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Alliance
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Platform for Big Data in Agriculture

Digital Agriculture Profile • Turkey

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HIGHLIGHTS

Agriculture accounts for approximately 6.4% of the Turkish Gross Domestic Product, currently valued at US$761.4 billion (current US$) (2019 est.)

Some of the biggest challenges in the agri-food system pertain to low productivity levels, lack of transparency in the value chains, inefficient public support, regional water shortages.

Digital infrastructure is well established in Turkey; the primary constraints to digital agricultural solutions are data collection and access, financial literacy, digital literacy, and the digital workforce.

The most promising technologies for addressing agricultural issues include database analytics, mobile phones, blockchain, sensors, and Internet of Things.

The public sector has already laid a strong foundation for digital agriculture, and additional opportunities exist in terms of creating enabling environment for promoting private sector entrepreneurship and introduction of digital solutions in agriculture.

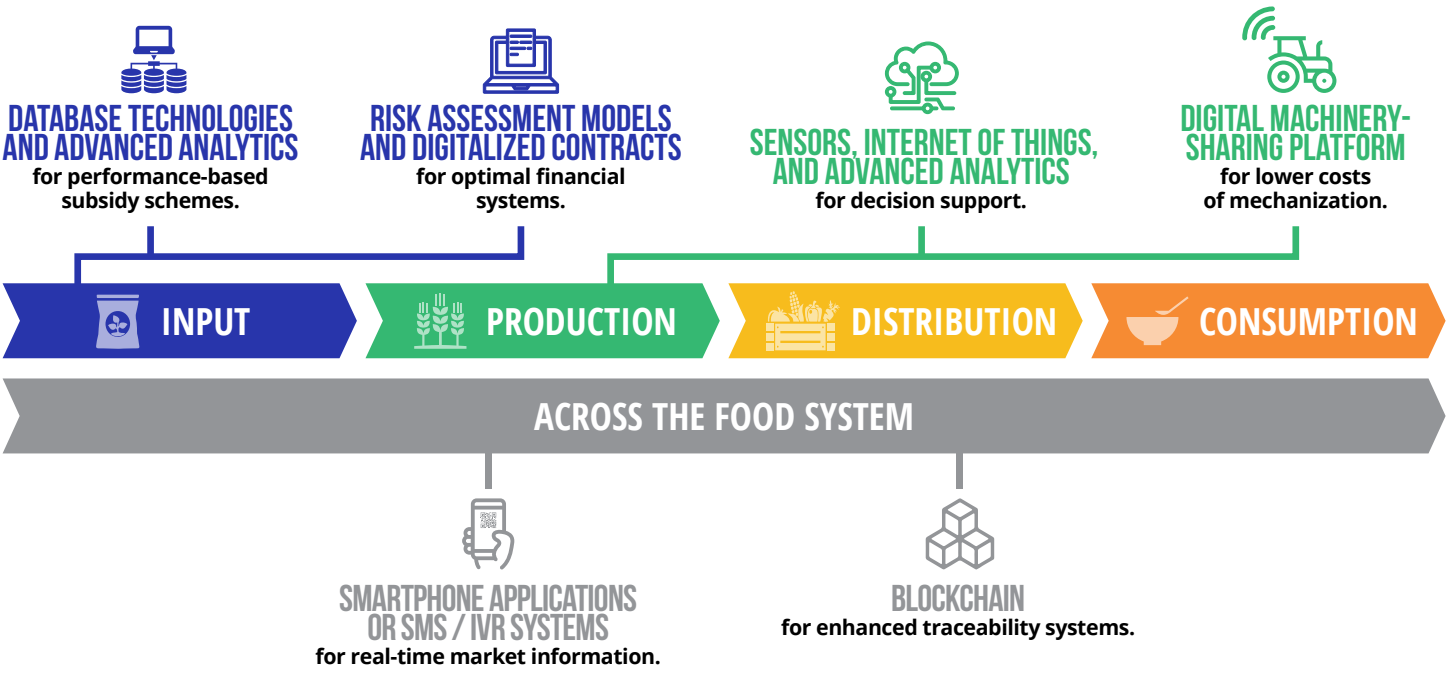
TURKEY RANKS 5TH OUT OF 150 COUNTRIES FOR IMPROVEMENTS IN NETWORK COVERAGE, PERFORMANCE, AND AVAILABILITY

