

## Assessing the Potential of Farm Management Information Systems (FMIS) to Enhance Agricultural Productivity in Iraq



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<https://doi.org/10.18280/ijdsdp.210124>

### ABSTRACT

**Received:** 16 December 2025

**Revised:** 22 January 2026

**Accepted:** 27 January 2026

**Available online:** 31 January 2026

#### Keywords:

*FMIS usage patterns, digital channels, adoption rate, agricultural decision-making*

The study examines the role of the farm management system (FMIS) in increasing agricultural productivity in Iraq, where challenges in the agricultural sector. By using secondary data from sources such as FAO and World Bank, the research evaluates the status, efficiency and obstacles of the adoption of FMI in Iraq from 2015 to 2022. Conclusions suggest that FMIS use, especially in mobile-based applications, is strongly associated with improved smartphone access and the development of digital infrastructure. However, regional inequalities persist, and the adoption rate in western and southern Iraq is quite low. The study sheds light on a positive correlation between the use of FMI and the quality of increased crop dividend, resource use efficiency, and decision-making quality. In 2022, for example, A significant correlation was observed where wheat yields were 34.9% higher for FMIS users compared to non-users in 2022. The efficiency of water use also increased by 25.7% due to FMIS adoption. Large obstacles include poor internet infrastructure (78.5% of farmers quoted by farmers), limited technical skills, high implementation costs, and a lack of Arab language solutions. Despite the five times the increase in public and private investments in agricultural information systems, the effort is fragmented. The study recommends targeted infrastructure development, policy help for small holders, mobile-first located FMIS solutions, and strong coordination between stakeholders. By addressing these intervals, FMIS can serve as a transformation tool for permanent agricultural development in Iraq.

## 1. INTRODUCTION

Agriculture is an important sector in Iraq's economy, and ensures food security, supports rural employment and contributes to the country's GDP [1, 2]. Recent empirical studies in Iraqi agriculture provide a compelling basis for using the Agricultural Management Information System (FMIS) to increase productivity [3]. Documentation of hazards related to severe climate, such as rising temperatures, water shortages, desert and altered rainfall, FMI requirements, able to integrate climate data to support adaptive agricultural schemes, and emphasize FMI requirements [4]. In addition, Hameed [5] demonstrated the use of GIS and remote measurement for the characterization of land and forest planting in the Bashiqa region, stating that the spatial data within FMI can inform the site-specific management decisions in FMI. There is digital equipment designed to collect, process and analyze the farm data to support a decision on form management system (FMIS). While Iraq has introduced efforts to digitize agriculture, it is largely limited to basic record keeping systems, with limited integration of advanced equipment such as IoT and satellite -based platforms. There is a difference between available agricultural data and the needs for decision -making in Iraq. While many international and

local databases provide agricultural figures, these resources are often reduced to decision-making processes due to the absence of structured errors that can translate raw data into action-rich insights [6]. For example, advanced FMIS components such as IoT sensors and satellite monitoring are largely unclear. In some studies, the importance of information systems and supportive infrastructures is emphasized, aligning closely with the role of FMIS in enhancing agricultural productivity in Iraq, and high costs were identified as the main barrier [7]. This observation prevents the data from informing and improving agricultural practices and policies. The importance of this research lies in the ability to bridge the available data and decision -making needs. This addresses a pressure challenge in Iraq's agricultural development - how to better integrate MIS into politics and practice - especially under the conditions of limited infrastructure and institutional capacity. The study is expected to offer practical recommendations to strengthen FMIS use in Iraq and promote permanent agricultural development to fit the national and international development goals [1, 8]. Despite the recognized importance of management information systems (MIS) to improve agricultural results, their implementation and efficiency in Iraq are limited. In developed agricultural economies, MIS is widely used to increase the farm plan, adapt

the resource allocation, and to support real-time decision-making [9]. In Iraq, however, challenges such as poor digital infrastructure, fragmented institutional efforts and lack of peasant training have created significant intervals between the availability of information systems and their actual use in farm management [1, 2]. In addition, while many international and local databases provide agricultural figures, these resources are often reduced in decision-making due to the absence of structured MIS that can translate raw data into action [6]. This research aims to investigate: For example, advanced FMIS components such as IoT sensors and satellite monitoring are largely unclear. Depending on the secondary data sources available are the extent to which Farm Management Information System (FMIS) is effective in supporting agriculture in Iraq, while studies in Pakistan and India [10] demonstrate that FMIS success is linked to stable energy and localized content, the Iraqi context reveals that institutional fragmentation and the absence of Arabic-supported platforms create unique barriers that hinder similar adoption rates. This study aims to evaluate the role of agricultural governance information systems to support agricultural decisions in Iraq by analyzing the existing digital agricultural data set. The purpose of this research is to assess how FMI has been implemented (or reduced) in Iraq's agricultural sector and identify intervals in use, access, and system integration.

