Governing Responsible Artificial Intelligence and Data
in the Middle East and North Africa (MENA)

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# AI & Food Security in Jordan



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# AI & FOOD SECURITY IN JORDAN

## *Case Study*

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## Acknowledgements

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# I. ABSTRACT

This study aims to explore the potential of responsible artificial intelligence (AI) governance and data in achieving food security in Jordan and shed light on local perspectives regarding challenges, opportunities, priorities and policy recommendations for responsible governance and the use of AI.

Interviews with academic researchers from Yarmouk University's department of Computer Science and AI were used in the research process, in addition to interviews with members of agricultural technology enterprises in Jordan and local farmers. A roundtable discussion was also held with state officials from the Jordanian Agriculture Ministry to look into the status of food security and agriculture in Jordan, and the Jordanian agricultural sector's readiness for opportunities related to the integration of AI.

The research findings guided the design of a set of policy conclusions and recommendations that could foster responsible governance of the use of AI technologies as well as the right to food.

While applications of digital technology and AI in the Jordanian agricultural sector are still limited, some steps can be taken to better prepare the sector for digitization and the introduction of AI applications. These include building the capabilities of farmers and agribusinesses to allow them to benefit from digital applications and Agriculture Ministry employees to allow them to offer digital services to investors and farmers.

# II. INTRODUCTION

Food security is a cross-cutting issue linked to numerous sectors, including agriculture, water, industry, trade and supply, health, social development and labor. The water, energy and food sectors are closely intertwined, with complicating effects on each other.[1] The agricultural sector is an essential pillar of food security, and this is especially the case in countries suffering from water shortage, such as Jordan.[2] While agricultural production is a major contributor to food security in Jordan, food security encompasses much more than farm production or food availability. It is a multi-stakeholder issue, requiring cooperation and coordination between various institutions including international, government, private sector and civil society to ensure sustainable and consistent access to sufficient amounts of food.[2]

The agriculture and food sectors are a key source of revenue and job opportunities in Jordan, as a significant portion of Jordanians live below the poverty line and many Syrian refugees rely on agriculture for a living. Twenty percent of the nation's exports of commodities come from agriculture, with fruit and vegetable exports reaching roughly only 50 percent of their potential. [3]

The Jordanian Agriculture Ministry, which includes the Food Security Directorate and the National Center for Agricultural Research, is currently working to take advantage of modern technology and digital systems. This includes offering a set of digital services to citizens, such as issuing digital registration certificates for agricultural organizations and offering digital renewals for the registration of vegetable varieties and licenses for agricultural nurseries.[4]

Looking at Jordan's AI Strategy and Implementation Plan 2023-2027,[5] there are several ambitious initiatives being implemented by the Agriculture Ministry in cooperation with the Digital Economy and Entrepreneurship Ministry. These goals include employing AI technology in forecasting to analyze historical water consumption patterns and expected population growth trends. This will help predict rainfall amounts in specific areas based on real meteorological data, thus promoting an equitable and more efficient distribution of water resources.[6] In Jordan's AI strategy, there is a focus on developing AI software to be fed data on weather conditions, humidity levels and images obtained from farmers and meteorological centers to predict a variety of threats, including pests that adversely affect crops. Alerts generated by such a system will be sent to an early warning system, alerting farmers to impending dangers, such as frost or pest outbreaks.[6]

This position paper aims to present local perspectives in Jordan on the opportunities, challenges and priorities in the adoption of AI in the sector through interviews with experts on food security, agriculture and AI. All of this comes under the banner of the responsible governance and use of AI to ensure food security. Current AI initiatives and practices in agriculture and

1    Jordanian Agriculture Ministry, National strategy for agricultural development 2020-2025. (2020). Retrieved from https://moa.gov.jo/AR/Pages/الاستراتيجية_الوطنية_للتنمية_الزراعية_20202025

2    Kingdom of Jordan, *The National Food Security Strategy 2021–2030.* (2021). Retrieved from https://jordan.un.org/sites/default/files/2022-10/Document%202%20-%20The%20National%20Food%20Security%20Strategy.pdf

3    The World Bank, *US$125 million to support Jordan's agriculture sector and improve its climate resilience.* (2022, October 11). Retrieved from https://www.albankaldawli.org/ar/news/press-release/2022/10/11/us-125-million-to-support-jordan-s-agriculture-sector-and-improve-its-climate-resilience

4    Jordan Times, *agriculture minister launches e-services for import, export.* (2022, June 26). Retrieved from https://www.jordantimes.com/news/local/agriculture-minister-launches-e-services-import-export

5    Ministry of Digital Economy and Entrepreneurship, *Jordan's artificial intelligence strategy and implementation plan 2023–2027.* Retrieved from https://www.modee.gov.jo/ebv4.0/root_storage/en/eb_list_page/40435648.pdf

food industry were studied based on the results of expert interview data. A set of policy recommendations and conclusions were suggested to move toward responsible governance of AI technologies and the right to food.

# III. FRAMING OF THE STUDY

## i. Comprehensive analysis of food security: Examining the four pillars

Food security is defined by the United Nations Food and Agriculture Organization (FAO)[6] as having four pillars: food availability, access, usage and stability. This paradigm enables countries to conduct uniform and thorough analyses of food security. This research uses the FAO's definition of food security as a theoretical framework, linking each pillar in the field to the application of AI.

1) Food availability: In its most basic form, food availability is how food is made to exist for consumption at local levels, where local people or families are able to locate necessary food items without exerting effort. Sufficient food must be available and its quantities secured, at all times, regardless of emergency situations or political unrest. Studying food availability involves monitoring food production levels, food inventories and the capacity to satisfy the population's nutritional demands, and is focused on the production and supply chains of various foods.

2) Access to food: This pillar focuses on a population's ability to obtain food, considering both the physical and financial component of accessing food items. Food distribution, pricing and people's income levels are all intertwined issues. Physical access, or proximity to food sources, and economic access, or the ability to buy and acquire food, are also considered.

3) Food consumption: This pillar focuses on the use of food, through adequate diet, clean water, sanitation and health care, to achieve nutritional wellbeing where all physiological needs are met. Studying food consumption highlights the importance of non-food inputs for food security.[7]

4) Stability (long-term food security, dietary stability): This pillar focuses on the food system's ability to sustain itself and endure shocks, such as natural catastrophes, economic crises or other disruptions.

## ii. Case study: Jordan's journey toward comprehensive food security

## 1. Food availability in Jordan:

Jordan faces several challenges in ensuring sufficient food supply considering the limited amount of arable land due to the country's lack of exploitation, inefficient harvesting and a scarcity of water resources. Sustainable agricultural initiatives such as water-saving and weather forecasting techniques are crucial to improving the supply and availability of food and decreasing waste. Jordan's food availability is influenced by weather conditions and climate change, as indicated by increasing water scarcity and desert regions. Natural resources, particularly water, have an important role in determining the capacity to meet food demand.[8] Moreover, climate change has serious impacts on food security, which negatively affects agricultural productivity in the country.[9] The agricultural sector already consumes a large part of the country's scarcely available water resources.[10]

It is important to note that in countries that suffer from chronic water shortages, like Jordan, the agriculture sector and its productivity, is considered crucial in ensuring food security at a national level. [11]

AI can be used to implement sustainable agricultural practices, including for resource conservation and environmental risk mitigation. A project was launched in Jordan by the International Union for Conservation of Nature to enhance the use of AI on farms in the country's eastern and northern deserts, with the aim of saving energy and water.[12] One of the private sector initiatives

6   Msuya, T. S. *The contribution of special program on food security*. (2013). Retrieved from http://www.suaire.sua.ac.tz/handle/123456789/427

7   Food and Agriculture Organization (FAO), *Food Security Concept Note*. (2006). Retrieved from https://www.fao.org/fileadmin/templates/faoitaly/documents/pdf/pdf_Food_Security_Cocept_Note.pdf

8   Al-Addous, M., Bdour, M., Alnaief, M., Rabaiah, S., & Schweimanns, N., *Water resources in Jordan: A review of current challenges and future opportunities.* (2023). *Water, 15*(21), 3729. https://doi.org/10.3390/W15213729

9   Al-Bakri, J. T., Al-Bakri, H. M., Alsharif, M. A., & Shaaban, M. M., *Impact of climate and land use changes on water and food security in Jordan: Implications for transcending 'The tragedy of the commons'.* (2013). *Sustainability, 5*(2), 724–748. https://doi.org/10.3390/SU5020724

10   UNICEF Jordan, *The costs of the water crisis in Jordan*. Retrieved from https://www.unicef.org/jordan/costs-water-crisis-jordan

11   Rother, B., Ozturk, S., Wang, T., & Zheng, Y., *Fall 2023 global food crisis update: Recent developments, outlook, and IMF engagement*. Retrieved from https://www.imf.org/-/media/Files/Publications/IMF-Notes/2023/English/INSEA2023002-S001.ashx

12   Al Jazeera, *A project to use artificial intelligence techniques in desert farms in Jordan*. (2021). Retrieved from https://www.aljazeera.net/videos/2021/10/10/%D9%85%D8%B4%D8%B1%D9%88%D8%B9-%D9%84%D8%A7%D8%B3%D8%AA%D8%AE%D8%AF%D8%A7%D9%85-%D8%AA%D9%82%D9%86%D9%8A%D8%A7%D8%AA-%D8%A7%D9%84%D8%B0%D9%83%D8%A7%D8%A1

in Jordan is the Smart Green Initiative, which is transforming the agricultural sector from traditional to digital using new technologies.[13]

### 2. Access to food in Jordan:

Financially enabling all people to increase access to food is a key priority in Jordan. Poverty and unemployment constitute the most important challenges facing access to food, requiring proactive measures to address food insecurity for vulnerable groups.