FROM **2015** TO **2017** **DOWNLOAD SPEEDS INCREASED BY** **300%**

4G COVERAGE REACHES **90%** OF THE POPULATION

97% OF INHABITANTS HAVE **MOBILE SUBSCRIPTIONS**

71% OF **INDIVIDUALS ACTIVELY** USE THE INTERNET



Introduction

The Turkish agricultural sector employs 20% of the population and contributes 6.4% to Gross Domestic Product (2019 est.).[1] Turkey exports approximately US$16.9 billion in agricultural products annually.[2] There are significant opportunities and challenges for continued sectoral growth.

Many of Turkey's agricultural producers currently lack the contemporary technologies and decision support tools necessary for sustaining and improving yields. This challenge is exacerbated by regional water shortages and the recent currency devaluation. Other stakeholders along agricultural value chains, including high transaction costs due to information assymetries and noncompetitive market structures.

One possible solution to address these challenges is digital agriculture. While the concept of digital agriculture is relatively new and still evolving, foundational technologies, such as mobile and Internet connectivity, are already available to support innovative digital solutions to the major challenges facing the agriculture sector.

Digital agriculture refers to tools that digitally collect, store, analyze, and share electronic data and/or information along the agricultural value chain.[3] Integrating digital solutions into agriculture can improve efficiency by decreasing transaction costs, providing information to support management decisions, iimproving product traceability, reducing losses, and/or ensuring effective and sustainable use of resources. Ultimately, the transition to digital agriculture presents a unique opportunity to spur sustainable economic growth and development by helping address some of agriculture's major challenges.

As part of the initiative on "What's Cooking: Digital Transformation of the AgriFood System" led by the World Bank, this Digital Agriculture Profile for Turkey, leverages the expertise of in-country stakeholders to evaluate the current landscape of digital agriculture in Turkey including the key players across value chains, the main barriers they face, and the potential to overcome these barriers through the adoption of innovative technologies. In identifying and prioritizing these technologies, this brief aims to support investors in maximizing their impact by focusing on the opportunities of highest potential.

1 The World Bank, "Agriculture, Forestry, and Fishing, Value Added (% of GDP)."

2 Investment Support and Promotion Agency, "Why Invest in Turkish Agri-Food Industry."

3 United Nations, "Digital Agriculture."

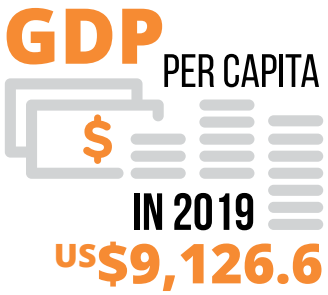
National Context

Economic relevance of agriculture

The Turkish economy has faced significant volatility in recent years. The 2008 financial crisis reduced the national GDP[4] by over US$100 million. A quick recovery ensued in 2010, followed by the unprecedented peak GDP of US$951 billion in 2013. The country then fell into a currency and debt crisis in 2018.

Agriculture has always held a crucial role in Turkey's national economy. Today, agriculture accounts for approximately 6.4% of Turkish GDP, currently valued at US$761.4 billion (current US$) (2019 est.). Agricultural employment peaked at nearly 48% of the total population in 1991, and now stands at approximately 20%.

Turkey's food-processing industry is well developed, and supplies both domestic and export demands. As of 2017 there were over 47,600 food processing enterprises and just under 600 beverage enterprises in Turkey. On a sales value basis, the 2017 food production industry represented over 14% of all manufacturing, and beverage production represented about 0.7%. National food retail and grocery sales have been increasing since 2012, and were valued at US$68 billion in 2018.[5]



Turkey has a positive agricultural trade balance and is one of the largest agricultural exporters in the region. The country's fertile soils, proximity to export markets, and comparative advantage in high-value production give it a significant growth potential in the global arena. It is an important producer of many agricultural and horticultural products, and leads the world in the production of hazelnuts, raisins, dried figs, and apricots. The primary cash crop exports include hazelnuts (7.7% of total export value), sunflower oil (3.8%), chicken (3.1%), tobacco (2.6%), and tomatoes (2.3%). Agricultural and food imports account for US$12.9 billion. Primary agricultural imports include sunflower oil, seed, and cake (12.3%); soy cake and beans (11.1%); cotton lint (11.1%); wheat (9.2%); and tobacco (3.1%).