## 2. MATERIALS AND METHODS

The study appoints research design with mixed methods by combining descriptive and analytical approaches to evaluate the effectiveness of FMIS in support of decisions on agriculture in Iraq. The descriptive component focuses on the current status and availability of FMI and related agricultural

data platforms and provides a relevant framework for analysis. The analytical component involves more intensive interpretation of how the Iraqi reference affects the decision-making process and affects agricultural productivity (or fails to influence). Given the inherent challenges of primary research in Iraq, including logical obstacles and security problems, this study receives secondary data analysis as its primary method of approach.

## 3. RESULTS AND DISCUSSION

### 3.1 Current status of farm management systems (FMIS) in Iraq

#### 3.1.1 Adoption trends and patterns

As shown in Table 1, the adoption of different types of agricultural management information systems (FMIS) in Iraq between 2015 and 2022 shows that the adoption rate of basic farm record systems increased from 12.3% in 2015 to 42.3% in 2022. Despite showing significant growth from just 0.8% in 2015, by 2022, only 12.8% of farmers using farm record systems were relatively low in the adoption rate of more advanced systems with extensive FMI (multi-module integrated systems). This result is close to that found by Farooq et al. [11] in their study in Mardan District, Pakistan. This pattern suggests that as basic digitization gains momentum, there is significant potential for further integration of advanced FMIS solutions into Iraqi agriculture. The variation in adoption reflects the different complexities, costs, and perceived benefits of different FMIS types. Basic recordkeeping systems serve as an entry point into agricultural digitization for many farmers, while more complex systems face more adoption barriers.

**Table 1.** Adoption rate for different types of farm management systems (% of farmers) in Iraq (2015–2022)

| FMIS Type                               | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|------|------|------|------|------|------|------|------|
| Basic agricultural registration systems | 12.3 | 14.5 | 17.8 | 21.4 | 26.7 | 32.5 | 37.8 | 42.3 |
| Crop management systems                 | 7.5  | 9.3  | 11.6 | 14.8 | 19.2 | 24.5 | 29.7 | 34.2 |
| Livestock management systems            | 5.2  | 6.8  | 8.5  | 10.7 | 14.3 | 18.6 | 22.4 | 26.8 |
| Economic management systems             | 4.6  | 5.9  | 7.8  | 10.2 | 13.5 | 17.3 | 21.5 | 25.1 |
| Irrigation management systems           | 2.8  | 3.9  | 5.4  | 7.8  | 10.6 | 14.2 | 18.5 | 22.7 |
| Supply chain control systems            | 1.5  | 2.3  | 3.1  | 4.5  | 6.8  | 9.2  | 12.8 | 16.5 |
| Extensive FMI (integrated module)       | 0.8  | 1.2  | 1.7  | 2.6  | 4.1  | 6.3  | 9.2  | 12.8 |

**Source:** Calculated from Iraqi Ministry of Agriculture [12], and FAO [13].

The steady year-on-year increase in adoption rates is attributed to the continued implementation of the World Bank's Agricultural Resource Efficiency Programs (2015–2022), which have provided a stable framework for technology deployment despite local economic fluctuations.

**Table 2.** Regional distribution of Farm Management Information Systems (FMIS) adoption in Iraq (% of farmers), 2022

| Region                 | Basic Farm Records | Crop Management | Livestock Management | Financial Management | Irrigation Management | Comprehensive FMIS |
|------------------------|--------------------|-----------------|----------------------|----------------------|-----------------------|--------------------|
| North-Iraq (Kurdistan) | 51.3               | 42.5            | 34.7                 | 31.5                 | 29.8                  | 18.6               |
| Central Iraq           | 45.7               | 37.8            | 28.5                 | 26.7                 | 24.3                  | 13.4               |
| Baghdad Region         | 53.8               | 45.2            | 32.1                 | 35.7                 | 28.6                  | 19.3               |
| Western Iraq           | 32.5               | 25.7            | 18.4                 | 16.2                 | 14.8                  | 7.5                |
| South- Iraq            | 28.7               | 21.3            | 15.8                 | 14.3                 | 13.5                  | 5.2                |