Spending on food consumption at the household level in Jordan came in at 39.6 percent in 2010, decreased to 32.7 percent in 2017, and then decreased further to around 26.52 percent during the first nine months of 2020.

Some local agricultural companies in Jordan have begun using new technologies and innovations in smart agriculture and big data analysis to improve productivity, reduce costs and improve crop quality. Despite these efforts, the agricultural sector still faces challenges, including limited financial resources, low investment, weak marketing activities, low productivity in rain-fed agriculture and depletion of resources.[14,15]

### 3. Food use in Jordan:

Food patterns also help people connect with their cultural or ethnic groupings. Food is a way that people maintain their cultural identity. Food preferences and aversions are largely influenced by where families live and originate. For instance, in Jordan, Mansaf is considered the national dish, and is present at weddings, funerals and almost any occasion. Although it is also eaten in the Badia al-Sham region located between Iraq, Jordan, southern Syria and northern Saudi Arabia, Jordanians are the most famous for it. These dietary preferences result in specific food choice patterns within each cultural or geographical group.[16] Environmental sustainability practices are essential for long-term food utilization and nutritional well-being in Jordan.

### 4. Stable food security in Jordan:

The food security system in Jordan needs to demonstrate stability to be able to withstand various shocks and disturbances. This can be achieved through cooperation between various ministries and research centers, as well as harnessing technology to improve food security, for example the use of modern irrigation techniques and artificial intelligence in distributing arable land and creating disease-resistant crops.. Natural disasters, economic crises and other challenges, such as COVID-19, affect food security in Jordan. Although the country struggled in facing these challenges, it was able to overcome them[17] by seizing moments of opportunity. For example, during the pandemic,[18] some countries requested Jordan's assistance in agricultural production, since the country enjoys a comparatively suitable climate, lower prices and higher production quality.

## IV. BACKGROUND

### i. The current status of AI, data policies and existing governance frameworks as relevant to the Agri-Food sector in Jordan

Jordan ranked 63 in a global report measuring the readiness of governments to adopt AI technologies[19] in 2022, 17 places ahead in the general index compared to its previous ranking at 80 in 2021. Jordan advanced in the global report[20] known as Insights Oxford, recently issued by the British (Insights Oxford) Foundation,[25] which measures governments' readiness to adopt AI technologies based on the government's efforts and successive steps during the last two years to enhance the use of AI in the government and private sector.

Technical experts in the field of digital transformation confirmed that the most prominent steps that enhanced Jordan's progress in the global report were the government's approval in 2020 of a state policy for AI, the formulation of a strategy for the use of AI, the preparation of the National Charter for AI Ethics and the implementation of a project to measure the readiness of state institutions to adopt AI. Methods for promoting progress in this agricultural sector are

13    Spark, *Meet Jordan's agri-tech entrepreneurs reducing farmers' water consumption*. (2023). Retrieved from https://spark.ngo/story/were-making-jordan-greener-healthier-and-more-sustainable/

14    Al-Hiary, M., Al-Zu'bi, B., & Jabarin, A., *Assessing Porter's framework for national advantage: The case of the Jordanian agricultural sector. (2010).* Retrieved from https://www.researchgate.net/publication/261456224_Assessing_Porter's_Framework_for_National_Advantage_The_Case_of_Jordanian_Agricultural_sector

15    Soliman, I., & Mashhour, A., *National agro-food policies in Jordan*. (2012). Retrieved from https://www.researchgate.net/publication/321866400_National_agro-food_policies_in_Jordan

16    Wathi, *Food: Identity of culture and religion.* (2018). Retrieved from https://www.wathi.org/food-identity-of-culture-and-religion-researchgate/

17    Interview with Mervat Yahya Ali Al-Shamayleh. *Assistant Director of the Directorate of Rural Development and Women's Empowerment* and Head of the Agricultural Economics and Extension Division at the Syndicate of Agricultural Engineers.

18    "With the Corona virus crisis, the Jordanian government cannot manage the situation well and the remaining impacts resulting from the availability of resources," Available here.

19    "UNIDO, *Jordan improves its position in Government AI Readiness Index 2022*. Retrieved from https://www.unido.org/news/jordan-improves-its-position-government-ai-readiness-index-2022

20    Oxford Insights. (2019). *Government AI Readiness Index 2019*. Retrieved from https://www.oxfordinsights.com/ai-readiness2019

being created as well, and the National AI Code of Ethics regulating AI has been formed. [21,22]

## ii. The strength of Jordanian society in using AI:

- Jordan relies on human capital to achieve economic growth.

- The availability of existing legislation and regulations in the areas of digital transformation and emerging technologies creates a regulatory environment that can absorb and accommodate AI application as well as manage its risks. Existing legislations, including for data and risk management, are being studied by the Digital Economy and Entrepreneurship Ministry in cooperation with relevant authorities, such as the Agriculture Ministry.

- The presence of several investment programs and initiatives targeting AI application. For example, , the FAO and the National Center for Agricultural Research (NARC) in Jordan signed a capacity-building that saw trainers provided with the resources to hold workshops with farmers in six villages to teach them how to use the mobile application With Farms (Ma al-Muzare) that focuses on best agricultural practices. This agreement comes with the support of the Digital Innovation for Rural Transformation in the Near East and North Africa initiative and prioritizes digital village companies. The main objective of this agreement, which is funded by the FAO's regional office, is to support the digitalization and rural transformation n of agricultural services in Jordan by providing technical training to employees of the NARC, to train farmers and agricultural faculty students on the With Farms app. Participants will learn how to use various extension services, including the Expert to Farmer forum, where they can post a question, upload a photo, and communicate with other farmers and experts. Through the platform, farmers will also have access to local weather forecasts, crop calendars, sowing dates and harvest

dates. In addition, farms will be provided with advice on good agricultural practices in irrigation and fertilization to improve product quality and increase productivity. The hope is that this will lead to more productive farms while preserving natural resources.[23]

- The framework also makes way for a number of other initiatives, including agreements with Jordanian start-up companies, such as the start-up World of Plants, and the National Agricultural Research Center and to develop an application aimed at the early detection of plant diseases using AI techniques.[24]

- Data plays a crucial role in driving economic development, enhancing performance, and supporting decision-making through AI-driven analysis and predictions.

- Government AI, and supporting decision-making processes based on analyzes and predictions generated by AI systems. In Jordan, a plenty of open government data related to the agri-food sector is available through the Department of Statistics.[25] Additionally, several policies ensure the protection and proper management of this data, including the Personal Data Protection Law, the Open Government Data Policy, and the Government Data Classification and Management Policy.[26]

## iii. Weaknesses of Jordanian society in using AI:

- Weak societal awareness of the importance of AI in the agricultural field and other important sectors.