Agricultural production systems

Turkey's 785,350 km² landmass connects eastern Europe to western Asia and has three distinct climatic regions. The Aegean and Mediterranean coastal areas feature a Mediterranean climate with mild wet winters and hot dry summers. The Black Sea coastal areas have an Oceanic climate with warm wet winters and cool, wet summers. The Oceanic climate areas are the only regions of Turkey that receive high levels of precipitation throughout the year. Turkish interior has a continental climate with sharply contrasting seasons, hot summers, and severe winters.[6]

Agricultural land comprises approximately 50% of the total land area. This figure has remained relatively constant, varying only from 47.4% to 53.6% over the past several decades. Nearly 70% of farmers hold less than 5 hectares of land, and the average farm size is 6 hectares.[7] As of 2017, the primary crops according to quantity were wheat (21.2 million tonnes/year), sugar beet (180 million tonnes/year), tomatoes (123 million tonnes/year), barley (6 million tonnes/year), and maize (6 tonnes/year). Turkey is the world's largest producer of both fresh and dried apricotsand averages 767 million tonnes annually. About 767 million tonnes of apricots are grown throughout the country every year.[8] [9]

Turkey is also a large producer of livestock and livestock products. The country had 1.38 million registered cattle farms as of 2018. Small farms (with less than 5 heads of cattle) represent about 60% of the total number of farms. As of 2017, sheep for meat and milk dominated the meat market at 20,800,000 and 1,753,000 heads, respectively. Goats for meat (4,500,000 heads) and milk (4,964,000 heads), beef cattle

4 Gross Domestic Product

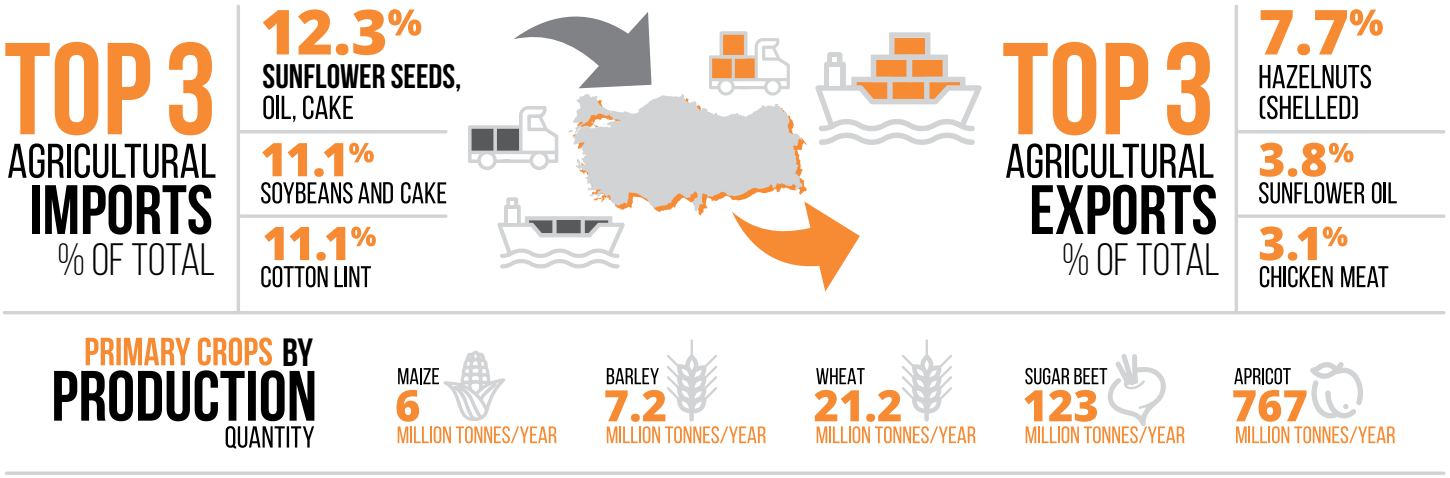
5 Erdogan, "Turkey's Advanced Food Sector Provides Opportunities in Spite of Economic Downturn."

