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Digital Revitalization of the Agri-food Sector in Mashreq

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Digital Revitalization of the Agri-food Sector in Mashreq

Focus on Iraq, Jordan, and Lebanon

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Acronyms

ACSAD	Arab Center for the Studies of Arid Zones and Dry Lands
AES	Agricultural Extension System
AI	Artificial Intelligence
APSS	Agricultural Prices Statistics System
AUB	American University of Beirut
BdL	*Banque du Liban*
BES	Bees Management System
CAP	Common Agricultural Policy
CBJ	Central Bank of Jordan
CCIAZ	Chamber of Commerce for Industry and Agriculture in Zahle
CEO	Chief Executive Officer
CMI	Center for Mediterranean Integration
CNRS-L	National Council for Scientific Research of Lebanon (*Conseil National pour la Recherche Scientifique*)
CPSS	Cost of Production Statistics System
CREAL	*Centre de Recherches & d'etudes Agricoles Libanais*
CSA	Climate-smart Agriculture
DLT	Distributed Ledger Technology
EO4SD	Earth Observation for Sustainable Development
EPI	E-Participation Index
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FCS	Forestry Centers System
FDI	Foreign Direct Investment
FFV	Fresh Fruits and Vegetables
FLS	Fishing License System
FPO	Farmer Producer Organization
G2B	Government-to-Business
G2C	Government-to-Citizen
G2G	Government-to-Government
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIS	Geographic Information System
GNI	Gross National Income
GPS	Global Positioning System
HACCP	Hazard Analysis and Critical Control Points
IACS	Integrated Administration and Control System
ICT	Information and Communication Technology
ID4D	Identification for Development
IDP	Internally Displaced Person
IFAD	International Fund for Agricultural Development
IHSES	Iraq Household Socio-economic Survey
ILO	International Labour Organization
IoT	Internet of Things
IPR	Intellectual Property Rights
ISIL	Islamic State of Iraq and the Levant

ISO	International Organization for Standardization
ISSF	Innovative Startups & SMEs Fund
ITU	International Telecommunication Union
IVR	Interactive Voice Response
IWMI	International Water Management Institute
JEDCO	Jordan Enterprise Development Corporation
JEGP	Jordan's Economic Growth Plan
JEPA	Jordanian Exporters and Producers Association for Vegetables and Fruits
JoPACC	Jordan Payments & Clearing Company
KEI	Knowledge Economy Index
KYC	Know Your Customer
LARI	Lebanese Agricultural Research Institute
LoRaWAN	Long Range Wide Area Network
LPIS	Land Parcel Identification System
M&E	Monitoring and Evaluation
MENA	Middle East and North Africa
MFI	Microfinance Institution
MoU	Memorandum of Understanding
NCARE	National Center for Agricultural Research and Extension
NDP	Net Domestic Product
NERCITA	National Engineering Research Center for Information Technology in Agriculture
NGO	Nongovernmental Organization
NPTP	National Poverty Targeting Program
NSAD	National Strategy for Agricultural Development
OECD	Organisation for Economic Co-operation and Development
PDS	Public Distribution System
PPSS	Programs and Projects Service System
PRS2	Second Poverty Reduction Strategy
POC	Proof of Concept
R&D	Research and Development
REGEP	Rural Economic Growth and Employment Project
RFID	Radio Frequency Identification
SAT-IRR	Satellite for Irrigation Scheduling
SMEs	Small and Medium Enterprises
SMS	Short Message Service
SPS	Sanitary and Phytosanitary
SuNaR	Sustainable Natural Resource Management Platform and Early Warning System
UN	United Nations
UN-ESCWA	United Nations Economic and Social Commission for Western Asia
UNCTAD	United Nations Conference on Trade and Development
UNECE	United Nations Economic Commission for Europe
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNHCR	United Nations High Commissioner for Refugees
UPU	Universal Postal Union
USAID	United States Agency for International Development
VAT	Value Added Tax
WaPOR	Water Productivity Open-Access Portal
WFP	World Food Programme

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Methodology

This background paper has been informed by a desk-based literature review, secondary data analysis, direct input from the lead and contributing authors, and consultation with private sector experts. Consultation with experts was not exhaustive but based on a purposive sample. The paper defines Mashreq as the region comprising Iraq, Jordan, Lebanon, Syrian Arab Republic, and West Bank and Gaza. The focus of the paper, however, is specifically on Iraq, Jordan, and Lebanon.

Executive Summary

Sustainably developing the agri-food sector in Mashreq countries is of paramount importance for food security, job creation, expanded export potential, and social stability and inclusion. With increased competition for land, water scarcity, and high transportation costs, agriculture in Mashreq will need to shift toward high-value, high-tech, and water- efficient crops and production systems. The Mashreq countries of focus (Iraq, Jordan, and Lebanon) have significant comparative advantage for exporting high-value fresh products to premium markets and expanding water- efficient agricultural production. Stimulating the agriculture sector will also stimulate other economic sectors in all three countries, supporting input supplies, food processing, logistics, and financial services. Supporting agriculture provides an economy-wide multiplier effect. COVID-19 impacts have already had a tremendous negative impact on jobs worldwide, reinforcing calls for revitalizing and rethinking the agri-food sector, including in Mashreq countries.

Digital technologies could create a new momentum for economic development by accelerating the structural transformation process and by supporting the transition toward a more competitive, commercially oriented, and export-oriented agriculture and agri-business sector. Digital technologies, supported by appropriate policies, can raise on-farm productivity, increase resource use efficiency (e.g. water, energy, fertilizers, and pesticides), and build climate resilience through targeted fertilizer application and precision irrigation. E-government can improve the transparency and efficiency of public services by digitizing land tenure mapping and registration, subsidy distribution, weather forecasting, and water resource management. E-extension services can help overcome constraints of traditional extension and provide cost-effective ways of reaching more farmers at lower costs. Access to information can also promote the inclusion of marginalized rural producers in markets. Digital marketplaces for agricultural products can: use e-platforms to directly link producers to consumers, shorten agricultural value chains, provide access to new markets, improve price transparency, reduce food loss, and offer new business opportunities for both small agricultural producers and small and medium enterprises (SMEs). Mobile money, digital credit scoring, and remote sensing can facilitate trade and improve farmers' access to insurance and savings . A range of digital technologies including food sensing technologies, blockchain, and e-platforms can improve value chain transparency and traceability, delivering safer and better quality agri-food products to local and export markets.

Digital agriculture provides opportunities for more diverse and remunerative employment, especially for youth. Yet it requires that users develop new skills. The knowledge base for developing and operating digital technologies could represent new employment opportunities that may be particularly attractive to youth. Modernizing the agriculture sector itself can thus create more productive, skill-intensive, remunerative and competitive jobs in the agri-business sector and along value chains. It can also create new markets for agricultural products. Digital technologies can be designed to enable smallholder farmers to learn and upgrade their skills as they use them. This can encourage inclusion rather than displacement of low-skilled smallholders and help raise their productivity.

Like any major technology change, digital transformation of the agri-food sector also comes with risks that need to be understood and appropriately managed. The risks are associated with: inequality in access and affordability; concentration of market power of e-commerce platforms, social networks, and search engines; data privacy and consumer protection; and cybersecurity. There are equity concerns that using advanced digital technologies in the agriculture sector may widen the digital divide if smallholders are unable to make use of these technologies due to high cost and specialized skills needs. While evidence is scarce, emerging data suggests that increased use of digital technologies in the agriculture sector leads to displacement of manual and low-skilled jobs; hence, people who are less trained and educated are at risk of losing such jobs. Given the relatively low level of education for farmers in the focal countries, this displacement risk is potentially high. Digital innovations should not deepen inequalities for women, youth, refugees, and other vulnerable groups. Therefore, the public sector needs to identify and foster needed skills for widespread use of digital technologies, spanning audiences from small farmers and other vulnerable groups to developers and businesses.

Digital technologies show promise for advancing the digital transformation of the agriculture sector in the three Mashreq countries (Iraq, Jordan, and Lebanon), although their adoption is still at a relatively early stage. In Mashreq, the digital transformation agenda already features prominently in the respective countries' economic and sector development strategies. Indicators measuring Information and Communications Technology (ICT) for the three countries already show promising prospects for advancing digital technologies.

Digital agriculture in Iraq, Jordan, and Lebanon is limited by many factors, including:

- low awareness and understanding of digital technologies and their potential agriculture sector applications,
- limited interest among public and private sector agents,
- a mismatch between the language used by technologies and those understood by farmers, and
- inadequate access to finance and data.

Achieving successful results in Mashreq will require that:

- users have a better awareness of digital applications, and
- digital applications provide timely, localized, and customized information addressing specific farming concerns in a comprehensible format and in Arabic or local languages.

The public sector has an important role in identifying public goods, policies, and investments needed to maximize the societal benefits from digital agriculture in increasing efficiency, equity, and environmental sustainability in agri-food systems. To achieve the development goal of digital transformation, the public sector can facilitate and attract private investment resources by: promoting direct investment; adjusting the regulatory and incentive frameworks for private sector investments; and forming partnerships with the private sector, donors, and nongovernmental organizations. Public action to facilitate digital technologies adoption can contribute through three pathways: developing a vision, then developing the foundation, and providing catalytic investments and policies. The vision should include an aspirational statement and specific targets and actions to foster digital agriculture. The vision can be realized though a national agricultural strategy or a stand-alone e-strategy. Further, digital technologies are only a means to reach development objectives, and adopting these technologies should not be considered as the end goal. They must be accompanied by enabling policies and reforms.

The catalytic investments and policies include establishing e-Government systems for all public services, facilitating the deployment of smart irrigation and fertilizer management systems along with appropriate policies to safeguard overexploitation of natural resources, and fostering digital ecosystem development.

E-Government systems can include: gathering and disseminating statistics relevant to the agriculture sector, creating farmers' digital identification, providing extension services, regulating land tenure and markets, and ensuring delivery of public support payments. While promoting the deployment of smart irrigation and fertilizer management systems, it is important to apply diverse service delivery approaches to enable smallholders to adapt digital technologies. To promote innovation, it is important to invest in platforms for data collection and access from public and private sources. This investment may accelerate the development of appropriate products and services for smallholders and develop a foundation of data for evidence-based policy making. Parallel investments are required in the enabling ecosystem at country, regional, and international levels for developing and supporting incubator and accelerator services targeting start-ups and private sector innovators in the agri-food sector. Lastly, adopting policies on digital privacy, ownership, and data use is essential to safeguard against unintended consequences.

To stimulate the agriculture sector's digital transformation, governments should enable the following digital and non-digital foundations. The digital foundation includes improving the quality of infrastructure and the speed of mobile and internet connectivity in rural areas. Also, reducing the use costs to end users may facilitate broader agriculture sector adoption of digital technologies. This entry point is particularly important in Iraq, where over 8.8 million rural residents lack broadband network connectivity. The non-digital foundation addresses connectivity to markets and power supply constraints of network providers in rural areas. It is difficult to sell products on e-commerce platforms if there are no roads to markets or to sell high-quality fresh foods to online customers if there is no cold storage to preserve their freshness en route to distant markets. Rural electrification through renewable sources can help facilitate rural-based food processing and green growth.

Even though digital technologies can contribute to efficiency, equity, and environmental sustainability, they are only tools that support achieving these development goals. Their success will depend on how broadly Mashreq's agri-food policy frameworks are revitalized. Future extensions of this work should identify the required policy and regulatory reforms to transform the Mashreq's agri-food system toward an inclusive, productive, resilient, and sustainable growth path.

Introduction

Sustainably developing the agri-food sector is of paramount importance for food security, job creation, social stability and inclusion, and expanded export potential in Mashreq countries. However, agricultural production is primarily constrained by water scarcity and inefficient natural resource use, small and fragmented farm structures, weak extension services, limited rural access to finance, and low food safety and traceability standards.

In Mashreq, digital technologies could be harnessed to create a new momentum for inclusive economic development by accelerating the structural transformation process and by supporting the transition toward a more commercially oriented, competitive, and export-oriented agri-food sector. As Mashreq countries have experienced structural transformation, and the relative economic contribution of agriculture has declined, their agriculture sectors have tended to be overlooked as a source of further growth. Because the agri-food sector has a significant unlocked potential, this publication seeks to promote revitalization of agriculture in the Middle East and North Africa, particularly in the three Mashreq countries of Iraq, Jordan, and Lebanon. Specifically, this study seeks to stimulate the discussion on the potential for digital transformation to accelerate agriculture sector modernization and promote public and private investment in the agriculture sector of the Mashreq region, particularly benefitting smallholder farmers, displaced persons, women, and youth. It does so by addressing the following questions:

- How can Mashreq countries take advantage of digital technology innovations to more rapidly transform the agriculture sector toward sustainable agricultural practices and livelihoods?
- How can digital technologies increase agricultural productivity and climate resilience and also increase water use efficiency given increased climate variation and extremes, to access new markets and to make agriculture more inclusive?

This paper considers opportunities for digital agriculture along the agri-food value chain and identifies solutions that can be applied over the medium term. In light of COVID-19 and other pressing challenges, short-term opportunities are highlighted while long-term options and strategies will likely need to be reviewed regularly, given the rapid pace of change in digital technologies.

This background paper is organized as follows: Chapter 1 documents the current contributions and challenges of the agri-food sector within selected Mashreq countries—Iraq, Jordan, and Lebanon—across a range of economic, social, and environmental dimensions. Chapter 2 introduces the concept of digital agriculture and illustrates the potential application of digital technologies in agriculture in the Mashreq region. Next, Chapter 3 presents the digital ecosystem in the three focus countries, which lays the foundation for future digital transformation, and illustrates the current status of digital agriculture in the Mashreq region. The chapter then explores the current status of digital technologies in the agriculture sector of the three focus countries. The background paper gathers relevant knowledge and perspectives on digital technology innovations in agriculture from a range of stakeholders (farmers' organizations, private sector, research institutions, and so on). Finally, Chapter 4 presents the public policy options to facilitate the digital acceleration of agricultural transformation in the selected Mashreq countries. The objective of this background paper is to inform policy making and contribute to building political momentum that supports the context-based digital transformation of agriculture in the respective countries. Therefore, it is addressed to government policy makers, private sector and business stakeholders, the innovation and academic community, civil society institutions, and farmers and their associations.

Chapter 1
The State of Agri-food Systems Opportunities and Challenges

Key Messages

- Sustainably developing the agri-food sector is of paramount importance for food security, job creation, expanded export potential, and social stability and inclusion.
- The agri-food sector has untapped potential exports that can decrease dependence on food imports and increase foreign currency inflows.
- The agriculture sector stimulates other economic sectors, including input supplies, food processing, logistics, and financial services, and can have an economy-wide multiplier effect.
- COVID-19 impacts have reinforced calls for revitalizing and rethinking the agriculture sector.

Chapter 1
The State of Agri-food Systems - Opportunities and Challenges

This chapter introduces the contribution and importance of the agri-food sector for jobs, exports, multiplier effects on the economy, and social stability and inclusion in Mashreq countries. It also introduces the unique role of agriculture in diverse post-conflict contexts. It lays the groundwork for the potential contribution of a new, digitally empowered agricultural strategy for economic growth and food security.

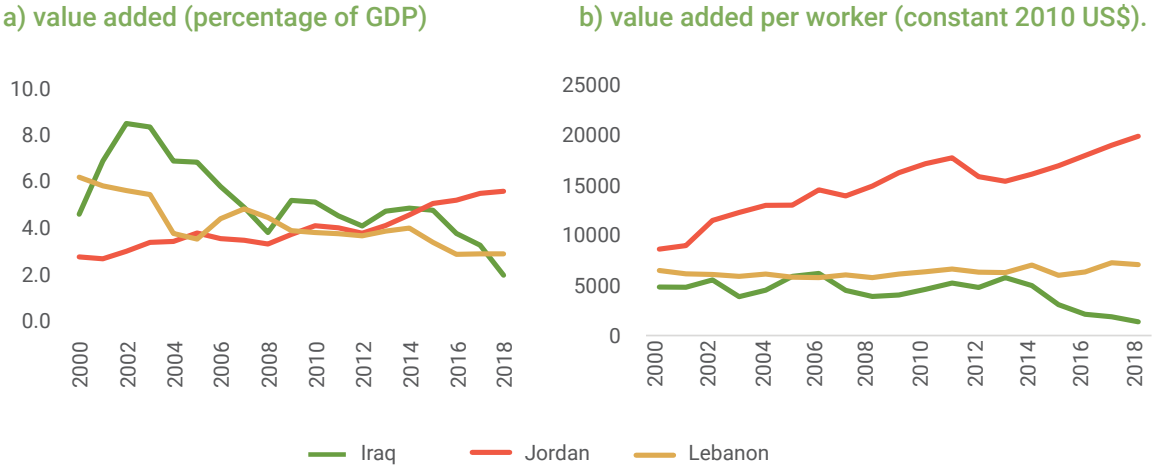
Economic Dimensions

Agriculture and food production are important for the economies of Mashreq countries and have large potential for expansion. Although primary agriculture contributes only a small share of gross domestic product (GDP) (Iraq 1.5 percent, Jordan 4.9 percent, and Lebanon 3.1 percent in 2019), the broader agri-food sector contributes to a higher share of GDP. For example, in Jordan, it contributes to 26–28 percent of GDP when the related value chain activities are included (Netherlands Enterprise Agency 2016). Agriculture's share of GDP in Iraq and Lebanon is below the 2018 average of 4 percent for the Middle East and North Africa countries, while Jordan slightly exceeds the regional average (World Bank 2020c). The relative share of agricultural GDP has risen only in Jordan over 2011–2018 compared to the previous decade (2001–2010) (from 3.5 to 4.8 percent) (Figure 1a), and Jordan also shows a positive growth in labor productivity (Figure 1b).

In the three countries, the agri-food sector could help build a more resilient and diversified economy and reduce reliance on more volatile sectors such as oil, finance, and real estate. Agricultural productivity has large potential for expansion in these countries. For example, projections indicate that achieving Iraq's net domestic product (NDP) yield targets for fruits and vegetables, livestock, and cereals would lead to a 27 percent increase in agriculture GDP in the short to medium term (average annual increase in agricultural GDP of 4.9 percentage points) and would increase both rural and urban household incomes, even more so for female-headed households (World Bank 2019i). Building a resilient agri-food sector has paramount importance for avoiding the devastating impacts of short-term economic shocks such as COVID-19 and longer-term impacts from climate change.

Figure 1. Contributions of agriculture, forestry, and fishing to GDP

Source: World Bank national accounts data, Organisation for Economic Co-operation and Development (OECD) national accounts data files, and employment data from International Labour Organization, ILOSTAT database.



➔ **Box 1.** Agricultural Production Systems

Iraq

Agriculture occupies one-fifth of the land in Iraq, and multiple farming systems are present. Agricultural land occupied 21.4 percent of all land area in Iraq in 2016, below the Middle East and North Africa average (33.3 percent of all land area). In absolute terms, agriculture occupied 93,000 km² in 2016. Irrigated farming systems dominate between the Tigris and Euphrates Rivers; the northwest is a combination of pastoral, dryland mixed, and rain-fed mixed farming systems; and highland mixed farming systems are found along the border with Iran (Lewis, Monem, and Impiglia 2018). Today, more than 80 percent of farms are less than 10 ha in total area, with plots nonadjacent in their location.

Iraq's leading agricultural products include cereals, fruits, vegetables, and livestock. Wheat and barley are the chief cereal crops and account for one-third of national cereal production (FAO 2018a); they are farmed primarily in the northern and central rain-fed areas of the country (Al-Haboby *et al.*, 2016; Lucani, 2012). Prices for locally produced grain have been reduced as a side effect of the national food basket subsidy program that relies on imported foodstuffs (Lucani 2012). The main crops produced on the largely irrigated land are rice, dates, cotton, vegetables, fruits, legumes, and alfalfa (FAO 2018a; Lewis, Monem, and Impiglia 2018; Lucani 2012). Raising livestock—notably cattle, goats, and sheep providing meat, wool, milk, and skins—is widespread among farming households, representing one-third of the total value of agricultural production. The country's food processing sector is small in comparison to primary agricultural production (Al-Haboby *et al.* 2016). The yields of the agriculture sector fall below international comparators as a result of prolonged conflict, international economic sanctions, insufficient infrastructure for input production, deteriorated research and extension services, and droughts (Al-Haboby *et al.* 2016). Iraq lost about 40 percent of its agricultural production after the Islamic State of Iraq and the Levant (ISIL) took control of some of the country's most important agricultural areas in 2014.

Jordan

Agriculture occupies a minor share of the land area in Jordan, and the major agricultural products include vegetables, fruits, and roots and tubers. Agricultural land occupied only 12.0 percent of all land area in Jordan in 2016, below the Middle East and North Africa average (33.3 percent of all land area). In absolute terms, agriculture occupied 10,660 km². The production volumes have at least doubled between the 1960s and 2010s, largely due to yield improvements. In contrast, the production of cereals and pulses has declined in volume over the same period, as the area devoted to the production of these crops has fallen (World Bank 2018a). Vegetables are produced primarily in irrigated areas of the Jordan Valley and to a lesser extent in the eastern plains. Citrus and palm trees are grown under irrigation in the Jordan Valley. Stone fruits and grapes are mainly grown in the northeastern areas of the country under irrigation. Olive trees comprise a major share of all trees grown (72 percent), though only a minor share of these are irrigated (38 percent) (Department of Statistics 2017a). Jordan is self-sufficient in the production of vegetables, citrus, olives and olive oil, goat meat, poultry, table eggs, and fresh milk (Jordan Investment Commission 2017).

The livestock subsector dominates the vast rangeland agroecological zones. Small ruminants, including about 3.4 million head of sheep and 0.8 million head of goats, account for about 35 percent of this total; broilers and cattle milk are also highly valuable. The livestock sub-sector employed 50,300 individuals in 2017, primarily of household members (69 percent), followed by permanent employees (25 percent), casual employees (5.2 percent), and finally, seasonal employees (<1 percent).

Lebanon

Agriculture occupies a majority of the land area in Lebanon. Agricultural land occupied 64.3 percent of all land area in Lebanon in 2016. Accordingly, Lebanon exceeded the Middle East and North Africa average (33.3 percent of all land area). In absolute terms, agriculture occupied 6,580 km² in 2016. The majority of Lebanon's cropland (54 percent) is irrigated (Lebanese Ministry of Agriculture, 2016).

Lebanon's major agricultural products by volume include fruits, vegetables, and roots and tubers (World Bank 2018a). Major crops include potatoes, citrus fruits, apples, grapes, and bananas (IDAL 2017). The production of livestock and animal products is also important and rising in Lebanon in recent decades (IDAL 2017). Animal production represents one of the main activities in rural Lebanon, particularly the southern and northern areas that have the highest rates of poverty in the country, with approximately 60 percent of farmers depending on dairy production as a primary means of subsistence (CNRS-L, FAO, and Lebanese Ministry of Agriculture 2018). While the cultivation of cannabis is illegal, it is significant in the central and northern Bekaa Valley in area cultivated (estimates range from 20,000 ha to 30,000 ha), as a source of demand for irrigation water, and as a contribution to agricultural livelihoods.

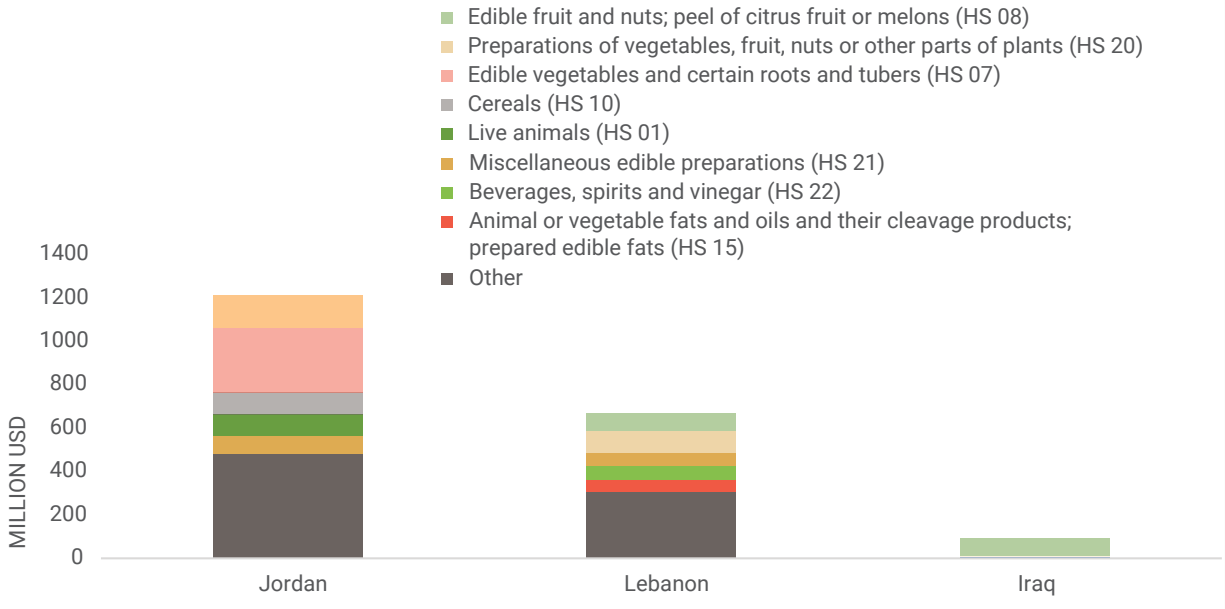
The agriculture sector can be a catalyst for job creation and stability given the current economic challenges and social instability in Mashreq countries. Agriculture is a labor-intensive sector and has a relatively strong long-term value-added elasticity of employment in the Middle East and North Africa region. For every percentage point of growth in the value added of the agriculture sector, employment increased by 0.36 percentage points (while the corresponding employment increases for industry and service sectors were 0.30 and 0.20 percentage points, respectively) (World Bank 2018a). In 2019, the agricultural labor force accounted for 18.1 percent of total employment in Iraq and 13.6 percent in Lebanon but only 3.0 percent in Jordan. Jordan reported the highest agricultural labor productivity (b). Only Iraq's agricultural labor force exceeded the corresponding Middle East and North Africa average (15.8 percent). However, the damage from conflicts has had a devastating impact on employment in Iraq. It is estimated that the agri-food sector in Iraq has the potential to add over half a million jobs to the economy in the short run and about 2.5 million jobs over the medium term (5–10 years) (World Bank 2019i). This potential can have significant impacts, including for improved livelihoods and poverty reduction. Jobs are created in the production stage and also all along the value chain, including in processing, packaging, and distribution, and related sectors such as services, transport, and communication. Already, the overall agri-food sector contributes to the livelihoods of about a quarter of the population in Jordan, Lebanon, and Iraq (UN-ESCWA 2017). Poverty is especially found in rural areas with households depending on agriculture as their primary source of income.

Modernizing the agriculture sector requires developing new skills that can provide opportunities for more diverse and remunerative employment. Agriculture is also less capital intensive than many other sectors, so it offers investment opportunities to small- and medium-scale entrepreneurs who may not be able to enter other sectors dominated by larger companies. This also creates opportunities for large capital investors, which would result in even higher multiplier effects. In all three countries, agriculture has been independently identified as a key driver of growth (Iraq Economic Monitor by the World Bank, 2019; Jordan Elements of a Growth Strategy by Harvard University, 2019; and Lebanon Economic Vision by McKinsey, 2018).

The agriculture sector also stimulates other economic sectors, including input supplies, transport, food processing, logistics, and financial services, and can have an economy-wide multiplier effect. Agricultural growth multipliers are estimated between 1.3 and 1.8 in developing countries, suggesting strong potential for agriculture sector investment to trigger wider economic growth (Haggblade, Hammer, and Hazell 1991; Haggblade, Hazell, and Dorosh 2007). For example, in Jordan, US$1 invested in agriculture adds close to a US$4 value to the economy, compared to a return of US$1.3 in industry and US$0.5 in service sectors (World Bank 2018a). Multiplier effects are higher in economies or sectors with more unemployed resources, as idle resources can be utilized with less disruption than in situations when employed resources must be reallocated from their current use (GAO 1984). For employment and

➔ Figure 2. Leading Agricultural and Food Exports by Value (US$, millions), 2018

Source: ITC 2019.



labor demand, the multiplier effect operates as follows: productivity growth in agriculture accumulates additional purchasing power among rural families expanding job opportunities in off-farm sectors and thereby releasing labor to non-farm sectors (Yeboah and Jayne 2018). The multiplier effect of agriculture on the wider economy indicates that it is powerful in stimulating wider economic growth and in generating employment.

Food comprises a minor share of merchandise exports from the focus countries, though Jordan and Lebanon far exceed exports compared to Iraq. The top five categories of agricultural and food exports by value are presented in Figure 2. Food exports accounted for an average of 20.1 percent of merchandise exports from Jordan over 1998–2017 and 21.1 percent in Lebanon but only 0.2 percent in Iraq, compared to a Middle East and North Africa regional average of 2.7 percent for the same period (World Bank 2020c). The limited contribution of food to total merchandise exports in Iraq is explained by the high dependence on high-value oil exports from the country. Agricultural and food exports in Jordan are significantly higher in absolute value terms than in either Lebanon or—especially—Iraq. Jordan's agricultural and food exports were valued at more than US$1 billion in 2018, Lebanon's at about US$665 million, and Iraq's at US$91 million. In Jordan, the top five categories of agricultural and food exports by value in 2018 were edible vegetables, roots, and tubers; edible fruits and nuts; cereals; live animals; and miscellaneous edible preparations (ITC 2019). Lebanon's top five categories of agricultural and food exports by value in 2018 were preparations of vegetables, fruit, or nuts; edible fruits and nuts; beverages, spirits, and vinegar; miscellaneous edible preparations; and animal or vegetable fats and oils (ITC 2019). The top five categories of Iraq's agricultural and food exports by value in 2018 were edible fruits and nuts; preparations of vegetables, fruit, and nuts; sugars and sugar confectionery (HS 17); meat and edible meat offal (HS 02); and dairy products, eggs, honey, and edible products of animal origin (HS 04) (ITC 2019).