- The absence of a central governmental body concerned with supervising and organizing research and development

21    DataGuidance, The government approves the Jordanian artificial intelligence strategy and implementation plan (2023-2027). Retrieved from https://www.dataguidance.com/news/jordan-ministry-announces-draft-ai-strategy-and

22    Ministry of Digital Economy and Entrepreneurship, The national artificial intelligence code of ethics. (2022). Retrieved from https://www.modee.gov.jo/ebv4.0/root_storage/ar/eb_list_page/%D8%A7%D9%84%D9%86%D8%B3%D8%AE%D8%A9_%D8%A7%D9%84%D9%86%D9%87%D8%A7%D8%A6%D9%8A%D8%A9_-_%D9%85%D9%8A%D8%AB%D8%A7%D9%82_%D8%A7%D9%84%D8%A7%D8%AE%D9%84%D8%A7%D9%82%D9%8A%D8%A7%D8%AA_-_%D8%A7%D9%84%D9%85%D9%82%D8%B1%D8%A9_%D9%85%D9%86_%D8%A7%D9%84%D8%B9%D8%B1%D8%A8%D9%8A%D8%A9_%D9%88%D8%A7%D9%84%D8%A7%D9%86%D8%AC%D9%84%D9%8A%D8%B2%D9%8A%D8%A9.pdf

23    United Nations in Jordan, FAO, NARC to support digitisation process of agricultural services in Jordan. (2023, December 12). Retrieved from https://jordan.un.org/en/141750-fao-narc-support-digitisation-process-agricultural-services-jordan

24    National Agricultural Research Center (NARC), Agriculture incubator project 33. Retrieved from https://www.narc.gov.jo/agriincubuator/project33.html

25    Department of Statistics Jordan, Crops statistics. Retrieved from https://dosweb.dos.gov.jo/agriculture/crops-statistics/

"Crops Statistics | Department of Statistics Jordan.". Available: https://dosweb.dos.gov.jo/agriculture/crops-statistics/

26    Digital Economy and Entrepreneurship Ministry. Data classification & management policy. (2019). Retrieved from https://www.modee.gov.jo/EBV4.0/Root_Storage/EN/EB_List_Page/Data_management_and_classification_policy.pdf

"DATA CLASSIFICATION & MANAGEMENT POLICY", . Available: https://www.modee.gov.jo/EBV4.0/Root_Storage/EN/EB_List_Page/Data_management_and_classification_policy.pdf

projects and initiatives in the field of AI, as universities work on scientific research in the fields of agriculture, water and energy and are not linked to the Agriculture Ministry. There is also a lack of awareness of the importance of including AI projects in the annual plans of government institutions, and few partnerships between researchers and different sectors to activate important applied research.

- Slow procedures for granting licenses, registration and issuing to emerging companies.

- The data stored in government databases is not ready in the required form, but in the Department of Statistics Jordan, which specializes in collecting information in several fields such as agriculture, technology, population figures and other data that is open source and accessible.[27]

## V. METHODOLOGY AND APPROACH:

An expert panel of academics, agricultural researchers, government employees, entrepreneurs in the field of agricultural technology and AI and farmers participated in several interviews and roundtable discussions. Face-to-face and online interviews were conducted, but they were not recorded.

The interview included questions concerning AI and agriculture in Jordan, existing AI applications and opportunities and challenges associated with the adoption of AI solutions by the government.

As part of the methodology, interviews were conducted based on the core concepts of the FAO framework: food availability, economic and physical access to food, food use and stability (vulnerability and shocks) over time.

Table 1, below, outlines the number of interviews conducted, the people interviewed and the type of questions focused on.
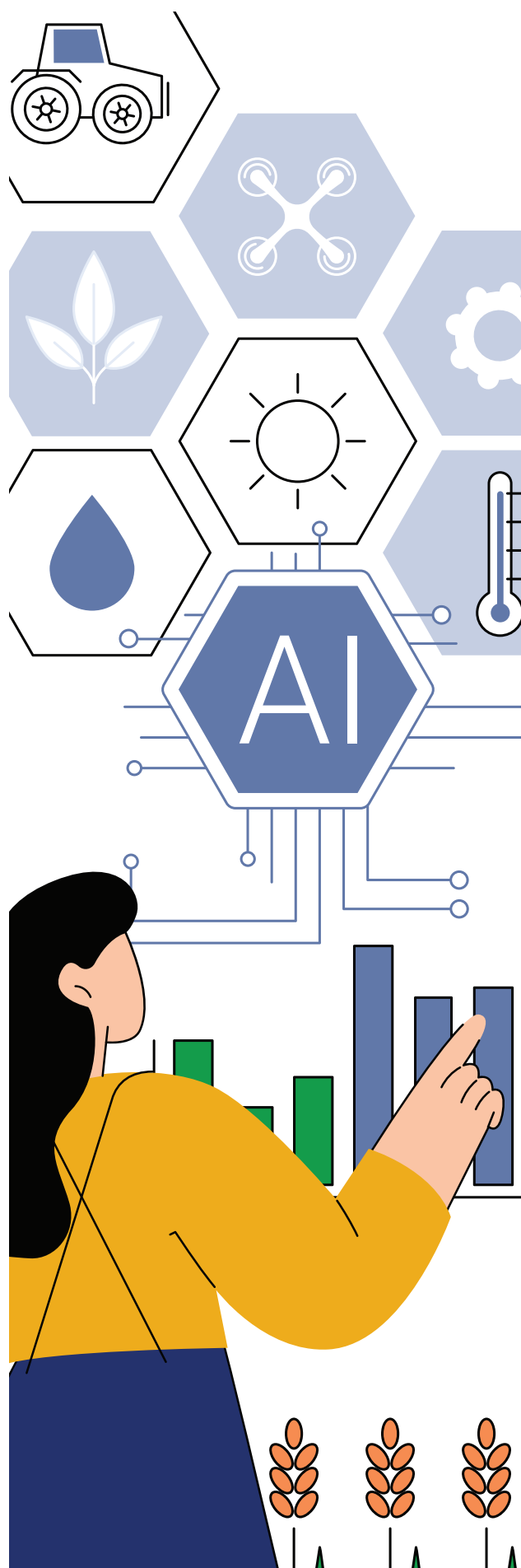
27   Department of Statistics Jordan, *Environment statistics*. Retrieved from https://dosweb.dos.gov.jo/environment/environment-surveys/

**Table 1:** Interview Information**.**

| DEPARTMENT / NATURE OF QUESTIONS | INTERVIEWEE | NATURE OF THE INTERVIEW AND DURATION |
|---|---|---|
| • Yarmouk University / Department of Computer Sciences.<br><br>**Main Point:** The potential of AI to address agricultural challenges, the main gaps in the agri-food sector, and the potential role that AI technologies can play in this regard. | 1. Dr. Qasem al-Radaideh, professor of data science and AI and dean of the Information Technology and Computer Sciences Faculty. | One-hour face-to-face interview. |
| | 2. Dr. Ameera S. Jaradat, associate professor. | One-hour, face-to-face interview. |
| | 3. Dr. Nahlah Shatnawi, assistant professor. | Two-hour, face-to-face interview. |
| • Directorate of Rural Development and Women's Empowerment<br>• Jordanian Agriculture Ministry<br><br>**Main Point:** The Jordanian Agriculture Ministry's view on integrating AI into the agricultural sector, the initiatives that have been implemented, the main gaps in the agri-food sector in Jordan and the potential role that AI technologies can play in this regard. | 4. Osama Mohd Adnan Izzo Kattan | Two-hour roundtable in Jordan. |
| | 5. Mervat Yahya Ali al-Shamayleh | |
| • NARC<br>• Jordanian Agriculture Ministry<br><br>**Main Point:** Thoughts on the strategies and policies developed by the NARC to support the adoption of AI in agriculture. | 6. Dr. Muhammad al-Bashabsheh, an expert in the field of plant protection | One-hour, face-to-face interview. |
| | 7. Amgad Saleh Hjazin, agricultural researcher. | Half-hour online interview. |

| | | |
|---|---|---|
| • Agricultural technology companies<br><br>**Main Point:** The current status of the use of AI in the field of work in Jordan, including the role of start-ups in promoting AI technologies in agriculture, the main projects or initiatives, challenges and opportunities for both startups and research institutions in the field of AI and agriculture in Jordan. | 8. Belal al-Qaisi, COO and founder of Mahsoul. | One-hour face-to-face interview. |
| | 9. Omar Marwan Bawab, CEO and cofounder of iPlant. | One-hour online interview. |
| | 10. Ashraf Amayreh, technical manager at O-Minds. | One-hour face-to-face interview. |
| | 11. Saqer Bassam Ali Maryha, agriculture engineer and founder of Phytobase | One-hour face-to-face interview. |
| • Working in Jordan's agricultural sector as a farm owner, farmer, or agricultural engineer<br><br>**Main Point:** The impact of AI technology on agricultural practices, the benefits or challenges, specific applications or tools of AI that are particularly useful in daily agricultural activities, and expectations and concerns regarding the responsible use of AI in agriculture, especially about data privacy and security. | 12. Muhammad al-Shannaq, Jordanian farmer | One-hour face-to-face interview. |
| | 13. Ibrahim al-Rifai, agricultural executive engineer | One-hour online interview. |
| | 14. Mohamed Kalad Mohamed Aloun, agricultural engineer | One-hour face-to-face interview. |
| | 15. Osama Muhammad al-Zyoud, chairman of the Agriculture, Water and Environment Committee in the Zarqa Governorate Council from the Ministry of Local Administration. | One-hour online interview . |
| | 16. Mohammed Saleh Khataibh, agricultural engineer. | Half-hour online interview. |

# VI. INTERVIEW FINDINGS

## i. Academic researchers

AI has potential to reduce costs in the agricultural process, contrary to the misconception that it increases expenses. The adoption of AI supports the emergence of innovations that serve humanity today and in the future.