**Source:** Calculated from Central Statistical Organization of Iraq [14], and FAO [15].

### 3.2 Regional disparities in Farm Management Information Systems (FMIS) adoption

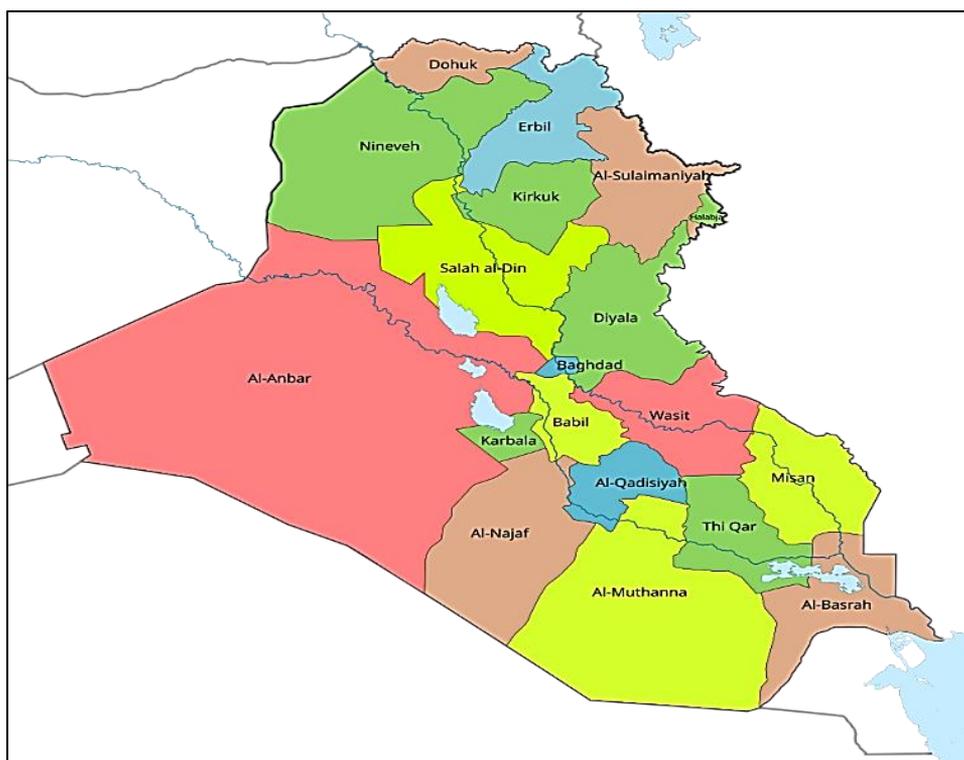
Table 2 shows that the Kurdistan Region in northern Iraq and the Greater Baghdad Area exhibit significantly higher

adoption rates across all categories of financial management information systems compared to western and southern Iraq. For example, 53.8% of farmers in the Baghdad Area use the basic agricultural registration system, compared to only 28.7% in southern Iraq. Similarly, widespread financial management

information system adoption ranges from 19.3% to 5.2% in southern Iraq, specifically in Baghdad. A similar study was conducted by Shandana and Khan [10] in Khyber Pakhtunkhwa. Three districts (Swat, Haripur, and Mardan) in Khyber Pakhtunkhwa were selected for this study, and the results were similar to ours. A notable feature of financial management information system adoption in Iraq is the significant regional disparities. These disparities can be attributed to several factors, including infrastructure development, educational level, size of the agricultural sector, and proximity to technological support services.

In this study, 'Central Iraq' is operationally defined to include the governorates of Babylon, Karbala, and Wasit, while the 'Baghdad region' exclusively covers the capital's agricultural periphery. These definitions follow the administrative areas of the Iraqi Ministry of Planning (2021).

Table 3 shows that the Internet coverage in rural areas increased from 21.5% in 2015 to 53.2% in 2022, but this improvement has not been equally distributed in all areas. Data shows that digital skill problems are important challenges in democratizing access to agricultural information systems in Iraq.