Mashreq countries have significant comparative advantage for exporting high-value fresh products to premium markets. Jordan and Lebanon have an estimated potential to increase exports of strawberries, tomatoes, herbs, potatoes, and other fresh fruits and vegetables by US$1 billion and US$0.6 billion, respectively. Both countries can build on existing trade agreements with Europe. The Jordan Valley, with its exceptional climate at 300 m below sea level, is uniquely suited for production and export of early season fruits and vegetables to Europe and the Gulf markets. Potential food exports from Iraq also include fruits, vegetables, meat, and dairy products (Lucani 2012). Dates represent Iraq's second source of exports after oil (Schnepf 2004), and the country could take advantage of a fast-growing global demand. Unlocking agriculture's export potential would help reduce the high dependence on food imports. Expanding agri-food exports can also increase foreign currency inflows, which would be especially welcome in Lebanon where foreign currency is scarce.

Trade in agricultural and food exports of the focus countries is generally concentrated within the Middle East and North Africa region, which is the most common current destination for agricultural and food exports by value (based on most recent data available from 2018). While Iraq's largest export categories were destined for countries in Mashreq and the Maghreb, Jordan's trade geography is more specifically in the Gulf countries. Lebanon's exports appear to be the least concentrated within the Middle East and North Africa region, with major export destinations in North America and Europe (ITC 2020).

Opportunities exist to increase production to meet the growing domestic demand driven by population growth and changing diet patterns. The Mashreq countries of focus are all net agricultural importers. Available data for 2017–19 indicate that Iraq, Jordan, and Lebanon are all net importers of agricultural and food items, based on value (ITC 2020). These countries import at least 50 percent of the food calories they consume (Lampietti *et al.* 2011), and this is projected to increase in all three countries due to population growth and changing dietary patterns. For example, Iraq imports more than 80 percent of its food needs, including cereals, meat, refined sugar, cooking oil, canned and processed foods, fruits and vegetables, dairy products, dried fruits and nuts, and fruit juices (FAO 2018a). Agricultural and processed food imports comprise 30 percent of the total import bill in Iraq (World Bank 2019i). There is potential for Iraq's local agricultural producers to replace imports and reduce the cost of imported food, particularly horticultural and animal products (FAO 2018a), for the large and growing domestic market. Yet, there are challenges to unlocking the economic potential in the focus countries due to credit constraints, poor integration of input and output markets, missing insurance markets, weak infrastructure, and suboptimal agricultural practices and management.

Social Dimensions

Supporting the agri-food sector could help close the gaps related to food and nutrition security in the focus countries, which lag behind Middle East and North Africa regional averages on multiple indicators. Undernourishment affected approximately 29.0 percent of Iraqis, 12.2 percent of Jordanians, and 11.0 percent of Lebanese as of 2016–18, versus a regional average of 9.7 percent (Figure 3). Simultaneously, around a third

of adults in Iraq (27.4 percent), Jordan (33.4 percent), and Lebanon (31.3 percent) were obese, exceeding the regional average (27.2 percent) (FAO *et al.* 2019). The agri-food sector could play an important role in improving these outcomes by increasing incomes through agricultural development and redirecting support to more nutritious agricultural products (such as fruits and vegetables), actions which could enhance food and nutrition security (World Bank 2019i).

Farmers and agricultural operators in Lebanon and Jordan tend to be older adults, and this population is ageing. In Jordan, as of 2017, farmers ages 45 years or older controlled 75 percent of all agricultural holdings and 83 percent of all agricultural land; farmers ages 55 years or older controlled 47 percent of agricultural holdings and 55 percent of agricultural land. Young farmers under the age of 35 controlled only 4 percent of all landholdings and only 6.7 percent of agricultural land (Department of Statistics 2017b). In Lebanon, the average agricultural operator was approximately 52 years old, while female agricultural operators were an average of 55 years old. Younger adults under the age of 35 represented only a minor share (11.1 percent) of all operators and operated a similar share of the total utilized agricultural area (12 percent). The figures are more extreme for farmers under 25 years, who comprise only 2 percent of agricultural operators and use 1 percent of the total agricultural area (Lebanese Ministry of Agriculture 2012). No comparable information is available for Iraq.

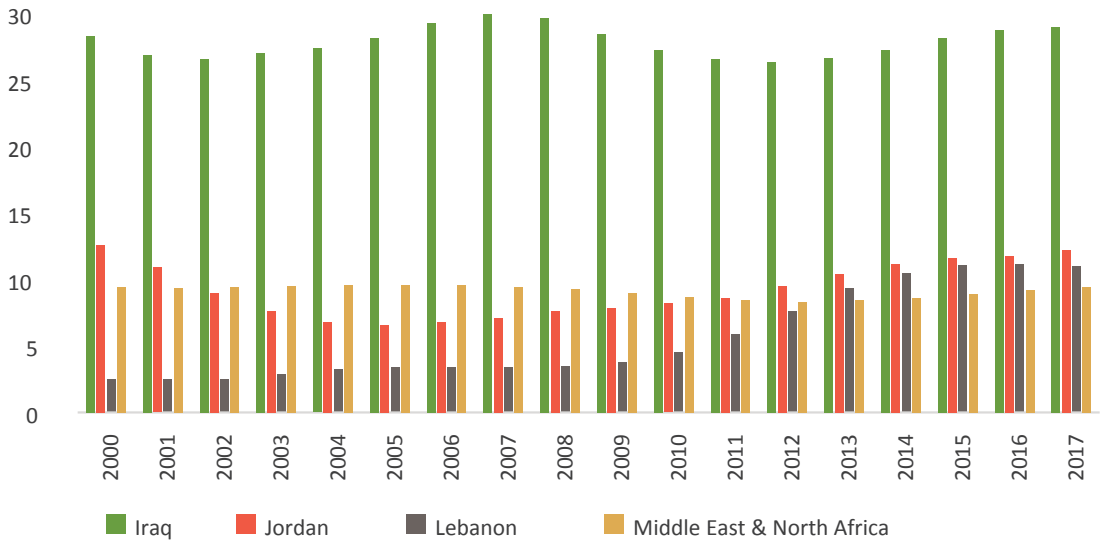
Female labor force participation in agriculture in Mashreq exceeds female ownership of agricultural assets. In Iraq and Lebanon, women are more heavily employed in agriculture than men, while the inverse is true in Jordan. However, women's employment in agriculture tends to be both informal and seasonal. Female empowerment is further undermined by women's limited ownership of productive assets, estimated at 5 percent of all agricultural assets in Mashreq countries. The distribution of agricultural land reveals gender disparities, with female farmers systematically controlling smaller parcels of land than male farmers in both Jordan and Lebanon (Bahn, Tell, and Zurayk 2019; Lebanese Ministry of Agriculture 2012). In Jordan, approximately 6 percent of landholdings by number are controlled by female farmers (2 percent of landholdings by area), while in Lebanon, women control 8.6 percent of farms (4 percent of the country's utilized agricultural area). Furthermore, female-headed households comprise a minority of households in Iraq, Jordan, and Lebanon. Latest available figures are estimated at 26.2 percent in Iraq (Iraq Household Socio-economic Survey [IHSES]); 12.9 percent in Jordan (2012 figure) (World Bank 2020c); and 18.5 percent in Lebanon (2018–2019 figure) (CAS *et al.* 2020).

The countries of the Middle East and North Africa region hosted a significant number of displaced persons by the end of 2016, and Iraq had among the highest levels of internal displacement in the region (Table 1). Lebanon and Jordan were among the Middle East and North Africa countries hosting the largest numbers of displaced persons as a result of conflicts in Iraq, Syria, and West Bank and Gaza. Most displaced people came from Syria.

With appropriate enforcement of social protections, agriculture can play a critical role in reducing poverty and vulnerability by employing poor and marginalized populations, including migrants, refugees, and other displaced people. Most displaced persons in Jordan and Lebanon work in agriculture with low wages and precarious working conditions. Jordan's agriculture sector accounted

➔ Figure 3. Prevalence of Undernourishment (Percentage of Population)

Source: FAO *et al.* 2019.



➔ **Table 1**. Refugees and Internally Displaced Person (IDPs) due to conflict and disaster

Country	Total Number of Refugees by Country of Asylum (2016)	Total Number of Refugees by Country of Origin (2016)	Total Number of IDPs Due to Conflict and Violence (2018)
Iraq	261,864	316,063	1,962,000
Jordan	685,197	1,933	—
Lebanon	1,012,969	4,740	11,000

Source: UNHCR 2017 and IDMC 2019.

for nearly 48 percent of all work permits for displaced Syrians from 2016 to 2019, making it the second-largest employer among all sectors (Ministry of Labour 2020). In Lebanon, agriculture is the second-highest employer of displaced and working Syrians (17 percent of those who have a regular job, second only to the construction sector); this figure was reported at 27 percent among children ages 5–17 in 2019, though agricultural employment changes over agricultural seasons (UNHCR, UNICEF, and WFP 2019). Lebanese adult men earn agricultural wages that are 34 percent higher than those paid to Syrian men in Lebanon, and wages paid to Syrian men are significantly higher than wages paid to women and children (Syrian or Lebanese) (FAO and UNICEF 2019). In Iraq, agriculture is critical to the resettlement of IDPs: 47 percent of people returned to rural areas, where agriculture, farming, and animal husbandry rank in the top three sources of income (IOM 2019). Evidence shows that more people have been returning to areas where agriculture, livestock, and market activities around agriculture were resumed. With the right investment and appropriate enforcement of social protections, agriculture can unlock progress toward social inclusion and reduce vulnerability.

The high degree of informality in the agriculture sector of the three focus countries currently limits access to social protections. In Lebanon, for example, the agriculture sector is almost completely informal, with an estimated 92 percent of agricultural producers working without explicit and registered work contracts (Ajluni and Kawar 2015). The high degree of informality means that social safety net programs often exclude farmers and others working in the agriculture sector. Indeed, in Lebanon, social protection services guaranteed under the national labor law and the National Social Security Fund are not available to farmers or informal workers, many of whom are women.

Environmental Dimensions

Water scarcity is often perceived as a limiting factor for agricultural expansion in Mashreq countries. The agriculture sector is the single largest user of total water withdrawals in Iraq and Jordan (Table 2, column 1) but not in Lebanon (where industry accounts for greater withdrawal). An alternative metric is agricultural water use as a share of total renewable water resources (Table 3, column 2). This share is the highest in Jordan and the lowest in Lebanon (FAO 2016). Some 43 percent of cropland in the Mashreq countries is irrigated (RICCAR 2017). Though water is a scarce resource, agricultural water use efficiency remains very low in the three focus countries (Table 3, column 3). Iraq's agricultural water use efficiency in 2015 was reported at US$0.1 per m^3, behind that of Jordan (US$0.7 per m^3) and Lebanon (US$1.2 per m^3) (FAO 2018b). For comparison, the highest water use efficiency is reported in the Netherlands (US$55.3 per m^3). While water scarcity may be a challenge at the national level, individual farmers may not worry about scarcity if

➔ **Table 2.** Agricultural water withdrawal and water use efficiency

	Agricultural Water Withdrawal		Water Use Efficiency	
	As % of Total Water Withdrawal	As % of Total Renewable Water Resources	Agricultural Water Use Efficiency in US$/$m^3$ (Global Average of 1.1)	Total Water Use Efficiency in US$/$m^3$ (Global Average of 15)
Iraq (2016)	91.49	39.25	0.1	1.3
Jordan (2016)	53.13	59.20	0.7	26.5
Lebanon (2015)	38.04	15.55	1.2	23.3

Source: FAO 2016.

they can access sufficient water by using groundwater resources, even though these resources are threatened by over extraction and declining quality. Modern technologies can improve water use efficiency and productivity; however, they need to go hand in hand with policies which will restrict over extraction and environmental rebound effect.

Expanding agricultural production and exports needs to recognize water scarcity and to sustainably use scarce natural resources, specifically blue (irrigation) water. The EAT-Lancet Commission has strongly recommended against expanding irrigated agriculture within the Tigris-Euphrates watershed since excessive water use has already led to declining water tables and soil salinization (Willett *et al.* 2019). Yet, modern technologies such as drip irrigation and hydroponics can multiply water productivity, allowing farmers to produce more with less water. Also, balancing competing demands for water and food by growing populations will be essential

Water pollution and substandard water infrastructure are restricting governments from meeting the agriculture sector's water demands. In Lebanon, most wastewater is discharged into watercourses and the sea without any treatment. Few industries pretreat their effluent, so harmful waste is discharged into the sewer system or the environment. Bacteriological contamination is affecting the water resources in agricultural areas, and the runoff and infiltration of fertilizer and pesticide residues further degrades these water resources.

Unsustainable use of agricultural inputs including fertilizers, pesticides, and herbicides is damaging the current export potential and long-term sustainability of agriculture. Lebanon, for example, reports higher levels of fertilizer use than countries with similar agroclimatic conditions. Fertilizer overuse can reduce yields over the long term. Excessive and inappropriate (ill-timed) application of pesticides reduces the quality of production and limits exports to markets that impose strict food safety and sanitary and phytosanitary (SPS) standards. The absence of a robust public extension service and farmers' de facto reliance on private sector input providers contribute to this overuse (McKinsey 2018).

Arable land is another key limitation to agriculture in Iraq, Jordan, and Lebanon and is threatened by desertification. Declining soil fertility is a pervasive problem for agriculture in Mashreq. For example, in Iraq, widespread desertification affects 75 percent of the nation's land and has resulted in the loss of about 100,000 km² of arable land annually, forcing many Iraqis to abandon their land (Gibson 2019). Declining soil fertility, high soil salinity, erosion, and expanding sand dunes are serious problems for agriculture (IAU 2012). While recent figures are not available for Jordan, most of Jordan's arid and semiarid areas suffer from desertification (Al-Alawi 2007). Al-Alawi (2007) reports that 79.6 percent of Jordan's land was desertified and another 11.2 percent is vulnerable to desertification. In Lebanon, desertification affects an estimated 40 percent of all land (Darwish *et al.* 2012).

Climate change is already affecting Iraq, Jordan, and Lebanon. It has especially affected and will continue to affect temperature and precipitation patterns, raising the risk of extreme weather events including droughts, floods, and heat waves. The average temperature in the Middle East and North Africa region is expected to increase by up to 4.8°C by 2100, with a higher rate of warming in summer than winter. Total precipitation is projected to decline in the Mediterranean area and the upper Tigris and Euphrates Rivers (Lewis, Monem, and Impiglia 2018). Droughts will become more frequent and more intense due to biodiversity loss and lower soil moisture, both linked to climate change (Bocci, Smanis, and Gaaloul 2019).

Climate change will directly affect agriculture and worsen the existing challenges the agriculture sector is facing by undermining rural livelihoods and potentially leading to more fragility, displacement, and tensions. The expected impacts across farming systems in Iraq, Jordan, and Lebanon are presented briefly in Table 3. Changes in agroclimatic conditions may include higher temperatures during the growing season, more days above threshold temperatures and during key plant development times, longer dry seasons, unpredictable rainfall, saltwater infiltration due to sea-level rise, decreased groundwater recharge, reduced surface water flows, and lower soil moisture and soil carbon (Lewis, Monem, and Impiglia 2018). Crop yields in Middle East and North Africa could fall by 10–20 percent by 2050 under worst-case scenario models (Lewis, Monem, and Impiglia 2018). Traditional crops such as wheat, olives, and grapes are particularly affected by the higher temperatures and increased water stress associated with climate change (Bocci, Smanis, and Gaaloul 2019). Livestock productivity will fall due to less available animal feed, increased animal heat stress, and a higher risk of infection and disease (Lewis, Monem, and Impiglia 2018).

Climate change will disproportionately affect small-scale farmers. According to the Global Commission on Adaptation (2019), without adaptation, there may be significant production declines since "climate change may depress growth in global agriculture yields by up to 30 percent by 2050 with the strongest impacts on small farms." Small-scale farmers are already among the poorest and most marginalized in Mashreq. Small-scale farmers directly depend on the climate and natural resources for their livelihoods but generally have less access

➔ **Table 3.** Exposure to climate change and expected impacts across farming systems in Iraq, Jordan, and Lebanon

Farming System	Exposure	Impact/Sensitivity
Irrigated	✓ Increased temperatures ✓ Reduced supply of surface irrigation water ✓ Reduced groundwater recharge	✓ Greater stress on water resources ✓ Increased demand for irrigation and water transfer ✓ Reduced yields when temperatures too high ✓ Salinization from reduced soil leaching capacity ✓ Reduced cropping intensity ✓ Reduced crop yields linked to soil erosion, floods, sea-level rise (Shatt al-Arab/Arvand Rud)
Highland mixed	✓ Increase in aridity ✓ Greater risk of drought ✓ Possible lengthening of growing period ✓ Reduced supply of irrigation water	✓ Reduced yields ✓ Reduced cropping intensity ✓ Increased demand for irrigation
Rain-fed mixed	✓ Increase in aridity ✓ Greater risk of drought ✓ Reduced supply of irrigation water	✓ Reduced yields, especially olive and dairy milk ✓ Reduced cropping intensity ✓ Increased demand for irrigation
Dryland mixed	✓ Increase in aridity ✓ Greater risk of drought ✓ Reduced supply of irrigation water	✓ Reduced yields, especially wheat and barley ✓ Vulnerability to declining rainfall ✓ Transformation/reversion of agricultural land to rangeland ✓ Increased demand for irrigation ✓ Increased emphasis on barley production (despite reduced yields) ✓ Increased soil erosion
Pastoral	✓ Increase in aridity ✓ Greater risk of drought ✓ Reduced water for livestock and fodder	✓ Reduced carrying capacity because of desertification ✓ Adoption of non-farm activities, exit from farming, and migration

Source: Adapted from Bocci, Smanis, and Gaaloul 2019 and Lewis, Monem, and Impiglia 2018.

to resources, markets, extension services, and social protection systems than larger farmers. This makes them more vulnerable to the effects of climate change and more susceptible to pressures to migrate out of agriculture and rural areas. On- and off-farm livelihood diversification may be needed to offset the loss in production and income. This diversification will affect on-farm gender dynamics, increasing the role and responsibilities of women, as men more frequently pursue off-farm employment, including via migration. These shifting family and social structures may also increase reliance on child labor (Lewis, Monem, and Impiglia 2018).

Adapting to climate change in the agriculture sector and promoting climate-smart agriculture (CSA) practices may yield economic, social, and environmental benefits. CSA is an integrative approach to address the interlinked challenges of food security and climate change. It explicitly aims to (a) sustainably improve agricultural productivity, increase farm incomes, strengthen food security, and promote development in an equitable manner; (b) adapt and build the resilience of agricultural and food security systems to climate change at multiple levels; and (c) reduce and/or remove greenhouse gas (GHG) emissions from agriculture whenever possible. According to the Global Commission on Adaptation (2019), "Investing in adaptation, and in the innovation that comes with it, . . . can provide a triple dividend: it avoids economic losses, brings positive gains, and delivers additional social and environmental support.". The return on investment in resilience to climate change is high and positive, estimated from 2:1 to 10:1. Promising areas for investment include early warning systems, climate-resilient infrastructure, and improved dryland crop production. Moreover, efforts to improve water allocation to more efficient uses could, even under conditions of climate change, yield better economic performance (Global Commission on Adaptation 2019). Furthermore, climate-smart practices can provide low-cost mitigation opportunities since the agriculture sector is also a significant source of GHG emissions.

Common Challenges to the Agri-food

Sector in Iraq, Jordan, and Lebanon

The common challenges that face the agri-food sector in Iraq, Jordan, and Lebanon are found at the farm level and extend throughout the value chain, with disproportionate effects on small farmers. The key challenges in farming outlined in Table 4 may have disparate and disproportionate impacts on different types of farmers, mainly smallholder farmers as opposed to larger, commercial farmers. Farms are often small and land parcels are fragmented, making it hard for farmers to achieve economies of scale.

Over 80 percent of both Jordan's and Lebanon's total number of agricultural landholdings are small farms of less than 2 ha. They make up only 14 percent of Jordan's total agricultural area but 33 percent in Lebanon. Figure 4 presents this distribution of farms in terms of total number and total area in Jordan and Lebanon; no comparable data are available for Iraq. The prevalence of smallholders, who are often nonprofessional and noncommercial, creates logistical complexities, increases transportation costs, and raises overall cost of production. Smallholder farmers are more likely to follow out-of-date agricultural practices, decreasing their resilience to climate and other shocks. This highlights the importance of access to quality public extension services. Small-scale farms have limited capacity to know about or invest in modern farming technologies. They are also poorly positioned to access markets, and when they do, they have weak bargaining power, as the links between agri-businesses and producers are weak. Distorted quality-price relationships discourage farmers from improving the quality of agricultural products. Smallholder farmers face additional challenges in reaching higher-value export markets. They need to overcome quality and food safety issues, yet they also tend to produce smaller volumes, which raises their transaction costs and offers less scope for them to cover their investment costs. Given their different starting points, smallholder and larger, commercial farmers also have different potentials for adopting digital technologies.

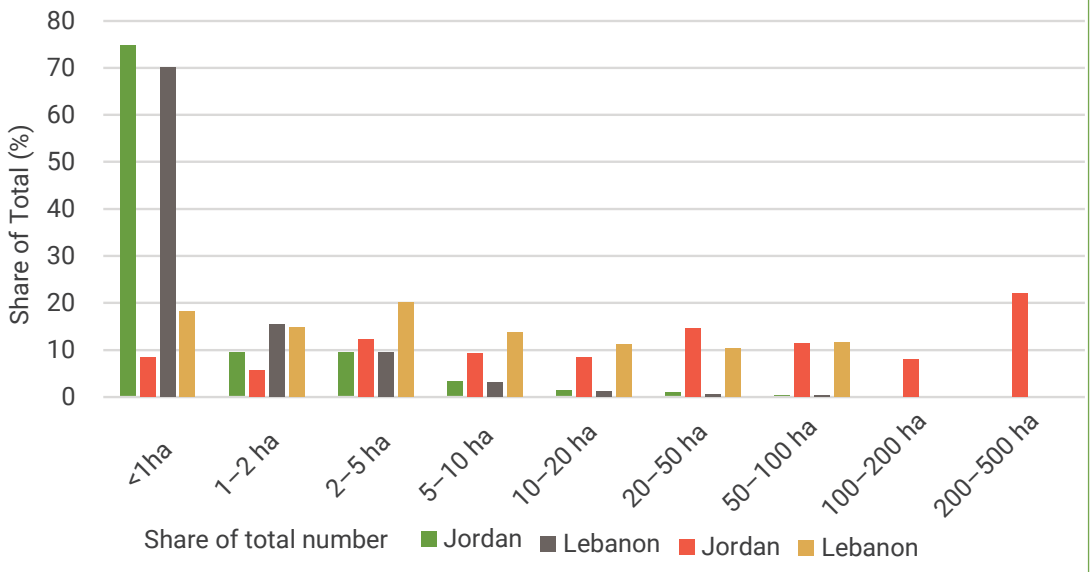
Agricultural Policy Frameworks in Mashreq

The agri-food sector in Mashreq does not receive needed attention from policy makers despite its economic importance and potential to deliver greater benefits. The sector is underfunded and rarely seen as a priority in major economic policy reform and investment programs. Iraqi, Jordanian, and Lebanese governments' relative expenditures on the agriculture sector are limited, reflecting a general neglect of the agriculture sector (Iraq 2.8 percent, Jordan 0.7 percent, Lebanon 0.49 percent of total government expenditures in 2016) (AOAD 2018; Official Gazette of Iraq n.d.). Low public expenditure and foreign direct investment (FDI) in the agriculture sector has contributed to weak investment in agricultural research and poor performance of public extension systems in Iraq, Jordan, and Lebanon. As a result, agricultural research is mainly conducted by universities, which may be driven by objectives (for example, academic publication and promotion) that may not match the sector's needs. The lack of public extension services has meant that the private sector provides advice, driven by sales revenue and profit motives. There are also limited efforts by the public sector to provide quality control for private sector extension services. Moving forward, agriculture should be front and center for policy makers instead of an afterthought.

Jordan's agriculture sector generally benefits from

➔ Figure 4. Distribution of Land Holdings by Size and Area (Census Year: Jordan 2017 and Lebanon 2010)

Source: FAO 2019.



➔ **Table 4.** Common challenges to the agri-food sector in Iraq, Jordan, and Lebanon

1. Water scarcity and inefficient use of scarce water exacerbated by the climate change and natural hazards

- ✓ Agricultural water use efficiency remains very low in the three focus countries. Irrigation often suffers from inefficient on-farm water delivery and water losses. Major investments are needed to rehabilitate and upgrade irrigation infrastructure, extend the network of reservoirs that supply irrigation water, and increase water use efficiency and on-farm management through better technologies. Improved water use efficiency should be also accompanied with appropriate policies to safeguard against overexploitation. For example, Jordan's water tariffs for irrigation are low, resulting in inefficient water use. Inappropriate farming practices and mismanaged water resources in the dry climate contribute to increasing rates of desertification.

2. Lack of knowledge about improved agricultural practices in rural areas due to weak public and private capacity for knowledge transfer and extension

- ✓ In all three countries, public and private systems for agricultural research, education, and knowledge transfer have only limited capacity to inform and motivate small-scale farmers to adopt modern farming technologies and improve fertilizer use efficiency.
- ✓ The links between research and development (R&D), extension, and farmers are poor. Traditional extension systems have had low usage from farmers and often new production technologies, such as improved seed varieties, nutrient management, and pest control methods, are not reaching farmers. Farmers lack guidance on a range of topics, including crop planning calendars and international certifications for export. The challenge for extension providers is to find cost-effective ways to transfer information and knowledge to farmers and guide them in the technology adoption.

3. Limited access to agricultural machinery and post-harvest systems

- ✓ The large up-front cost of farm machinery and post-harvest systems often puts it out of reach of many smallholder farmers. Where machinery is available, it is often outdated.

4. Weak and inefficient connections to the input and output markets, especially for small and fragmented farms

- ✓ Farmers have limited access to quality fertilizer, agrochemicals, seeds, livestock feed, and high-quality livestock breeds. Inadequate access to finance exacerbates these constraints.
- ✓ Agricultural supply chains are dominated by various intermediaries with substantial market power. One source of market power lies in the fact that intermediaries are better informed about market conditions, especially the prices further down the supply chain.

5. Limited access to rural finance and credit

- ✓ High interest rates and lack of collateral restrict the access of farmers to credit, further limiting their capacity to invest. Farms in Mashreq are overwhelmingly self-financed or informally financed given a lack of agricultural finance. For example, in Iraq, over 60 percent of rural households report borrowing from friends and family compared with fewer than 3 percent from a formal financial institution, including MFIs (Global Findex Database 2017). Iraq's microfinance sector has been overwhelmingly focused on urban borrowers, who represent over 90 percent of clients. Most Iraqis agree that all types of finance, including microfinance, are desperately needed in rural areas. However, in the past few years, the Iraqi financial sector has evolved, creating potential for far-reaching changes. In Lebanon, farmers have traditionally secured inputs on a credit basis, repaying the input supplier the full price of the inputs at the time of harvest. In Lebanon, before the current financial crisis, the agriculture sector accounted for only 1 percent of all commercial bank loans. This low rate of lending resulted from a mismatch between terms/conditions of loan products and needs of agricultural borrowers, mainly smaller ones; high collateral requirements; high interest rates; and a lack of loan products structured to account for agricultural seasonality (DAI 2014). Similarly, in Jordan, access to finance is out of reach due to factors such as high interest rates, insufficiently flexible repayment terms offered by lenders, long waiting periods to receive loans, and a lack of guarantee mechanisms. The banks and microfinance institutions (MFIs) provide very limited finance to agricultural producers, who rely almost exclusively on the state-owned Agricultural Credit Corporation.

6. Low food safety and traceability

- ✓ Due to low traceability and food safety standards, countries do not maximize their export market access under a number of favorable trade agreements.

7. Demographic challenges

- ✓ Demographic challenges reduce agricultural lands and put more pressure on already scarce water resources. Urbanization and population growth are putting severe strains on dwindling natural resources. The population of the Arab countries, estimated at approximately 407 million (2016), with 100 million considered to be in poverty, is expected to reach approximately 635 million by 2050. With a total population of 6 million in 2017, Lebanon's population has almost doubled since 2000. With a total population of 9.7 million in 2017, Jordan's population has grown very rapidly, increasing more than 10 times in 55 years. The largest increase in both countries took place during the last decade, especially because of the large influx of displaced people since the Syrian Crisis started in 2011.

favorable government policies and faces few legal and regulatory constraints to growth compared to Iraq and Lebanon. Jordan earned a score of 50.23 on the Enabling the Business of Agriculture index in 2019, reflecting a reasonable enabling environment for the agriculture sector in relation to regulatory good practices that affect farmers (World Bank 2019d). Jordan has recently adopted reforms related to accessing finance, which improved its index score in recent years. This generally favorable enabling environment for the agriculture sector is echoed in other assessments (Myers 2012). Iraq earned a lower score of 22.62 on the Enabling the Business of Agriculture index in 2019, reflecting room for improvement. Details of Jordan's and Iraq's performance are tabulated in Table 5. While the Enabling the Business of Agriculture index is not available for Lebanon, the enabling environment for the agriculture sector and its resultant growth are understood to be marked by governmental neglect rather than intensive and burdensome constraints imposed on the sector.