In Jordan, the use of AI, especially in agriculture and food security is at its lowest levels. The main gaps in the agri-food sector are the low adoption rate of AI, especially in agriculture, and the lack of effective planning in food resource management, hindering food security.

The lack of proper planning is evident culturally among farmers in Jordan, and requires workshops to enhance awareness and education regarding the benefits of AI applications in several fields.[8]

The technology and sensors present in the Jordanian market are impractical (commercial) and give inaccurate results when used, for example with regards to sensors to measure humidity and soil temperature. There is no infrastructure for heavy machinery, agricultural land remains underutilized and the availability of data on new technologies is limited. Collecting agricultural data is an ongoing challenge. The technology and sensors present in the Jordanian market are impractical (commercial) and inaccurate (they give inaccurate results when used, such as sensors to measure humidity and soil temperature).

Various AI technologies can provide innovative and promising solutions in efforts to preserve and sustain the environment.[28] AI and advanced technologies have the potential to address agricultural challenges in multiple sectors,[8] a lack of proper planning in the field of agriculture and management of food resources,[8] weak regulations and legislation for investment, weak harmony between policies and strategies, and between relevant agricultural and sector institutions, are all factors that affect the country's readiness to adopt newer, more innovative technologies

Technical challenges include the development of advanced smart systems, providing sufficient and accurate data and also collecting it. For example, there is a set of data available in the Jor-

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28   Interview with Qasem Al-Radaideh, professor of Data Science and AI at Yarmouk University

danian Department of Statistics[30] that includes a group of sectors, but according to the Jordanian AI strategy, data problems are related to the lack of reliable and comprehensive data stored on databases. Government data is not as required and there is no evidence of historical data available with many governmental and private agencies. On the other hand, economic and political challenges include the cost of implementation and its impact on the labor market and local and international legislation.

To successfully deploy AI to address agricultural difficulties in Jordan, factors such as access to technology, infrastructure, data availability and farmer training must be considered. Some examples of potential AI uses in agriculture include crop monitoring, yield forecasting, pest and disease management, and water resource management.[29]

There are various research gaps and challenges in Jordan's agri-food business which demand a comprehensive approach involving investments in water management, land rehabilitation, climate-resilient agriculture, technology adoption, capacity building and market development. The gaps that must be addressed are related to water scarcity, arable land, climate change and inadequate skills.[34]

Data governance in AI is important. The National Charter of Ethics for AI was issued, outlining a set of basic ethical principles necessary in the field, including accountability, transparency, impartiality, privacy, promotion of human values and other principles that promote the rule of law. The charter also considers t most important ethical issues for using AI, including in relation to innovation and the protection of intellectual property rights. An example of such requirements is standards surrounding the protection of farmers' information once it is uploaded to applications used in the agricultural field.

Among the recommendations is to benefit from the experiences of countries that have adopted AI technology in agriculture, such as the Netherlands, regarding technologies such as fruit ripeness sensors, soil suitability assessment, applications for predicting the maturity of crops and drones and satellites that have been used to detect agricultural pests remotely. Additionally, examples include the use of Internet of Things (IoT) technology in animal farms, especially to monitor water-related issues, such as water quality or if it is contaminated.

Among the recommendations to ensure food security in Jordan and avoid failure is the call to educate and inform farmers about the benefits of AI and modern technology to enhance the efficiency of agricultural productivity, such as early detection of agricultural pests using computer vision. Strengthening strategic planning by the Jordanian Agriculture Ministry is crucial to enhancing productivity and preventing the occurrence of problems seen in traditional agricultural practices, which are often caused by farmers making uninformed decisions, for example planting certain crops in unsuitable areas and at inappropriate times. Strengthening this area would allow AI to be used to create a smart decision support system that provides recommendations to farmers about the best crops that can be grown according to the geographical region in Jordan.

### The current situation in Jordan regarding food security and AI:

- At present, AI is not being used in the field of agriculture and planning, or in the management of resources in Jordan, which contributes to achieving food security. In the future, it is expected that it will be used to achieve resource-sufficiency and improve the level of food security through the implementation of its strategies [6] and a national food security strategy. Academic researchers confirm that the use of AI, especially in agriculture and food security, is currently at its lowest level[8] in Jordan. It must be integrated into the food and manufacturing sector to monitor food processing, identify errors and correct them.

- The situation calls for thoughtful planning, strategic implementation and benefiting from the experiences and success stories of developed countries that have enhanced their production and economy through AI.

- Technology adoption is primarily local and limited, and its application is still in its infancy. As an example, the Jordanian Agriculture Ministry's digital website offers digital transactions such as license renewal and agriculture license creation, aimed at facilitating agricultural services for Jordanian businesses, but AI is not used to facilitate or enhance these or other processes.

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29    Interview with Dr. Ameera Jaradat, assistant professor in the Department of Computer Science, College of Information Technology and Computer Science, Yarmouk University.

### *Technological infrastructure challenges:*

- In terms of technology infrastructure, Jordan faces challenges.[6] Technology and sensors currently on the market are impractical (commercial) and inaccurate (when using IoT sensors to measure humidity and temperature of soil, the results were inaccurate).
- There is no infrastructure for heavy machinery, and agricultural land remains underutilized.
- The availability of data knowledge of new technologies is limited6 because they are relatively new in Jordan.
- The collection of agricultural data is an ongoing challenge.

### *ii.  Startups in Jordan (private sector)*

The founder of the "Mahsoul" application[30] in Jordan contributes and supports farmers in marketing their products locally by displaying their products through the application. Currently, AI is not used in the application. Jordan has always been a pioneer in the adoption of modern technology to develop its sectors, and the most important sector that currently needs development is the agricultural sector. Therefore, the founder of the application believes that the introduction of these technologies will have a positive impact on the sector as well as a positive economic impact on Jordanian farmers.

Startup iPlant[31] seeks to innovate in vertical farming through AI. iPlant is in the early stages of implementing AI technologies, as they have vertical farming units and monitoring and control systems to analyze existing collected data to improve productivity and reduce resource consumption.

The PalmProtect[32] device was created for early detection of palm weevils. It relies on AI to analyze sounds. It is a device used to identify the most prominent problems affecting palm trees by analyzing the sounds of the caterpillar gnawing inside the leg to determine whether there is an infestation or not within a period not exceeding two minutes.

Phytobase[33] is a startup company that relies on information technology, AI and a device for smart agriculture to measure vital factors around the plant to analyze data, such as mea-

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30    Interview with Belal Alqaisi, COO & founder at Mahsoul

31    Interview with Omar Marwan Bawab, CEO and co-founder of iPlant

32    Interview with Ashraf Amayreh, technical manager at O-Minds

33    Interview with Saqer Bassam Ali Maryha, agriculture engineer and founder of Phytobase
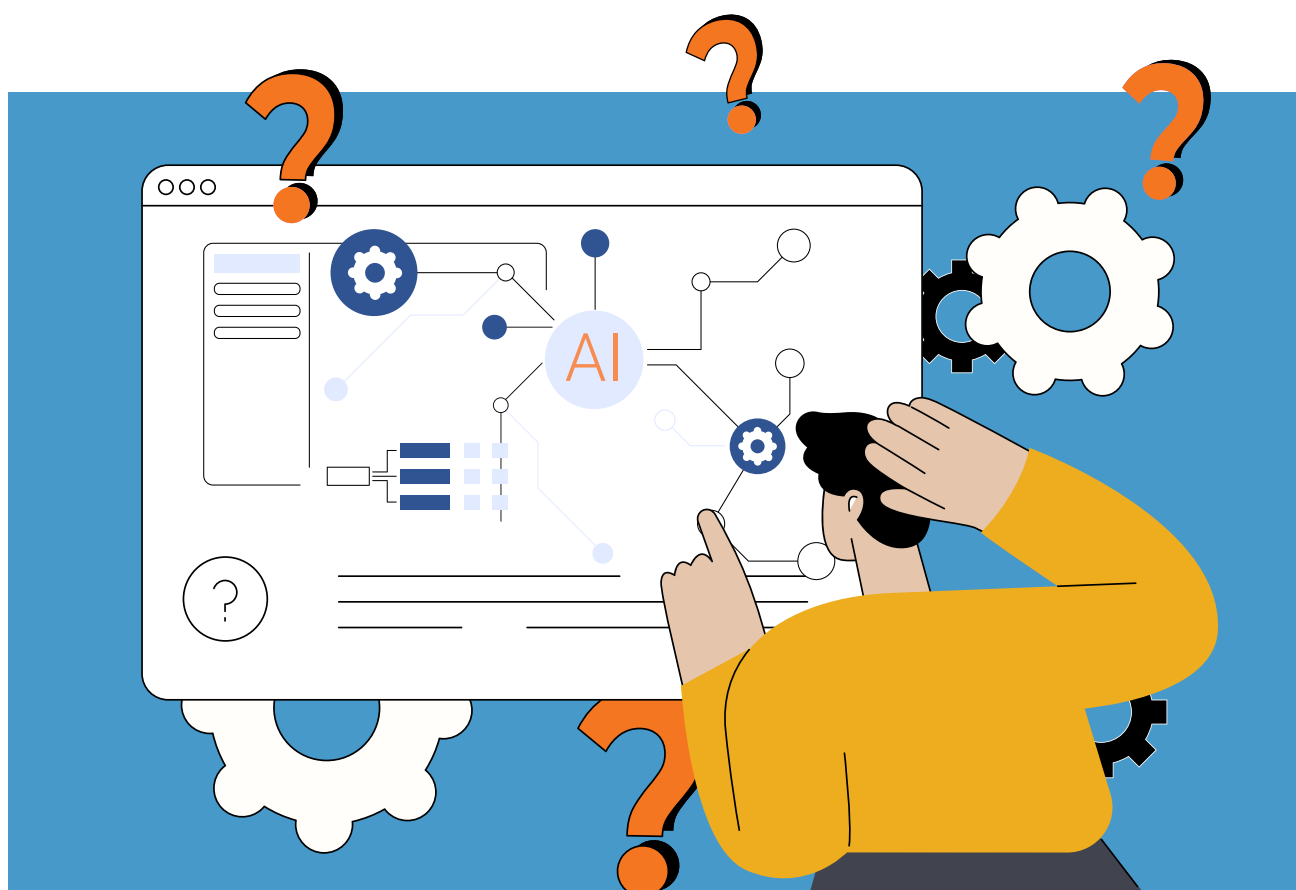
suring the percentage of salts and acidity and measuring the level of water level rise in hydroponics, and converting it into digital data used to measure and therefore predict the actual water and nutrient needs of plants. Several training initiatives have been conducted for farmers to use these technologies in the agricultural sector, specifically by introducing modern technology to reduce operational costs.