**Figure 1.** Map of Iraq showing the studied agricultural regions (Baghdad, Central, Northern, Western, and Southern)

### 3.3 Evolution of Farm Management Information Systems (FMIS) access platforms

The geographical scope of this study encompasses various agricultural regions across Iraq, as illustrated in Figure 1. These regions, including the Northern, Central, and Southern areas, represent diverse farming environments where the adoption of Farm Management Information Systems (FMIS) is being evaluated. Table 4 shows a clear change from the desktop/PC-based system to mobile applications. In 2015, 62.3% of users of FMIS users mainly gained access to these systems via stationary computer, while only 21.5% of the mobile applications used. In 2022, the dramatic shift from 21.5% to 65.9% in mobile access is primarily due to the rapid expansion of 4G networks in rural Iraq and the relative affordability of smartphones compared to traditional desktop computers, which lack the mobility required for field-based farm management. The infection corresponds to a sufficient increase in the use of smartphones among farmers, which increased from 28.7% to 67.5% in 2015 (Table 3). Preference for mobile platforms reflects their greater access, convenience and adaptation with the daily operational context of agriculture. This change has significant implications for FMIS developers and agricultural expansion services, which suggests that the mobile-first approach is likely to have more

entry into the Iraqi agricultural context. The platforms that farmers use FMI has made a remarkable change in the study period. In the same context, Naik et al. [16] conducted a study in the Anantapur district of Andhra Pradesh during the 2017–2018 academic year, and the results were similar.

**Table 3.** Development of the internet and mobile infrastructure, as well as platform use trends between Farm Management Information Systems (FMIS) users in Iraq (2015–2022)

| Year | Internet Coverage in Rural Areas (%) | Smartphone Usage Among Farmers (%) | Electricity Availability in Rural Areas (Hours/Day) |
|------|--------------------------------------|------------------------------------|---|
| 2015 | 21.5                                 | 28.7                               | 8.5   |
| 2016 | 24.6                                 | 33.2                               | 9.3   |
| 2017 | 27.8                                 | 39.5                               | 10.1  |
| 2018 | 32.4                                 | 45.6                               | 11.2  |
| 2019 | 38.5                                 | 51.3                               | 12.5  |
| 2020 | 42.3                                 | 58.7                               | 13.6  |
| 2021 | 48.6                                 | 63.4                               | 14.2  |
| 2022 | 53.2                                 | 67.5                               | 15.1  |

**Source:** Calculated from World Bank [15], International Telecommunication Union (ITU) [17], and Iraqi Ministry of Planning, Central Statistical Organization [12].

**Table 4.** Used to reach Farm Management Information Systems (FMIS) in Iraq (% of FMIS users), (2015–2022)

| Platform            | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---------------------|------|------|------|------|------|------|------|------|
| Desktop/PC Based    | 62.3 | 58.5 | 52.7 | 46.8 | 40.5 | 35.2 | 31.6 | 28.4 |
| Mobile Applications | 21.5 | 27.8 | 35.4 | 42.7 | 49.8 | 56.3 | 61.7 | 65.9 |
| SMS-Based Services  | 14.7 | 12.3 | 10.5 | 8.9  | 7.3  | 5.8  | 4.2  | 3.1  |
| Web-Based Services  | 1.5  | 1.4  | 1.4  | 1.6  | 2.4  | 2.7  | 2.5  | 2.6  |

**Source:** Calculated from International Telecommunication Union (ITU) [18] and World Bank [2].

The dramatic change in mobile access (65.9%) is attributed to the expansion of 4G networks and the lower cost of smartphones compared to desktop hardware in rural Iraq.

### 3.4 Impact of Farm Management Information Systems (FMIS) on agricultural productivity in Iraq

#### 3.4.1 Productivity differences between FMIS users and non-users

Table 5 shows that in all larger crops, FMIS users get continuous high returns. For wheat, the 34.9% yield gap in 2022 represents a cumulative 'learning-by-doing' effect. Data indicates this gap has widened from 30.2% in 2020, suggesting that long-term FMIS users are optimizing resource application (water and fertilizer) more effectively than those who rely on traditional methods. Similar trends are seen for other crops, where the productivity difference varies from about 28% to 35%. These differences are statistically important and suggest

that using FMI is associated with sufficient productivity benefits in Iraqi agriculture. The increasing size of productivity differences over time may indicate the effect of coercive learning, making farmers more proficient in using these systems to inform their decisions because they gain experience with them. However, these results indicate the correlation rather than a certain reason, as controlled studies were not done. One of the most compelling conclusions from data analysis is the sufficient productivity difference between farmers who use FMI and those who do not. A team of researchers, Kumar et al. [19], made extensive use of information technology at the farm level and the results were satisfactory in terms of optimal handling of information technology and its significant impact on the farms and farmers.