6 Erdogan; General Directorate of Meteorology, "Yıllık Toplam Yağış Verileri."

7 Giray, "Turkish Agriculture at a Glance."

8 Food and Agriculture Organization of the United Nations, "FAOSTAT."

9 Caliskan and Polat, "Fruit Set and Yield of Apricot Cultivars under Subtropical Climate Conditions of Hatay, Turkey."



(3,602,000 heads), and dairy cows (5,969,000 heads) were also widely produced. Chicken production was relatively limited by comparison (1,228,000 heads).[10] The country produced about 25 million MT[11] of feed in 2017, including that produced on-farm. About half of the feed ingredients (12 million MT) were imported, including soybeans, sunflower seeds, corn products, and additives.[12]

People, livelihoods and agriculture

Turkey is home to approximately 80.75 million people, over 25% of whom live in rural areas. The rural population growth was -0.45% in 2017, indicating an urbanization trend in excess of birth rates. Indeed, the rural population has been steadily declining from its peak in the 1960s (64%) to its current all-time low. Men represent an outsized portion of those migrating to cities, meaning women are more likely to remain in rural areas and work in agriculture.

Turkey scores 0.32 on the Gender Inequality Index,[13] which evaluates the reproductive health, empowerment, and economic status of men and women. In comparison, the developing country average is 0.47, and the average for OECD[14] member states is 0.19. This may indicate that there are significant gender power dynamics to be negotiated as Turkey's agricultural sector continues to develop. For example, as of 2014, about 33% of women and 16% of men were employed in agriculture. (These shares have steadily decreased over time; in 2004, 51% of women and 22% of men were employed in the agricultural sector). Nevertheless, women farmers are more likely than men to perform informal and unpaid work; 80% of female farmers and less than 25% of male farmers conduct unpaid family farm labor. Women's work outside the home is culturally seen as an extension of housework, and is therefore not considered an economic activity. Additionally, rural women do not own land and are limited in terms of their access to educational opportunities.[15]

Turkey performs well in terms of international poverty rates: only 2.6% of the population lives on less than US$3.10 per day, and 0.28% on less than US$1.90 per day. However, 14.5% of people are below the national poverty line. Over 96% of the population has access to potable water and 99.9% have access to electricity. Almost all (99.7%) youth aged 15-24 are literate. The number of compulsory years of education for youth increased from 8 to 12 years in 2012.

In spite of these recent socioeconomic gains, Turkey's population grapples with important nutritional challenges. Over 30% of women of reproductive age have anemia, and 14% of adult women and 13% of adult men have diabetes.[16] The country also suffers from an obesity epidemic; recent estimates show at least 22% of the total adult population, and up to 39% of women and 24% of men, are obese.[17]

Challenges in the agricultural sector

The performance of the agri-food sector has been constrained by low levels of productivity. The agricultural sector has grown by 2.48% per year on average over the last two decades, but this growth has been very cyclical and well below growth of the overall economy. Data on

10 Food and Agriculture Organization of the United Nations, "FAOSTAT."
11 Metric tons
12 Foreign Agricultural Service, "Turkey Livestock and Products."
13 United Nations Development Programme, "Gender Inequality Index."
14 Organization for Economic Cooperation and Development
15 FAO, "National Gender Profile of Agricultural and Rural Livelihoods."
16 Global Nutrition Report, "Turkey Nutrition Profile."
17 OECD, "Obesity Update"; Global Nutrition Report, "Turkey Nutrition Profile."

total factor productivity (TFP) show that growth in TFP has not only slowed but that it was negative for the period from 2012 to 2016 (-0.4%), as the input use index grew faster (1.3%) than the output index (0.9%).

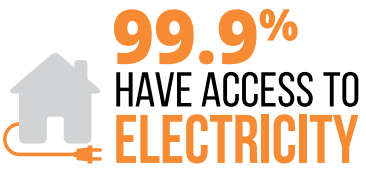
Turkish infrastructure and institutions have improved, but they still hinder growth of agribusiness chains. The Enabling Business of Agriculture Report 2017 (World Bank, 2017), which identifies legal barriers and measures transaction costs affecting to agriculture in 62 countries, shows that Turkey ranks 50th (out of 62) in agricultural trade, 29th in market regulations, 31st in Information and Communication Technologies (ICT), 51st in water management and irrigation.

