host countries where company branches are located. Technological capabilities are essential not only for attracting research and development activities but also for leveraging the benefits of foreign partnerships and cooperation with companies.

Conclusion:

Adopting and expanding technology and innovation in agricultural development requires a strategic vision within the framework of a suitable agricultural policy linked to a national policy. This will enable the achievement of the goals set for agricultural development, taking into account the available environment and resources.

[1] Pochtrager and others, S. N. (2026). Addressing challenges in agriculture: Exploring smart farming technologies to support future farming practices. Smart Agricultural Technology Journal, v13, 2026, p 13.

Furthermore, certain resources are necessary to ensure food security[1]. Among the most important are suitable agricultural land, irrigation water, advanced technology, and diverse and healthy plant and animal varieties, all under advanced strategic management. Conducive conditions for the operation of agricultural production technologies must also be in place. These conditions include preparation and readiness to engage with modern technologies, continuous development and improvement, and enhancing the efficiency of human resources, particularly through the adoption of a comprehensive agricultural technology policy and strategy.

Agricultural technology helps reduce the exploitation of natural resources, thus preventing their depletion or destruction. It utilizes these resources rationally through development and innovation, while simultaneously seeking alternatives to widely used materials to ensure their longevity without generating excessive pollution. Modern technology strives to develop agriculture to enhance food security by creating user-friendly technologies, explaining their application, making them accessible to everyone, and reducing the costs of various agricultural technologies without causing environmental risks.

Among the findings are the following:

- Agricultural technology aims to reduce water consumption and improve water use efficiency in urban and rural agricultural and industrial development. It also works to ensure adequate protection of water resources, groundwater, freshwater resources, and their ecosystems.
- Agricultural technology aims to improve and increase agricultural and livestock productivity to achieve food security and strive for self-sufficiency and export.
- Scientific and technological research is working to develop new soilless farming methods that reduce the required agricultural land.
- Agricultural technology aims to develop other modern agricultural techniques such as protected agriculture, organic farming, agricultural information technology systems, artificial intelligence, and more.

[1] Belmadi, S. (2024). Environmental displacement: The problem of the phenomenon and the data. Al-Mi'yar journal, 2024, p 319.

- Genetic engineering technology plays a vital role in improving agricultural productivity through the use of improved genes that lead to increased yields.
- Agricultural technology enables the cultivation of various seasonal plant varieties, such as summer crops in winter and winter crops in summer.
- Agricultural technology helps reduce environmental risks and minimize resource use while increasing quality and productivity.

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