**Table 5.** Productivity difference between Farm Management Information Systems (FMIS) users and non-users in Iraq (2020–2022) (tons/hectare)

| Crop     | FMIS Users |       |       | Non-FMIS Users |       |       | Productivity Difference (%) |       |       |
|----------|------------|-------|-------|----------------|-------|-------|-----------------------------|-------|-------|
|          | 2020       | 2021  | 2022  | 2020           | 2021  | 2022  | 2020                        | 2021  | 2022  |
| Wheat    | 3.45       | 3.60  | 3.75  | 2.65           | 2.71  | 2.78  | +30.2                       | +32.8 | +34.9 |
| Barley   | 2.78       | 2.85  | 2.92  | 2.15           | 2.19  | 2.23  | +29.3                       | +30.1 | +30.9 |
| Rice     | 4.10       | 4.25  | 4.35  | 3.20           | 3.25  | 3.30  | +28.1                       | +30.8 | +31.8 |
| Tomatoes | 28.50      | 29.75 | 31.20 | 22.30          | 23.10 | 23.80 | +27.8                       | +28.8 | +31.1 |
| Potatoes | 22.80      | 23.90 | 25.10 | 17.60          | 18.20 | 18.90 | +29.5                       | +31.3 | +32.8 |

**Source:** Calculated from Iraqi Ministry of Agriculture [12] and World Bank [20].

The yield difference of 34.9% is the result of precise irrigation and optimized fertilizer application. This gap has widened since 2020, indicating a "learning-by-doing" effect among long-term FMIS users.

### 3.5 Resource use efficiency improvements

Table 6 shows that water use efficiency in 2022 improved by 25.7% compared to traditional management methods. Similar improvements were observed in fertilizer use (23.5%), pesticide use (21.4%), and land use adaptation (21.3%). The data are consistent with those found in the review of Papadopoulos et al. [21]. These efficiency gains are particularly important in the Iraqi context, where water level volatility, soil degradation, and production start-up costs pose significant challenges to agricultural stability. Statistics indicate that agricultural management information systems (FMIS) can simultaneously increase productivity and play a crucial role in promoting more sustainable farming practices, enabling farmers to "produce more with less." In addition to increasing raw material productivity, the adoption of FMIS has led to a significant improvement in resource use efficiency.

### 3.6 Information access and agricultural decision-making

Table 7 provides insight into how FMI can affect productivity. Access to the weather forecast increased from 24.3% in 2015 to 67.5% in 2022, while the use of the market price in the same period increased from 18.5% to 59.8%. The

range of the Technical Agriculture Council increased by about five times from 9.3% to 48.5%. It contributes to better decision-making on better information such as planting time, entry application, autumn planning and market engagement. Data suggests that FMIS plays an important role because information links the connection to important knowledge resources, which enables more informed and timely agricultural decisions. Increase in farmers' access to different types of agricultural information through digital channels. The results were similar to those obtained by Patel and Mallappa [22] in a study conducted in the Gandhinagar district of Gujarat to assess farmers' knowledge of social media in 2021.

**Table 6.** The effect of FMI (% improvement) on form resource management in Iraq (2020–2022)

| Resource                         | 2020 | 2021 | 2022 |
|----------------------------------|------|------|------|
| Water use                        | 18.5 | 22.3 | 25.7 |
| Fertilizer efficiency            | 15.7 | 19.2 | 23.5 |
| Pesticide application efficiency | 14.3 | 17.8 | 21.4 |
| Labor                            | 12.8 | 16.5 | 19.7 |
| energy efficiency                | 10.5 | 13.2 | 16.8 |
| Agricultural adaptation          | 13.7 | 17.5 | 21.3 |

**Source:** Calculated from World Bank [20] and Ministry of Water Resources, Iraq [23].

**Table 7.** Access to agricultural information through digital channels in Iraq (% of farmers), (2015–2022)

| Information Type              | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|-------------------------------|------|------|------|------|------|------|------|------|
| Market prices                 | 18.5 | 22.3 | 27.6 | 34.2 | 41.5 | 48.7 | 54.6 | 59.8 |
| Weather forecast              | 24.3 | 28.5 | 34.7 | 42.3 | 49.5 | 56.8 | 62.3 | 67.5 |
| Pests and disease warning     | 12.6 | 15.8 | 19.4 | 25.6 | 32.5 | 39.2 | 45.7 | 51.4 |
| Technical Agriculture Council | 9.3  | 12.5 | 16.2 | 21.7 | 28.4 | 35.6 | 42.3 | 48.5 |
| Entrance availability         | 7.8  | 10.3 | 13.5 | 18.9 | 25.3 | 32.7 | 39.4 | 45.2 |
| Government schemes/grants     | 5.4  | 7.6  | 10.8 | 15.4 | 21.6 | 27.8 | 34.2 | 40.6 |
| financial services            | 3.2  | 4.8  | 7.3  | 11.5 | 16.8 | 22.7 | 29.5 | 35.8 |

Source: Calculated from FAO [13] and Iraqi Ministry of Agriculture [12].