In recent years, Jordan's government has taken steps to improve its enabling environment for the agriculture sector by adopting regulatory good practices. Jordan has pursued both umbrella strategies and sectoral strategies to address the challenges limiting the agriculture sector and to increase the involvement of private sector actors therein. The umbrella strategy is known as 'National Agenda, Jordan Vision 2025'. To this, there is a sectoral strategy that has emerged, the National Strategy for Agricultural Development (NSAD) 2016–2025. Agriculture has also been targeted in government growth strategies with interim deadlines: Jordan Economic Growth Plan (JEGP) 2018–2022 and Government Priorities 2019–2020 (in the Footsteps of the Renaissance). The NSAD 2016–2025 is Jordan's second-ever strategy for the agriculture sector and sets out ambitious growth and efficiency targets. Key goals of the NSAD include increasing agricultural GDP growth to 22.3 percent, increasing agriculture's share of exports by 24 percent, and increasing irrigation efficiency by expanding the area of land irrigated by drip irrigation. The JEGP 2018–2022 similarly emphasizes agriculture as a major engine for growth. Within the agriculture sector, the plan proposes 12 government reforms, 21 projects, and 2 investment opportunities, at a total estimated cost of US$639 million. Jordan's new National Agriculture Strategy 2020–2025 sets out an ambitious and transformative agenda for the agri-food sector.

A strong agriculture sector has recently been viewed as a critical element of the Iraqi government's vision of a more diversified economy that is less dependent upon energy resources. The agri-food sector has recently received more attention as a source of jobs, growth, and social stability. Under the economic development plan for 2013–2017, agriculture was identified as one of five sectors of focus for investment intended to diversify sources of growth and reduce economic inequality between urban and rural areas of the country. Investment in the agriculture sector was further targeted as a way to reduce dependence on grain imports, with an objective to increase domestic production to 6 million metric ton of wheat and 1.2 million metric tons of barley by 2017 (Salman 2013). The more recent National Development Plan 2018–2022 set out four objectives for the agriculture and water resources sector, including

➔ **Table 5.** Enabling the business of agriculture - Jordan and Iraq scores (0–100) by index and indicators (2019)

Index or Indicator	Jordan	Iraq
Enabling the Business of Agriculture (Overall)	50.23	22.62
Supplying Seed	60.47	14.81
Registering Fertilizer	76.42	0.00
Securing Water	10.00	0.00
Registering Machinery	60.05	22.46
Sustaining Livestock	26.67	48.33
Protecting Plant Health	80.00	20.00
Trading Food	68.19	55.39
Accessing Finance	20.00	20.00

Note: Indicators are as follows:

- ✓ Supplying seed: Time and cost to register a new cereal variety and the quality of the seed regulation.
- ✓ Registering fertilizer: Time and cost to register a new chemical fertilizer product and the quality of the fertilizer regulation.
- ✓ Securing water: Requirements for water information access and opportunities to participate in water resources management decisions.
- ✓ Registering machinery: Time and cost to register a two-axle, four-wheel-drive agricultural tractor.
- ✓ Sustaining livestock: Quality of the regulations for manufactured feed and veterinary medicinal products.
- ✓ Protecting plant health: Quality of phytosanitary regulation.
- ✓ Trading food: Time and cost to obtain documents to trade agricultural goods and the quality of food regulation system.
- ✓ Accessing finance: Measures laws and regulations on the use of warehouse receipts and inclusive finance.

a targeted increase in the contribution of agriculture to GDP from 4.5 percent in 2015 to 5.2 percent in 2022 and raising the growth rate of the sector to 8.4 percent annually (Ministry of Planning n.d.). Iraq's second Poverty Reduction Strategy (PRS2) 2018–2022 aims to reduce poverty including by promoting income generation of income generation from agriculture projects.

The Iraqi government has subsidized farm inputs and applied price controls to strategic crops for decades, which has distorted agri-food markets. The government determines which crops can be grown, the price of inputs, and final harvest prices. Publicly financed state-owned enterprises dominate input supply chains and output markets, and the food system is dominated by two publicly subsidized and managed programs. The Public Distribution System (PDS), with a US$1.43 billion budget in 2019, provides a 'food basket' to each Iraqi family. The second public program is the US$1.25 billion Wheat and Barley Purchase Program, which buys wheat and barley straight from farmers at double the international prices.

Iraq's Ministry of Trade maintains a near complete monopoly on importing basic commodities such as wheat, rice, oil, and pulses, inhibiting agri-food market development. The Ministry of Trade releases these commodities at highly subsidized prices (no transport and distribution costs are applied) into the local market through the PDS. The mass supply of these commodities lowers their market price. The high prices the government pays for some domestic commodities distort the market and limit private sector investments and innovations. A key challenge for Iraq's food system is to develop the policy framework that creates the right balance between economic efficiency and risk mitigation to avoid a national food crisis.

The Lebanese government adopted a laissez-faire attitude to the agriculture sector following the country's civil war, but more recently has taken steps to promote investment in the agriculture sector, notably by targeting access to finance. This hands-off approach was reflected in the prioritization of public investments and promotion of the financial and real estate sectors, while investment in agriculture and rural communities was limited. Agricultural access to finance had been limited due to the short loan periods offered and high interest rates charged by banks and farmers' general lack of management training and collateral. To expand access to finance, the government directed its public stimulus programs through the country's private banking sector, as Lebanon does not have a public agricultural bank. Kafalat, a quasi-public financial company, launched in 2000 with a mandate to assist SMEs in selected sectors including agriculture to access commercial bank finance through the provision of loan guarantees. In recent years, Kafalat also introduced the US$30 million iSME Program to expand equity investment in sectors including agriculture and agri-food. Additionally, the Lebanese government has offered subsidized loans to support the real economy, including the agriculture sector; subsidized loans are funded through the Lebanese central bank or *Banque du Liban (BdL)*. The government offers subsidies for selected agricultural inputs (chemical inputs, financing via subsidized loans, and loan guarantees) and final products (wheat and tobacco) and provides some limited control of the prices consumers pay for food. Yet, the sector is largely left to the market and the private sector (Bahn, Nisr, and El Labban 2018).

The overall policy environment is marked by an absence of comprehensive regulations for agriculture in Lebanon. The agriculture sector largely but not exclusively falls under the authority of Lebanon's Ministry of Agriculture, which regularly develops strategy documents to guide its work in supporting the growth and development of the agriculture sector. In 2020, the Ministry of Agriculture prepared the National Agriculture Strategy 2021–2025. Policy coherence in Lebanon is at times missing, in part due to lack of coordination across governmental institutions. For example, the Ministry of Agriculture Strategy 2015–2019 explicitly acknowledges the persistent lack of coordination and cooperation due to dispersed and at times overlapping responsibilities and mandates of public, private, donor, and civil society organizations (Bahn, Nisr, and El Labban 2018).

Looking forward, the national strategies across the focus countries aim to improve agricultural productivity and water use efficiency and increasing agricultural exports and GDP. The key goals of Jordan's NSAD 2016–2025 include increasing agricultural GDP growth to 22.3 percent, increasing agriculture's share of exports by 24 percent, and expanding the area of land under drip irrigation. Jordan's Agricultural Sector Advancement Plan (2018–2022) focuses on (a) maximizing the value added of the sector, (b) transforming toward commercial agriculture, and (c) increasing the sector's contribution in combating poverty and unemployment in the difficult economic conditions. Jordan's National Agricultural Development Strategy for 2020–2025 aims to modernize the agri-food sector and integrate the digital agriculture solutions. Lebanon's Ministry of Agriculture has adopted a strategy for 2021–25 with five key pillars: (a) restoring the livelihoods and productive capacities of farmers and producers, (b) increasing agricultural production and productivity, (c) enhancing efficiency and competitiveness of agri-food value chains, (d) improving climate change adaptation and sustainable management of agri-food systems and natural resources, and (e) strengthening the enabling institutional environment. The strategy also identifies the need to improve and modernize digital

services to farmers as one of the flagship programs. Iraq's PRS2 2018–2022 aims to reduce poverty, including promoting income generation from agriculture projects. These strategies have a particular focus on rural women.

Current Crises and Agriculture in Mashreq: Political Instability and COVID-19

Political events in Iraq and Lebanon in mid to late 2019, combined with economic shocks, have compounded the challenges facing their respective agriculture sectors. In both Iraq and Lebanon, popular protests resulted in the resignation of their respective prime ministers and governments in late 2019. Iraq depends heavily on oil revenues for foreign exchange revenue and to finance government expenditure. It has felt pressure from the sharp decline in oil prices in early 2020, reducing fiscal revenue and making the government's ability to pay for agricultural and food subsidies unclear (FAO, WFP, and World Bank 2020). In Lebanon, popular protests against the government were linked to an ongoing economic and financial crisis and a devaluation of the local currency on the informal market, which had multiple effects on the agriculture sector. A currency crisis limited imports of inputs including seeds and was expected to reduce the competitiveness of Lebanese agricultural products on export markets in the short term. Financial arrangements between agricultural input suppliers, farmers, and other actors have shifted, and informal credit mechanisms have been cancelled in favor of cash-only operations, limiting farmers' ability to plant on credit as in the past. Agricultural production was projected to decrease (plant production by 47 percent; animal production by 26 percent) and agricultural GDP to decrease by 38 percent in 2020 as a result of reduced use of inputs due to absence of credit facilities, currency devaluation, and reliance on imported inputs (estimates by the *Centre de Recherches & d'Etudes Agricoles Libanais* [CREAL]). As of early 2020, CREAL also estimated that farmers owed US$80 million to input retailers, whereas retailers owed US$60 million to banks, importers, and wholesalers. However, the currency devaluation and the banking crisis have renewed interest in Lebanon's productive sectors and especially in agriculture given its potential to replace imports. According to the World Food Programme (WFP) (2020), the price of the basic consumer basket increased in Lebanon by 183 percent between October 2019 and December 2020.

The impacts of COVID-19 have reinforced calls for revitalizing and rethinking the agriculture sector. COVID-19 has already had a tremendous negative impact on jobs worldwide. Across Mashreq, fewer than 33 percent of all jobs can be done from home, with 32 percent in both Iraq and Lebanon and 24 percent in Jordan (World Bank 2020d). Overall impacts, including disruptions in the food trade and supply chains, reduced production, increased post-harvest losses, and food logistics breakdowns, have been felt in all three countries, though to a varied extent. The corresponding food inflation stemming from these aggravating factors also varies: from deflation in Iraq (1.4 percent annualized as of August 2020), to a moderate increase in Jordan (3.3 percent annualized as of October 2020), to hyperinflation in Lebanon (433 percent annualized as of September 2020), where it builds on the substantial food price increases due to the deterioration of the macroeconomic conditions. COVID-19 places a large proportion of the vulnerable population at a very high risk of hunger and undernourishment and could lead to the failure of all protective and precautionary measures and the collapse of social safety nets. While country-level figures are not available, the WFP has estimated that COVID-19 could push an additional 130 million people into acute hunger by end-2020—nearly a doubling from pre-COVID projections—with the worst effects felt in Africa and the Middle East (Anthem 2020).

COVID-19 has led to multiple shocks to the agriculture sectors across Mashreq. Therefore, both COVID-19 and the financial crisis are threatening Lebanon's overall food security, demonstrating a need to rethink the food system. Shocks that undermine food security and worsen service provision can contribute to a breakdown of the social contract, posing serious threats to the region. Such shocks can have an adverse impact on fragility and the risk of conflict within Mashreq. COVID-19's impact on Iraq's agri-food sector is already tangible, particularly after all agricultural imports from Iran (mainly vegetables) were banned in early 2020, contributing to a price shock. Prices for tomatoes, cucumber, and potatoes increased by 100 percent in Baghdad within one week, from March 9 to March 16, 2020, according to the Ministry of Agriculture. In contrast, Jordan's agriculture sector and food supply chains seemed better positioned to weather the shocks due to early public action to maintain domestic and foreign market access, extend loans to farmers, and protect the health of agri-food workers. Even so, price increases of imported goods over the longer term are expected (FAO and WFP 2020). Both Jordan and Lebanon are expected to suffer from significant reductions in remittances exacerbated by COVID-19, which will reduce receiving households' capacity for productive investment (including in agriculture) and also for consumption (including food) (Cochrane 2020). Box 2 provides information on distorted value chains in Lebanon. The cumulative threat posed by COVID-19 to Lebanon's food security is significant given its reliance on agricultural and food imports, the current economic and monetary crises, and the capital control measures hindering the payment of suppliers.

➔ **Box 2.** Distorted Value Chains in Lebanon, Exacerbated by Financial Crisis and COVID-19

In Lebanon, there are different ways that large and small farmers secure agricultural inputs, with small farmers paying a higher total cost. Prior to the current crises, larger farmers had access to capital and secured discounts of up to 30 percent on inputs (seed, fertilizer, and so on) by paying cash on delivery. Smaller farmers without access to capital typically secured inputs on a credit basis, repaying the input supplier the full price of the inputs at the time of harvest. Lebanon's monopoly laws prevent small farmers from organizing into marketing cooperatives and importing inputs at a more competitive price. The law grants exclusive rights for imported inputs to the sole agent.[1] Because of Lebanon's financial crisis that began in 2019, and worsened by the COVID-19 impacts, this arrangement has been cancelled in favor of cash-only operations, limiting farmers' ability to plant on credit as in the past. Estimates suggest that this will cause agricultural production and GDP to decrease because farmers reduced input use due to currency depreciation, absence of credit facilities, and a need to rely on more expensive imported inputs.

The wholesale market (*hisbeh*) structure for fresh fruits and vegetables is challenging to farmers, particularly small producers. Farmers typically deposit their products with one of many agents (*wokala*) at the wholesale market and return approximately 10 days later for payment. These are consignment sales with prices fixed by the wholesaler according to market conditions, with the wholesaler taking an 8–15 percent commission on sales. Payment is made based on volumes and prices, with a fee imposed for disposing of any unsold products. The system is based on trust, with no formal receipts provided. Farmers report that the agents take advantage of them and do not pay them what is due. Yet, the dominance of the hisbeh and the lack of transparency in the system leave farmers and damans discontented and with no practical alternatives.[2] Because of this, there is a strong incentive for sellers to bypass wholesale markets with direct sales to retailers or even consumers. Yet, interviews with wholesale market operators and the distributors and wholesalers who buy from them indicate that the vast majority of neighborhood grocery shops, larger families, and some restaurants get the majority of their produce through these operators (DAI 2014).

[a] Interview with Ali Ismail, conducted November 18, 2019.
[b] Interview with Ali Ismail, conducted November 18, 2019.

Chapter 2

Opportunities from Digital Agriculture - Which Digital Agriculture Technologies Can Help Improve the Agri-food System Outcomes in Mashreq?

Key Messages

- Digital technologies of particular relevance in the Mashreq countries are oriented toward resource efficiency and improved climate resilience, youth employment, access to knowledge, trade, financial inclusion, improved traceability and food safety, and improved public services.
- Selected digital technologies may be particularly relevant to improving the performance of the agri-food sector and its response to shocks or crises, for example, the COVID-19 pandemic.
- Digitally transforming the agri-food sector comes with risks that need to be understood and appropriately managed as with other major technological changes. Ensuring that small farmers and small businesses benefit from digital innovation as much as larger operators is imperative.
- Digital innovations should not deepen the inequalities for women, youth, refugees, and other vulnerable groups that may lack equal access to technologies and skills.

Chapter 2
Opportunities from Digital Agriculture - Which Digital Agriculture Technologies Can Help Improve the Agri-food System Outcomes in Mashreq?

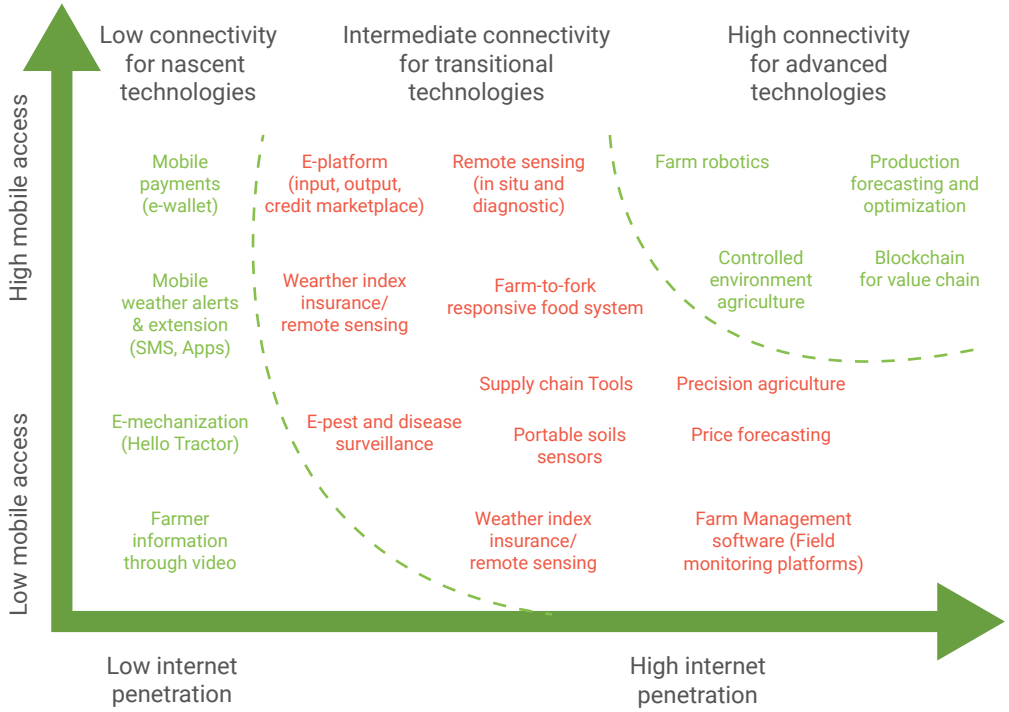
This chapter presents the digital technologies that offer a potential contribution to transform the agri-food sector in the Mashreq countries, highlighting those technologies best suited to the challenges and opportunities for the agri-food sector in the focus countries. After a brief introduction to digital agriculture, the various technologies and platforms are reviewed thematically. Current examples from other country contexts are used to illustrate this potential.

Digital technologies offer new opportunities for developing the agri-food sector in Mashreq, for job creation, and for increased incomes, making it even more important for policy makers in Mashreq to prioritize the sector and to provide leadership for its transformation. With increased competition for land, scarcity of water, and high transportation costs, agriculture in Mashreq will need to shift toward high-value, high-tech, and water-efficient crops and production systems. Digital agriculture, a term synonymous with e-agriculture or information and communication technology (ICT) in agriculture, refers to the use of digital technologies in agriculture or the wider agri-food sector. Digital technologies can be harnessed to raise on-farm productivity, address resource use efficiency challenges, and build climate resilience (Trendov, Varas, and Zeng 2019). Digital technologies can make the agri-food sector more efficient, inclusive, and environmentally sustainable, thereby increasing benefits for farmers, consumers, and society at large. They can help overcome information asymmetries and reduce inefficiencies caused by relying on market intermediaries. Farmers' decision-making may be enhanced through better agronomic data, weather data, and price information, ultimately increasing farmer profits and incomes (World Bank 2019b). Access to information can also promote the inclusion of marginalized rural producers in markets. Female farmers can benefit from tools that encourage knowledge and information sharing. Digital agriculture requires that users develop new skills, and it provides opportunities for more diverse and remunerative employment. e-Government can help improve the transparency and efficiency of public services by digitizing land tenure mapping and registration, subsidy distribution, weather forecasting, and water resource management. Selected digital technologies may be particularly relevant to supporting how well the agri-food sector performs in response to shocks or crises, for example, the COVID-19 pandemic.

A wide range of digital agriculture applications exist, and those that can operate at low and medium internet connectivity are especially well suited to connect smallholders along agri-food value chains. The increased capacity to capture, analyze, and exchange data relevant to agriculture or the food system more broadly is at the core of the digital revolution within the agriculture sector. This enables evidence-based decision-making processes and improves efficiency, equity, and sustainability of the food system. Digital agriculture spans a range of tools including sensors; robots; blockchain, a distributed ledger technology (DLT) that facilitates the process of recording transactions and tracking assets in a business; cloud-based technologies; computational decision and analytical tools; and digital communication tools. Based on the data management type, digital technologies can be grouped largely into four categories: collection, storage, analysis, and distribution. Digital agriculture technologies are producing ever-larger volumes of data including high-resolution soil data, site-specific weather maps, aerial imagery, nutrient applications, animal productivity and health records, and e-commerce platforms to facilitate agri-food trade. Both integrating data and real-time data transfer can connect value chain segments. The data can be transferred via mobile or broadband connections to cloud-based services (Figure 5). Many digital agriculture technologies can be deployed even in low-connectivity, rural environments (World Bank, 2019j). Second generation (2G) networks are essentially restricted to voice and text messaging, while third generation (3G) and fourth generation (4G) networks allow for broader applications and use of smart phones. Even in poorly connected rural contexts, or with marginalized groups that have less access to information and markets, sophisticated offline digital agricultural technologies can provide opportunities to support poor or illiterate farmers (World Bank 2019j).

➔ Figure 5. Categories of Digital Agriculture Devices by Access and Penetration Needs

Source: World Bank 2019j.



The digital transformation of the agri-food sector also comes with risks that need to be understood and appropriately managed, as with any major technology change. Negative distributional impacts are one concern. The *World Development Report 2016: Digital Dividends* (World Bank 2016), for example, provides an overview of the various risks related to internet use, including inequality in access and affordability; concentration of market power of e-commerce platforms, social networks, and search engines; data privacy and consumer protection; and cybersecurity. Digital technologies may displace agricultural labor with labor-saving technologies (Box 3). Such technologies may include harvesting robots, driverless tractors, sprayer drones, artificial intelligence (AI) to manage chemical and fertilizer application, and precision dairy farming (Gallardo and Sauer 2018). On the other hand, automation within the agriculture sector could create high-skilled, high-paying jobs such as managing and maintaining robots or analyzing and interpreting data collected from digital sources and AI (Gallardo and Sauer 2018). Another risk of adopting digital technologies in agriculture relates to resource use. Trying to optimize resource use, especially for scarce resources such as groundwater, may perversely lead to their expanded use (known as rebound use) if use limits are not imposed (Perry 2011; World Bank 2021). Additionally, it is important to ensure equity in the benefits of digital transformation, for example to help small farmers and small businesses to benefit from digital innovation in the same way that larger operators will. Furthermore, digital innovations should not deepen the inequalities for women, youth, refugees, and other vulnerable groups as they may not have equal access to technologies and may end up on the losing side of the sector's digital transformation.

Digital Technologies to Improve On-Farm Efficiency, Equity, and Environmental Sustainability

Digital technologies can increase on-farm productivity and address the challenges of resource use efficiency and adapting to climate change, thereby promoting food security and sustainable development. These digital technologies include, for example, e-Extension services, precision agriculture, and matching markets for mechanized services and other inputs. By optimizing and reducing the input usage such as water, energy, fertilizers, and pesticides, digital technologies generate climate benefits. Yet, digital technologies could also accelerate natural resource depletion and increase the absolute value of GHG emissions via the rebound effect if efficiency gains lead to increased use (Perry, 2011; World Bank 2021). There are equity concerns that using advanced digital technologies in the agriculture sector may widen the digital divide if smallholders are unable to make use of these technologies due to the high cost and specialized skills needs. Examples of technologies for improving on-farm efficiency and evaluation of their impact on efficiency, equity, and environmental sustainability are provided in Table 6. For a detailed description and examples, refer to World Bank 2021.

➔ **Box 3.** Digital Technologies' Impact on Jobs

Many digital technologies may be labor enhancing since they increase the efficiency of agricultural labor and the productivity of agricultural operations by lowering production costs, increasing yields, reducing loss and waste, and providing higher revenues. However, while evidence is scarce, the emerging data showcase that increased use of digital technologies in the agriculture sector leads to displacement of manual/low-skilled jobs; hence, people less trained/educated are at risk of losing such jobs (Gallardo and Sauer 2018, World Bank, 2021). Given a relatively low level of education for farmers in analyzed countries, this risk of displacement is potentially high. This is most likely to apply to selected technologies and wealthier farms. For example, capital-intensive enterprises might use robotic technology for tasks such as weeding, harvesting, and cow milking instead of manual labor.

At the same time, the knowledge base for developing and operating digital technologies could represent new employment opportunities that may be particularly attractive to youth. Therefore, modernization of the agriculture sector itself can create more productive, more skill-intensive, and remunerative and competitive jobs in the agri-business sector and along value chains and create new markets for agriculture products. Digital technologies can even be designed to enable smallholder farmers with limited knowledge to learn and upgrade their skills as they use them. This can encourage inclusion rather than displacement of low-skilled smallholders and help raise their productivity.

Source: Gallardo and Sauer 2018, World Bank 2021.

➔ **Box 4.** Artificial Intelligence (AI) and Applications for Agriculture

AI refers to artificial intelligence, the ability of computerized systems to think and act like humans, including the ability to scan the environment, learn from it, and take responsive action. AI can simulate human abilities including reasoning, language, perception or vision, and spatial processing. There are three major types of AI applications: basic AI, with examples including credit scoring or online matching; advanced AI, with examples including facial and speech recognition; and autonomous AI, which is not widely available in commercial applications. AI can build on rules-based or machine learning algorithms that allow more sophisticated parsing and learning from data, including richer data sets including unstructured data like images, audio, and texts. Basic AI is already used in emerging economies to provide financial services to underserved or unserved populations through credit scoring, using nontraditional data, and targeted advertising. In the agriculture sector, the Nuru machine learning app identifies leaf damage recorded through photos from farms in Kenya, Mozambique, and Tanzania and transmits the information to relevant authorities that monitor invasive pests. This limits adverse impacts on farm revenue and food security. AI applications also show promise at other stages within the value chain, for example, through online marketplaces. AI-driven efficiencies in public services delivery could similarly benefit the agri-food sector. Risks associated with using AI in emerging markets—regardless of the economic sector—include a widened digital and technological divide; transformation of job requirements and disruption of traditional job functions; and privacy, security, and public trust.

Source: Strusani and Houngbonon 2019.

Digital technologies can improve the quantity and quality of agricultural output while using less inputs (such as water, energy, fertilizers, and pesticides), increasing efficiency by performing farming practices remotely, and achieving positive environmental effects through lower input (fertilizer and pesticides) use (World Bank, 2019b). Controlled-environment agriculture (greenhouses, indoor farms, and vertical and hydroponic farms) increasingly uses digital technologies including sensors, robots, and digital communication. More advanced digital agriculture approaches such as precision agriculture leverage digital, mobile, Internet of Things (IoT), and cognitive technologies by relying on tools including global positioning system (GPS) enabled guidance, control systems, sensors, robotics, drones, autonomous vehicles, variable-rate technologies; automated hardware, telematics (that is, an interdisciplinary field that encompasses telecommunications), electrical engineering, computer science, and vehicle technologies; and software. Precision agriculture practices for livestock farming include sensors, radio frequency identification (RFID), and automated or robotic milking and feeding systems.

As precision agriculture technologies become easier to implement and more affordable, they could help raise incomes on smaller farms. Predictive analytics software and/or AI analyze data to provide farmers with guidance on crop rotation, optimal planting times, harvesting times, and soil management. Goldman Sachs estimates that yields can rise by 15–20 percent due to more targeted fertilizer application, 13 percent due to better planting, 4 percent due to more precise spraying, and 10 percent due to precision irrigation. Smart irrigation systems with optimized fertigation (fertilization via irrigation) water use are particularly beneficial for Mashreq countries given the water scarcity and inefficient water use. Sensor-based irrigation can use sensors embedded directly in trunks of fruit trees while remote sensing via satellites or drones can assess water productivity, cropping intensity, and equity in water distribution within large-scale irrigation schemes. Farmers can benefit from the data-driven, machine learning solutions for orchard growers to track the health status of trees using AI, IoT multi-sensor data, and drone imaging. Yet, affordability and lack of technical expertise are restricting the adoption of some on-farm digital technologies. For example, the cost of fertilizer spraying drones starts at around US$4,000, while a professional automated mapping drone can cost up to US$25,000.

➔ **Box 5.** Digital management of water resources in agriculture

Expanding water-efficient agricultural production is an important goal for water-scarce countries, but the use of partial productivity measures (crop per drop) can be misleading and the exact definition of water is often unspecified—is it water extracted, water applied, or water consumed? Moreover, the crop per drop measure is rarely if ever an indicator that farmers will seek to maximize in their production decisions. Smart irrigation systems incorporating Internet of Things (IoT) and remote sensing technologies may be one option to move toward more water-efficient agricultural production that accounts for farmer incentives. High-resolution satellite images used along with specific algorithms can determine spatial and temporal variability of agricultural water and land productivity. For example, Water Productivity through Open access of Remotely sensed derived data portal (WaPOR[1]) of the Food and Agriculture Organization (FAO) of the UN can compute and map key variables related to water and agriculture, such as evapotranspiration, biomass production, and water productivity. In the field, remote sensors can measure water use and monitor net withdrawals of groundwater, and the resulting data can inform sustainable targets for irrigation water management and water allocations to system users. Then, farmers' or landholders' water pumps can be integrated into the smart irrigation systems, allowing for real-time metering and even remote shutoff if the water user has exceeded his/her water allocation (World Bank, 2018, 2019e). In an example from India, the Nano Ganesh irrigation system uses digital applications that allow farmers to use their mobile phones to control their irrigation pumps remotely and save time, energy, and water (Tulsian and Saini, 2014). Digital tools support the physical improvement of irrigation management at the farm level and can strengthen information exchange at basin or regional levels between irrigation schemes. Water users, managers, and authorities can be linked through an effective communication system, allowing for knowledge transfer and developing irrigation management technical skills at the different scales within a basin (FAO and IWMI 2020).