Another application that aims to help farmers is Jordanian startup World of Plants,[34] which uses AI for the early detection of agricultural pests by integrating AI.

The most important challenge facing the field of AI is the infrastructure, in addition to the lack of awareness among the target group, farmers and their limited knowledge of AI. Farmers were resistant to accept that using technology is difficult and expensive due to their lack of awareness of it.

Moreover, there is a lack of the required competencies in the Jordanian labor market. Students who graduated in the field of AI only have theoretical information and lack practical experience in the field.[37]

Challenges also include a lack of funding to develop technologies and infrastructure.[36] There are indirect relationships between AI and food security,[37] for example in the project for the early detection of palm weevils using AI. The device

works to reduce damage to palm trees, which works to reduce costs and losses on consumers and farmers, both because palm production will increase and the amount of economic losses. Here, AI will lead to enhancing food security.

AI can provide data-driven recommendations, boosting productivity and reducing waste. In Jordan, this means reducing water consumption and increasing yields.[36]

There is a need to build a strong infrastructure that supports AI technologies, and to train cadres to spread awareness. The agricultural sector can take advantage of these technologies by training farmers on their use and providing adequate infrastructure, including internet access to farms, in order to facilitate its implementation and use.[38] It is recommended that stakeholders from the government sector or investors adopt AI technologies, disseminate them among the layers of the agricultural sector and commercialize them by encouraging access to a greater number of innovative solutions and providing places for experiments in these areas of food security.[38]

There is no problem in legal matters, as there are no laws that hinder the use of AI in Jordanian companies. Infrastructure, such as software, needs to be run on a laptop or desktop device with certain specifications capable of dealing with AI software. However, there is a problem with job skills in the labor market, such that the

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34    Interview with Shahed Al-khateeb, founder of the world of plants
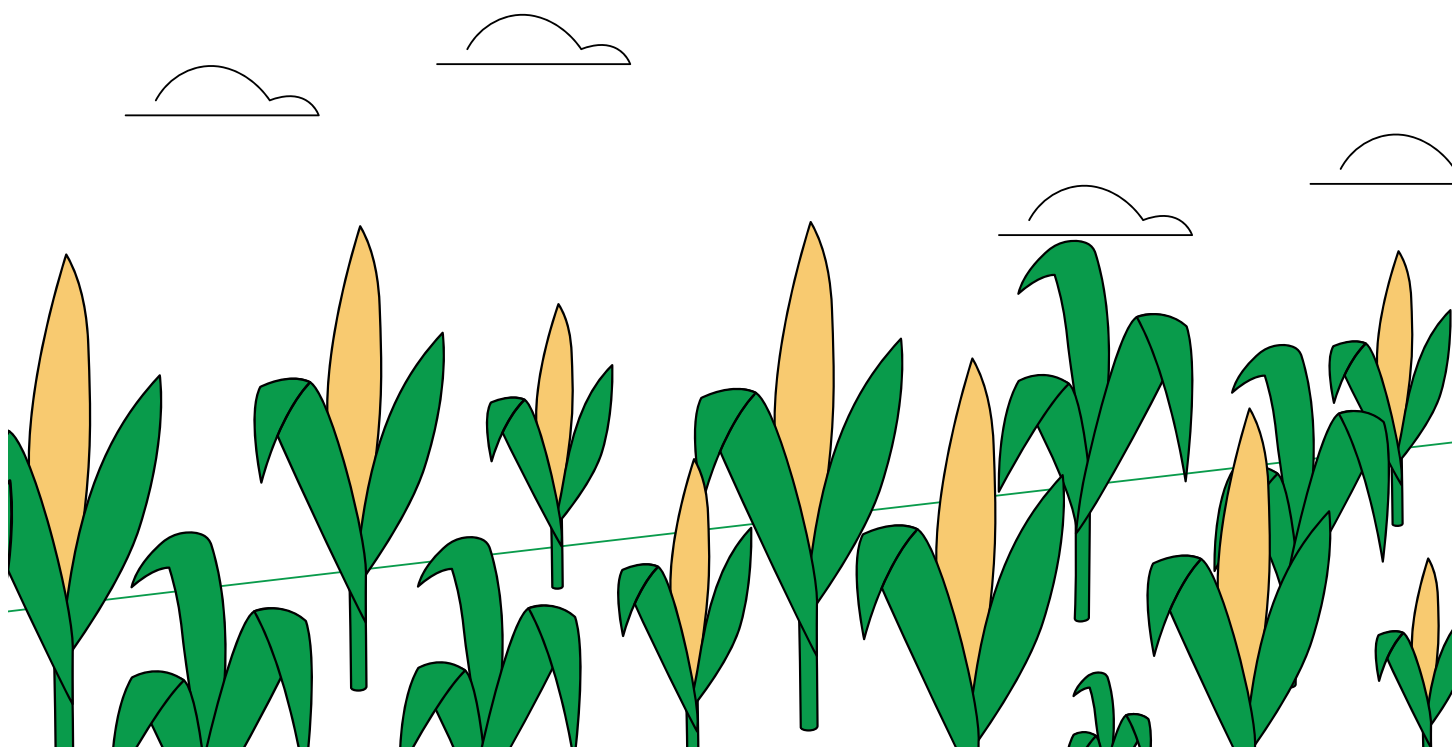
skills of graduate students are not suitable for work on developing AI software.[37]

Jordan needs extensive investments in technological infrastructure and the development of a comprehensive agricultural database.[35] Farmers also need training programs on how to use these techniques. Recommendations regarding infrastructure and challenges include developing communication networks for fast data transfer, supporting emerging projects such as iPlant through grants and financing, encouraging partnerships between the public and private sectors to develop innovative solutions and establishing research and development centers specializing in agricultural technology.[36]

The cooperation between stakeholders would create a conducive environment that would contribute to developing the agricultural sector and improving the quality of products.[35] The best way to adopt AI in Jordan is by facilitating cooperation between private sector companies and universities to help qualify students' skills in the field of AI and accelerate growth in the field of AI.[37]

### iii. Farmers and agricultural workers in Jordan

The following findings are based on the responses of farmers and agricultural engineers who have begun adopting AI in their practices.

AI has significantly accelerated the process of disease identification and investigation in agriculture, drastically reducing the time and effort required by farmers. Tasks that once demanded extensive manual assessment can now be completed with greater speed and accuracy, enabling more efficient management of crop health.[35]

Moreover, AI systems have proven extremely helpful in managing various issues such as crop diseases, insect infestations, shortages of farm items, and unfamiliar diseases not covered in formal education. Differentiating between similar crop diseases was often a challenge, with advice from others resulting in varying and frequently inaccurate diagnoses. In this context, AI software has become an indispensable tool, analyzing plant images to accurately identify problems and recommend optimal solutions for prevention, control, and treatment..[36]

The impact of AI on agricultural practices has been profound, leading to increased productivity among farmers. AI applications have played a pivotal role in monitoring crops and identifying factors that influence their productivity.