### 3.7 Challenges and obstacles to the adoption of FMI in Iraq

#### 3.7.1 Basic structure and technical barriers

Table 8 indicates that the poor Internet infrastructure is most often cited the challenge (78.5% farmers), limited technical skills (72.3%) and a high cost of hardware and software (65.7%). These findings match the data of Table 3, which shows that internet coverage in rural areas has improved, they have still reached only 53.2% by 2022. Despite the encouraging increase in the FMIS adoption, important challenges remain. This is what was found by the study conducted in three districts, namely Newai, Malpura and Deoli, of Tonk District, and five villages from each district. The study revealed weak response of farmers to technology, lack of communication, difficulty in language difference and other difficulties including: lack of awareness about the proper functioning of ICT tools (69.33%), lack of training of farmers on the use of different ICT tools (68.00%), insufficient internet supply (67.33%), lack of continuous power supply (66.00%), difficulty in understanding the language of ICT tools content (66.67%), lack of local language to deal with and understand the software (66.67%), poor mobile/internet connectivity in rural areas (66.00%), in addition to some other constraints that the farmers also faced Mahajan and Mahajan [24].

**Table 8.** Major challenges with FMI's adoption in Iraq (2022)

| Challenge  | Percentage of Farmers Indicating This Challenge (%) |
|--|---|
| Poor Internet infrastructure                             | 78.5  |
| Limited technical skills                                 | 72.3  |
| High costs for hardware and software                     | 65.7  |
| Arabic language lacks FMIS solution                      | 61.2  |
| Low awareness of FMIS benefits                           | 59.8  |
| Limited technical assistance                             | 54.6  |
| Available solutions are not suitable for local reference | 48.9  |
| Data Safety and Privacy Problem                          | 42.3  |

Source: Calculated from Central Statistical Organization of Iraq [14] and Food and Agriculture Organization (FAO) [13].

Table 9 suggests that challenges are not evenly distributed across the sizes of the farms. Reporting of early investment costs (such as a significant obstacle) and digital reading skills (81.7%) face many more obstacles when it comes to initial investment costs (83.5%) and digital literacy (81.7%) compared to small farms (5 hectares) respectively. This

suggests that without targeted interventions, the adoption of FMI can increase existing differences between large and small agricultural producers. The results were similar to what Patel and HM [25] had concluded. Smallholders face significant barriers as high initial implementation costs (83.5%) cannot be easily repaid on small land holdings. Furthermore, a lack of security prevents these farmers from accessing digital transformation loans, unlike larger commercial farms that benefit from economies of scale.

**Table 9.** Challenges to Farm Management Information Systems (FMIS) implementation in different agricultural categories (% reporting as significant obstacles) in Iraq (2022)

| Barrier                 | Small Farms (< 5 ha) | Medium Farms (5–20 ha) | Large Farms (> 20 ha) |
|-------------------------|----------------------|------------------------|-----------------------|
| Initial Investment Cost | 83.5                 | 71.2                   | 58.7                  |
| Technical Knowledge     | 78.6                 | 65.3                   | 53.2                  |
| Internet Connectivity   | 72.3                 | 67.5                   | 61.8                  |
| Digital Literacy        | 81.7                 | 62.8                   | 47.3                  |
| Perceived ROI           | 68.9                 | 52.6                   | 39.5                  |
| System Integration      | 42.5                 | 57.3                   | 65.8                  |
| Data Privacy Concerns   | 35.2                 | 42.7                   | 53.6                  |

Source: Calculated from Iraqi Agricultural Research Center [26] and FAO [13].

### 3.8 Cultural and educational factors

Table 8 also states that 61.2% of farmers cited the lack of Arabic language FMIS solutions as an obstacle, while 59.8% indicated low awareness of FMIS benefits. These figures indicate important cultural and educational dimensions of the challenge of adoption. Many internationally developed FMI solutions are not sufficiently localized for the Iraqi context, when it comes to adapting both language and local agricultural practices and conditions.

The data in Table 10 shows a gradual change to locally developed solutions, with the Iraqi software market's ownership interest in 2015 to 45.8% in 2022. This trend suggests a prominent responsibility for the requirements for references and users' solutions that are better adapted to local agricultural systems, language settings and user functions. This is consistent with what was reported in a study in Nigeria [27].