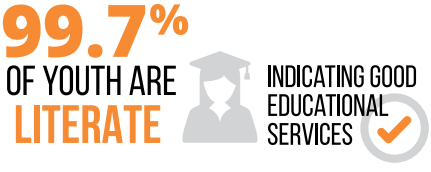
Existing research also attributes inefficiencies in Turkish value-chains to structural constraints at farm level and beyond. Turkey's ineffective farm organizations and marketing infrastructures, fragmented land size, small scale of production, lack of product standardization, and non-existence of demand-supply forecasting systems limit market penetration and expansion, curb profitability, and slow down income growth for farmers.

Several policy-related constraints hinder sector performance, including strong focus on input subsidies and relatively low support for general services and public goods, high levels of overall trade protection and uneven integration into global agricultural markets, ad-hoc approach to policy making, both trade and agricultural that creates uncertainty in the sector.

The current market system includes powerful regional distributors that buy from producers and sell to national and international markets. A more balanced system would augment national GDP and agricultural innovation by ensuring that a larger portion of market profits reache producers.

The country has substantial water resources. However, central Anatolia, where maize and sugar beet are the predominant crops, relies heavily on groundwater resources. Overdraft has extended to the point of causing sinkholes,[18] and climate change impacts are expected to exacerbate these emerging water scarcity issues. Sustainable solutions are needed for the agricultural economy to prosper in this region without causing devastating environmental impacts.





18 CNNTurk, "Konya'da 6 Günde 3 Yeni Obruk Oluştu."

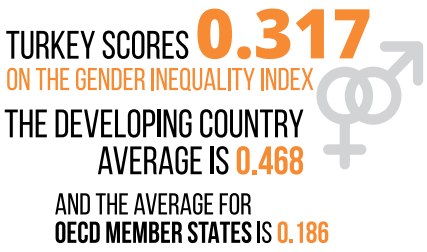
Current landscape of digital tools and policies

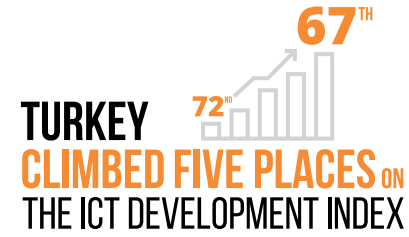
Digital infrastructure, availability and access

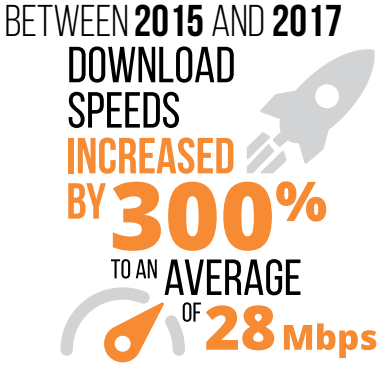
Turkey has made monumental gains in terms of improving access to digital technologies and services within the last decade. The GSMA[19] Mobile Connectivity Index[20] ranked Turkey 5th out of 150 countries for improvements made to 3G and 4G coverage, network performance, and spectrum availability. The most significant improvements were towards physical infrastructure. Between 2015 and 2017, download speeds increased by 300% to an average of 28Mbps, and 4G network coverage reached 90% of the population.[21] Within the same period, Turkey climbed five places on the ICT[22] Development Index, from 72nd to 67th place.[23]

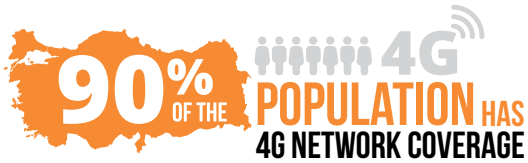
The International Telecommunications Union reported that over 97% of surveyed inhabitants had mobile cellular subscriptions, whereas only 14% had fixed telephone subscriptions.[24] The latest census data from the Ministry of Transport and Infrastructure shows over 80 million mobile telephone subscriptions in the country.[25] Mobile technologies are also the preferred and dominant means of Internet access.