The positive and direct impact of AI is reflected in the many benefits it offers, including reduced time spent on tasks, improved quality of work, faster operations, and enhanced data analysis capabilities.

A key application used in agricultural crop monitoring is *PictureThis*, which aids in assessing

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35    Interview with Muhammad Al-Shinnaq, Jordanian farmer

36    Interview with Ibrahim Al-Rifai, agricultural executive engineer

plant conditions and identifying pests. However, its accuracy is not flawless, with a reported accuracy rate of approximately 70 percent. Additionally, the *HydroBuddy* app is utilized to calculate hydroponic nutrient formulations.

The owner of the Olive Press has implemented a range of technologies in quality control, electrical control, and work management, leveraging AI to ensure operational continuity and efficient maintenance. In agricultural operations, electronic irrigation systems are in place, with water pumps remotely controlled and operating automatically 24 hours a day.

Another valuable tool in agriculture is the *Windy* application, which provides global weather and wind forecasts, along with animated weather maps.[37]

Overall, there are no significant concerns regarding the use of AI applications, and confidence in their effectiveness is generally high. However, a potential risk of personal data theft exists, prompting agricultural engineers to advise against saving and storing private information on phones. Fears of hacking also persist, with concerns about the potential loss or misuse of data for illegal purposes.[38]

Data security in the agricultural sector is largely dependent on the entities handling the data. While AI has made the transfer of information more secure, concerns remain about the buying and selling of farm owners' data. The lack of secure data storage practices allows confidential information to spread, and there is a risk that farmers' data could be used against them. For example, AI-based sensors can reveal the quantities of water being extracted from wells, which could be used to enforce government restrictions on illegal water extraction.

### iv. Government Institutions

Jordan's AI Strategy states that several initiatives are being carried out, including the use of AI in the water industry via an early detection system for water waste. Additionally, the use of AI (agri-tech) in the agricultural sectors through the use of drones to classify soil fertility and develop a frost early warning system for farmers.[39]

Currently, the government sector, particularly the Jordanian Agriculture Ministry, does not deploy agri-tech. However, the ministry sees AI as a potential option for reducing food waste and production losses, creating new job opportunities and improving digital government services.

The National Agricultural Research Center has taken a role in the national sphere through the establishment of the Agricultural Innovation Incubator on February 26, 2019. This initiative for supporting entrepreneurs and start-ups created and promoted entrepreneurship, innovation and creativity in the agricultural sector to achieve food security and promote sustainable agriculture. The Agricultural Innovation Incubator is mainly aimed at incubating a diverse array of innovative and creative works to create a wide range of success stories embracing the ideas of innovative youth.[40] Emerging companies in Jordan that are founded based on AI solutions in the field of food security are supported, so that entrepreneurship guidance is provided as well as financial support.

The establishment of the National Strategy for Agricultural Development (2020-2025) is one of the initiatives, as is the digitization of the agricultural sector and the use of digital technology, applications and AI to track and monitor the palm weevil. The project will run from 2023 to 2025 to develop capabilities and disseminate knowledge about agricultural digitization.

The Director of Rural Development at the Jordanian Agriculture Ministry says that the issue of food security is big, and one of the initiatives that have been implemented is to help local associations by providing huge financial support to strengthen the agricultural alliances project "Dates Associations" in Jordan in the Deiralla region.[41] The project aims to develop packaging and inspection operations to prevent spoilage of dates using AI, provide intelligent packaging lines to separate dates into five types, separate dates of poor quality from those of excellent quality, use smart cameras installed with an automated hand that relies on AI in the classification process, as well as recommend other necessary measures. Smart initiatives are introduced in Jordan by training farmers on modern technologies and how to use them, such as smart irrigation techniques.

Among the initiatives, the Agriculture Ministry launched the ARDI program to enhance the resilience of the agricultural sector and develop the value chain and innovation, in cooperation

37   Interview with Mohammed Saleh Khataibh, agricultural engineer with a bachelor's degree in plant disease prevention

38   Interview with Mohammad kalad mohammed Aloun, agricultural engineer

39   *Jordan's Artificial Intelligence Strategy (Revised Version).* (2022). Retrieved from https://www.unido.org/sites/default/files/files/2022-11/Jordan%27s%20Artificial%20Intelligence%20Strategy%20%28Revised%20Version%29-2.pdf

40   *Agricultural Innovation Incubator.* Retrieved from https://narc.gov.jo/Body.aspx?id=Innovation_EN&id2=MenuItemPAGE

"Agricultural Innovation Incubator." Available: https://narc.gov.jo/Body.aspx?id=Innovation_EN&id2=MenuItemPAGE

41   Osama Moh'd Adnan Izzo Kattan, Position: Ddirector of rRural dDevelopment and wWomen eEmpowerment dDirectorate at Agriculture/Ministry of Agriculture,

with the World Bank.[42] The agriculture minister, Engineer Khaled al-Hunaifat, said that the program came as part of the implementation of the goals of the National Plan for Sustainable Agriculture 2022-2025. ARDI highlights Jordan's commitment to creating an enabling environment for the transition to more comprehensive, sustainable and efficient food systems, and supports the achievement of a set of priorities included in the sustainable agriculture plan to create an enabling and encouraging environment for investment.

Implementing the sustainable agriculture plan through ARDI aims to enhance the development of agriculture in Jordan, improve the sector's ability to withstand climate change, increase competitiveness and inclusion, and ensure food security in the region. The program, [48] which is to be implemented until 2028, aims to address the urgent challenges facing the agricultural sector, relying on two pillars: climate resilience and sustainability, and competitiveness and exports, by supporting rainwater harvesting projects and improving climate-smart agriculture, encouraging innovation and exports, and encouraging farmers to use modern technology by improving access to financing. Digital agriculture refers to the design, development and application of digital technologies in the agricultural sector, which can be applied to all stages of agri-food production systems.

Among the challenges of food security in Jordan is the fragmented approach to food security and the absence of a reference body for it. Effective food security measures require coordination between ministries and government agencies, and without a central entity overseeing food security, any efforts lack cohesion and efficiency. Establishing a dedicated task force to legislate and coordinate food security initiatives can help streamline efforts and ensure a unified approach.

One of the main gaps in the agricultural food sector in Jordan is the lack of a general policy for farmers regarding agricultural areas and appropriate agricultural varieties, the lack of knowledge of food preservation practices, and there is food waste.[43]

AI programs can help farmers, relying on data from agricultural areas, they provide advice on the best agricultural varieties to plant, the ap-

propriate time to plant them, as well as future prices for crops. For example, if agricultural data about tomato yield is entered by large farms, the farm owner will make a profit, but in the case of a small farm, AI would make recommendations to farmers to grow crops of another type of vegetable that will give a lower cost. Having AI applications in the field of agriculture is important to develop smart agriculture, analyze the Jordanian market and reduce the amount of food waste. For example, AI applications can analyze market data and customer needs for agricultural products in various regions of Jordan, so that recommendations are made about the best crops that citizens prefer in specific seasons and regions in throughout the country so that food waste is reduced y by avoiding growing a single variety among many farmers, since too much production of one crop leads to crop waste and surplus production.

One of the most prominent gaps is the import of fruit products that are not grown in Jordan due to the lack of climatic conditions and the lack of necessary water, such as Somali bananas. By introducing agricultural technology, it is possible to reduce production costs and give quick and accurate results. Modern irrigation technologies that rely on AI can be used to distribute water to crops in an appropriate manner and also according to the available quantities.

Food security is defined as the production of enough fundamental resources, such as wheat and barley, to secure the state's military security and independence and to ensure that there is never a lack of them. Jordan's agri-food sector has numerous obstacles, and AI technologies have the potential to play a significant role in tackling these issues.

### The Role of AI in Enhancing Agricultural Productivity and Food Security in Jordan

1) AI has the ability to enhance productivity and contribute to food self-sufficiency by improving agricultural operations, giving recommendations for the best agricultural crops based on inputs, and managing agricultural and water resources, which leads to achieving food security through increased food availability for every person.

2) Inefficient land use: Jordan's agricultural industry needs to enhance its efficiency in using agricultural land. AI aids land management by assessing soil parameters, climate data and crop performance to determine the best crop options for specific locations. Various crops can be developed

42    Petra News Agency, Launching an Agriculture Resilience, Value Chain Development And Innovation (ARDI) program to enhance the agricultural sector's resilience. (2023). Retrieved from https://petra.gov.jo/Include/InnerPage.jsp?ID=241115&lang=ar&name=news,

Ministry of Planning and International Cooperation (MOP), ESSA Jordan ARDI. (2022). Retrieved from https://www.mop.gov.jo/EBV4.0/Root_Storage/EN/EB_HomePage/ESSA_Jordan_ARDI_MAY_17_2022_CLEAN_(2).pdf

43    Interview with Amgad Saleh Hjazin, researcher at National Agricultural Research Center.

that include different minerals required by humans to gain the highest benefit based on soil properties recommended by AI. This can increase output while decreasing expenses and conserving resources like water.