[1] https://wapor.apps.fao.org

➔ **Table 6.** Common On-farm Challenges and the Impacts of the Potential Digital Technology Solutions on the Efficiency, Equity, and Environmental Sustainability

Examples of Digital Enabler	Efficiency	Equity	Environmental Sustainability
Challenge: Water scarcity and inefficient use of scarce water and land resources exacerbated by climate change			
✓ Digital technologies to improve natural resource use efficiency such as smart irrigation systems with optimized fertigation, precision agriculture, robots, sensors, remote sensing (satellite and drones), robotic milking, and feeding systems.	✓ Limit the use of external inputs (fertilizer and pesticides). ✓ Optimize the use of scarce resources like water and land. ✓ Provide farmers accurate, timely, and location-specific weather information.	✓ Create more attractive and competitive jobs for youth. ✓ Strengthen climate change resilience and adaptation through improved use of irrigation systems. ✓ May include the displacement of labor with labor-saving automated technologies. ✓ May lead to inequality and competitiveness decrease if digital technologies require substantial investments and certain skills.	✓ Reduce ecological footprint, for example, smart irrigation systems can reduce/optimize water use and lower the risk of soil salinity. ✓ May perversely lead to expanded use of resources, such as groundwater, if limits to their use are not imposed ✓ May lead to decreased return flows and thus less water available for downstream users, thus creating a new negative externality for them. ✓ May generate GHG emissions related to energy-intensive data storage or the waste of electronic or digital materials.
Challenge: Vulnerability to natural hazards			
✓ Digital technologies to improve risk mitigation such as automated early warning systems related to weather, pests, and diseases. Digitally enabled smart contracts for weather-related risks.	✓ Reduce risks from such external threats as pests and weather. ✓ Increase efficiency of risk-prevention strategies. ✓ Improve efficiency of payouts with only marginal transaction costs.	✓ Reduce damage and loss from natural hazards. ✓ Reduce inequalities through lower transaction costs, which makes these contracts inclusive for smallholders.	✓ Result in a more sustainable use of agricultural inputs and climate resilience. For example, prevention of spreading of pests through early warning system can reduce a need for pesticides. ✓ Facilitate adaptation to climate change if improved weather forecasts are made accessible to producers.
Challenge: Lack of knowledge due to weak extension services			
✓ E-extension services through multiple channels such as video, IVR, SMS, and radio.	✓ Facilitate knowledge transfer and skill acquisition at low cost.	✓ Reduce spatial, social, and economic divides. ✓ Empower smallholders by providing access to data and knowledge.	✓ Improve knowledge about climate-smart and sustainable practices.
Challenge: Limited access to the agricultural machinery and agricultural services			
✓ Digital platforms for improved physical and human capital allocation.	✓ Increase the technical and allocative efficiency of capital (machinery, equipment, and so on) or match agricultural services provider.	✓ Empower smallholders by providing access to physical and human capital.	✓ Reduce GHG emissions through improved energy and material use in processing, storage, and transportation, especially for products requiring cold chain. ✓ May result in increased GHG emissions due to improved farmers' access to machinery.

Note: For the detailed description and examples, refer to World Bank 2021.

Digital Platforms for Improved Physical Capital Allocation in the Agri-food Sector

Digital platforms can improve access to agricultural machinery and agricultural services. Due to the high cost associated with some agricultural equipment, alternatives to direct purchase such as leasing arrangements, contract-based provision, and/or cooperative approaches may be more appropriate, especially by smaller farmers. Contractors typically target two groups of customers: (a) small farms that face high costs to mechanize individually and (b) farms whose owners lack management skills or time to apply the technology. Cooperative approaches including joint investment or sharing equipment may be best suited to equipment that is not required on a continuous or permanent basis, for example, precision guidance, soil sampling, variable-rate fertilization, and yield mapping (Kutter, *et al.,* 2011). Digital platforms can create new and efficient markets for machinery rentals through (a) providing more affordable access to physical capital for smallholder farmers and (b) putting underused assets to work by matching suppliers of machinery rental services with farmers wanting these services, just as Uber matches drivers with customers for taxi services. As the marginal cost of matching buyers and sellers through digital platforms is extremely low, they have the potential to reduce unit costs of machinery rental services through saved transaction and search costs (World Bank, 2019b). For example, *Hello Tractor* brings tractor services through its mobile platform to farms upon request. With a model similar to that of Uber, Hello Tractor leverages the sharing economy to improve farm productivity through tractor rental. Instead of purchasing the machinery at a huge up-front investment, the service creates an opportunity for tractor owners to earn additional income when their fleet is idle and for renters to free up part of their financial resources by purchasing tractor services on demand. A similar approach is used by DigiCow, which developed a platform to connect animal health and veterinary care providers with small dairy animal owners through a mobile application that works like Uber. This has led to a significant increase in service availability for dairy animal owners. The service time is reduced from two days to two hours, leading to significant improvement in animal health. However, the experience of digital platforms serving the agriculture sector has not been uniformly positive, and some platforms have failed or failed to scale up for a variety of reasons (FAO, IFPRI, and OECD 2017; World Bank 2016).

Digital Technologies to Improve Access to Knowledge and Facilitate Evidence-Based Decision-Making for Improved Farming Practices

E-extension services can help overcome constraints of traditional extension services and provide cost-effective ways of reaching a greater number of farmers at lower cost. E-extension can help provide relevant and real-time access to information on how farmers can resolve general and highly specific problems ranging from sustainable farming practices, climate-smart solutions, and market access (World Bank 2019b). Digital technologies can be used as a complement to field advisory visits, rather than a complete substitute. Meta-analyses suggest that transmitting agricultural information through mobile technologies can increase yields by 4 percent and adoption of recommended agrochemical inputs by 22 percent in Sub-Saharan Africa and India (Fabregas, Kremer, and Schilbach 2019). Given the low and rapidly declining cost of information transmission, benefits likely exceed costs by an order of magnitude. Messages could be customized on the basis of farmer characteristics, such as education or financial circumstances. For example, FarmStack by Digital Green delivers location and time-specific advice to farmers to boost sustainable agricultural productivity, rural livelihoods, resilience, and nutrition outcomes. FarmStack combines information such as weather forecasts, market prices, soil health, and irrigation availability with in-built mechanisms to push advisories to farmers across multiple channels (for example, face-to-face, video, interactive voice response [IVR], short message service [SMS], and radio). AccessAgriculture hosts more than 200 videos in over 80 languages. Agrocares is a Dutch firm providing digital services ranging from crop growth monitoring and insect scouting to managing soil fertility and animal feed.

E-extension can be provided by both private and public sectors, yet vetting private sector e-Extension services is needed to address data integrity and avoiding intentional falsification of data by malicious actors (World Bank 2021). While there are various forms of e-Extension, many are fairly recent, and evaluation is still ongoing to identify which forms of agricultural e-Extension services work best and under what conditions (World Bank, 2019b). The adoption of digital e-Extension services is limited in many countries due to lack of country-specific content and services for the agriculture sector in local languages.

Capacity development programs delivered online or through distance learning are particularly appropriate to mitigate the restrictions posed by COVID-19. For example, to mitigate COVID-19's impact, China Agricultural University and the National Engineering Research Center for Information Technology in Agriculture (NERCITA) in Beijing launched the New Farmer Lecture Series online training courses for farmers. Some 12,000 farmers participated in the first series of lectures, which lasted 4.5 hours and covered topics ranging from preventing pest infestations to smart agricultural services and equipment. The tailor-made content from agronomists was delivered via a livestreaming platform.[1]

Digital Technologies to Improve Risk Mitigation

Enhancing management and efficiency and mitigating risk are possible by combining remote sensing and big data. Novel applications, when these are combined, include automated early warning systems for crop or livestock health related to weather, pests, and diseases that can facilitate proactive and timely management responses. For example, the World Bank Agriculture Observatory is accessing ground-based hydrometeorological data (sparse in most developing countries) and high-density weather satellite radar platforms and applying machine learning to generate a continuous weather surface across the earth's croplands (World Bank, 2019b). The resulting weather data comprise 7 billion data points generated daily by 1.5 million virtual weather stations across the world. These are updated four times a day, to generate 'real-time' weather data at intervals of 9 km across global agricultural land. This data surface represents a disruptive approach to the traditional method of relying solely on ground-based hydrometeorological stations that need to be procured, installed, calibrated, and maintained even before the data are accessed, analyzed, and synthesized. By coupling the high-resolution weather surface with cropping calendars, it is possible to make real-time assessments of crop performance and take proactive risk mitigation interventions and provide decision support. These interventions span the entire value chain, comprising farmers, input suppliers, logistics providers, markets, and policy makers. Because early projections of crop yield anomalies are possible at the subnational, national, regional, and even global level, the World Bank Agriculture Observatory platform can provide early warning of potential food shocks several months in advance of normal harvest periods. Information and analysis from the World Bank Agriculture Observatory are guiding the design and implementation of agriculture projects. National Agriculture Observatories are in operation or are being set up in Ethiopia, Kenya, the Russian Federation, Zambia, and Zimbabwe, in close collaboration with national agricultural and meteorological agencies.

Digital technologies delivered through smart contracts can provide a risk mitigation tool that is flexible, low-cost, secure, and highly customizable to a multitude of risks and payouts (large and small), with only marginal transaction costs (World Bank, 2019b, 2021). Access to financial risk mitigation tools for weather-related risks is limited or out of reach for many farmers and small- to medium-size businesses in the focus counties. Smart contracts can address these constraints and allow performing credible transactions without third parties. They are traceable and irreversible. Smart contracts contain all the information about the contract terms and execute all envisaged actions automatically. They work as follows: at first, assets and contract terms are coded and put into the blockchain. This contract is distributed and copied multiple times between the nodes of the platform. After the trigger (that is, delivery of a product to a predefined location) happens, the contract is performed in accordance with its terms. The program checks the implementation of the commitments automatically. Smart contracts can be used for weather-based crop insurance. A smart contract could then read these data and trigger a payment in case of persistence of bad weather. Smart contracts provide
(a) security, as a smart contract cannot be altered;
(b) economy and speed, as most processes are automated and most intermediaries are eliminated; and
(c) standardization, as there is a wide range of smart contract types that would fit the parties' needs. There are also many emerging digital risk mitigation tools. However, structural reforms, both in agriculture and in the financial sector, including improving access to finance and developing insurance markets, still need to be implemented for enabling complex product offerings.

Digital Technologies to Facilitate Trade and Financial Inclusion

This section describes how digital technologies can facilitate trade by linking farmers to the upstream and downstream markets, increase food safety, and support financial inclusion of smallholders. Common agri-food trade and fintech-related challenges and the impacts of the potential digital technology solutions on efficiency, equity, and environmental sustainability are provided in Table 7.

Digital marketplaces for agricultural products can directly link producers to consumers via e-platforms, potentially shorten agricultural value chains, provide access to new markets, improve price transparency, reduce food loss, and offer new business opportunities for small agricultural producers and SMEs (World Bank 2019b). Lowering information-related transaction costs through digital technologies helps expand access to input and output markets—and reduce information asymmetries and

[1] https://stories.pinduoduo-global.com/articles/china-springs-into-action-to-kickstart-food-production-after-covid-19.

➔ **Table 7.** Common Agri-food Trade and Fintech-Related Challenges and the Impacts of the Potential Digital Technology Solutions on the Efficiency, Equity, and Environmental Sustainability

Examples of Digital Enabler	Efficiency	Equity	Environmental Sustainability
Challenge: Connections to input and output markets remain weak and inefficient for small and fragmented farms			
✓ Digital technologies to deliver market information and access such as e-commerce platforms and market price databases. ✓ Digital platforms to optimize the performance of value chain aggregators and logistics.	✓ Reduce transaction costs: ♦ For information, decision-making, supervision, and enforcement. ♦ In downstream and upstream markets by facilitating price discovery. ✓ Reduce reliance on market intermediaries and middlemen due to low search costs. ✓ Accelerate matching buyers and sellers and reduce cost and time of each transaction. ✓ Improve post-harvest storage management for both inputs and outputs, cold chain management, and transportation. ✓ Empower points of aggregation by bringing producers, aggregators, and buyers to one platform.	✓ Narrow spatial divides and disadvantages of remoteness by lowering hurdles to information, services, and markets. ✓ Reduce the social divide preventing women from accessing downstream and upstream markets. ✓ Increase smallholder profits by lowering transaction costs to lift farmgate output prices. ✓ May create or widen a digital divide between small and large farmers due to low literacy skills of smallholders. ✓ Enable farmers to access cheaper services for processing their production through diffusion of a large number of mobile processing units (shared via digital platforms).	✓ Decrease GHGs across supply chain segments by increasing logistical infrastructure efficiency. ✓ Enable farmers/processors to reduce food loss by improving storage planning and linking agricultural sensors with transport management and processing systems. ✓ Change relative output prices and access to new markets, leading to on-farm shifts in resource allocations and new incentives for quality improvements and environmental sustainability.
Challenge: Limited access to rural finance and insurance			
✓ Digital technologies to deliver financial inclusion and risk management by using big data analytics and remote sensing to assess farmers' creditworthiness for financing.	✓ Reduce the time and cost of establishing farmer creditworthiness by improving their credit history (access to databases with more information on potential clients). ✓ Establish mobile digital footprint data to reduce transaction costs and accelerate loan application processing, especially for customers in remote areas. ✓ Improve insurance products to serve as a de-risking factor for small-scale agriculture investment. ✓ Improve subsidized access to high-quality inputs through e-vouchers.	✓ Overcome rural isolation by reducing the transaction costs of depositing and withdrawing savings in formal institutions. ✓ Accelerate access to friends' and family's savings in times of need.	✓ Increase climate resilience by reducing risks of smallholders associated with natural hazards and market risks through access to insurance coverage, yield prediction, and smart contracts.
Challenge: Low food safety and traceability			
✓ Digital technologies such as food sensing, DLTs, and e-platforms.	✓ Reduce transaction costs associated with the food safety and quality requirements' compliance between different principals and agents across value chains.	✓ Facilitate fair trade by informing about food production practices and environmental impacts.	✓ Ensure better traceability of environmentally certified production. ✓ Enable food loss reduction in agri-food systems.

Note: For detailed description and examples, refer to World Bank 2021.

inefficiencies caused by reliance on market intermediaries and middlemen (Aker and Fafchamps 2015; Nakasone *et al.* 2014; World Bank 2021). Price transparency will further provide benefits to consumers who may identify lower prices more easily. The power of e-platforms is that they match producers and consumers at nearly no cost. This has the potential to sharply reduce past market failures and profoundly reshape market access and value chains. In China, for example, 9.85 million online shops operated by rural farmers who employed over 280 million people reached a total online sales volume of agricultural products of over CNY 240 billion in 2017 (about US$36 billion), representing a 53.3 percent year-on-year increase (Department of Market System Development, China Ministry of Commerce). In June 2018, the Alibaba Group announced its plan to expand the coverage of its rural initiative (Rural Taobao) to 1,000 counties (representing 68 percent of all Chinese counties) and 150,000 villages in the next three years (Hsu 2018). In Africa, e-Soko, an online mobile-based marketplace for agricultural products, publishes daily prices of agriculture crops for wholesale and retail which strengthens farmers' bargaining power and addresses information asymmetries. e-platforms can also reduce food waste. For example, Twiga reduced post-harvest losses in Kenya to 5 percent, compared to 30 percent at informal markets (Box 6). E-commerce platforms are predominantly used to shorten food supply chains at the national level. Yet, a lack of explicit international guidance to assist national regulators regarding e-commerce, food trade, and consumer protection hinders the growth of food-related e-commerce that crosses international borders (WHO 2019). The international Codex Committee on Food Labelling has been working on guidance on the labelling of foods sold through internet/e-commerce. Efforts to develop international guidance are under way. In 2019, the Codex Committee on Food Labelling launched discussions to develop guidance on labelling of foods sold through e-commerce (WHO 2019).

E-commerce may prove another solution to support agri-food producers by shortening supply chains, to respond to COVID-19's disruption in traditional markets. COVID-19 has accelerated the shift in sales of products, including food, toward digital marketing and sales platforms, and this shift is predicted to persist to some extent post-crisis. Serbia[2] and Croatia[3] have taken action to keep short supply chains functioning and improve the structural issues linking farmers to markets in both countries through digital approaches. In China, when wholesale markets closed due to COVID-19, Pinduoduo Inc. (PDD), an e-commerce platform supporting 585 million active buyers, created a sales channel on its app specifically for farmers. PDD also hosted livestreaming sessions featuring community leaders and farmers who introduced their local specialties to a wider audience.[4] COVID-19 has increased farmers' willingness to go digital. For example, a 2019 pre-COVID-19 McKinsey Survey of European farmers found that approximately 30 percent wanted to use digital channels for purchases, while a post COVID-19 survey showed 69 percent willing. Across Europe, that adds up to almost 4 million more farmers who say they are ready to use online channels as their main sources of ordering (McKinsey 2020).

➔ **Box 6.** Twiga Foods[1] Platform

The Twiga Foods platform uses mobile phone technology to match supply and demand, aggregating market participants and finding buyers for farmers' produce in Kenya's large but highly fragmented fruit and vegetable market. Twiga's e-commerce platform enables vendors to order fresh produce when needed from farmers across Kenya. The system is a win for both sides—farmers have guaranteed access to a fairly priced, transparent, mobile marketplace while vendors can consistently source high-quality produce that Twiga conveniently delivers to their doorstep for free. By increasing efficiency in the supply chain, Twiga reduces waste and ultimately reduces food prices for end use consumers. The company operates collection centers across the country, in addition to a central pack house with cold storage facilities. They mobilize trucks and vans for swift collection and distribution of produce. The smooth logistics system limits Twiga's post-harvest losses to 5 percent, compared to 30 percent in informal markets, where farmers typically sell produce. Since it launched operations in 2014, Twiga has grown and now works with over 13,000 farmers and 6,000 vendors in Kenya. The company initially started off matching vendors to banana farmers but now works with other produce such as tomatoes, cabbage, mango, potato, and onion. Farmers who sign up with Twiga receive payments within 24 hours. Twiga is proving that smart use of technology and innovative business models can vastly improve large and inefficient agricultural markets.

[1] https://twiga.com

[2] https://pijaca.minpolj.gov.rs.
[3] https://trznica.mps.hr.
[4] https://stories.pinduoduo-global.com/articles/livestreaming-hogs-the-limelight-amid-pandemic-shutdown.

Digital Platforms to Optimize the Performance of Value Chain Aggregators and Logistics

Digital technologies can also improve agricultural supply chain organization and management by optimizing aggregators' performance, which limits value chain disruptions from COVID-19. Smallholder farms increasingly turn to aggregators such as farmer cooperatives and organizations that use digital tools to improve collection, transportation, and quality control. A single platform that gathers producers, aggregators, and buyers can increase transaction volumes, raise prices for farmers, create enterprise opportunities for the aggregators, and deliver traceable and better-quality produce to buyers. Digital platforms are especially useful in deep rural areas as coordination between producers, truckers, and warehouse owners and aggregate traders is needed to get products to market. For example, TruTrade collects and aggregates data on farm produce on a digital platform, which is used by a network of village aggregators and buyers to market and sell produce across Kenya and Uganda. During the COVID-19 pandemic, TruTrade has focused on keeping supply chains open, framing emergency food system response initiatives, and training agents and farmers on COVID-19 awareness and preventative measures to promote safe sourcing. Similarly, the 'Kisan Rath' mobile app has facilitated transporting grains and perishable foods during COVID-19 lockdowns. Consignors (farmer, farmer producer organizations [FPOs], buyer/trader) post a requirement for transportation, which is disseminated to transport aggregators, who in turn interface with truckers and fleet owners to obtain a competitive quote and then pass back the quote and trucker details to the consignor. The consignor directly negotiates offline with the trucker to finalize the deal. After the trip, the user rates the trucker in the app, establishing a feedback mechanism to improve transport services and to inform consignors' future decisions.[5] Similar platforms were not identified in the focus countries.

Digital Technologies to Improve Traceability and Quality Control

The range of digital technologies improving value chain transparency and traceability includes food sensing technologies, blockchain (distributed ledger), and e-platforms (World Bank 2019b). Barcodes and digital scanners have been used to improve traceability since the 1970s, and they have been improved by higher-capability coding systems (for example, DataBar and RFID chips) (GS1, n.d.). DLTs, such as blockchain, have promised to increase efficiency and transparency in agricultural supply chains by improving product traceability and integrity, contract certainty, and compliance with SPS requirements (Box 7). Blockchain technology prevents data from being improperly altered, ensuring transparency and building trust among retailers and consumers located at the end of decentralized supply chains (The Seam 2019). For example, Carrefour, a supermarket chain based in France, uses blockchain to provide consumers with detailed information on chicken for sale, such as veterinary treatments, freshness, and other metrics (Jouanjean 2019). American retailing giant Walmart uses the IBM Food Trust platform to track fresh produce, including lettuce and spinach (Corkery and Popper 2018) and shrimp exports from India, to its points of sale in the United States, to ensure that the seafood meets strict US food standards (Cant 2019). Improving traceability of food products can also reduce expenses associated with food safety issues, which are particularly important in low- and middle-income economies where food-borne illnesses cost US$110 billion each year (Jaffee *et al.* 2019).

Digital Technologies to Deliver Financial Inclusion and Risk Management

Digitization of transactions and payments can improve the inclusion of formerly unbanked and vulnerable farmers into credit markets. Financial services and risk management delivered via digital technologies can include digital payment systems, mobile phone-based financial and insurance products, and big data analysis that can reduce the cost of credit and weather-based crop insurance. Currently, only a minor share of smallholder farmers have access to formal credit in the three focus countries. Big data and advanced analytics can significantly reduce the cost of establishing farmer creditworthiness and assessing insurance risk. These lower costs can potentially lower interest rates and insurance premiums for farmers, thereby increasing access to these financial services. They can also allow smallholder farmers to overcome rural isolation and access friends' and family savings in times of need. Remote sensing technologies can reduce the monitoring costs of traditional insurance contracts, improve the contracts available for smallholder farmers, and reduce their costs (World Bank 2021). Many studies show that digital financial solutions have a positive and significant effect on annual household input use, agricultural commercialization, and household income (Jack and Suri 2011; Kirui *et al.* 2013). Farmdrive in Kenya and Harvesting in Uganda are examples of companies using data analytics to assess farmers' creditworthiness for financing. Kenya's M-Pesa represents a prominent example of financial inclusion through digital technology (Box 8). This mobile phone-based payment system was introduced in 2007 and had already reached 65 percent of Kenyan households by 2009, which lifted an estimated 2 percent of rural Kenyan

[5] http://agriadda.in/kisan-rath-mobile-app-to-facilitate-transportation-of-food-grains.

➔ **Box 7.** Blockchain Technologies for Improved Traceability

Blockchain is a shared Distributed Ledger Technology (DLT) that facilitates the process of recording transactions and tracking assets in a business network. An asset can be tangible or intangible (for example, intellectual property such as patents, copyrights, or branding). Virtually anything of value can be tracked and traded on a blockchain network (Sylvester 2019).

Blockchain technology is receiving increasing attention as a mechanism to ensure food traceability. Blockchain in the food retail industry helps mitigate risks of food fraud and safety by offering enhanced traceability and better auditing around the sourcing of products and ingredients, shipping dates, and expiration dates. Increased transparency and better auditing would empower the supply chain to be more responsive to any food-borne illness outbreaks and other recalls, as blockchain makes it significantly easier to track issues, recall products, and issue warnings in a more timely and accurate manner. Tampered products can be easily identified and isolated, preventing expensive product recalls, and for contamination, only unsafe products need to be sent to a landfill, keeping safe products on store shelves. This would reduce food waste and food adulteration (estimates suggest that one in ten food products is adulterated or mislabeled). Walmart has already completed two pilots using blockchain to improve food safety. In one pilot, the retail giant conducted a trace-back test on mangoes in one of its stores. It took almost seven days to trace the fruit back to its original farm using traditional methods. By using blockchain, Walmart was able to access the information in 2.2 seconds (Walmart Corporation 2018). This demonstrates that blockchain can be effectively used to track product quality, which is especially important for group sales (for example, cooperatives), to remunerate group members according to quality. Blockchain is suitable for certification and fair-trade schemes. Food loss in food systems could be reduced by up to 30 million tons annually using blockchain-enabled traceability to monitor information in half of the world's supply chains (WEF 2018). The United Nations Economic Commission for Europe (UNECE) is developing an online, blockchain-supported marketplace and a smart food loss management system (Annovazzi-Jakab 2019).

Blockchain technology can also speed up transactions, enabling farmers to be paid more rapidly and preventing coercion and retroactive payments, common in the food industry. It can eliminate intermediaries and enable growers' direct connection with retailers, food service operators, and even consumers. Blockchain can potentially build trust by making contracts more readily enforceable and flexible (pay-per-use approach) and make money transfers more transparent, faster, and cheaper. Small producers are likely to benefit from fairer prices and a wider consumer base.

Blockchain also has disadvantages as an infant technology that is relatively unstable, expensive, complex, unregulated, and selectively distrusted. Across its many applications, blockchain remains stuck at an initial stage in the product lifecycle (with a few exceptions) (McKinsey 2019). Most proofs of concept (POCs) are in the pioneering mode (or being wound up) and many projects have failed to get to more advanced funding rounds. From a regulatory standpoint, this means that the standards are underdeveloped and not yet mature to replace the law. In a few cases, doubts about its commercial viability have been raised. There are currently many types of blockchain in both software and operational design, so its interoperability (the possibility of having different types of blockchain talk to each other) has to be addressed. Among various operators, IBM is piloting crypto-anchors to avoid this problem that allows a one-to-one unalterable link between products and their blockchain by embedding plant DNA and/or edible shade of magnetic ink and digital fingerprints into food and agricultural inputs.

Source: World Bank 2019k.

➔ **Box 8.** Financial Inclusion through M-Pesa Platform

M-Pesa is a digital financial solution that is now being replicated worldwide. Safaricom is a telecommunication company that pioneered this digital solution. It has 26 million subscribers or near universal coverage in Kenya. Safaricom outlets and franchisees deliver payment and financial services in remote corners of the country. Kenya has 7 million smallholder farms, and 90 percent of these farmers own mobile phones. Nearly 68 percent of the farm value after leaving the farm goes to brokers, intermediaries, and logistics. Only 1 percent of the smallholders get access to credit. Many national and international processors and buyers of commodities are struggling to get the desired quantities of good-quality produce, thus limiting development of SMEs and agribusiness enterprises in Kenya. Involvement of Safaricom to invest in a digital platform analogous to M-Pesa has the potential to transform Kenyan agriculture. M-Pesa allows digital contracting between farmer and buyer, to use apps for improved just-in-time logistic services, and to create digital markets to engage some 300,000+ farmers on this platform.

Source: World Bank 2019b,k.

households out of poverty through financial inclusion. Interoperability, the possibility of paying and receiving funds from banks, internet, and mobile platforms, is becoming standard which further facilitates the use of digital payments.

Digital Technologies to Deliver e-Government for Improved Public Services

This section describes how digital technologies can improve the delivery of public sector services to the benefit of the agri-food sector. Table 8 presents common governance challenges and the impacts of the potential digital technology solutions on efficiency, equity, and environmental sustainability.

Digital technologies can help reduce costs and increase efficiency and transparency of all public services, including those related to the food system (World Bank 2019b). Digital government, or e-government, can transform the public sector's relations across three modalities: Government-to-Citizen (G2C), Government-to-Business (G2B), and Government-to-Government (G2G). E-Government can support the public sector in digitizing information related to the agriculture sector such as land tenure mapping and registration, subsidy distribution, e-Extension, early warning systems, environmental monitoring, and dissemination of statistics. Governments, for example, can use digital ID systems to effectively target input and cash subsidies to farmers, establish reliable systems that record agricultural asset ownership, create digital farmer profiles to improve service delivery, and open up new economic opportunities for the poor. For example, Estonia's public administration applies a principle of digital-by-default (OECD 2019). Currently, 99 percent of Estonia's public services are online, and 98 percent of Estonian nationals use e-IDs that produce more than 10 million digital signatures per year. The use of the data exchange layer X-Road saved Estonian administration 804 working years compared to previous calendar years, and it is estimated that using the electronic signature saves 2 percent of the Estonian GDP each year.[6] Estonia reduced the time spent on applying for agricultural subsidies from 300 minutes to 45 minutes by using digital technologies (Kärner 2017). In 2011, the Nigerian government spent approximately US$180 million in public funds intended to support 600,000–800,000 smallholders, yet little money ever reached the intended beneficiaries (Grossman and Tarzai 2014). In 2013, with the e-wallet digital payment system, the Nigerian government reached 4.3 million smallholders at a cost of approximately US$96 million, showing that digital technologies increased efficiency by 5–7 times (IFAD 2013). This demonstrates how the e-wallet program in Nigeria reached a higher number of recipients with lower cost and leakage through an e-wallet program for subsidized fertilizers. International organizations are using digital payments for efficient distribution of assistance. For example, the WFP's recent advances in biometric beneficiary registration and verification allow Syrian refugees living in Jordan to purchase food using an eye scan. Digital public services can be bundled in one system, such as the Integrated Administration and Control System of the European Union (EU) (Box 9).

Digital delivery of public services may be one area for rapid transformation given the economic shocks caused by COVID-19. Digital or virtual extension services provided in local languages could communicate necessary agricultural information to farmers, expanding to include new information on personal hygiene and safe handling of food products. Such services would ideally be delivered free of charge and through official channels, to avoid mistrust. Digital delivery of market information and pricing platforms could allow for transparency while reducing physical contact among essential workers. Frequent digital monitoring and/or real-life crowdsourcing of food prices can allow for taking legal action against any vendor manipulating prices during the crisis. Providing social safety net payments digitally would improve efficiency and reduce human contact; for example, the use of e-vouchers could provide efficient public support to the vulnerable population.