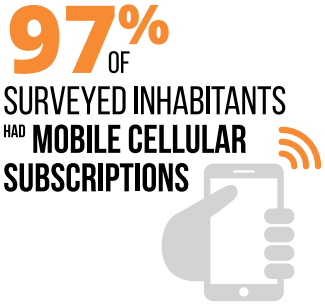
As of 2018, 81% of Turkish households had Internet access. Approximately 74% of surveyed inhabitants were mobile broadband subscribers, and 16% had fixed broadband subscriptions.[26] Only 57% of households owned a computer, although 71% of individuals actively use the Internet. Nevertheless, the Information and Communication Technologies Authority reports full market competition for wireless broadband, DSL,[27] and cable modem Internet services. As of late 2017, the country had over 450 ICT[28] service operators. Turkcell is the largest mobile service provider, covering nearly 44% of the market, followed by Vodafone and Türk Telekom.[29] Turkey also has three Internet exchange points: IST-IX, TNAP, and DEC-IX.











19 Groupe Spécial Mobile Association, also known as Global System for Mobile Communications

20 Connected Society, "Mobile Connectivity Index."

21 Bahia, "State of Mobile Internet Connectivity."

22 Information Communication Technology

23 International Telecommunications Union, "Economy Card: Turkey."

24 International Telecommunication Union, "Country Profile: Turkey."

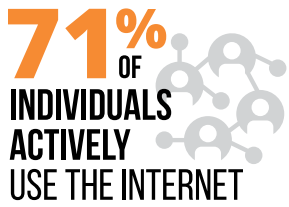
25 Turkish Statistical Institute, "Communication Statistics."

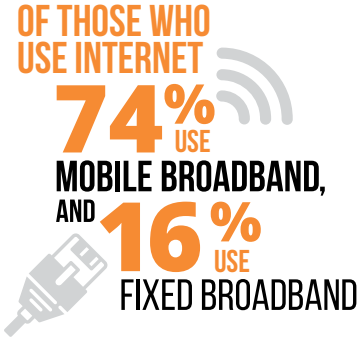
26 International Telecommunication Union, "Country Profile: Turkey."

27 Digital Subscriber Line

28 Information Communication Technology

29 Freedom house, "Turkey."





Turkey ranks "high" on the E-Government Development Index (53rd globally) and "very high" on the E-Participation Index (37th globally),[30] both of which measure the degree to which public services are available digitally. For example, the Turkish Presidency's Communication Center, originally launched in 2006, is an electronic tool to facilitate civic engagement and public information requests.

Turkey has historically been behind the global average in terms of enabling the development of key technologies, such as cloud-based services, Broadband, and IoT.[31] Policy, including Internet censorship and permissive enforcement of intellectual property protection, has played a prominent role in decelerating the development and adoption of these technologies. The political environment is shifting, however; the country set forth a National Broadband Strategy to deliver high-speed broadband to 95% of households by 2020.[32] Marked progress has been made for cloud-based and big data services, and both supply and demand for digital products have increased as a result.[33] These improvements earned the country a relatively high 2016 Networked Readiness Index score (48th out of 139 economies).

In the last decade, Turkey has also increased its access to, and use of, EO[34] resources, which play a significant role in information extraction. With the launch of the RASAT satellite in 2011, Turkey began offering EO data through the open GEZGIN online portal. A second EO data platform, GEOPORTAL,[35] was established as part of the national initiative to strengthen economic development and environmental monitoring through EO services.[36] The European Union FP7-funded EOPOWER followed soon thereafter.[37] In June 2016, the European Space Center launched Turkey's Göktürk-1 satellite, which is equipped with remote sensing technology to monitor pollution, natural disasters, and law enforcement. In 2020, Turkey will expand its satellite capabilities by deploying Göktürk-3 to capture high resolution imagery using a synthetic aperture radar.[38]

Currently, Turkey is preparing for the deployment of 5G technologies, which will allow for machine-machine and machine-human connections. The country has also been working with the United States' Open Networking Foundation to develop the next generation of ICT[39] technologies, including enhanced mobile broadband, enhanced machine-type communications, and ultra-low latency communications.[40] Following Information and Communication Technologies Authority approval, Turkcell, Vodafone, and TT Mobil have begun piloting 5G technologies in Istanbul, Izmir, and Ankara, giving Turkey a leading position in the international race to 5G.[41]