3) Rising temperatures and changing rainfall patterns pose a serious threat to agriculture in Jordan, reducing the sector's production output. AI can help farmers adapt to these difficulties by providing real-time weather data and predictive analytics. Additionally, AI-powered systems can optimize irrigation schedules, monitor water supplies and recommend drought-tolerant crop varieties, stabilizing food security against risks.

4) Water scarcity:[22] Jordan suffers from significant water scarcity, and agriculture is considered a major consumer of water resources. AI can improve water management by monitoring soil moisture levels, automating irrigation systems and using precision irrigation techniques. This can save a significant amount of water while maintaining healthy crops, leading to food stability.

5) Pest and Disease Control:[7] Image recognition in AI helps in the early detection and treatment of pests and diseases in crops. Farmers can take advanced and timely action to protect their crops, reduce losses and ensure food security by detecting problems early, resulting in increased agricultural yields and, in turn, increased availability of food.

6) Market access and trade: AI can help farmers access broader markets by analyzing market trends and demand patterns. This information can help farmers make informed decisions about what to produce and ensure that their products meet market demand while maintaining local and global competitiveness, reducing poverty among farmers and increasing their profits, and also contributing to stability despite fluctuations in food prices.[44] Local data that includes information about farmers, their lands and production capacity, in addition to open local agricultural data, requires AI processes specifically designed to meet the needs of the target group, such as an Arabic language, user-friendly design and interface, as well as the ability to maintain the privacy of information and not tamper with it.

The necessity to teach and certify people to use technology and the need to promote awareness among farmers about on-the-ground observations regarding technology to feel its impact pose challenges in the early years of AI integration due to the high expenses involved. However, in the long term, adopting AI technology speeds up operations while also providing accurate findings and lowering costs.

One of the issues for adopting AI techniques in the agricultural food sector is that farmers do not like change, and many farmers fear taxes and do not like to reveal their private information. But the use of AI is an opportunity to organize the agricultural sector and obtain information, and it is expected that using AI in the sector in Jordan will be successful.

In light of the Jordanian Agriculture Ministry's initiatives, such as the National Strategy for Agricultural Development 2020–2025 and other strategies, such as the National Strategy for Food Security 2021–2030, in comparison to past years, the country has[47] become better and more equipped to absorb AI solutions. Therefore, we have begun to assess and evaluate the services offered, as well as the time of completion, so that the procedures become faster. Many government processes can be acquired more quickly and easily through the ministry. The results show the extent of the agricultural sector's readiness to apply AI technologies, which allows the automation of services electronically. High financial expenses and the necessity of having local expertise in the field of AI and smart devices, as well as training target groups on new software, are among the obstacles to adopting AI.[47]

To promote its growth and ensure responsible and safe development, several actions have been taken in the fields of digital transformation and AI in the form of regulations covering a wide range of issues, including data governance, privacy and the investment environment. The policies are summarized below:

1) Personal Data Protection Regulations: The purpose of this law is to preserve people's privacy and personal information. It establishes the norms and regulations that businesses must follow while collecting, processing and keeping personal data, as well as the penalties for failing to do so. For example, safeguarding and preventing the alteration or falsification of food and agricultural information, such as production and expiration dates for specific items.[31]

44    Food and Agriculture Organization (FAO), *Measuring different dimensions of food security*. (2013). Retrieved from https://www.fao.org/3/i3434e/i3434e02.pdf

2) Policy on Open-Source APIs: This policy promotes the use of open-source APIs to improve interoperability and online collaboration. The policy encourages the development of open, accessible systems that may be used by a wide range of stakeholders. This can be applied to agricultural food data, such as digital data collected by the General Statistics Department, which is open source and available electronically. The Crop Production Section of the General Statistics Department [30] conducts many annual agricultural surveys to collect agricultural statistics. These surveys look at several crop production sectors and have the following general objectives: estimating the cultivated area, estimating the production of various field crops, fruit trees and vegetables by type of crop and cultivation period, as well as estimating the total number of fruit trees by type of fruit and estimating the size of the agricultural labor force by type, gender, nationality and age group. There is also information about water resources, such as rainfall amounts with long-term averages dating back to 1995 up to 2022.

3) Open Government Data Policy: Making government data available to the public enhances transparency and simplicity of access. Citizens in Jordan can gain free access to accurate and reliable digital information. Agriculture-related statistics,[30] such as crop censuses and energy-related information, such as energy and water usage quantities, are made available by the Department of Statistics.

4) Investment Environment Regulation Legislation: This law establishes a framework for regulating investments in the digital transformation and AI industries. Incentives, rules and guidelines may be included to encourage and promote investment in these critical sectors.

***According to Jordan's AI strategy, the following challenges exist in adopting AI:***

- Government policies and strategies should keep pace with rapid technological development, as modern technology
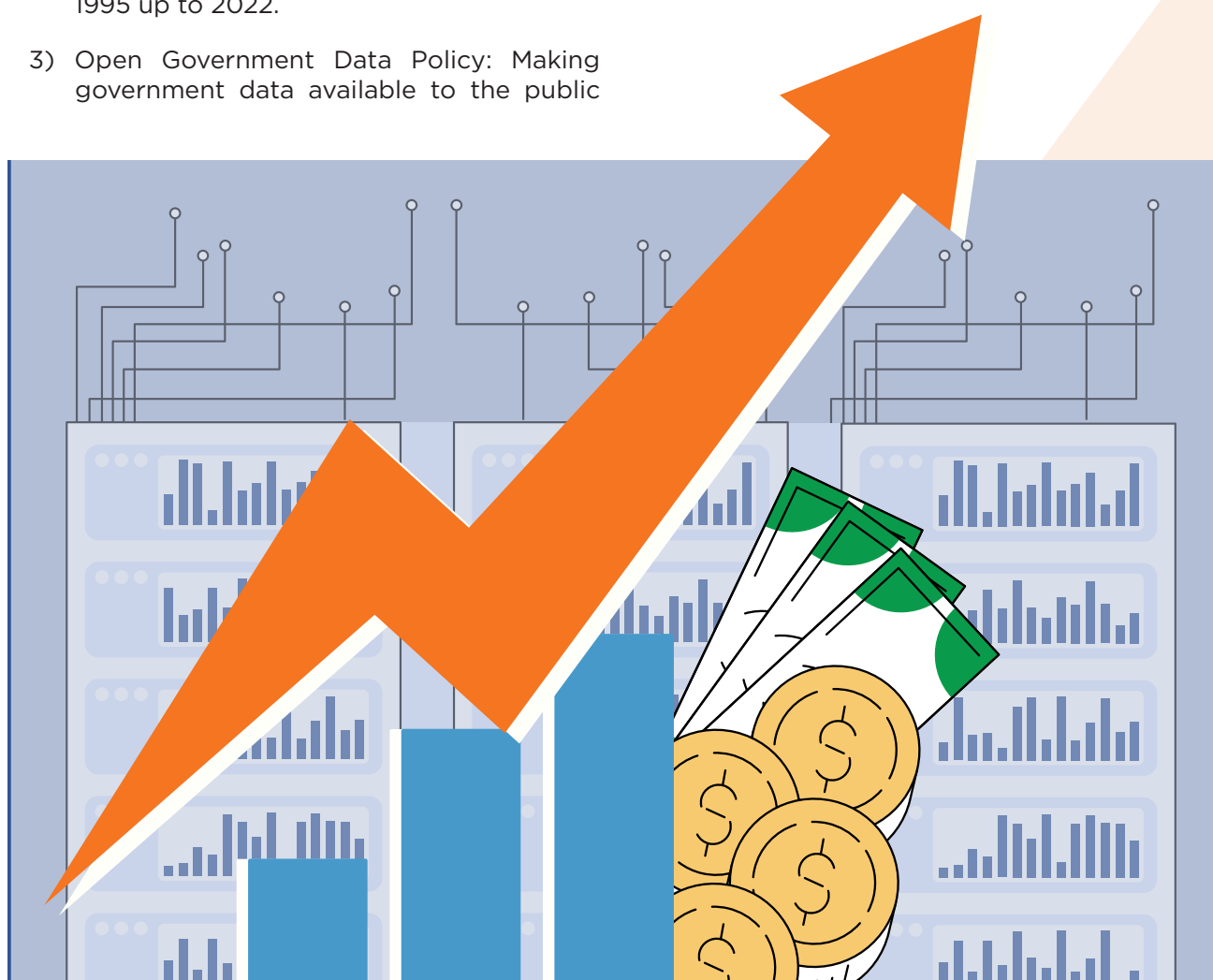
requires periodic updates according to existing policies and strategies.[49]

- The Code of Ethics aims to emphasize the creation of a common ethical rule that regulates work developing and using AI technologies that originate from humans. In addition to awareness of the risks that may result from practices outside the scope of responsibility, and a secure ethical framework, the code of ethics generally also includes a set of basic ethical principles which cover accountability, inclusivity, transparency, neutrality, respect for privacy and promotion of other human and moral values. These are principles that promote the rule of law, human rights, democratic values and diversity.