**Table 10.** FMI sources (% market share) in the Iraqi market, (2015–2022)

| Source                          | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---------------------------------|------|------|------|------|------|------|------|------|
| Local Iraqi software            | 15.3 | 18.7 | 22.4 | 26.8 | 31.5 | 35.7 | 41.2 | 45.8 |
| Regional (Middle East) software | 42.5 | 40.3 | 38.6 | 37.2 | 35.8 | 33.5 | 31.7 | 29.6 |
| International software (local)  | 28.7 | 27.5 | 26.3 | 24.8 | 23.1 | 22.5 | 20.8 | 19.3 |
| Open Source Solutions           | 13.5 | 13.5 | 12.7 | 11.2 | 9.6  | 8.3  | 6.3  | 5.3  |

Source: Calculated from Iraqi ICT Market Research Council [28] and Ministry of Science and Technology Iraq [29].

### 3.9 Farm size and Farm Management Information Systems (FMIS) usage patterns

Table 11 analysis of FMIS use frequency reveals interesting patterns that can have implications for use strategies. The daily use of FMI among adopters has increased from 12.3% in 2018 to 34.5% in 2022, which over time suggests the intensive integration of these systems in agricultural management practices. At the same time, the percentage of farmers who use FMI is compared to a monthly 8.2% to 1.2% decrease. When combined with a farm size analysis in Table 9, these patterns suggest that successful FMIS adoption not only requires initial recording but also requires continuous commitment and integration into regular farm management practices. Small farms face several challenges in achieving this level of integration, which potentially limits the benefits they receive when adopting FMIs. In the same context, what was stated in the research conducted by Khodifad and Solanki [30].

### 3.10 Public and private investment trends

Table 12 shows the continuous increase in investment in agricultural information systems in Iraq, which has increased from a total of \$ 8.8 million in 2015 to \$ 43.1 million in 2022. It represents an increase of about five times in seven years. International development assistance has been the largest

**Table 12.** Investment in agricultural information system in Iraq (millions of dollars), (2015-2022)

| Investment Category                  | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|--------------------------------------|------|------|------|------|------|------|------|------|
| Government investments               | 2.3  | 2.8  | 3.5  | 4.7  | 6.2  | 8.5  | 11.3 | 14.6 |
| International development assistance | 5.8  | 6.5  | 7.2  | 8.9  | 10.5 | 12.8 | 15.4 | 18.2 |
| Private sector investment            | 0.7  | 1.2  | 1.8  | 2.5  | 3.8  | 5.2  | 7.6  | 10.3 |
| Total investment                     | 8.8  | 10.5 | 12.5 | 16.1 | 20.5 | 26.5 | 34.3 | 43.1 |

Source: Calculated from World Bank [20] and Ministry of Finance Iraq [32].

### 3.11 Agricultural production trends and farm management information adoption

#### 3.11.1 FMIS relationship between adoption and production versions

Tables 13 and 14 together with FMIS adoption data reveals interesting relationships between using information system and the trend of agricultural production. The total cultivated area in Iraq came up between 2015 and 2022, reaching the peak of 2,792,000 hectares in 2020 before it decreased by 2,590,000 hectares in 2022. However, the production versions for most crops showed more consistent growth, which suggests productivity improvement rather than expanded farms. For example, wheat production increased from 3,150,000 tons in 2015 to 3,850,000 tons in 2022, despite an increase of only 9.6% in agriculture for wheat in the same period. These benefits in land productivity coincide with a rapid FMIS adoption period suggest a possible causal relationship that warrants further investigation. In this regard, in a similar study in Anantapur district of Andhra Pradesh, India, intensive use of information technology at the farm level for

continuous source of investment, although the authorities have shown the most dramatic relative growth (\$ 2.3 million to \$ 14.6 million). Investments in the private sector in 2015, which started with a low base of \$ 0.7 million, have increased to the fastest to reach \$ 10.3 million in 2022. This suggests increasing commercial capacity for agricultural information systems in Iraq. However, the constant dominance of public and international sources of funding indicates that FMIS development in Iraq is very dependent on the auxiliary mechanism that is not the market. The results were similar to those obtained by Shanmuka et al. [31] in a study in Andhra Pradesh, a state that revolutionized information technology, using a random sampling method on a sample of 126 farmers from three districts.