30 United Nations Department for Economical Social Affairs, "E-Government Survey."

31 Internet of Things

32 BSA, "Global Cloud Computing Scorecard."

33 Huawei, "Global Connectivity Index."

34 Earth Observation

35 Satellite Image Processing and Geoportal Development Project

36 Deveci et al., "The benefits and challenges of having an open and free basis satellite data sharing platform in Turkey"

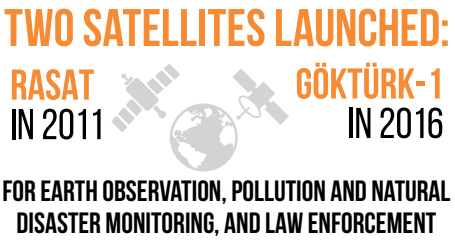
37 Earth Observation for Economic Empowerment

38 Khan, "Turkey's Göktürk-1 Earth Observation Satellite Now in Orbit."

39 Information Communication Technologies

40 Open Networking Foundation, "Turkey Will Become First to Field Test New Communication Technologies Developed at the ONF."

41 Anadolu Agency, "Turkey Goes Full Throttle in 5G Technology Tests."



End-user diversity and demand

Digital agriculture end users may be generally grouped into four hubs. Each hub has unique resources and needs in terms of digital agriculture, and each hub faces unique challenges for which digital agriculture could offer solutions. The hubs are not mutually exclusive; any given individual may function within multiple end user hubs.

The **Input hub** includes all actors providing agricultural inputs, such as seeds, feeds, agrochemicals, machinery, and finance. The main challenges faced in this hub include limited access of farmers to finance and limited knowledge about different types of inputs and their benefits. Most farmers rely on what they have traditionally used or simply what local retailers offer. A large percentage of farmers purchase inputs on credit provided by local retailers. Regional and national supplier networks employ market and supply chain forecasting technology; local establishments rely on low-tech information sources.

The **Production hub** fundamentally consists of farmers. A survey of more than 3,000 farmers across 81 regions in Turkey indicates that only 39% of farmers access the Internet using a computer. Of these, 25% use it for social media, 12% use it to view weather forecasts, and only 3% use it to acquire agricultural information. Almost half (44%) of farmers use smartphones; of those, 33% access social media, 2% use agriculture-oriented apps, and 3% use banking services.[42] Additionally, many farmers currently receive climate information via SMS. Another study of 114 farmers around Izmir found that Internet usage increases with education level. Of the farmers that seek out agricultural information on the Internet, most have only a moderate level of confidence in the information they find. In the last five years, about 54% of farmers who sought out agricultural information online applied it.

High-profit farmers (generally large-scale livestock and cereal producers, smaller scale fruit and nut producers, and greenhouse producers) compose about 2.5% of all farmers. This group is most likely to use digital technologies for farming. They possess the highest levels of digital solutions, including weather stations, soil/livestock sensors, Internet of Things, and decision support tools providing information on markets, weather, pests, and diseases. These data suggest that farmers who trust the information source are willing to use digital resources.[43]

The **Distribution hub** includes all actors in the value chain between farmers and consumers, such as traders, transporters, and processors, among others. Distribution hub end-users are most often constrained by limited access to financial solutions, poor traceability, and a lack of communication with other value chain stakeholders. Large regional, national, and international distributor networks have strong digital solutions, including high connectivity, information access, and forecasting systems. Local retailers, markets, and farmer organizations operate with low-tech solutions.

In Turkey, farmer organizations (e.g. cooperatives, unions) fall into the Input, Production, and Distribution hubs. Producer organizations are particularly important in areas with a large number of small farms; the organization mitigates potential small-scale issues that would otherwise increase average production and transaction costs. Some of the more advanced producer organizations, such as those with regional and national reach, have already started using digital technologies in their operations, including harvest, processing, and marketing. Some are even using drones and sensors to help track production for their members.

42 Doktar Digital Agricultural Solutions, "Doktar - Çiftçinin Nabzı."

43 Gulter, Yildiz, and Boyaci, "Çiftçilerin Bilgi ve İletişim Teknolojilerini Kullanma Eğilimleri: İzmir İli Menderes İlçesi Örneği."