- Lack of ethical compliance with AI is a challenge because it can be used to manipulate the consciousness or thinking of individuals, mislead them, harness unsafe AI technologies to cause harm, or use, exchange, delete, manipulate, manage or take any action without obtaining appropriate permission and approval in reference to the existing laws and regulations. This can result in defaming individuals, blackmailing them and other types of harm.

- Data protection, fear of privacy violations and cybersecurity requirements.

- Lack of optimal use of digital infrastructure, such as weak networks.

- The financial allocations and initial investment costs in AI technology are very high.[47]

Suggestions for AI implementation are summarized below:

1) Improving water distribution: By utilizing various data such as previous and current rainfall amounts, as well as available meteorological data collected from a network of meteorological stations located throughout Jordan and maintained in specialized databases for usage and dissemination by appropriate government departments. AI may be used to evaluate meteorological data in real-time, monitor reservoir water levels and forecast water demand.

2) Forecasting food waste and production losses: The value of food waste in Jordan is estimated at no less than 120 million dinars (US$170 million) per month.[45] AI can be utilized to predict food waste amounts and production losses, and in turn minimize these losses.

3) Optimal use of fertilizers and pesticides: AI can be used to provide suggestions on the optimal use of fertilizers.

4) Capacity building and training: Educating farmers and stakeholders about the benefits and potential of AI in agriculture is crucial to ensure its widespread acceptance and success.

5) Effective coordination between government ministries for responsible use of AI: Establishing a single organization responsible for managing AI activities related to food security would help achieve the goals of digitizing the agricultural sector faster while increasing agricultural productivity and reducing costs.

6) Political and legislative frameworks: Among the risks are not ensuring the confidentiality and privacy of data for individuals and neglecting cybersecurity, as well as how to mitigate or respond to hacking cases. The solution is to spread awareness to institutions and individuals by unifying the mechanisms for processing data according to existing regulations, so that they are protected and have the tools to preserve their privacy, and eventually develop more policies and regulations to encourage and manage the responsible use of AI in agriculture.

## VII. ANALYSIS

### 1. Availability of food

Jordan relies heavily on the global food market to secure its grain needs. The percentage of imports increased from 91.1 percent in 2010 and 93.6 percent in 2012 to 97.6 percent in 2018. The country is developing and disseminating modern techniques and agricultural technology suitable to local conditions by employing AI techniques in agricultural scientific research with a budget of 400,000 Jordanian dinars.[46]

45 هدر الطعام سلوك اجتماعي في الأردن [Food waste: A social behavior in Jordan]. (2023). Retrieved from https://www.alaraby.co.uk/society/%D9%87%D8%AF%D8%B1-%D8%A7%D9%84%D8%B7%D8%B9%D8%A7%D9%85-%D8%B3%D9%84%D9%88%D9%83-%D8%A7%D8%AC%D8%AA%D9%85%D8%A7%D8%B9%D9%8A-%D9%81%D9%8A-%D8%A7%D9%84%D8%A3%D8%B1%D8%AF%D9%86

46 *Strategy of the National Agricultural Research Center for the years (2019-2023)*. Retrieved from http://www.ncare.gov.jo/NARCDATAInfo/STRATEGIC/NARCSTRATEGIC.pdf

AI can be utilized to optimize agricultural processes, improve crop yield predictions and enhance resource allocation in the sector. Precision farming, driven by AI, can contribute to increased availability.

## 2. Access to food

The percentage of spending on food items reached 39.6 percent of total Jordanian household spending in 2010 and decreased to 32.7 percent in 2017.[2] Increased poverty and unemployment rates impact people's access to food. AI can support targeted social programs to ensure vulnerable populations have better access.

## 3. Food use and nutrition

The research indicates a decrease in the utilization of renewable sources of water in agricultural practices, dropping from 119 percent, in the period spanning 2010 to 2012, to 116 percent from 2017 to 2019.[2]

The NARC works to achieve a significant increase in the efficiency of water use in all sectors and ensure the withdrawal and supply of fresh water sustainably, to address water scarcity, by developing techniques that increase the efficiency of water use in agricultural production. Increasing the efficiency of the amounts of water used with a budget of 1,500,000.00JD.[53] AI uses predictive analytics to forecast water availability based on climate models and historical data, increasing water resource efficiency.

## 4. Stability

In 2019, Jordan scored 0.05 in the Vulnerability to Climate Change Index, indicating that the country is not significantly affected by weather-related disasters, sea level rise and loss of agricultural productivity. But this does not mean that Jordan is completely immune from all the effects of climate change. AI can contribute to climate modeling and prediction, helping to assess and mitigate the impact of climate change on food production.

## VIII. CONCLUSION AND RECOMMENDATIONS

In conclusion, our research has delved into the intersection of food security and AI in the agricultural landscape of Jordan. As a country, Jordan suffers from weak agricultural systems due to a range of challenges posed by a dry climate and limited water resources.

Notably, ongoing efforts led by research centers like the National Agricultural Research Center, affiliated with the Jordanian Agriculture Ministry, are geared toward embracing modern technologies and cultivating sustainable crops that are adaptable to environmental changes. The center supports emerging companies in the AI and food security sectors through incubation programs.

Jordan's strides in AI, as recognized by the global index of government readiness in the field of AI, the Oxford Index, are reflected in the growing number of AI indicators and the formulation of a national strategy encompassing initiatives for AI application in crucial sectors like agriculture, water and energy. The creation of an AI-based assistant for farmers exemplifies this practical application. By providing analysis-based guidance and advice, the application helps farmers mitigate agricultural risks, ultimately leading to food availability and security for citizens.

In deploying AI, a focus on data protection, privacy, transparency and availability is paramount. The journey toward a resilient and technologically empowered food system necessitates a concerted effort, with collaboration and investment playing pivotal roles in realizing Jordan's potential as a model for AI-driven food security.

Our findings strongly call for the integration of modern technologies, including AI, into agricultural practices. This technological leap would significantly enhance productivity, address the challenges of water scarcity and contribute to the overall sustainability of food systems in Jordan.

# ANNEXES

## *Interview questions for academic researchers*

1) From your perspective as an academic expert, what potential do you see in AI to address agricultural challenges in Jordan? What are the major gaps within the agri-food sector in Jordan? What potential role can AI technologies play in this regard?

2) How important is data governance and ethical AI in the context of AI adoption in agriculture, and what recommendations can you provide in this regard?

3) What are the latest research developments or innovations that can significantly impact AI integration in the agricultural sector?

## *Interview questions for private sector workers*

1) What is the current state of AI use in your field in Jordan? Could you please provide some examples of existing applications?

2) Please describe the role of your organization/startup in promoting AI technologies in agriculture, and outline specific projects or initiatives you have undertaken.

3) What are the main challenges and opportunities for startups and research institutions in the field of AI and agriculture in Jordan? What do you consider to be the main challenges and gaps for the adoption of AI in your field, in Jordan?

4) What role do you think AI can play toward food security in Jordan? (especially in relation to food availability, access, utilization and stability)

5) In your opinion, what is needed (e.g. infrastructure, policies, skills) to support AI adoption in your field for improved food security in Jordan?

6) How do you envision collaboration between different stakeholders to accelerate AI adoption in agriculture?

## *Interview questions for farmers and agricultural workers*

1) Based on your practical experience, how has AI technology influenced your farming practices, and what benefits or challenges have you encountered?

2) Are there any specific AI applications or tools that you find particularly useful in your daily agricultural activities?

3) What are your expectations and concerns regarding the responsible use of AI in agriculture, especially in terms of data privacy and security?

## *Interview questions for government institutions*

1) How does the Jordanian Agriculture Ministry view the integration of AI in the agricultural sector, and what initiatives have been implemented so far?

2) What are the major gaps within the agri-food sector in Jordan? What potential role can AI technologies play in this regard?

3) Can you share insights into the strategies and policies that the National Center for Agricultural Research has in place to support AI adoption in agriculture?

4) What are the key challenges and opportunities you perceive in incorporating AI in Jordan's agricultural practices?

5) In your opinion, what are the main challenges and / or gaps (e.g. regulatory issues) hindering the adoption of AI-based applications / services in the agri-food sector in Jordan?

6) In your opinion, what are the key areas for policy action with regard to the responsible use of AI in the agri-food sector in Jordan?

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