Digital Technologies to Improve Food Control

Public actors can use digital technologies, including DLT, to improve food control systems. Food safety data collected through the use of remote technologies can inform the development of risk-based strategies for inspection along food chains (WHO 2019). These offer a more efficient use of public funds for food safety control than universal inspection. Box 10 presents an example of successful development of digital traceability systems in the livestock sector. Using e-certification for electronic transmission of SPS data can improve the accuracy and reduce the cost of international food trade, compared to traditional paper-based systems. While only five countries have adopted fully paperless e-certification systems for SPS control, international efforts are being made to expand the use of e-certification by developing countries (WHO 2019). Additional information on DLT is available in the subsection on digital technologies to improve traceability and quality control.

[6] https://www.x-tee.ee/factsheets/EE/#eng.

➔ **Table 8.** Improving Public Services and Monitoring Systems through Digital Technology Solutions and Their Impact on Efficiency, Equity, and Environmental Sustainability

Examples of Digital Enabler	Efficiency	Equity	Environmental Sustainability
✓ Digital payments for public support. ✓ Digital ID system for farmers. ✓ Rural e-cadaster to support land survey and facilitate open, transparent access to land records for all. ✓ Web-accessible systems to facilitate open, transparent access to data such as land use maps, soil maps, weather information, and yield prediction.	✓ Streamline and automate administrative processes and enhance regulations transparency. ✓ Support farmer identification and verification. ✓ Streamline the administration of state support payments (for example, input and cash subsidies). ✓ Facilitate farmer access to services (for example, e-Extension). ✓ Reduce the cost and effort of data collection through digital ID systems. ✓ Establish reliable systems that record agricultural asset ownership. ✓ Make the land market more efficient by transparently identifying available land. ✓ Reduce the cost of registering/renting land parcels.	✓ Support resilience of vulnerable communities during economic shocks (for example, COVID-19 impacts) through digital provision of social safety net payments.	✓ Improve knowledge about climate-smart practices and pest management through e-Extension services.
✓ Digitized monitoring systems through digital registries, remote sensing technologies, and digital early warning systems.	✓ Facilitate statistical surveys (census). ✓ React and respond quickly in case of animal and food-borne diseases. ✓ Increase efficiency of tracking land use change/level of degradation and water use and availability through remote sensing. ✓ Identify the most efficient options for achieving a given policy/service objective. ✓ Enable a fast and more cost-effective monitoring and overall policy evaluation.	✓ Allow small farmers to use knowledge of natural resources to their advantage, increasing their productivity and building climate resilience.	✓ Inform environmentally sustainable policies and more rational use of natural resources including soil and water.

Note: For detailed description and examples, refer to World Bank 2021.

➔ **Box 9.** The Integrated Administration and Control System of the EU

To ensure transparency in administration, control, and execution of agriculture and rural development support schemes in line with the established policy goals, EU member states are tasked with establishing the Integrated Administration and Control System (IACS). In physical terms, IACS consists of a number of computerized and interconnected databases. The interconnected databases include information on farmers and farms, land registry, payment entitlements, and animal registry. In particular, the three main databases are (a) the Farm Registry, (b) the Land Parcel Identification System (LPIS), and (c) the Animal Registry. These databases enable effective and efficient processing of agriculture support applications, carry out administrative controls, facilitate the selection for physical on-the-spot controls, and calculate the subsidy, which will be accounted and executed by the Paying Agency. In practice, based on the experience of recent accessions to the EU, the new member states required 3–5 years to develop an IACS with its integral components until it was fully operational.

Source: World Bank 2021.

➔ **Box 10.** Digital Traceability in the Livestock Sector - Uruguayan Example

Uruguay successfully developed digital traceability systems in the livestock sector. The country is a net food exporter and its agriculture sector (crops, livestock, and forestry) is an economic driver and contributor to GDP and employment. Uruguay has become a leading meat exporter. It has developed a National Agricultural Information System that helps integrate across agriculture, natural resource management, and new climate-related information from 32 national agencies in an online state-of-the-art platform tailored to different users' needs. Farmers' access to the internet allows early warning systems for livestock management, an agrochemical control system, rural risk assessments, soil and land use plans, water studies for irrigation, and remarkably precise climate forecasts. The system also includes a livestock traceability system, which was initially motivated by an outbreak of foot-and-mouth disease in 2000 and 2001, leading to the replacement of the paper-based system that had been in place for the previous 30 years. The new system allows monitoring of individual heads of livestock associated with each individual farmer, based on his/her national ID.

Source: World Bank 2019b.

Land e-Registries

Digital land information systems can also improve cadastral data. Cadastral maps often differ from the reality on the ground, constraining agricultural land market development and farm enlargement. Governments can consider initiating a mass assessment of the existing cadastral maps and implementing a systematic resurveying of land parcels to update digital cadastral maps or modify existing maps. Applying digital technologies can also improve land market functioning, for example, by reducing time and cost related to land use permitting and registration and improving transparency. Land use permits can be digitized and the application process automated can reduce times for filing and approval and increase transparency. Similarly, cadastral databases that are open to the public can help make the land market more efficient by transparently identifying available land and reducing the cost of registering land parcels (Woetzel *et al.* 2018). For example, agroecological zoning in North Macedonia categorizes land into land resource mapping units, each having a unique combination of landform, soil and climatic characteristics, and/or land cover, with units having a range of potential and constraint for agricultural land use.

Digital Technologies for Monitoring and Evaluation

Digital technologies also offer a broad spectrum of tools and data availability to enhance monitoring and evaluation of outcomes in agriculture. The uptake of digital tools and consequent data generation in agriculture can help enable a more cost-effective monitoring and evaluation (M&E) of results. For example, satellite earth observation provides unbiased, consistent, and timely information on whether investments in agricultural development take place in a sustainable and effective manner. Enhanced aerial imagery that allows plot-level monitoring; drone-based inspections; and sensor-based plant, water, and soil analyses are some of the approaches that have been used and continue to be developed. Globally, remote sensing technologies already and significantly reduce the cost and time required to monitor land cover and land use, elevation, soils and watersheds, particularly in remote areas (OECD 2019). For example, using a combination of digitally integrated satellite imagery, topographical maps, soil maps, cadastral information, climate data, and computerized models of biomass production can provide real-time information on changes in land use at high levels of resolution. This

information in turn provides the analytical base for deciding how best to respond to land degradation. Efforts to use digital technologies to improve both the collection and the publication of accurate and timely data specific to the agriculture sector would be useful in developing evidence-based policies and programs (World Bank, 2021).

Remote sensing could enable compliance checks of the implementation of agricultural policies. For example, under the EU Common Agricultural Policy (CAP) for 2014–20, national paying agencies were required to perform yearly on-the spot checks for at least 5 percent of beneficiaries. Under the new CAP, administrators will move toward new 'data-intensive' compliance approaches based on high rates of remote monitoring (near 100 percent). Remote-sensing-based spot checks can drastically reduce the administrative costs associated with policy monitoring. One study showed that using satellite data to monitor land conversion under the US water quality trading program reduced an administrator's time from 10 hours for on-site visits to 15 minutes.

Remote sensing may offer a particularly powerful and cost-effective means to assess agricultural production in inaccessible areas, such as the conflict-affected areas of Iraq, across a wide scale and over time. The potential uses of the satellite data include targeting (identifying areas needing assistance), analyzing adaptive and coping strategies in conflict-affected areas, improving design of future agricultural surveys, and assisting ongoing humanitarian programs; analyzing (assessing the impact of conflict on household incomes); and advance planning (identifying suitable areas for development assistance, identifying farmer input needs under rehabilitation activities, and improved planning of international assistance).

➔ Chapter 3:
State-of-the-Art Digital Ecosystem in Mashreq - What Is the Status of Digital Agriculture and Its Enabling System in Mashreq?

Key Messages

- ➔ The digital economy in Jordan and Lebanon is more advanced, while it is still emerging in Iraq. All three countries can leapfrog into digital development given the transformative potential of digital technologies and prioritization by national strategies.
- ➔ Significant improvements in digital infrastructure use over the past decade create a favorable condition for applying digital innovations in Iraq, Jordan, and Lebanon. Specific attention should be given to vulnerable populations in rural areas which face inequalities and impediments in digital access, especially in Iraq.
- ➔ In Iraq, Jordan, and Lebanon, digital technologies could create a new momentum for economic development by accelerating the structural transformation process and by supporting the transition toward a more commercially oriented, competitive, and export-oriented agriculture and agri-business sector.
- ➔ Early stage results indicate that digital technologies show promise in advancing the digital transformation of the agriculture sector in the Mashreq focus countries, and the countries have supportive economic and sector development strategies for this digital transformation.
- ➔ A dynamic development of digital agriculture in Iraq, Jordan, and Lebanon has been limited by low awareness and understanding of digital technologies and their applications' potential in the agriculture sector, limited interest among public and private sector agents, mismatch between the language used by technologies (English) and those understood by some farmers, and inadequate access to finance and data.
- ➔ Successfully deploying digital applications in Mashreq requires greater awareness and timely, localized, and customized information addressing specific farming concerns in a comprehensible format and in the local language.

Chapter 3
State-of-the-Art Digital Ecosystem in Mashreq - What Is the Status of Digital Agriculture and Its Enabling System in Mashreq?

This chapter addresses the enabling environment and the state of digital readiness in Iraq, Jordan, and Lebanon, which form the foundation for a digital transformation of the agri-food sector. Then, the chapter examines the status of digital agriculture in the focus countries, with contemporary examples.

Digital Readiness

The digital economy in Iraq is emerging, while it is more advanced in Jordan and Lebanon. The World Bank's MNA Tech Initiative reviewed the digital economy, that is, the economy that is based on digital computing technologies, across Middle East and North Africa countries, awarding scores (0–10) and rankings across five pillars: digital infrastructure, digital platforms, digital financial services, digital entrepreneurship, and digital skills (Table 10). The pillars are constructed based on a number of indicators presented in Appendix 2. For instance, the digital infrastructure pillar is based on indicators on quality, affordability, market competition, government ownership, and legal frameworks, whereas digital skills is based on internet use, social media, and other required skills. Iraq performs below the Middle East and North Africa average on each of the five pillars and is deemed 'emerging' according to the World Bank's analysis. Jordan performs near or above the regional average and is deemed 'advanced' except for the Digital Financial Services pillar. Lebanon's performance is mixed, earning a rating of 'advanced' on three pillars, falling below the regional average on both digital infrastructure and digital financial services, so it is 'emerging'. The detailed, per-country indicator results are presented in Appendix 2.

All three countries can leapfrog into digital development given the transformative potential of digital technologies and prioritization by national strategies. The Iraqi government has made digitization an explicit priority and has encouraged public-private partnerships, in its Iraq Vision 2030 development plan. The draft of the National Strategy for Food Security of Iraq has a section on monitoring food security as part of an early warning system. Jordan's REACH2025 digital economy action plan seeks to transform the country into a regional hub for ICT, stimulating additional GDP growth and creating new jobs and businesses (Oxford Business Group 2018). Lebanon's government previously promised to digitize its government services and develop a new telecom sector policy by revising Telecom Law 431 as a way of promoting a digital economy. The international development institutions' policy is also moving toward strengthening the digital economy. The need for digital development is even more urgent due to the adverse impacts of the COVID-19 pandemic.

Digital Infrastructure

Significant improvements in mobile penetration over the past decade create a favorable condition for applying digital innovations in Iraq, Jordan, and Lebanon. According to TeleGeography, Lebanon reported 58 percent fixed broadband household penetration, while Jordan's and Iraq's comparable figures were 25 percent and 17 percent, respectively. In contrast to the fixed broadband values, internet use has rapidly increased in the last decade (Figure 6b, ITU 2019a). For mobile penetration (number of cellular subscriptions per 100 people), Iraq, Jordan, and Lebanon currently lag the Middle East and North Africa regional and global averages, with mobile cellular subscriptions per 100 inhabitants reported at 95 in Iraq, 87.6 in Jordan, and 64.5 in Lebanon in 2018. In the Middle East and North Africa, the comparable figure was 108.5 per 100 inhabitants. Smartphone use among adults was reported at 86 percent in Lebanon and 85 percent in Jordan (Pew Research Center 2019), while figures are unavailable for Iraq. In Iraq, mobile broadband penetration lags behind the regional average, as does the share of the population with 4G network coverage. However, 93 percent of Iraq's population is covered by 3G

➔ **Table 9.** Digital Economy Performance by Pillars

Pillars	Digital Economy Values (0–10)				
	Iraq	Jordan	Lebanon	Middle East and North Africa Average	Middle East and North Africa Average Excluding Gulf Cooperation Council (GCC)
1. Digital Infrastructure	3.83	5.85	4.55	5.01	4.17
2. Digital Platforms	4.08	5.02	6.01	5.44	4.81
3. Digital Financial Service	3.47	3.98	4.49	5.34	4.39
4. Digital Entrepreneurship	2.95	5.59	5.10	4.18	3.55
5. Digital Skills	2.83	5.13	5.45	4.68	3.94

Source: MNA Tech Initiative (World Bank 2019e, 2019f, 2019g).

networks, on par with the regional average (World Bank 2019i). In Jordan and Lebanon, access to 3G and 4G networks is high (over 95 percent). In Iraq, a recent increase in security and stability across broader geographic areas has permitted new fiber optic cables to be installed and has led to a growth in mobile broadband subscribers. However, recent politically motivated service interruptions have raised concerns about reliability and volatility.

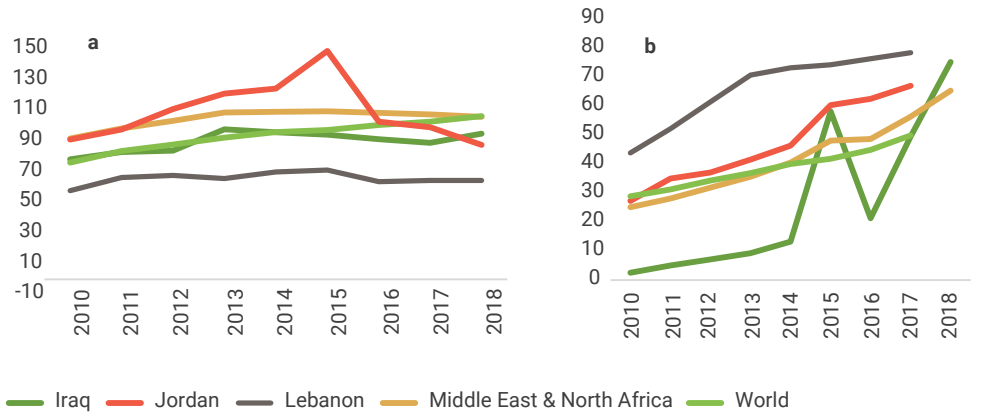
Decreases in the average cost of mobile data can foster the adoption of digital technologies and increase digital inclusion. Based on the Worldwide Mobile Data Pricing Survey for the cost of mobile data in 2020, Iraq, Jordan, and Lebanon ranked 146, 40, and 132 among 228 countries, respectively. A higher rank reflects more expensive service. The average cost of 1 GB of mobile data is lower in Mashreq (Iraq US$4.20, Jordan US$1.03, and Lebanon US$3.82, per month in 2020) than the regional average (US$4.46 per month). In fact, in Jordan the average cost of mobile data is even less than the global average (US$1.56 per month).[7]

Vulnerable populations face inequalities and impediments to digital access, especially in Iraq, compared to Jordan and Lebanon. The digital infrastructure in rural areas is usually less developed than in urban areas, with limited network coverage, lower smartphone ownership, and lower overall digital skills and awareness. These impediments are further complicated in Iraq with its recent history of internal and external conflicts. Inequalities in digital access between urban and rural areas are high in Iraq, where a much smaller portion of the rural population is yet to be connected to high-speed broadband networks. There is a significant gap in extending high-speed broadband networks to Iraq's rural population, and an estimated 8.8 million rural Iraqis lack such connection (Figure 7).

Internet access reflects gender disparities, and the digital gender divide in Mashreq is one of the widest in the world. Without closing this divide, digital transformation threatens to become less of an opportunity and more of a barrier. In Iraq, it is estimated that only 72 women use the internet for every 100 men, a gender gap of 28 percent, and only 89 women use mobile phones for every 100 men, a gender gap of 11 percent (World Bank 2020e). In Lebanon and Jordan, the internet gap is smaller at 10 percent, but the mobile phone gap is larger than in Iraq: 17 percent (Lebanon) and 21 percent (Jordan).

The digital divide means young women do not have access to or cannot excel in digital jobs, compared with young men. The limited access to technologies inhibits what is available in rural areas and widens existing gender inequalities. Low-skilled and rural women can also benefit from this digital transformation as opportunities for outsourcing and platforms connecting small-scale farmers and craftspeople emerge.

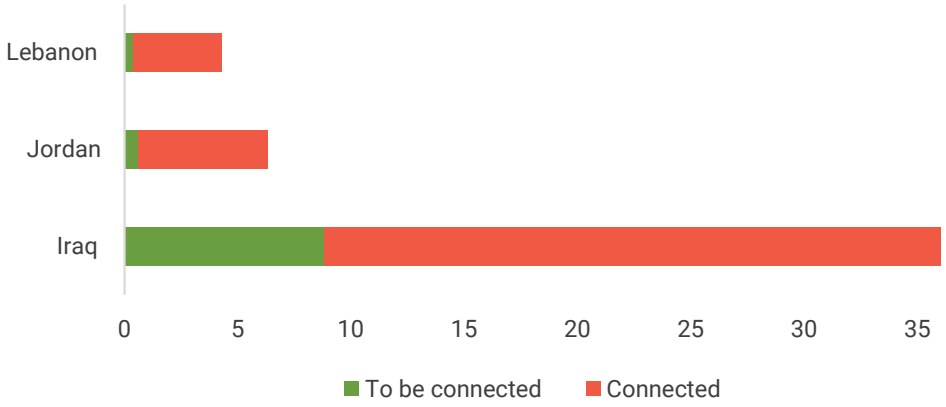
[7] https://www.cable.co.uk/mobiles/worldwide-data-pricing.



➔ Figure 6.
a. Mobile Cellular Subscriptions (per 100 people);
b. Individuals Using the Internet (Percentage of Population)

Source: World Development Indicators[1], ITU World Telecommunication/ICT Indicators database.

[1] World Development Indicators. https://databank.worldbank.org/source/world-development-indicators



➔ Figure 7. Population to Be Connected to High-Speed Broadband Networks (millions)

Source: MNA Tech Initiative.

Digital Finance

Government e-payments systems are at a nascent stage in Iraq and at an emerging stage in Jordan and Lebanon. EIU (2018) scored and ranked 73 countries based on their enabling environment for adopting government e-payments systems. E-Payments systems include functions such as income tax payments and refunds, obtaining and paying for an ID card, government social safety net payments, value added tax (VAT)/sales tax payments and refunds, company registration and fees payments, payments for goods and services, and disbursement of loans. Iraq's performance yields the lowest score (9.8) among all 73 countries assessed. Jordan's score of 45.1 translated into in a rank of 65, and Lebanon's score of 39.9 resulted in a rank of 70 (EIU 2018). Despite its low ranking, Iraq's e-payments ecosystem is undergoing remarkable changes. See the section on e-Governance for further details.

Lebanon and Jordan perform moderately with respect to e-commerce, while Iraq is at an emerging stage. The 2019 UNCTAD Business-to-Consumer E-commerce Index ranked Iraq 131, Jordan 87, and Lebanon 68 among 152 countries globally. The UNCTAD Business-to-Consumer E-commerce Index measures an economy's preparedness to support online shopping. Several digital payments mechanisms are currently in place and widely used in Jordan well beyond the agriculture sector. For example, E-Fawatircom is a widely used digital payments platform that allows users to pay fees and transfer money directly from commercial bank accounts. E-Fawatircom has been supported by the Central Bank of Jordan and adopted by the Jordanian government, even allowing users to pay for public utilities bills. Elsewhere, Zain Telecom offers a service called Zain Cash, a mobile phone-based application that enables the digital payment of bills. In Iraq, the number of digital storefronts on Facebook and Instagram are growing daily. In addition to these mainly

regional outlets, Amazon and eBay are both available. Iraq's first private digital payment card was launched in 2019 by Lebanese fintech startup NymCard, collaborating with Visa, to serve the underbanked Iraqi population. The card can be requested through a mobile app and enables users to make online purchases on both local and international websites, using a digital 'Know Your Customer' (KYC) process. The rapid rise of e-commerce from a negligible base and the growing use of mobile phones for transactions both point to latent unmet demand. In Iraq, the relative sophistication of the population with digital financial services compared with the low quality of formal financial services may lead to a leapfrogging, similar to mobile phone services over landlines in Sub-Saharan Africa (World Bank 2020a).

A growing share of Mashreq's rural population used digital technologies for financial services or e-commerce recently; however, there is still untapped potential for growth and digital financial inclusion (Figure 8). Even though fintech is increasing in urban areas, a minority of Iraqis ages 15 or older and living in rural areas had used financial services or digital payments technologies by 2017. Only 12.9 percent of rural Iraqis received digital payments, though this figure rose sharply from 2014 (3.5 percent). Similarly, only 8.7 percent of rural Iraqis had made digital payments and very few rural Iraqis had used the internet for online purchases (4.5 percent) or bill payment (8.2 percent) or used a mobile phone or internet to access a financial account (3.4 percent). In Lebanon, approximately 21.0 percent of rural Lebanese received digital payments during 2017. More rapid growth was reported in the share of rural Lebanese making digital payments, rising from 13.7 percent to 24.3 percent in 2017. Fewer rural Lebanese had used the internet for online purchases (15.3 percent) or bill payment (4.6 percent) or used a mobile phone or internet to access a financial account (4.8 percent). In Jordan, approximately 32.1 percent of rural Jordanians received digital payments, more than tripling since 2014. Only 11.2 percent of rural Jordanians had made digital payments within the previous year, up from 6.0 percent in 2014. Very few rural Jordanians had used the internet for online purchases (5.9 percent) or bill payment (1.6 percent) or used a mobile phone or internet to access a financial account (3.1 percent) (World Bank 2020b).

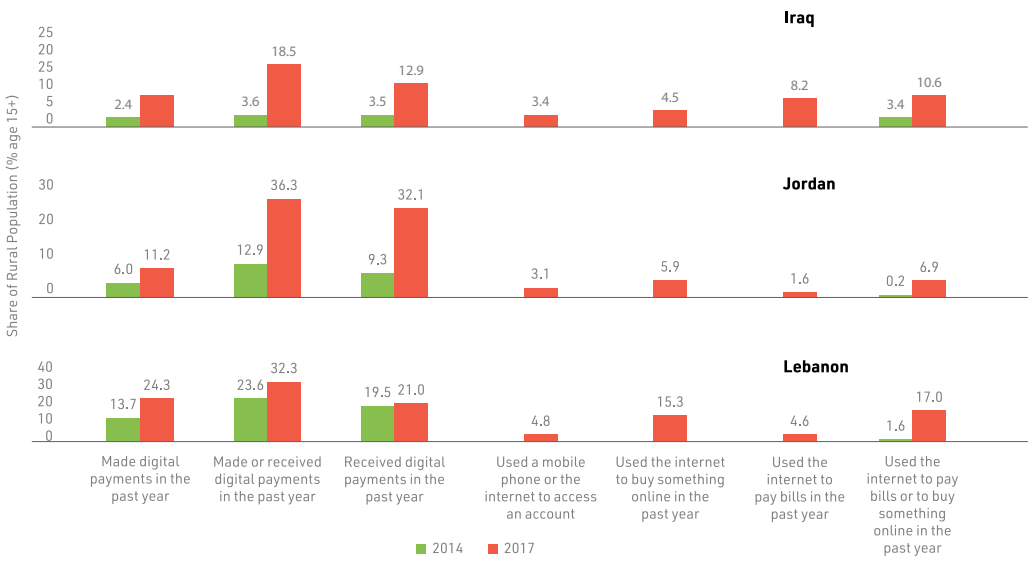
While there is a positive increase in the use of digital financial services and e-commerce in recent years, there is still a need to increase digital financial inclusion in these countries. The rapid expansion of mobile money wallets and e-commerce transactions may lower the risks and the friction of financing along the value chain and connect smallholders to markets (World Bank 2021).

Human Capital

Youth literacy rates are increasing, yet gender disparities in literacy still exist for adult women in Mashreq countries. Youth literacy rates exceed adult literacy rates in all three focus countries, which may favor youth compared to adults in their ability to use digital technologies. Total youth literacy rates were reported at 52.3 percent in Iraq (2013), 99.1 percent in Jordan (2012), and 99.2 percent in Lebanon (2009). Adult literacy rates are significantly higher in Jordan and in Lebanon than in Iraq. The latest estimates indicate that adult literacy was 97.9 percent in Jordan (2012 figure) and 91.2 percent in Lebanon (2009) but only 43.7 percent in Iraq (2013), which falls well below the average adult literacy rate across Middle East and North Africa countries (79.6 percent) (2016) (Table 10). This low performance is perhaps understandable considering Iraq's recent history of extended conflict, which disrupted the educational system. Adult female literacy rates are below those of adult males in all three countries. This observation also holds among youth in Iraq but not

➔ Figure 8. Usage Rates of Digital Technologies for Financial Services by Rural Population in Mashreq

Source: World Bank 2020b.



➔ **Table 10.** Comparative Literacy Rates in Focus Countries

Country	Adult (%)			Youth (%)		
	Total	Female	Male	Total	Female	Male
Iraq	43.7	38.0	53.0	52.3	48.6	57.0
Jordan	97.9	97.4	98.4	99.1	99.2	99.0
Lebanon	91.2	88.1	94.3	99.2	99.3	99.2

Source: World Development-Indicators.[1]

Note: Youth are defined as people ages 15–24. Adults are defined as people ages 15 and above.

[1] https://databank.worldbank.org/source/world-development-indicators

in Jordan or Lebanon, where young women have slightly higher literacy rates than male youth. Thus, women may be disadvantaged in adopting and using digital technologies.

Farmers and agricultural operators in the focus countries tend to have less education. Literacy figures specific for rural populations are not readily available, but since these communities have generally lower education levels, the national figures in Table 10 likely overestimate literacy rates among agricultural communities in the three countries. In Jordan, illiterate farmers manage nearly 5 percent of Jordan's agricultural areas; those with only the ability to read and write control another 13 percent of agricultural areas; and those with an elementary-level education control 33 percent of agricultural land. The remaining agricultural lands are managed by farmers with a secondary education (20 percent), an intermediate diploma (4 percent), or a university-level education (24 percent) (Department of Statistics 2017b). In Lebanon, 16 percent of farmers are illiterate; another 61 percent of farmers have only primary-level education but control 60 percent of the total utilized agricultural area in the country (Lebanese Ministry of Agriculture, 2012). No comparable information is available for Iraq.

Internet use is increasing in all three countries and digital skills among Jordanians and Lebanese exceed the Middle East and North Africa average, while the Iraqi population falls short of it (World Bank 2019i, 2019j, 2019k; Appendix 2). According to the World Bank's MNA Tech Initiative, Iraq's underperformance is based on the low share of internet users among the general population and limited rates of social media use (below 50 percent). Farmers have lower literacy and education rates compared to the wider population, which may be a barrier to their adoption of digital technologies. In terms of internet use, Jordan and Lebanon report usage rates higher than the Middle East and North Africa regional and global averages, while Iraq is on par with the global average as of 2017. All three countries have recorded significant increases in internet subscriptions from 2010 to 2017 (Figure 6b) (World Bank 2019a). In 2018, the population using the internet increased to 75 percent in Iraq. Internet use among adults was 87 percent in both Jordan and Lebanon in 2018 (Pew Research Center 2019). Iraq was not included in that study.

The Knowledge Economy Index (KEI) identifies Jordan as an intermediate knowledge economy, while Lebanon is categorized as an early knowledge economy. The KEI is a measure of the ability of an economy to grow through innovation, and again the countries under consideration perform moderately. The KEI scores countries on a scale of 0–10; it assessed 38 countries as of 2019, including Jordan (score value: 4.43) and Lebanon (score value: 4.07). Between 2011 and 2018, the index reported improvements in Jordan's ICT infrastructure and institutions for innovation but declines in performance related to the innovation system and skills for innovation. Lebanon improved its performance in ICT infrastructure but showed a worsening performance in institutions for innovation, skills for innovation, and innovation system from 2011 and 2018. No assessment is reported for Iraq (EBRD 2019).

Digital Entrepreneurship

The ecosystem for digital entrepreneurship is at the intermediate level in Jordan and Lebanon while Iraq's digital ecosystem is nascent. In the Global Entrepreneurship Index, Jordan ranked 63 while Lebanon ranked 66 among 137 countries in 2019. The Global Entrepreneurship Index measures both the quality of entrepreneurship and the extent and depth of the supporting entrepreneurial ecosystem in 137 countries. The Jordanian government intends to spur investment and bolster the entrepreneurial ecosystem through the Innovative Startups and SMEs Fund (ISSF). Lebanon's ecosystem for digital technologies was accelerated by targeted public funding and the presence of various incubators and accelerators (for example, Berytech, Speed@BDD, Flat6Labs, Smart ESA, and Talal and Madiha Zein AUB Innovation Park [AUB-iPark]). The Lebanese government has supported investment in the

knowledge economy through incentives offered under the *Banque du Liban* Circular 331, which provided US$400 million for commercial banks to channel for equity investment, accelerators, incubators, funds, and start-ups. This increased the quantity and value of technology investment in the country (Babin 2018). Given Lebanon's current fiscal climate, it is unclear whether Circular 331 can be extended or expanded. Beirut Digital District offers a business environment designed to foster digital start-up firms and to encourage entrepreneurship (BDD 2019). The AUB-iPark, launched in 2019, supports start-up ventures promoting innovation and entrepreneurship, including digital solutions (AUB 2020). There are no data on the number of start-ups or venture capital investors in Iraq (World Bank 2019i). Digital entrepreneurs in Iraq note that business start-up and growth are hampered by regulatory obstacles and complexity, especially with registration and tax payments.[8] One way to foster digital entrepreneurship is by establishing technology transfer offices in major research institutions that examine market demand and seek solutions inside academia. Box 11 presents a successful case study on facilitating digital entrepreneurship and technology transfer at Unicamp (University) in Brazil.