**Table 11.** Farm Management Information Systems (FMIS) uses frequency among adopters in Iraq (% of FMIS users), (2018–2022)

| Frequency           | 2018 | 2019 | 2020 | 2021 | 2022 |
|---------------------|------|------|------|------|------|
| Daily               | 12.3 | 16.5 | 21.7 | 27.8 | 34.5 |
| 2-3 times per week  | 24.6 | 28.9 | 33.2 | 36.5 | 38.7 |
| Weekly              | 32.5 | 30.8 | 27.6 | 23.4 | 18.5 |
| Monthly             | 22.4 | 18.5 | 14.3 | 10.2 | 7.1  |
| Not again and again | 8.2  | 5.3  | 3.2  | 2.1  | 1.2  |

Source: Calculated from Iraqi Ministry of Agriculture [12] and FAO [13].

technology transfer was promoted by Naik et al. [33] and was remarkably close to our results.

### 3.12 Crop-specific Farm Management Information Systems (FMIS) benefits

Productivity difference in Table 6 indicates that FMIS gains are not the same in crop types. While all major crops show sufficient productivity benefits for FMIS users, the magnitude varies from crop to crop. High prices Horticulture crops such as tomatoes and potatoes show particularly strong productivity differences (31.1% and 32.8% respectively in 2022). This can reflect the intensity and time sensitivity of more control over decisions for these crops, which potentially improves the benefits of better information access and management equipment. FMIs in these crop-specific differences have important implications for promotional strategies, suggesting that the high value, initial targeting of management-intensive crops can lead to the most visual benefits and thus accelerate widespread adoption through performance effects.

**Table 13.** Development of cultivated area in Iraq by crop type (in hectares), (2015–2022)

| Year | Wheat     | Barley  | Rice   | Vegetables | Fruits  | Total Cultivated Area |
|------|-----------|---------|--------|------------|---------|-----------------------|
| 2015 | 1,350,000 | 520,000 | 65,000 | 195,000    | 230,000 | 2,360,000             |
| 2016 | 1,285,000 | 485,000 | 61,000 | 201,000    | 233,000 | 2,265,000             |
| 2017 | 1,320,000 | 505,000 | 58,000 | 210,000    | 240,000 | 2,333,000             |
| 2018 | 1,450,000 | 530,000 | 70,000 | 225,000    | 245,000 | 2,520,000             |
| 2019 | 1,580,000 | 550,000 | 85,000 | 240,000    | 251,000 | 2,706,000             |
| 2020 | 1,620,000 | 565,000 | 92,000 | 255,000    | 260,000 | 2,792,000             |
| 2021 | 1,550,000 | 520,000 | 85,000 | 260,000    | 265,000 | 2,680,000             |
| 2022 | 1,480,000 | 495,000 | 75,000 | 270,000    | 270,000 | 2,590,000             |

Source: Calculated from Food and Agriculture Organization (FAO) [26]. Central Statistical Organization of Iraq [14].

**Table 14.** Total agricultural production in Iraq (in tons), (2015–2022)

| Year | Wheat     | Barley    | Rice    | Vegetables | Fruits  |
|------|-----------|-----------|---------|------------|---------|
| 2015 | 3,150,000 | 920,000   | 195,000 | 1,450,000  | 780,000 |
| 2016 | 2,950,000 | 865,000   | 181,000 | 1,520,000  | 795,000 |
| 2017 | 3,050,000 | 890,000   | 174,000 | 1,610,000  | 825,000 |
| 2018 | 3,450,000 | 960,000   | 210,000 | 1,750,000  | 845,000 |
| 2019 | 4,200,000 | 1,120,000 | 255,000 | 1,950,000  | 880,000 |
| 2020 | 4,500,000 | 1,200,000 | 276,000 | 2,150,000  | 920,000 |
| 2021 | 4,100,000 | 1,050,000 | 255,000 | 2,200,000  | 935,000 |
| 2022 | 3,850,000 | 980,000   | 225,000 | 2,320,000  | 955,000 |

Source: Calculated from Iraqi Ministry of Agriculture [12] and Food and Agriculture Organization (FAO) [34].

#### 4. CONCLUSIONS AND RECOMMENDATIONS

This research has assessed the potential and current status of farm management systems (FMI) to increase agricultural productivity in Iraq through extensive analysis of secondary data. Many major conclusions show up: technical solutions should prioritize 'offline-first' mobile applications to address internet instability. On the policy side, the government should introduce cost-sharing programs and digital subsidies specifically for small-scale farmers.

To increase usage, a two-pronged approach is needed: (1) technical: development of "offline-first" mobile applications to reduce Internet instability; and (2) Policy: introducing government-subsidized cost-sharing programs specifically designed for small-scale farmers to ease the financial burden of the digital transition.

#### ACKNOWLEDGMENT

The author is very grateful to the College of Agriculture and Forestry, University of Mosul, Iraq for their provided facilities, which helped to improve the quality of this work.

#### CONFLICTS OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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