Rising interest in agri-tech entrepreneurship has led to the creation of sector-specific incubators and accelerators in the region. In Lebanon, Berytech launched the Agrytech Accelerator, a yearly, 3-phase program through which Berytech supports start-ups with innovations across the agri-food sector, offering them the resources, knowledge, and funding to scale their ideas and grow into an international business with global impact (Agrytech 2020). Some of the start-ups supported by Berytech and Agrytech incorporate digital technologies. Similarly, Jordan's entrepreneurial ecosystem now includes Hassad, a private accelerator that is dedicated to developing agriculture sector start-ups. There are no data on the number of start-ups or venture capital investors in Iraq (World Bank 2019i), and no specialized sectoral incubators have been created yet (unlike in Lebanon and Jordan). Iraq continues to witness contributions of private sector actors in the ecosystem, such as co-working spaces (The Station, Tech Hub in Erbil, Fikra Space, Mosul Space, and The Lab) and incubators (51 Labs and Noah's Arc). In Lebanon and Jordan, start-ups that are innovating in agriculture sector digital technologies are clustered, designing solutions to reduce the use of scarce resources or to improve market access for farmers by connecting them to consumers.

➔ **Box 11.** From University to Industry - Technology Transfer at Unicamp in Brazil

Brazil has dramatically increased technology transfer and innovation by establishing the first technology transfer office at a Brazilian university. Called Inova, this technology transfer office was established in 2003 by the State University of Campinas (Unicamp), a multidisciplinary university with more than 31,000 students and 20 research units. Unicamp pursues a variety of technologies in many fields. By 2007, Inova was the most frequent patentor and licensor in Brazil. In only two-and-a-half years, it signed 128 technology transfer agreements, licensed 45 technologies to private companies and the government, and applied for 153 new patents, 22 trademarks, and 24 software registrations. Its technology transfer agreements will last for more than 10 years, and they have already generated royalties for the university ranging from 1.5 to 10 percent of the net income from the licensed technology. Unicamp grants inventors 33 percent of royalty and licensing income. Inova is driven by market demand. Instead of selecting Unicamp's technologies and offering them to the market, Inova examines market demand and seeks solutions inside the university. The technology transfer team comes from private institutions and has business skills. They are not researchers. Meanwhile, the government provides many incentives to companies, such as tax benefits to companies that pay royalties and those that invest in research and development, within or outside the company; compensation for taxes on royalties paid abroad during the execution of technology transfer contracts; tax exemptions for fees paid to maintain patents, trademarks, and cultivar registrations abroad; and sponsorship/subsidy of 60 percent of the salary of a scientist hired by a company. These coordinated efforts will increase patenting and technology transfer in Brazil, strengthen the relationship between public institutions (where Brazilian research is mainly concentrated) and private companies, and contribute strongly to innovation. Other public universities and research centers have been studying Inova's model to emulate it.

Source: Di Giorgio 2007.

[8] Interview with Mohammed Khudairi. Iraq Energy Institute, Iraq's New Digital Economy; February 2019. https://iraqenergy.org/2019/02/03/creative-disruption-voices-new-digital-economy-part1.

Bolstering the agri-tech entrepreneurial ecosystem requires developing multi-stakeholder partnerships capable of implementing new innovative initiatives. For example, the DigitalAG4Mashreq Innovation Facility (in design stage) would accelerate technological adoption in the agri-food sector by providing the necessary financial and technical support to leverage collective action, act as an effective communication and support tool encouraging stakeholder coordination, raise awareness, and disseminate knowledge.

Regulatory and Legal Framework

The regulatory framework for digital technologies is not yet complete in Mashreq countries. Jordan and Lebanon have already adopted a legal framework for preventing cybercrime. All three countries have a draft legal framework for data protection and online privacy and for electronic transactions and e-signature required for digital financial services. Yet, the three countries have not adopted a framework for consumer protection when making online purchases (World Bank 2019e, 2019f, 2019j). Lebanon has a legal framework establishing intellectual property rights (IPR), including for digital technology development that could be applied in the agriculture sector. But the IPR complexity and high cost has led entrepreneurs and academics to avoid its use, favoring alternative mechanisms. Alternatives to formal IPR protections include secrecy, exploitation of lead-time advantages, technical complexity, and use of trust-based relationships. Several institutions including the United Nations Economic and Social Commission for Western Asia (UN-ESCWA) and Lebanese academic institutions have also taken steps to protect intellectual property and foster innovation and technology transfer, for example, by developing policy templates that research institutions could adopt (UN-ESCWA and CNRS-L 2017). Setting up the needed digital and regulatory framework is essential for protecting the rights of both consumers and developers and facilitating the digital microfinance industry.

There is a diverse ownership pattern for mobile and fixed broadband markets among focus countries. Iraq's government does not own the mobile and fixed broadband markets, while Jordan's government owns approximately 20 percent of mobile and fixed broadband markets (World Bank 2019j). Lebanon's government owns all of the mobile and fixed broadband markets. See Appendix 2 for more detailed information.

Status of Digital Solutions in the Agri-food Sector in Mashreq

In Mashreq, digital technologies could be harnessed to address the immediate needs posed by COVID-19 and create a new momentum for economic development by accelerating the structural transformation process and supporting the transition toward a more competitive and export-oriented agri-food sector. The digital transformation is applicable to all stages of the agri-food value chain. Smart use of data enables potential efficiency gains to materialize, information to flow, and more evidence-based decision-making to improve sustainability within the food system. Mashreq countries face a risk associated with the non-adoption or low adoption of digital technologies as their agriculture sectors can lose competitiveness and fall further behind other countries. A lack of competitiveness has already limited agricultural producers in Mashreq from exporting their products to more lucrative markets.

COVID-19 heightens the potential risks to the stability of food supply chains and exacerbates any poorly performing elements of the value chain, but digital technologies can facilitate agri-food supply by optimizing agri-logistics, improving price information, and informing planting decisions. Countries with a larger share of subsistence agriculture or with greater internet penetration are better able to deal with the negative impacts of containment (for example, lockdowns to limit COVID-19 spread) (World Bank, 2020d). However, the Middle East and North Africa region is among the hardest hit regions globally as subsistence agriculture is limited and internet penetration is far from complete. In the midst of the COVID-19 crisis, promoting appropriate digital technologies within targeted value chains will require prioritization in the face of very limited time and resources to act. The most useful value chains to select would be those that (a) support continued production of food products that are vulnerable to extensive disruption (for example, fresh fruits and vegetables and other perishables) and (b) target the livelihoods and consumption of vulnerable communities including, rural and agricultural communities. This section presents digitally enabled solutions that can potentially address common challenges to the agri-food sector in Iraq, Jordan, and Lebanon, focusing on solutions related to production, trade, and e-Government.

Digital Technologies to Improve On-farm Efficiency, Equity, and Environmental Sustainability

A range of precision agriculture technologies have been introduced in recent decades to improve the productivity of major crops and livestock systems in Iraq, Jordan, and Lebanon, but adoption has been limited. Digital technologies are being introduced to Jordan's and Lebanon's agriculture sector, but these technologies are being adopted within the private sector by larger, higher-value, and/or export-oriented production agriculture producers and enterprises. These larger producers are better able to absorb the cost of investment in digital technologies and their operation. While there is evidence that Iraq initiated the use of digital technologies in agriculture as early as the 1970s, these systems deteriorated or were destroyed due to conflicts. For example, Iraq's Dujailah Project applied digital technologies within an integrated agro-industrial complex as early as the 1970s. The project devoted over 20,000 ha to cultivating cereal crops, mainly wheat and barley. Activities related to irrigation, drainage, and maintenance were fully computerized, and the system control center included data collection and communication, data processing and information generation, control, display and supervision of output, and operation. Today, it is not operational as a singular project as parts of the system are out of order (notably the system control center), but the irrigation and drainage channels remain operational.

Digital technologies are particularly used for improved irrigation and hydroponic production in Jordan, while vineyards and wineries in Lebanon are actively using digitally enhanced precision agriculture technologies to assess growing conditions and vine performance. In Jordan, the largest uptake of digital technologies on farm is the application of imported irrigation-related technologies such as sensors. The focus on irrigation is reasonable, given the scarcity and relatively high cost of water.[9] Digital technologies that control irrigation, fertilization, temperature, and humidity are used in many initiatives to develop soilless agriculture, led by Jordan's Ministry of Agriculture.[10] Large, private farms are also pursuing initiatives to digitize agricultural operations to control irrigation, fertilization, temperature, and humidity. Such technologies have been implemented by Abu Seido Farms in Deir Alla/Balqa, Jabali Farms in Giza/Amman Governorate, Abu Ghanam Farms in North Shouneh/Irbid Governorate, and the Hashemite Fund for Badia Development in Al-Mafraq Governorate. These technologies were supported with funding from the Embassy of the Netherlands in Amman.[11] In Lebanon, vineyards and wineries are actively using digitally enhanced precision agriculture including drone- and sensor-based IoT technologies to assess growing conditions and vine performance. For example, Domaine des Tourelles winery is using drone technology to relay high-definition imagery for monitoring water stress and wood diseases.[12] Large-scale potato producers in Lebanon oriented to food processing and export have invested in advanced precision agriculture technology.[13] In Jordan and Iraq, the use of digital images or drones in the agriculture sector is limited due to security concerns and the need for legal permissions.

The environmental impacts of digital technologies adopted by the agriculture sector in Iraq, Jordan, and Lebanon are as yet unknown. While digital technologies may offer important environmental benefits, including optimizing scarce inputs including water and energy, they may also generate new streams of resource use and waste, including GHG emissions related to energy-intensive data storage or the waste of electronic or digital materials. The importance of this impact on the development of digital agriculture—particularly in the context of Mashreq countries—and opportunities to mitigate these impacts remain areas for future inquiry.

Several private sector vendors are currently offering digitally enhanced agriculture technologies to the market in Jordan and Lebanon. In Jordan, private companies import precision agriculture technologies for the high-value and export-oriented firms, but there is a lack of local firms providing mobile applications for operations management or blockchain solutions in local languages.[14] Similarly, in Lebanon, several companies sell precision agriculture technologies. For example, Robinson Agri and Unifert sell digitally enhanced drip irrigation systems offering remote control and multiple irrigation programs to the market,[15] and George Hawa imports the *Electrocoup* digitally enhanced pruning system, which allows orchard and vineyard owners and managers to review data on pruning practices and improve their field operations.[16] Jallad, the agent for Caterpillar and John Deere in Lebanon, offers tractors and other large machinery that can be equipped with precision agriculture functionality (GPS tracking and steering, variable-rate applications, and so on) for purchase. However, few such tractors or machines with these precision agriculture applications are currently being sold in Lebanon,

[9] Interview with Mohamed Al Afranji, conducted January 13, 2020.
[10] Such projects are currently being implemented at Al-Hussein Station in Al Balqa Governorate; Al Wala Agriculture Station in Madaba Governorate; North Shouna Station in Irbid Governorate; and Al Hassan Agricultural Station in Tafila Governorate. Personal communication with Eng. Muhammad Tuwaiq, conducted November 19, 2020.
[11] Personal communication with Eng. Muhammad Tuwaiq, conducted November 19, 2020.
[12] Personal communication with Faouzi Issa of Domaine des Tourelles, conducted October 15, 2019.
[13] Interview with Moussa Sawan of Jallad Group, conducted January 22, 2020.
[14] Interview with Mohamed Al Afranji, conducted January 13, 2020.
[15] Personal communications with Nour Nahouli of Robinson Agri and B. Basta and Antoine Slim of Unifert, conducted October 3, 2019.
[16] Personal communication with Patrick Hawa of George Hawa, conducted October 3, 2019.

and the lack of sales could be due to high costs, relatively small farm sizes that minimize economies of scale, and limitations to digitally enhanced services including data transfer.[17] Automated irrigation systems that incorporate digital technologies are available on the Lebanese market, but the biggest uptake has been among non-agricultural users. Notably, the landscape industry is applying these technologies at the consumer level (for example, in the gardens of large villas) and within the sports industry (for example, at golf courses and on football fields). Lebanese smallholders have not yet adopted automated irrigation systems, preferring to maintain their traditional irrigation practices. The purported reasons for this non-adoption include gaps in farmer know-how, complexity of the available technology, a lack of consistent power supply in rural areas to run pumps and controllers, a lack of incentives to adopt the technology,[18] and a lack of financing. No information is available about comparable commercial offerings in Iraq.

In Jordan and Lebanon, additional digital technologies are under development by start-up companies, with plans for commercial sale in the future. In Jordan and Lebanon, the domestic start-up space is largely focused on developing technologies that are appropriate to small- and medium-size farmers. Large-scale farmers tend to import technology directly from outside. For example, a Jordanian start-up company has developed devices that can provide early detection of red palm weevil larvae inside palm trees. A device attached to a palm tree can assess whether the tree is infected by either listening to the sound produced as weevils eat the insides of the tree or by capturing vibrations from inside the tree. Measurements are then analyzed using algorithms to distinguish noises and vibration caused by weevils compared to other sources.[19] In Lebanon, IOTree is a start-up using digital solutions to target pests attacking tree crops found throughout the Middle East and North Africa region (Berytech 2019). IOTree physically captures the med fly and other pests, using smart traps that are connected via a wireless network (Executive Bulletin 2019). IOTree also offers a platform to send alerts via SMS or mobile application to farmers, informing them of the optimal time to spray pesticides (Berytech 2018). The system uses a deep learning algorithm and machine vision to detect, classify, and count different types of pests (Executive Bulletin 2019). LifeLab BioDesign, a Lebanon-based manufacturer of vertical hydroponic systems, aims to develop a system that will enable hydroponic growers to control inputs and manage their inventory; predict production yields, coordinate sales with end users, and facilitate payments; and incorporate machine learning to optimize production.[20]

Academic institutions are pursuing research that explores the application of digital technologies to the agriculture sector, though some research will take time to roll out. For example, Yarmouk University of Jordan has digitized irrigation, fertilization, and control of temperature and humidity in its greenhouses in Irbid Governorate; this work is made possible by a grant from the United States Agency for International Development (USAID). In Lebanon, Chateau Kefraya has partnered with a private ICT company Libatel, Ogero Telecom (Lebanon's largest telecom operator), and Université Saint-Joseph ESIAM to develop a 'precision viticulture' system, which relies on a wireless agriculture sensor network to gather soil and climate information at lower cost and to track the effect on grape production in real time (Libelium 2017). Soil and climate information include humidity, temperature, atmospheric pressure, solar radiation, soil humidity, soil temperature, and luminosity. The use of wireless sensors has replaced more expensive and time-consuming manual collection of the data and facilitates real-time data analysis on a backend platform that is accessible by computer or smartphone. Data can be used by the winery's agricultural engineers to inform their decisions (for example, to optimize irrigation) and to react to changing climatic conditions. Ogero is developing an IoT-LoRaWAN[21] network in Lebanon, which transmits the data gathered by the sensors to the Kerlink Gateway; from there, the data are sent via 3G through SIM card to a cloud platform and to Libatel private servers, where a dashboard and applications are developed (Libelium 2017). Libatel used the project as a proof of concept as part of its bid to support Ogero's deployment of a nationwide IoT network in Lebanon (Kerlink 2017). Elsewhere, the American University of Beirut is developing a mobile-based application to assess agricultural water use based on satellite data and an automated irrigation system linked to soil moisture sensors, weather station data, and evapotranspiration data. Both the mobile application and the automated irrigation system are under development and several years away from commercial adoption.[22] Additionally, in Lebanon, within the public sphere, the National Center for Remote Sensing at the National Council for Scientific Research of Lebanon (*Conseil National pour la Recherche Scientifique*, CNRS-L) has a range of digital field instruments available for use by academic research partners, including universities and the Lebanese Agricultural Research Institute (LARI). Examples include soil moisture sensors, advanced drones equipped with infrared sensors, and a field spectroradiometer used to produce spectral signatures of different crops. These instruments do not appear to be available for use by individual farmers or private sector actors.

[17] Personal communication with Moussa Sawan of Jallad Group, conducted October 3, 2019.
[18] Interview with Hadi Jaafar of the American University of Beirut, conducted February 5, 2020.
[19] Personal communication with Ashraf Amayreh, conducted October 22, 2019.
[20] Personal communication with Ali Makhzoum of LifeLab BioDesign, conducted September 18, 2019.
[21] LoRaWan stands for Long Range Wide Area Network.
[22] Interview with Hadi Jaafar of the American University of Beirut, conducted February 5, 2020.

Digital Technologies to Improve Access to Knowledge and Facilitate Evidenced-Based Decision-Making for Improved Farming Practices

Digital platforms for knowledge dissemination could improve the quality of extension services in Mashreq. Current extension services are insufficient to meet farmers' needs, offering limited farm visits and outdated information. e-Extension can target animal diseases and pest control, and pest control poses particular challenges to Mashreq's fresh fruit and vegetables production. Farmers in Mashreq have low usage of current extension systems. New production technologies often do not reach farmers and lack relevant agriculture sector information, including needed production calendars for local and (potential) export markets. Global resources are often available only in English, limiting their use and uptake in Jordan, Iraq, and Lebanon. Local language content related to the agriculture sector is largely missing. Achieving successful results in Mashreq requires e-Extension services to provide timely, localized, and customized information addressing specific farming concerns in a comprehensible format and in a local language such as Arabic.

The public sector employs several digital technologies to generate publicly accessible information required for evidence-based decision-making in the agriculture sector. For example, the National Center for Remote Sensing, a division within CNRS-L, hosts the Open-Access Geospatial Portal Database and the Sustainable Natural Resource Management Platform and Early Warning System (SuNaR), providing crop classification and crop yield estimations. The Open-Access Geospatial Portal Database[23] allows users to create and download thematic maps with information on soils, land use and land cover, watersheds, and disaster events (flood hazards, desertification, forest fires, and so on). This database serves Lebanon's public institutions that support the agriculture sector, including the Ministry of Agriculture, Green Plan, and the Central Administration of Statistics. Drought estimates based on satellite imagery are regularly published in partnership with the Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD). SuNaR produces and stores geo-information for emergency operations, prevention and preparedness actions, and disaster risk reduction programs. In cooperation with the FAO, SuNaR has produced an agricultural risk assessment and profile to enhance Lebanon's agriculture sector resilience (Abdallah *et al.*, 2019). Remotely sensed imagery from the center has been used to produce crop classification (Awad, Alawar, and Jbeily 2019) and crop yield estimations, for example, wheat biomass mapping (Nasrallah *et al.* 2018) and potato yield estimation for the Bekaa region (Awad 2019).24 The LARI-LEB App for Lebanon was recently developed by the International Water Management Institute (IWMI), FAO, and LARI to provide advice on climate-smart and agriculture solutions.

The public sector in Mashreq countries uses digital technologies to develop weather forecasts to inform farming practices and disaster risk reduction strategies. Iraq's Agricultural Meteorological Center was established in 2008 to operate and manage the Ministry of Agriculture's meteorological network. It provides agricultural meteorological services such as real-time data, information, analysis, and consultations and recommendations to beneficiaries (farmers, researchers, and extension agents). Its overall objective is improving the use of climate and natural resources data in agriculture and reducing risks and losses. Lebanon has a more advanced early warning system, established in 2017 by LARI to alert farmers to potentially destructive climatic conditions and adapt their farming practices. LARI monitors changes in microclimate throughout the country using an agrometeorological weather station and forecasts weather patterns using a Dacom Farm Intelligence model. Forecast information is then translated into agriculturally relevant Arabic language text that reaches farmers through SMS broadcast messages, a smartphone application, and the LARI website.25 Farmers can then use the information to manage impacts on their farming activities. For example, an SMS can tell farmers of a possible rain event, which informs when they should sow winter wheat.26 In 2019, the Chamber of Commerce for Industry and Agriculture in Zahle (CCIAZ) launched the AgVisor digital application that notifies farmers of interventions to combat crop pests and diseases. With these advances, Lebanese farmers have recently adopted digital applications to access weather forecasts and inform their production plans such as planting, pest treatments, and fertilization.[27]

E-extension services are currently underdeveloped in the focus countries, but efforts are emerging. For example, Lebanon's Ministry of Agriculture oversees a network of 31 agricultural centers located throughout the country, with more than 100 technical staff who provide farmer visits, seminars, and on-farm demonstrations reaching over 8,000 farmers in 2018. However, it is unclear if any of these activities included an e-Extension component (WARD 2018). Iraq's Directorate of Agricultural Extension and Training has implemented a project using mobile applications to communicate with farmers. Fifteen extension centers across the country provide information

[23] http://rsensing.cnrs.edu.lb/geonetwork/srv/eng/search.

[24] Personal communication with Dr. Ghaleb Faour of CNRS-L, conducted February 2020.

[25] http://www.lari.gov.lb/forecast.

[26] Personal communication with Dr. Ihab Jomaa of LARI, conducted February 2020.

[27] Personal communication with Said Gedeon of CCIAZ, conducted January 7, 2020.

to farmers related to the main farming activities within that governorate. The application provides recommendations on dates for different agricultural practices, use of herbicides and insecticides, and other techniques to improve productivity. Application information can help farmers anticipate and respond to pest attacks, crop failures, and climatic changes through timely weather-based agro-advisory messages.

Remote sensing and digital modelling are increasingly used to assess agricultural water use efficiency and the impacts of climate change in all three countries. AquaCrop is a digital model of climate change scenarios that has been applied in several Middle East and North Africa. AquaCrop has produced several scenarios to assess the need and potential for climate change adaptation in Iraq, specifically its agriculture sector, to determine the effects on evapotranspiration and water productivity. UN-ESCWA used AquaCrop scenarios for the recommendations of new techniques and methods for monitoring, planning, and creating strategies for water use efficiency and increased agricultural productivity for key crops in Iraq. Whether digital technologies are included is unclear (UN-ESCWA 2019). Similarly, in Jordan and Lebanon, remote sensing technologies are used to estimate evapotranspiration for monitoring agricultural water use. In Lebanon, the public sector, through the National Center for Remote Sensing at CNRS-L, has developed smart irrigation tools based on remote sensing, though their use appears oriented to other public sector actors involved in irrigation, such as (a) the SEBALI evapotranspiration system (Mhawej *et al.* 2020), developed in partnership with the FAO by the North Lebanon Water Establishment; and (b) the Satellite for Irrigation Scheduling (SAT-IRR) tool, developed under the EU-funded CHAAMS project.[28] Employees from the Bekaa Water Establishment and the Litani River Authority, both in Lebanon, were trained to use the SAT-IRR tool.[29] The Litani River Authority manages the major water source for the Bekaa Valley, Lebanon's agricultural breadbasket, and uses digital technologies including software programs to control water flows and detect overpumping from groundwater sources by agricultural users.[30]

Digital Technologies to Deliver Market Information and E-commerce

Several web-based applications have been introduced to support agri-food marketing by sharing information on prices in Mashreq. In Jordan, web-based applications on prices have proven very popular. For example, the Wholesale and Vegetable Market of the Greater Amman Municipality maintains a website[31] that displays the quantities of local and imported fruits and vegetables and the prices traded in the market (highest, lowest, and majority). The Jordanian Exporters and Producers Association for Vegetables and Fruits (JEPA)[32] also operates a website containing price data, including the local prices in the country of origin and market prices in the countries importing fruits and vegetables. It also details information and standards required by exporters. In Iraq, the Directorate of Agricultural Extension and Training works through 15 extension centers across the country and uses mobile applications to provide price information to reduce market distortions and help them plan production. In Lebanon, the AgVisor digital application launched by CCIAZ in 2019 allows farmers to compare prices across different crops and markets. The platform also offers a directory of actors in agriculture value chains. However, AgVisor faces challenges particularly related to collecting and updating its data and to its long-term financial sustainability.[33] While it appears that AgVisor has successfully disseminated price information, it is unknown whether farmers have effectively used that information to obtain higher market prices.[34]

Wider adoption of digital marketplaces can reduce price manipulation. For example, in Jordan, current practices within wholesale markets allow for manipulation, with traders (dallal) buying the same goods multiple times to artificially raise the prices. Farmers are paid the initial lowest price while the trader retains the margin between the lowest and highest prices obtained.[35] For digital marketplaces to be widely adopted and to meet their potential for significant growth, policies and investments are needed to eliminate the main constraints. These constraints to faster adoption of e-marketplaces include a lack of knowledge and skills, low trust in online transactions, and limited logistics infrastructure, such as storage and transportation of fresh produce.

[28] For more information, see http://www.eranetmed-chaams.org.
[29] Personal communication with Dr. Ghaleb Faour of CNRS-L, conducted February 2020.
[30] Personal communication with Mohammed Yunis of the Litani River Authority, conducted February 2020.
[31] http://www.awm.gov.jo/dotnet/aboutus.aspx.
[32] http://www.jepa.org.jo.
[33] Personal communication with Said Gedeon of CCIAZ, conducted January 7, 2020.
[34] Interview with Ramy Boujawdeh of Berytech, conducted December 20, 2019.
[35] Interview with Issa Halabi, conducted October 8, 2019.

➔ **Box 12.** An Online Marketplace Connecting Farmers with Businesses and with Consumers in Jordan

In Jordan, Ghoorcom seeks to address market access challenges including high margins captured by middlemen, unorganized and costly logistics and transport, delays in payment to farmers, nontransparent pricing, and lack of appropriate quality monitoring (including meeting export requirements). An e-wallet system is used to integrate payments between farmers and retailers. On the B2C side, Ghoorcom prepares, brands, and delivers food products (currently fruit products including fruit baskets) to retailers and to individual consumers (including corporate entities) in Amman. It markets its products via social media platforms, newsletters, and blogs. Ghoorcom also operates Ghoorcom Academy, offering training programs in financial inclusion, education, and agro-tourism. Ghoorcom's founders benefitted from business incubation service providers, including Amman Chamber of Commerce, Shamal Start, The Tank, and Injaz (Oqeili 2019). However, their site is only in the English language, limiting its popularity among farmers. The site data indicated only 600 users as of late 2019.

Private and public sector initiatives have sought to establish web-based applications for the marketing of agri-food products, linking producers and consumers. Ghoorcom launched in Jordan in 2017 as an online marketplace connecting farmers with businesses (B2B) and with consumers (B2C). Jordan also has the Open Market website[36] that focuses on popular food products but also sells electronics. There is only limited evidence of digital technologies being used to facilitate e-commerce in Iraq's agriculture sector. In Iraq, as in Lebanon and Jordan, informal Facebook and WhatsApp groups are used sporadically for agri-food e-commerce. Lebanon's e-commerce market—generally not restricted to agriculture—was recently assessed as growing slowly and facing challenges related to weak internet penetration, the persistence of cash-on-delivery payments (El Amine 2017), a lack of secure online payment mechanisms, and popular mistrust of online purchasing (Rahal 2013). Nevertheless, the Ministry of Agriculture has developed the 'Olive App' (زيت لبنان) smartphone application for promoting and marketing Lebanese olive oil. The app will connect olive oil producers with consumers and other stakeholders in the value chain.[37]

International development organizations are strengthening e-commerce within the agri-food value chain and improving the role played by cooperatives. For example, the International Labour Organization (ILO) has been planning to launch a website and an app for Lebanon's Federation of Cooperatives, designed to improve the functioning of agricultural cooperatives and facilitate market access for farmers. The website will track the payment of dues to the cooperatives and into the federation and allow farmers to upload information on what they have available for sale and buyers to make purchases through the app. Though the app is not intended to facilitate delivery, it is linked to a GPS. The app should eventually be managed by the Federation of Cooperatives, and all cooperatives and farmers will be given access to the app as potential sellers. Individual agricultural cooperatives will play a role in vetting information posted by farmers. The app is tied to the launch of the website (Bahn, Bayram, and Abou Jaoude 2019). In Jordan, an ongoing EU project is supporting the development of a digital agriculture platform, including access to finance and connection to input suppliers.[38]

The mixed performance of digital platforms serving agriculture suggests that policy makers and other relevant actors should consider their experiences as they work to develop and implement similar platforms in the region, since not all e-commerce attempts lead to successful outcomes. For example, Beyond Organic initially operated delivery-based sale of organic fresh fruits and vegetables (FFV) to consumers in Greater Beirut, receiving and managing consumer orders via a WhatsApp platform. However, the company closed this sales channel in early 2019, opting to sell instead through farmers' markets. This company has returned to WhatsApp sales since COVID-19 led to the closure/suspension of farmers' markets in Lebanon. In Jordan, a potential limitation to adopting digital technologies that would directly facilitate market access by producers of FFV is the incorrect belief among some producers that they are legally required to sell their products through the wholesale market.[39] In fact, there is no such legal requirement. Wholesale markets in Amman, Zarqa, and Irbid received 50 percent of locally produced vegetables and 56 percent of locally produced fruits in 2017, with the remainder sold directly to retail markets, supermarkets, and exporters (Ministry of Agriculture of Jordan 2017). Accordingly, there is no legal restriction on the sale of agri-food products through an online platform.

[36] https://jo.opensooq.com.
[37] Personal communication with Mariam Eid, Head of Department of Agro-Industry, Ministry of Agriculture, February 2020.
[38] Interview with Mohamed Al Afranji, conducted January 13, 2020.
[39] Interview with Issa Halabi, conducted October 8, 2019.

➔ **Box 13.** EU-Jordan Agricultural Twinning Project

The EU applies stringent traceability standards on all products entering the common market. To address this, the 'EU-Jordan Agricultural Twinning Project' sought to increase exports of animal products from Jordan to the EU by improving traceability, specifically animal health information. Several challenges contributed to the project's failure. First, Jordan's Ministry of Agriculture used the project's digital technologies to distribute subsidized feed for large and small ruminant animals (cows, sheep, and goats) rather than developing traceability requirements. Jordanian producers of animal products generally rely on government-subsidized animal feed to reduce their costs of production. To access subsidized feed, farmers were required to provide documentation for approval by the Ministry of Agriculture and project staff and later deposit with the Ministry of Trade. Specifically, the limited project and staff resources were used to validate documents related to feed subsidies leaving little time to collect health data required for traceability, and project resources were insufficient to hire additional staff for health data tracking. Software was also problematic, since the original software used under the project was programmed in Italian. The software eventually failed and there was no local expert to fix it and no funds to hire an Italian-speaking programmer. The Electronic Transformation Directorate at the Ministry of Agriculture later built a new software that is still functional. Finally, the project failed to account for legal barriers and did not include the required legislative amendments to establish the traceability system, especially those related to the registration and licensing of animal farms. Ultimately, while the project yielded a usable animal inventory, it lacked health data necessary for traceability to support expanded exports of animal-based products. This case highlights the importance of holistic project planning that considers the multiple functions of digital data and platforms; looks beyond technology to the legal and regulatory requirements; and addresses practical concerns like staff resources, training, and capacities.

Applying digital technologies alone may have a limited effect on expanding market access to Lebanese farmers, unless constraints related to finance and regulations are addressed. Crop farmers selling to wholesale markets have typically engaged in informal credit arrangements with both input suppliers and wholesale purchasers. The input suppliers provided seeds, fertilizers, and so on, on credit and received payment at the end of the agricultural season. The wholesale purchasers could then pay upon receipt of the produce. These informal financial arrangements served to limit the ability of a farmer to shift among input suppliers or wholesale purchasers, even when farmers were aware of price advantages elsewhere in the market.[40] The extent to which these informal credit arrangements persist and thus limit the impact of digital disruption is unclear in light of the country's current economic and financial crisis.

Digital Platforms to Optimize the Performance of Value Chain Aggregators and Logistics

Lebanese and Jordanian entrepreneurs are making use of digital technologies to coordinate the transportation of agricultural products between small farmers and the market. In Jordan, Ghoorcom has launched an app to facilitate transportation logistics, allowing farmers to order pickup and track their products. In southern Lebanon, small farmers can contact local transportation providers via WhatsApp and pay a small fee for moving their fresh products to the wholesale market in Saida, a distance of around 40 km for a fee of LBP 1,000 per box of produce.[41] No information is available about similar initiatives in Iraq.

Digital Technologies to Improve Traceability and Quality Control

Adopting digital technologies to improve traceability in Jordan, Iraq, and Lebanon could help expand exports to more demanding and lucrative markets. Food safety standards are a major restriction for exporting agricultural products from Jordan and Lebanon to European and Gulf markets. In Lebanon, there is limited traceability of agricultural products back to farms. In Jordan, the recent 'EU-Jordan Agricultural Twinning Project' sought to expand exports to the EU, but the project failed due to project-level challenges and lack of traceability (Box 13). Applying digital technologies to improve traceability would expand access to this valuable market while offering concurrent benefits of economic efficiency and improved food safety. For example, producers can use digital technologies to ensure compliance with maximum residue levels for pesticides in and on food products and standards preventing microbial contamination, required for imports into the EU.42 Using digital technologies for improved traceability may be the most promising for products and value chains that are more susceptible to food safety risks, including perishable fruits and vegetables and animal-based products, or those that raise sustainability concerns (for example, seafood). If maintained over the longer term, digital traceability systems could assist and guide producers in improving the quality, food safety, and sustainability standards of their production. Moving directly from very rudimentary technologies to digital technology adoption for improved traceability may be an opportunity to leapfrog over intermediary technologies.

[40] Interview with Ramy Boujawdeh of Berytech, conducted December 20, 2019.
[41] Interview with Ali Ismail, conducted November 18, 2019.
[42] https://www.cbi.eu/market-information.

➔ **Table 11.** Government Digital Platforms Performance

Indicator	Iraq	Jordan	Lebanon	Data Source
National ID coverage (age 18+)	—	—	97%	Identification for Development (ID4D) indicators
ID database digitized	Yes	Yes	Yes	
Digital authentication enabled	—	Yes	Yes	
e-Government Development Index	0.34	0.56	0.55	United Nations (UN) e-government database (Scale: 0 to 1)
Online Services Index	0.32	0.49	0.47	
e-Participation Index	0.48	0.69	0.12	
Share of population (age 15+) citing lack of necessary documentation as a reason for not having a financial account (2017)	23%	9%	0%	Global Findex, World Bank
Definition: E-Participation Index (EPI) is a measure of the extent to which online services facilitate 'provision of information by governments to citizens (e-information sharing), interaction with stakeholders (e-consultation), and engagement in decision-making processes (e-decision making)' (UN 2019b).				

Agri-food exporters and public sector agents in Jordan and Lebanon have recently begun adopting digital technologies to improve their traceability systems to improve food safety and/or facilitate trade. In Lebanon's private sector, adoption is greatest among exporters that have also adopted quality management systems such as International Organization for Standardization (ISO) and Hazard Analysis and Critical Control Points (HACCP) and that are exporting to large food retailers or to European markets.[43] Within the public sector, the Ministry of Agriculture created the Lebanese National Food Establishments Registry database to improve monitoring and tracking of food safety within food establishments (Table 11).

Efforts to use digital technologies to improve the cold chain for fresh and processed food products demonstrate increasing private sector demand. In Jordan, sensors and data loggers are already placed in trucks to monitor temperature and humidity levels within trucks moving fresh goods for export.[44] In Lebanon, efforts to use RFIDs showed early promise and had the support of the agri-food industry. Bel Group in Lebanon faced cheese distribution problems, so they supported a student-led start-up fostered by Agrytech to help them ensure that its imported processed cheese products were subject to minimal temperature fluctuation when distributed via multiple wholesalers. These efforts came to a halt when the team was dissolved, but the underlying problems and interest of the private sector in this area remain.[45]

Digital Technologies to Deliver Financial Inclusion and Risk Management

While it does not appear that any digital financial services and risk management tools have been developed specifically for the agriculture sector in Iraq, Jordan, and Lebanon, their potential is growing. As discussed in Chapter 3, more Iraqis, Jordanians, and Lebanese living in rural areas used digital technologies related to financial services or digital payments by 2017. This trend indicates that there is significant room for growth in this area and it can serve as a basis to bring tailored credit and insurance services to Lebanese farmers (World Bank 2020b).

Changes in the structure and role of the financial sector and its institutions in Mashreq countries may be required to widely use digital technologies to expand access to finance within the agriculture sector (including for agribusinesses and e-businesses). In the particular and extreme case of Lebanon, changes to and within the commercial banking sector since late 2019 have imposed informal capital controls that have further limited access to finance (investment, operational, and trade finance) and eroded popular trust in commercial banks. Many online banking operations, such as transfers, have been prohibited, and customers, including business clients, have been forced to conduct counter operations for tasks as simple as cash withdrawals. Commercial banks have ceased offering subsidized loans supported by public loan guarantees through Kafalat, including to the agriculture sector. Peer-to-peer lending may be a more acceptable and realistic path to fill the immediate gap in financing from commercial banks, particularly at a moment of glaring need. Yet, it is unclear whether Lebanon's regulatory structure permits such digitally enhanced financial tools to fill the gap.

[43] Personal communication with Said Gedeon of CCIAZ, conducted January 7, 2020.
[44] Interview with Issa Halabi, conducted October 8, 2019.
[45] Interview with Ramy Boujawdeh of Berytech, conducted December 20, 2019.

Digital Technologies to Deliver E-government for Improved Public Services in Mashreq

Jordan and Lebanon offer better government digital platforms than Iraq, based on a performance assessment (Table 11). Iraq's performance, while lagging, could address gaps and build on existing platforms. Iraq's Citizen E-gov portal offers limited functions, allowing citizens to only register complaints or requests. Iraq lacks an online access point for transaction services such as taxation, benefits, or identification. Iraq allows using bank transfers to make income tax payments but requires certified checks from an Iraqi bank to make pension contributions.

The citizen-state relationship could be supported by improving e-government functions and e-payments for government-related services (EIU 2018). To do so, Iraq could build on emerging platforms. Since 2017, International Smart Card, an Iraqi public-private joint venture, has supported electronic payments of government benefits, which beforehand had been wholly in cash. The system now reaches over 7 million Iraqis who can access government salaries and pensions electronically, usually linked to a biometric smart card.46 Additionally, since early 2017, United Nations High Commissioner for Refugees (UNHCR) and Zain Cash, a mobile wallet, have collaborated to deliver cash assistance through mobile money transfers. Although the journey ahead may be long, Iraq could target some quick wins by implementing some common government e-payment facilities (EIU 2018).

Mashreq countries have started delivering several public services through digital technologies related to the agri-food sector, but there is potential to increase the efficiency, accountability, and environmental sustainability of public payments in all focus countries. Lebanon's National Poverty Targeting Program (NPTP), launched in 2012, uses e-cards to transfer funds and support food purchases by poor households. The program was expanded in early 2020 in response to shocks including COVID-19 (Bou Khater 2020). In Jordan, public support is not provided through digital technologies, but experience from the nongovernmental organization (NGO) sector shows promising results. Making Cents International and BanQu have formed a partnership using blockchain technology to deliver digital economic identities to refugees, migrants, and undocumented and remote populations for delivering social, financial, and health services (FHI 360 2018). Available evidence indicates that the program has been extended through 2020, targeting 2,000 refugees in both Jordan and Lebanon (Making Cents International 2019). For agricultural subsidies, the National Center for Remote Sensing in Lebanon used very-high-resolution satellite imagery to produce a wheat production map that has been used by the Ministry of Economy and Trade in implementing its wheat subsidy program.[47] The remote sensing validation reduced fraudulent claims. However, digital payments were not used for subsidy payments and the check-based system that was used created delays in payments; as smaller farmers were less able to bear the delay, they tended to sell their wheat to larger farmers who then received the subsidy. If digital payments could be installed that speed the payment to farmers, this could represent an opportunity to reduce inequalities in the subsidy system.[48] In Iraq, field inspection of seeds produced for strategic crops has applied digital technologies by issuing electronic certificates. Iraq's public food distribution program is being digitized through biometrically protected smart cards. Iraq's agricultural subsidy program could be revised to prioritize payments to farmers using improved digital technologies that use scarce resources more efficiently. For example, subsidies could be directed to facilitate the adoption of smart irrigation as an efficient alternative to flood irrigation.

Digital technologies are used by the public sector to estimate crop yields, measure water efficiency, and assess impacts of climate change. Iraq's National Program for Agro-Ecological Zones produced and digitized maps on land use and cover (arable land types, cultivated areas, and irrigated/rain-fed areas) and surface water resources. Additionally, Earth Observation for Sustainable Development (EO4SD) through the Sentinels, a launched fleet of satellites supporting the European EO Copernicus program, aims to support the Ministry of Agriculture and assess the extent of cultivated areas, the number of cropping cycles in a year, crop yields, and irrigation performance. This activity will help assess and monitor the status of and trends within the agriculture sector and adaptation and coping strategies in light of Iraq's recent conflict. Lebanon's Ministry of Agriculture regularly uses geographic information system (GIS) and remote sensing techniques to assess the vulnerability of the agriculture sector to climate change.[49] The GIS-based land maps are currently available through the Ministry of Agriculture Department of Statistics and CNRS-L. The Ministry of Agriculture of Lebanon also uses the FAO's AquaCrop crop growth modeling tool to determine crop water productivity and to assess the potential effect of climate change on agricultural production. In 2020, under a partnership with LARI, the Ministry of Agriculture is using the tool to develop optimal irrigation protocols for major strategic crops in different agricultural areas of the country.[50] With the support of the FAO regional project 'Implementing the 2030 Agenda for Water Efficiency/Productivity and Water

[46] Financial Times; April 2019.

[47] Personal communication with Dr. Ghaleb Faour of CNRS-L, conducted February 2020.

[48] Personal communication with Dr. Salwa Tohmé Tawk, conducted May 30, 2020.

[49] Personal communication with Ralph Zughaib of the Ministry of Agriculture, conducted February 2020.

[50] Personal communication with Maya Mhanna of the Ministry of Agriculture, conducted February 2020.

Sustainability in NENA', Lebanon's Ministry of Agriculture is preparing evapotranspiration maps and water productivity maps for selected crops. These maps will draw on the FAO Water Productivity Open-Access Portal (WaPOR), which uses remote sensing technologies to generate data.[51]

Governments have used digital technologies for early warning of animal diseases, such as Iraq's Directorate of Veterinary Services work to develop a geospatial surveillance and monitoring system. The project started with the use of tracking systems and geospatial monitoring within hospitals and villages in most of the Iraqi provinces and poultry fields. The project uses Google Earth as a first stage and then a system of mapping GIS. By supporting surveillance and real-time reporting capacities in Iraq and improving communication between stakeholders, the system enhances early warning and response to animal disease occurrence with high impact on food security and livelihoods.

Jordan's public sector accelerated the use of digital solutions to ease challenges arising from the COVID-19 pandemic. Jordan launched an e-government program in 2001, setting the stage for deploying online e-services through the National Government Portal (including e-tax and a real estate registry), along with mobile services and official government websites. The principal public websites serving the agriculture sector include Jordan's e-government website and the websites for the Ministry of Agriculture, the National Agricultural Information System, the National Agricultural Research Center (formerly the National Center for Agricultural Research and Extension [NCARE]), and the Agricultural Credit Corporation. These websites provide basic functionality and offer both offline and online services but reflect weak management and updating, have insufficient security tools for handling personal information, and do not offer features for users with special needs, according to an analysis by Abu Rumman and Szilágyi (2018). Due to the COVID-19 pandemic, the Ministry of Agriculture launched an online application for import and export licenses through its website to protect the health of citizens during the COVID-19 crisis and facilitate and simplify the procedures for providing services for exporters, importers and all transit orders. Pressures imposed by COVID-19 may serve to accelerate the introduction of digital financial services, as in a case from Jordan (Box 14).

[51] Personal communication with Maya Mhanna of the Ministry of Agriculture, conducted February 2020.

Lebanon's Ministry of Agriculture uses a range of web applications for internal use to facilitate its monitoring, inspection, and development responsibilities for agriculture, aquaculture, extension services, natural resources management, and food production.[52] A brief overview of web applications in use at the Ministry of Agriculture as of February 2020 is provided in Table 12. The ministry is also implementing pilot activities for monitoring crop yields and measuring water efficiency using remote sensing technologies and for establishing a farmer's registry system using GIS technology.[53] Whether this system will be utilized for improving extension services delivery remains to be seen.

Iraq's public food distribution program is being digitized. The efficiency of the Public Distribution Program which reaches 39 million Iraqi citizens has been hampered by manual, paper-driven processes. The government has been working with the WFP to implement a digital distribution system using biometrically protected smart cards. In 2019, the Minister of Trade has launched a pilot to cover 35,000 users, with hopes to expand to the whole population. The new approach could help limit fraud and raise efficiency and accountability and will also introduce huge swaths of the population to digital social services.

Using digital technologies to collect and disseminate available data on time has been identified as an opportunity in all three focus countries. This need is particularly acute in Iraq, where data gaps appear to be the largest. Moreover, providing timely and accurate data could also be helpful in identifying specific challenges facing the agriculture sector, which digital technologies could ameliorate.

Digital Technologies for Monitoring and Evaluation in Mashreq

Digital technologies are increasingly used for monitoring and evaluation (M&E) of outcomes in agriculture in Mashreq. In the focus countries, remote sensing technologies are used for land use monitoring. For example, in Lebanon, satellite imagery was used to verify land parcels planted with wheat and thereby contributed to a cost savings of US$10 million for the country's wheat subsidy program the first year it was applied. In addition to potential productivity gains and cost savings, monitoring via satellite technology enables governments to study how agricultural practices affect the ecosystem, develop better regulations, enforce sustainable land management practices, and address vulnerability to climate change.

[52] Personal communication with Randa Serhal of the Ministry of Agriculture, conducted February 2020.
[53] Personal communication with Amal Salibi of the Ministry of Agriculture, conducted February 2020.

➔ **Box 14.** Case Study - JEDCO/REGEP E-wallets' Experience Responding to the COVID-19 Pandemic

Rural Economic Growth and Employment Project (REGEP) is an agricultural development project funded by the International Fund for Agricultural Development (IFAD) for six years (2015–2021). The Jordan Enterprise Development Corporation (JEDCO) manages the project through the REGEP's project unit that manages and monitors implementation of project activities and its progress and achievements in five governorates: Mafraq, Al Balqa, Jerash, Ajloun, and Madaba. REGEP develops agricultural projects to integrate small-scale farmers in value chains and help them acquire the needed funding in rural areas. It also works to enhance small farmers' capacity building and competitiveness and their contributions to selected value chains in rural areas. The project consists of two closely linked technical components:

- **Value Chain and Enterprise Development,** which addresses key constraints in value chains to enhance access to high-value domestic and international markets, improve quality standards, and strengthen value chain links. A subcomponent, Support for Value Chain Upgrading and Business Model Innovation, with a window of 600 grants, will finance smallholder farmers, farmers associations, processors, and exporters to improve their business.
- **Inclusive Rural Finance.** This is implemented through the Central Bank of Jordan (CBJ) and supervised by JEDCO. CBJ established the Rural Finance Fund collaborating with the commercial banks and MFIs to provide loans to the target groups. So far, 499 grants with 1,910 total beneficiaries totaling US$1.4 million have been disbursed. During Q4 of 2019, 249 grants were approved to be distributed to small farmers, with 171 grants to groups and 78 individual grants supporting productive agricultural projects in the five governorates, for a total value of US$827,800, with group grants valued at US$4,500 and individual grants at US$1,500. The submitted proposals involved entrepreneurial ideas for agricultural production projects, creating new job opportunities for youth and women while improving the standards of living in the fund-targeted governorates.

In March 2020, because of the COVID-19 pandemic, the government announced both a lockdown and movement restrictions, affecting the project's progress, especially grant disbursement. To deliver the assistance from the JEDCO-provided fund, especially to small farmers who had the highest need, the project used e-wallet applications to transfer the grants to beneficiaries. A quick survey indicated that only 47 percent of beneficiaries in the project area had experience using this application. Accordingly, the project set specific criteria for selecting the e-wallet service provider (for example, commissions, agent network, and coverage). To begin implementation, disbursement was made to a sample of 51 grantees in two governorates (Jerash and Ajloun). The grants were transferred quickly to the beneficiaries through e-wallet applications at a preferential cost of 65 percent less than the ordinary cost. The experience is satisfactory, and JEDCO will complete the transfer procedures for the remaining beneficiaries in the other governorates over the coming days. A few grantees reported difficulty in signing up for e-wallets and receiving the money due to specific technical problems.

To scale the initiative and spread the model, JEDCO will sign a memorandum of understanding (MoU) with the Jordan Payments & Clearing Company (JoPACC) to facilitate digital financial services (e-wallet) adoption. This will include setting up digital skills, awareness campaigns, and trainings to small farmers in the five governorates.

Author: H. E. Dr. Bashar Al Zoubi, Chief Executive Officer (CEO) of JEDCO.

➔ **Table 12.** Web Applications in Use at the Ministry of Agriculture of Lebanon

Lebanese National Food Establishments Registry database
Improves monitoring and tracking of food safety within food establishments. The database is accessible only by Lebanese ministries and public entities with a responsibility for food inspection and control. The database seeks to improve interministerial coordination, harmonize the categorization of food establishments (located at any stage of the food value chain), establish a common categorization and coding for food safety violations, exchange information on food safety inspection and control, act as a reference for annual food safety monitoring plans, and establish an interministerial alert system for risk communication. The database began through the Qualeb project, as a collaboration between the Ministry of Agriculture and the Ministry of Economy and Trade.[1]
Archiving and Document Workflow
Automates paperwork and improves over a manual workflow, accelerating the transfer of documents between all the Ministry of Agriculture entities located in the Ministry of Agriculture headquarters and regional services and centers.
Programs and Projects Service System (PPSS)
Handles all project data including objectives, activities, areas of intervention, targeted regions, and so on. Project managers can enter and update projects with the ability to upload attachments. The application allows funding agencies to be informed about the areas of interventions of each other to collaborate and avoid duplication.
Agricultural Extension System (AES)
Provides electronic extension services to all the Ministry of Agriculture regional centers and all other users. This application allow users to enter and maintain extension documents by the Ministry of Agriculture and NGOs; collect information on NGOs and other extension service providers; gather information about extension activities undertaken by projects; classify the extension information, documents, activities, agricultural practices, and so on; provide communication and information and lessons learned among extension to farmers; and generate and disseminate the required report.
Fertilizers Module System (FMS)
Registers all fertilizers being imported and that might be eligible for a sampling process. The Ministry of Agriculture users can monitor fertilizer imports by establishment, date, fertilizer, or manufacturer on a day-by-day basis.
Bees Management System (BES)
Enables the data management on bees in Lebanon with census data and information on diseases, treatments, holdings, and ID Cards for responsible people in the beekeeping field.
Forestry Centers System (FCS)
Tracks and monitors citizen requests to register cutting, pruning, charring, and other requests in forests to issue licenses or grant approvals and track numbers, citizen name, and place. Also, the system allows keeping information of the seizure records and irregularities on fields. The request can be sent from regional centers to head office.
Fishing License System (FLS) Application
Tracks licenses given to boats for fishing and other information needed internally. FLS has seasonal reports where months catch data is entered to be able to study the best months for catching.
Cost of Production Statistics System (CPSS)
Supports data collection on the cost of production of different agricultural products, to analyze cost structures of agricultural activities. This survey covers major agricultural products (crops and livestock) products at the level of mohafazas (governorates).
Agricultural Prices Statistics System (APSS)
Allows data collection and data processing for tracking and analyzing agriculture prices. Data are recorded on a monthly basis and entered according to mohafaza (governorate). Simple analysis of the data is carried out in terms of calculating averages that were recorded in the different mohafazas. Also, prices of agricultural products (wholesale and retail prices) are aggregated for Lebanon.

[1] Personal communication with Mariam Eid of the Ministry of Agriculture, conducted February 2020.

➔ Chapter 4:
Which Public Actions Can Facilitate Broader Adoption of Digital Technologies and Harness Their Impacts on Food System Outcomes?

Key Messages

- A key role for the public sector in facilitating broader adoption of digital technologies in the agri-food system is to identify the public goods, policies, investments, and societal benefits that digital agriculture will bring by increasing efficiency, equity, and environmental sustainability in agri-food systems.

- The public sector can achieve the development goal of digital transformation by facilitating and attracting private resources for investment that it can pursue through direct investment promotion; adjusting the regulatory and incentive frameworks for private sector investments; and forming partnerships with the private sector, donors, and NGOs.

- The public sector should set forth a vision for digital agriculture and strive to provide the foundations—digital, non-digital, and legal—for a digital transformation of the agri-food sector.

- Even though there is a tremendous opportunity for digital technologies to support a transformation of the agriculture sector in the focus countries of Iraq, Jordan, and Lebanon, they are only tools to support the achievement of the development goals, and their success will depend on the extent of the revitalization of the agri-food policy frameworks in Mashreq.

Chapter 4
Which Public Actions Can Facilitate Broader Adoption of Digital Technologies and Harness Their Impacts on Food System Outcomes?

The agri-food sector in the focus countries faces a range of challenges, which digital technologies may be well suited to address. Digital readiness and digital agriculture are in the early stages in Iraq, Jordan, and Lebanon, but there is a forward movement and an opportunity to build on the established momentum. To facilitate a digital transformation of the agriculture sector and support improved efficiency, equity, and environmental sustainability, the public sector in the respective focus countries should consider action as described below.

The public sector has an important role in identifying public goods, policies, and investments that will maximize the societal benefits of the increased efficiency, equity, and environmental sustainability in agri-food systems brought about by digital agriculture (World Bank 2021). To achieve the development goal of digital transformation, the public sector can facilitate and attract private investment resources by promoting direct investment; adjusting the regulatory and incentive frameworks for private sector investments; and forming partnerships with the private sector, donors, and NGOs. The public sector can also use digital technologies to improve the efficiency, transparency, and accountability of public services. Public action to facilitate digital technologies adoption can contribute through three pathways: developing a vision, developing the foundation, and providing catalytic investments and policies. Table 14 provides recommendations for different time frames.

Vision and Strategy

The vision should include an aspirational statement and specific targets and actions to foster digital agriculture. The vision can be realized though a national agricultural strategy or stand-alone e-strategy. Table 13 presents a Digital Agriculture Moonshot Targets Framework for Mashreq that each country can use to define its targets for enabling the digital transformation of its agri-food sector. The strategy can also provide a policy framework for providing diverse extension and service delivery approaches to enable digital innovations and solutions to be developed for smallholders (World Bank 2019j). The strategy should identify the needed enabling environment for building partnerships since most of these solutions will require partnerships between input suppliers, service providers, and digital innovators. The strategy should adequately identify potential user needs, including language, content, and complexity, and different digital applications should be customized accordingly. It should explicitly promote gender-sensitive digital technologies in the region, in acknowledgement of women's lack of empowerment within agriculture and the wider agri-food sector in Mashreq. Given this, the strategy should explicitly seek to address (and at a minimum, not to exacerbate) existing, gender-based inequalities. The preparatory work for developing a strategy should include a comprehensive review on how the current public support and policies for agriculture could be modified to improve farmers' incentives to adopt digital technologies. For example, a review could identify problematic policies such as subsidies to farmers for fuel and electricity that reduce the marginal cost of pumping for irrigation and could disincentivize smart irrigation.

Foundation

To stimulate digital transformation in the agriculture sector, the government should enable the following foundations: digital and non-digital.

Expand rural network coverage to enable good-quality and predictable rural connectivity. Public action is needed that improves the quality of infrastructure, including the speed of mobile and internet connectivity in rural areas, and reduces the use costs to end users, which may facilitate digital technologies adoption in the agriculture sector. Robust regulatory systems that provide certainty for investment serve as a necessary condition for expanding digital infrastructure in rural areas. Additionally, providing the enabling environment for network competition can help expand network coverage, including in rural areas. The public sector can lower infrastructure taxes and/or import duties on relevant equipment to reduce the cost of network installation and maintenance. Connectivity for smallholder farmers and service providers would enable better access to services and digital solutions. This entry point is particularly important for Iraq, where over 8.8 million rural residents lack broadband network connectivity.

➔ **Table 13.** Digital Agriculture Moonshot Targets Framework for Mashreq (Modified after World Bank 2019j).

Overall Target: EVERY FARMER, AGRIBUSINESS, AND PUBLIC SERVICE RELATED TO THE AGRI-FOOD SECTOR IS DIGITALLY ENABLED BY 2030.				
Rural digital infrastructure	**Digital skills and literacy**	**Agriculture digital platforms**	**Digital agri-finance services**	**Digital agri-entrepreneurship**
Universal internet coverage in rural areas is achieved.	All 15-year-old students have basic digital skills and competencies.	All farmers can prove their identity digitally through digital farmer IDs (public or private).	Universal access to digital financial services in rural areas is achieved.	The number of new digitally enabled agribusinesses is increased by x percent. The number of agri-technology firms created annually is increased by x percent.
Affordable internet for all at less than 2 percent of GNI per capita is achieved.	The number of graduated agri-food specialists with digital skills in the curriculum is increased by x percent.	The Government Online Service Index is increased x times.	Public support (for example, subsidies) provided through digital payments systems reaches x percent.	Financing for agri-technology entrepreneurship reaches x percent of agriculture GDP.
Doubling of broadband connectivity by 2030 is achieved.	The number of rural schools delivering digital education modules is increased by x percent.	The number of farmers who regularly use the internet to access government or commercial services (for example, access weather and price information) is increased by x percent.	The number of farmers who access insurance through digital solutions is increased by x percent.	The food traded through digital tools is increased by x percent of value added.
The digital monitoring of water use in the agriculture sector is increased by x percent.	The number of farmers using digital hardware (for example, sensors and drones, if allowed) and software to collect, assemble, process, and analyze data (gender disaggregated) reaches x percent.	The number of farmers engaged in regional crowdfunding and peer-to-peer platforms for agriculture inputs, outputs, and financing reaches x percent.	The number of farmers who made or received digital payments in the past year in rural areas (% age 15+) reaches x percent.	The volume of food traded with digital traceability information systems is increased by x percent.
Digitization of agriculture, land, and soil information is achieved.	Basic mobile literacy (gender disaggregated) among all farmers is achieved.	The number of farmers receiving agriculture extension (public and private) delivered through digital content and devices is increased by x percent.	The number of farmers who used a mobile phone or the internet to access an account in rural areas (% age 15+) is increased by x percent.	

Provide non-digital complementary investments, including in rural roads and electrification. These can address connectivity to markets and power supply constraints of network providers in rural areas. It is difficult to sell products on e-commerce platforms if there are no roads to markets or to sell high-quality fresh foods to online customers if there is no cold storage to preserve their freshness en route to distant markets. Rural electrification through renewable sources can help facilitate rural-based food processing and green growth.

Catalytic Investments and Policies

Establish e-government systems for all public services and resources administered through ministries to improve efficiency, reduce cost, and increase transparency and accountability. This can include gathering and disseminating statistics relevant to the agriculture sector, creating farmers' digital identification, providing extension services, regulating land tenure and markets, and ensuring delivery of public support payments. Digital identification of farmers linked to land and livestock assets is a powerful bridge for farmers to access financial services, reduce fraud, and improve efficiency in delivering goods and services

and for governments to better target agricultural support. Additionally, farmers' identification can support start-ups and digital agricultural solution providers who spend about half of their initial business development efforts in profiling and identifying target farmers. Channeling input subsidies and other public payments through digital services can also provide a prompt support to smallholders and be used to mitigate impacts of crises like COVID-19. The public sector also has to develop its capacity to foster digital innovation and develop human capital.

Facilitate the deployment of smart irrigation and fertilizer management systems to foster environmental sustainability and efficiency. The public sector can (a) deploy remote sensing using evapotranspiration for groundwater monitoring, (b) use IoT technology for irrigation, and (c) use advanced remote sensing of soil moisture and soil surface temperature. Through e-Extension services, the public sector can advocate for improving irrigation and fertilizer application. This is particularly important considering water scarcity and GHG emissions from inorganic fertilizers in Mashreq countries. Even though modern technologies can improve water use efficiency and productivity, they need to go hand in hand with policies which will restrict environmental rebound effect.

Adopt diverse service delivery approaches to enable adaption of digital technologies by smallholders for contributing to equity. Risk-averse smallholder farmers, a lack of information on the technology, and lack of trust in the technologies' promised benefits constrain the digital technologies adoption (World Bank 2021). Evidence shows that a fundamental condition for farmers, particularly smallholder farmers, to adopt new technologies is that they should be profitable (Fuglie *et al.*, 2020). To reduce uncertainty about a practice's effectiveness, the public sector can support piloting and knowledge exchanges. Public action facilitating digital agriculture technology adoption should target smallholders. If adoption is focused on farmers who can achieve the largest financial returns, there is lost potential for the large social and environmental gains that small farmers achieve. Public sectors can redirect subsidies and provide monetary incentives to support adoption of environmentally sustainable technologies.

Invest in platforms for data collection and access from public and private sources. Open data can advance innovation, serve as a platform for entrepreneurship, and increase transparency and accountability in the food system. This investment may accelerate the development of appropriate products and services for smallholders and develop a foundation of data for evidence-based policy making (World Bank 2021). Open data platforms can include national digital land use and soil maps, real-time agricultural weather observatory and early warning systems, and market data.

Foster digital entrepreneurship to enable innovators in the digital space to operate and grow. In parallel, invest in the enabling ecosystem at country, regional, and international levels for developing and supporting incubator and accelerator services targeting start-ups and private sector innovators in the agri-food sector. Public action can improve access to finance for start-up and early maturity agri-tech enterprises. Blended (public and private together) finance can provide financial support to high development impact investments that would be unlikely to attract financing on strictly commercial terms because their risks are high and their returns are either unproven or low compared with the level of risk.

Invest in agricultural research and foster an innovation ecosystem, including through partnerships between academic programs and industries focused on digital agriculture technologies and innovation. The public sector can support this by hosting events on disruptive agricultural technology and linking innovators with local and international investors and farmers through periodic forums, conferences, and industry network groups. In Iraq, public action could facilitate the foundation for incubation and acceleration services to develop digital technologies tailored to the needs of the local agriculture sector. The country's innovation ecosystem appears to be at the earliest stages, suggesting there is a role for the public sector to lead the way in stimulating private interest and engagement. Iraqi policy makers could look to the successes of models in neighboring countries including Jordan and Lebanon. In Jordan and Lebanon, where an entrepreneurship ecosystem already exists, the public sector can help expand it rather than duplicate it, by promoting digital technology initiatives focused on the needs of the local or regional agriculture sector.

Identify and foster needed skills for widespread use of digital technologies, spanning audiences from developers to businesses to small farmers and other end users. Investment in skills development could take different forms, depending on the target audience. If targeting farmers and agricultural operators, the most needed skills may be those related to basic digital literacy, business and farm operations management, and use of customer-facing technologies. If targeting entrepreneurs and start-ups, the most needed skills may be related to business development and finance (World Bank 2019j). Incorporating more entrepreneurial and digital technology content in the curriculum of agricultural universities and

➔ **Table 14.** Recommendations for Accelerating the Digital Technologies by Time Frame

IDENTIFY CLEAR TARGETS FOR THE DIGITAL TRANSFORMATION OF THE AGRI-FOOD SECTOR	Short Term (1–2 years)	Medium Term (2–5 years)
Develop an E-Agriculture Strategy with specific targets and integrate it into the overall agriculture sector and development strategies. The 'Digital Agriculture Moonshot Targets Framework for Mashreq' is presented in Table 13.	x	
IMPROVE EFFICIENCY OF PUBLIC SERVICES AND PROVIDE PUBLIC GOODS		
Collect foundational data and develop platforms such as - Digital farmer IDs; - Open access databases that would include digital land use and soil maps, yield predictions, real-time agricultural weather observatory, and market data; and - E-government systems for all public services and resources administered, including subsidies distribution, rural cadaster, and so on.	x	
Provide incentives for deploying automated smart irrigation and fertigation systems to mitigate the adverse impacts of climate change and reduce pollution from fertilizers.		x
Adopt diverse extension and service-delivery approaches (both digital and non-digital) to enable digital innovations and solutions to be tested and tried for smallholders.	x	
Develop digital surveillance technologies for early warning systems (including pests and diseases).		x
Deploy digitally enabled traceability systems.		x
CREATE AN ENABLING ECOSYSTEM FOR INVESTMENT AND RESEARCH SUPPORTING THE DIGITIZATION OF THE AGRI-FOOD SECTOR		
Support the incubator and accelerator services targeting start-ups and private innovators in the agri-food sector.	x	
Encourage successful digital applications to be customized and offered in Arabic.	x	
Develop good-quality curricula for digital skills, innovation, and applications.	x	
Develop data policies that clarify data privacy, ownership, and sharing rules.		x
Facilitate the last-mile internet delivery programs and payment systems in rural and remote areas.	x	
Link innovators with local and international investors and farmers through periodic forums, conferences, and industry network groups.	x	

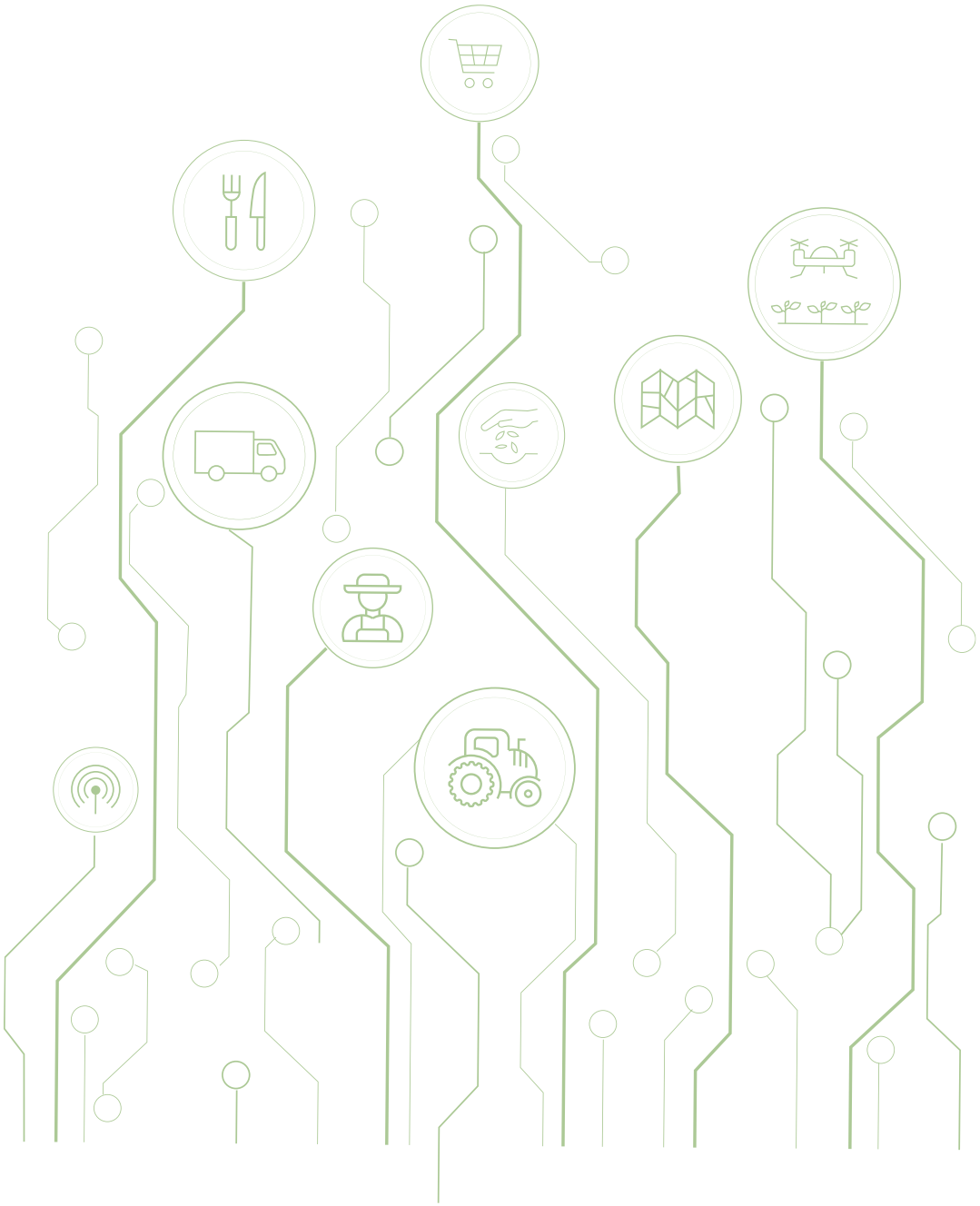
training institutes, together with faculty staff training, could help develop skill sets to foster digital development in the agri-food system. The public sector can also facilitate skill development for computer specialists and app developers.

Adopt policies on digital privacy, ownership, and data use to facilitate entrepreneurship and safeguard users. While an increasing volume of data originating on-farm and off-farm relies on cloud computing and transnational systems, there are concerns about data ownership and use. Digital policies and regulations should ideally strike a balance between protecting the privacy of individuals and firms that generate data while allowing for the use and aggregation of relevant data to inform other uses—including generating statistics, analysis, and management decisions. Ensuring data integrity and the accuracy of information services should serve to build trust among data users (World Bank 2021). Good governance of data generated by farmers will build their trust in digital technologies. Additionally, improved integrity of all data relevant to the agriculture sector should support development of evidence-based policies, programs, and interventions. Supportive policies such as the ease of starting a business, tax policy, and patent protection can also help facilitate entrepreneurship.

Facilitate enabling policies for digital payment systems in rural and remote areas. Digital payment systems are only successful if there is sufficient interest (and trust) from both entrepreneurs and customers to use this form of payment. Digital payments, including through e-commerce platforms, can help broaden an entrepreneur's client base and allow farmers to more easily sell or purchase products on these platforms. An appropriate consumer protection framework, robust digital networks, and banking and telecoms policies that support digital financial services are all important components of a functioning digital payments system (Klapper 2017).

Conclusion and Next Steps

In conclusion, there is tremendous opportunity for digital technologies to support a transformation of the agriculture sector in the focus countries of Iraq, Jordan, and Lebanon. Digital technologies can contribute to efficiency, equity, and environmental sustainability. However, they are only tools to support the achievement of the development goals, and their success will depend on the extent of the revitalization of the agri-food policy frameworks in Mashreq. Future extensions of this work should seek to identify the required policy and regulatory reforms to transform the agri-food system toward an inclusive, productive, resilient, and sustainable growth path in Mashreq.



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Appendix 1. Key Sector Indicators and Trends in Jordan, Lebanon, and Iraq.

Indicator	Unit	Jordan	Iraq	Lebanon
Surface	ha, millions	8.9	43.5	1.0
Population	Millions	10.4	38.4	6.8
Human Development Index		0.73	0.6	0.75
GDP	US$, billions	40.0	225.9	56.6
GDP per Capita	US$	4,129.7	5,878.0	8,269.8
Share of Agriculture in GDP	%	5.6	2.0	2.9
Share of Agriculture in Employment	%	3.7	18.6	11.9
Government Expenditure for Agriculture	% of total expenditure	0.75	n.a.	0.5
Agricultural Land	ha, millions / % of total area	1.0 / 12.0	9.2 / 21.3	0.7 / 64.3
Arable Land	ha, millions / % of total area	0.2 / 2.6	5.0 /11.5	0.1 / 12.9
Pastureland	ha, millions / % of total area	0.7 / 0.8	4.0 / 0.9	0.4 /3.83
Forest Area	ha, millions / % of total area	0.0 / 1.0	0.8 / 1.9	0.1 / 13.4
Area Equipped for Irrigation	% of agricultural area	9.9	38.0	20.2
Share of Water Withdrawals for Agriculture	%	60	n/a	59.5
Share of CO2-equivalent of Agriculture	tons, millions	1.1	6.8	0.79
Trade Balance, All Sectors	US$, millions	−7,708.5	35,054.7	−13,708.7
Agro-food Trade - Export	US$, millions	1,214.1	86.4	732.2
Agro-food Trade - Import	US$, millions	3,711.6	10,590.8	3,206.3
Stunting	%	7.8	22.1	16.5
Wasting (Children under 5 years)	%	0.7	2.8	2.9
Undernourished Population	%	1.2	11.1	11.0

Appendix 2. Digital Economy Performance in Mashreq

Components and Indicators		Iraq	Lebanon	Jordan	Middle East and North Africa Average	Middle East and North Africa Average minus GCC	Data Source
Pillar 1: Digital Infrastructure		**3.83**	**4.55**	**5.85**	**5.01**	**4.17**	
Access	Mobile broadband capable market penetration	19%	57%	49%	45%	34%	GSMA
	Fixed broadband household penetration	17%	58%	25%	44%	37%	TeleGeography
	Fiber to the Premises broadband penetration	2%	0%	5%	15%	1%	TeleGeography
	Total used international bandwidth per internet user - Kbps	30.9	63.6	32.1	146.3	70.6	Analysis based on TeleGeography/ World Bank
	% of population covered by 3G networks	93%	99%	99%	93%	89%	GSMA Intelligence
	% of population covered by 4G networks	25%	95%	99%	82%	70%	GSMA Intelligence
Quality	Mobile broadband download speed (Mbit/s)	7	38.1	15.2	24.9	17.5	Ookla
Afforda-bility	Fixed broadband download speed (Mbit/s)	15	6.6	29.6	17.4	8.9	Ookla
	Mobile broadband price - price of 1 GB % GNI per capita	3.00%	2.70%	1.60%	3%	4%	World Bank Research
	Entry level Fixed broadband basket price % of GDP per capita	8.40%	2.30%	11.00%	8%	12%	World Bank Research
Market Competition	Mobile market concentration index (HHI (Herfindahl-Hirschman Index)	3,222	5,007	3,570	4,491	4,632	GSMA
Government Ownership	Fixed broadband concentration index (HHI)	—	8,907	4,768	6,804	7,424	TeleGeography
	% of government ownership in the mobile market and fixed markets	0%	100%	23%	46%	49%	Digital development team
	% of government ownership in the Fixed market	—	94%	17%	59%	67%	Digital development team
Legal Frame-works	Does the country have a legal framework for data protection / privacy online?	Draft	Draft	Draft	Draft	Draft	UNCTAD Cyberlaw Tracker
	Does the country have a legal framework for cybercrime prevention?	Draft	No	Yes	Yes	Yes	UNCTAD Cyberlaw Tracker

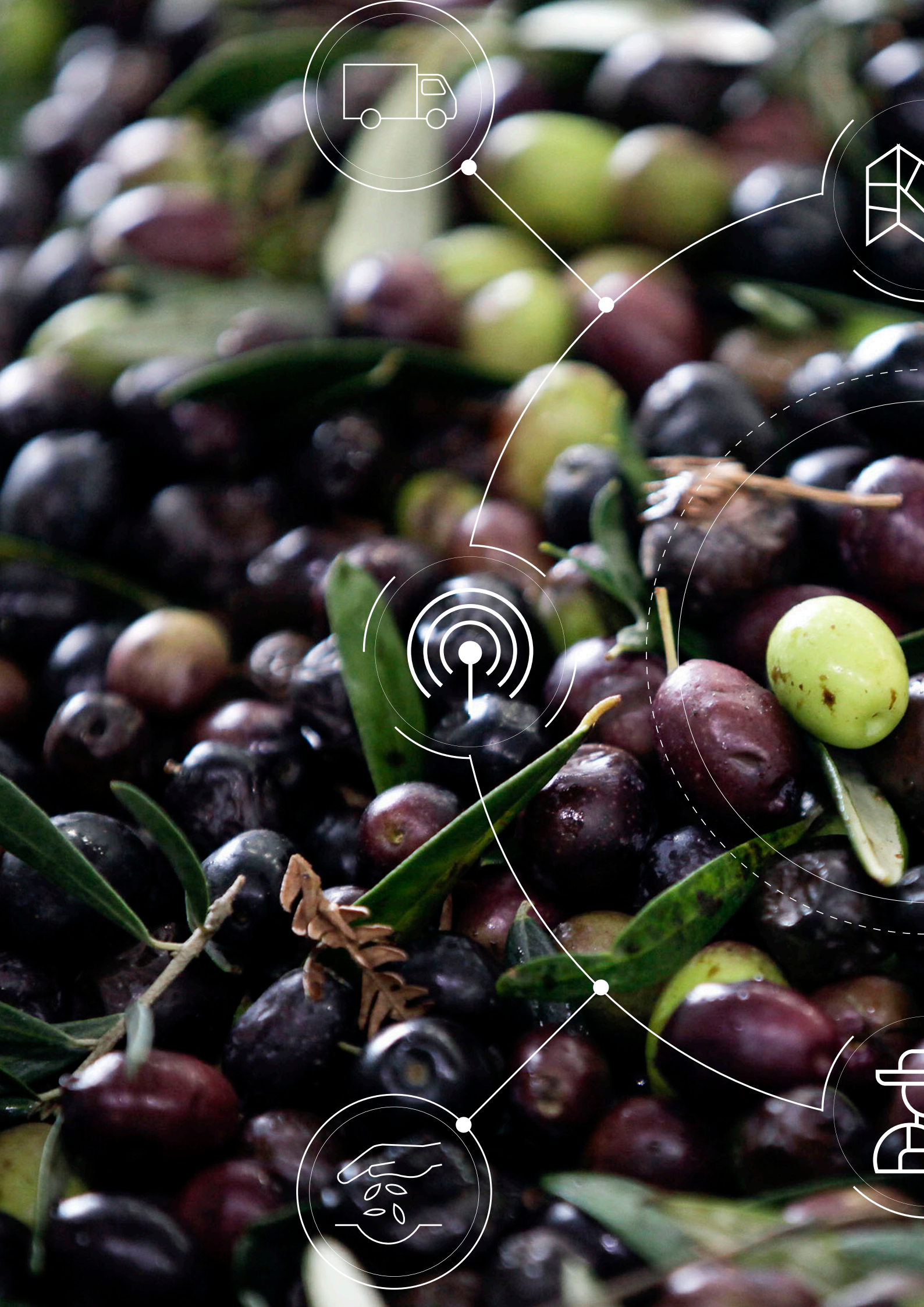
Components and Indicators		Iraq	Lebanon	Jordan	Middle East and North Africa Average	Middle East and North Africa Average minus GCC	Data Source
Pillar 2: Digital Platforms		**4.08**	**6.01**	**5.02**	**5.44**	**4.81**	
Government Platforms	Under-5 birth registration rate	99%	100%	90%	93%	92%	ID4D Indicators
	National ID coverage (age 18 +)	—	97%	—	97%	97%	ID4D Indicators
	ID database digitized	Yes	Yes	Yes	Yes	Yes	ID4D Indicators
	Digital authentication enabled	—	Yes	Yes	Yes	Yes	ID4D Indicators
	e-government Index	0.34	0.55	0.56	0.54	0.44	UN e-government database
	Online Services Index	0.32	0.47	0.49	0.55	0.41	UN e-government database
	e-Participation Index	0.48	0.12	0.69	0.53	0.54	UN e-government database
	Share of population (age 15+) who cite lack of necessary documentation as a reason for not having a financial account (2017)	23%	0%	9%	8%	9%	Global Findex, World Bank
Logistics	Percent of Population Having Mail Delivered at Home	65%	100%	1%	51%	59%	UPU
	Percent of Income Linked to Parcels and Logistics Services	62%	11%	6%	24%	22%	UPU
	Postal Reliability Index	15.9	79.4	59	58.7	53.9	UPU
	Percent of the Population Without Postal Services	0%	0%	61%	14%	19%	UPU
	LPI International shipments score	2.3	2.8	3.2	2.9	2.6	Logistics Performance Index, World Bank
	LPI Logistics competence score	2	2.5	2.9	2.8	2.5	Logistics Performance Index, World Bank
	LPI Tracing & tracking score	2	2.8	3	2.8	2.5	Logistics Performance Index, World Bank
	LPI Timeliness score	2.7	2.9	3.3	3.2	3	Logistics Performance Index, World Bank
	Burden of customs procedures	—	3.1	4.5	4.1	3.6	3.60
Private Sector Platforms	Country value in the UNCTAD B2C E-commerce Index	14.3	57.4	41.3	49.2	39.2	UNCTAD
	B2C Internet Use, 1–7 (best)	—	3.5	4.7	4.2	3.8	The Networked Readiness Index Historical Dataset © 2012–2016 World Economic Forum

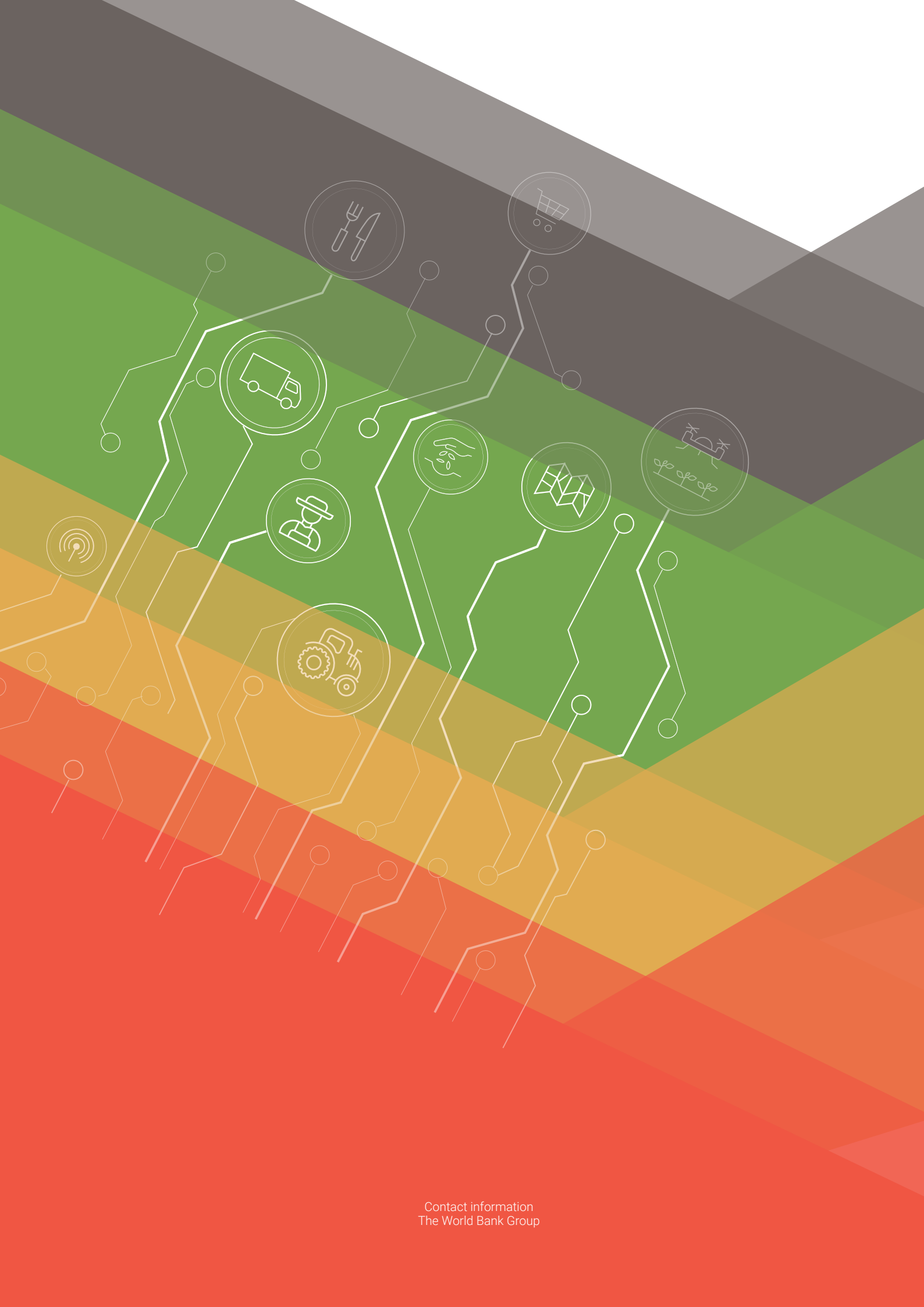
Components and Indicators		Iraq	Lebanon	Jordan	Middle East and North Africa Average	Middle East and North Africa Average minus GCC	Data Source
Pillar 3: Digital Financial Service		**3.47**	**4.49**	**3.98**	**5.34**	**4.39**	
Payments	Debit card (% age 15+)	4%	33%	19%	34%	19%	Global Findex, World Bank
	Debit card used in the past year (% age 15+)	1%	20%	6%	24%	12%	Global Findex, World Bank
	Credit card (% age 15+)	2%	11%	2%	12%	4%	Global Findex, World Bank
	Credit card used in the past year (% age 15+)	1%	9%	2%	9%	4%	Global Findex, World Bank
	Cashless retail transactions per capita	0.07	—	5.82	17.3	4.6	Global Findex, World Bank
	Percentage of Adults having an Account at a financial institution (% age 15+)	20%	45%	42%	49%	36%	Global Findex, World Bank
	Mobile money account (% age 15+)	4%	—	1%	8%	6%	Global Findex, World Bank
	Made digital payments in the past year (% age 15+)	19%	33%	33%	34%	27%	Global Findex, World Bank
	Paid utility bills: using an account (% age 15+)	6%	4%	4%	10%	7%	Global Findex, World Bank
Legal Frame-works	Does the country have a legal framework for electronic transactions/e-signature?	Yes	Draft	Yes	Yes	Yes	UNCTAD Cyberlaw Tracker
	Does the country have a legal framework for consumer protection when purchasing online?	No	Draft	No	Draft	Draft	UNCTAD Cyberlaw Tracker
Pillar 4: Digital Entrepreneurship		**2.95**	**5.1**	**5.59**	**4.18**	**3.55**	
Access to Finance	Number of deals	0	41	33	24	18	https://magnitt.com
	Number of deals by industry/sector	—	14	11	21	14	https://magnitt.com
	Value of disclosed funding by industry/ sector	—	6	11	27	8.7	https://magnitt.com
	Total disclosed funding (US$, millions)	0	80	27	47.8	15	https://magnitt.com
Entrepre-neurship	Number of Startups	—	85	88	47	42	Pitchbook
	Number of VC Investors	—	13	7	15	7	Pitchbook
Technology Absorption	Firm-level technology absorption	—	4	5	4.7	4.2	The Networked Readiness Index Historical Dataset © 2012–2016 World Economic Forum

Components and Indicators		Iraq	Lebanon	Jordan	Middle East and North Africa Average	Middle East and North Africa Average minus GCC	Data Source
Pillar 5: Digital Skills		**2.83**	**5.45**	**5.13**	**4.68**	**3.94**	
Internet Use	Internet users (per 100 people)	17.2	74	53.4	53	38	ITU Database
Social Media	Active mobile social media penetration	37%	52%	61%	46%	36%	Statista 2017: US Census Bureau, Facebook
	Active Social media users as % of population	48%	66%	58%	59%	47%	Datareportal: press releases and investor earning announcements, MENA
	Mobile social media users as % of population	45%	59%	54%	53%	44%	Datareportal: press releases and investor earning announcements, MENA
	Use of social networks Value	—	5.7	5.7	5.6	5.3	The Networked Readiness Index Historical Dataset © 2012-2016 World Economic Forum
Digital skills	Digital talent as a share of total Full-time employees	—	—	—	1.7	1.9	McKinsey Digitization Index
Skills	Percentage of graduates from Science, Technology, Engineering and Mathematics programmes in tertiary education, both sexes (%)	—	23%	26%	27%	28%	UNESCO Institute for Statistics
	Percentage of female graduates from Science, Technology, Engineering and Mathematics programmes in tertiary education, female (%)	—	18%	—	21%	21%	UNESCO Institute for Statistics
	Gross enrollment ratio, tertiary, both sexes (%)	-	38%	32%	39%	38%	UNESCO Institute for Statistics

Source: World Bank's MNA Tech Initiative, World Bank. 2019f,g,h.

Note: ITU = International Telecommunication Union; UNCTAD = United Nations Conference on Trade and Development; UNESCO = United Nations Educational, Scientific and Cultural Organization; UPU = Universal Postal Union.





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