The **Consumer hub** consists of consumers of both raw and processed agricultural products—in effect, the entire population. Consumers are subdivided by income and geographic proximity to large cities. All consumers have similar rates of connectivity, but those with higher income and greater urban proximity have much higher access to smartphones and much greater interest in the nutritional value of food. This results in an increased tendency to make informed purchasing decisions and utilize traceability technologies when buying agricultural goods.

Institutions and policies for digital agriculture

Until recently, Turkey's digital agriculture advancements were not based on a national strategy or plan. The soon-to-be-released 5-Year Development Plan includes, for the first time, objectives related to digital transformation and digitization for various sectors, including agriculture. Implementing modern agricultural practices is also underscored in the climate commitments of Turkey's Intended Nationally Determined Contributions.[44] As such, a major push for digital agricultural solutions is expected in the coming years.

All new and current digital agriculture programs conducted in Turkey fall under the supervision of the Digital Transformation Office, which was established as part of the presidential governance system and across all ministries and sectors. The primary responsibilities of this office include coordinating e-government development, undertaking the necessary projects to develop national digital solutions and raise awareness of the same, conduct big data analyses in priority areas, and improve cybersecurity and information security.

The Science, Technology, and Innovation Board also falls under the presidential office and is tasked with making recommendations regarding multiple areas directly relevant to digital agricultural solutions, including:

- Opportunities for regional and global competition, entrepreneurial culture, digital solutions, and catalyzing research and development of new technologies
- Infrastructure, human resource, and other development projects to improve economic, social, and national security
- Areas of strategic technology opportunity
- Medium- and long-term national technology strategies and policy plans
- Programs to reduce import dependency and increase the competitiveness of the Turkish industry
- Policy and strategy for promoting effective and accessible digital solutions in the fields of economy, commerce, recreation, science, education, and culture.

The Ministry of Agriculture and Forestry is the primary government actor responsible for agricultural production and the most prominent investor in Turkish digital agricultural solutions. The Ministry's 2019 budget is approximately US$4.5 billion, of which approximately US$884 million is allocated for investments. An estimated 3% of the investment fund (US$26.5 million) is dedicated solely to digital agriculture solutions.

Within the Ministry, the General Directorate of Agricultural Research and Policies is responsible for conducting research; the General Directorate began digital agriculture research programs in 2002. Some of these programs include: Determination of Variables Affecting the Yield in Cereal Cultivation Areas Using Precision Agricultural Techniques; Field Specific Variable Rate Fertilizer Application in Maize Production in the Çukurova Region Using Information Technologies Supported by Satellite Images; and the Integrated Project for Planning, Development, and Dissemination of Precision Agricultural Applications in Crop Production.

The Ministry also supports research programs conducted by ASELSAN, the largest defense electronics company in Turkey, with the aim of transferring the use of unmanned aerial devices, communication platforms, and traffic and automation systems to the field of agriculture. Some of ASELSAN's projects to date include: Automatic Tractor Steering and Control System Development; Farm Management Systems Development, Image Processing Based Precision Agricultural Applications with Unmanned Aerial Vehicles, System Development for Monitoring and Tracking Wheat Losses During Harvest, and Development of the Intelligent Measurement Platform Prototype for Sheep and Goat Breeding.

Also within the Ministry of Agriculture and Forestry, the Integrated Control System Department under the General Directorate of Agrarian Reform is responsible for several national datasets and the digital services they support, including:

- National Geographic Information Systems
- Farm Accountancy Data Network
- Land Parcel Identification System
- Integrated Management and Control System

44 Republic of Turkey, "Intended Nationally Determined Contributions."

- Agricultural Information Network
- Farmer Registration System
- Animal Registration System
- Farmland Registration System
- Village Database

These data sets support product verification and tracking, national research programs, map and satellite imagery production, and other key Ministry operations. The Agricultural Information Network, which includes 52 different registration system subsets, tracks personal details, geographic location, ownership status, yield, size, and crop information for approximately 2.3 million farmers, and directly informs subsidy amounts based on comparative regional yield averages. There are 400 stations throughout Turkey for receiving and processing this data. The dataset is not publicly accessible. The Farm Accountancy Data Network collects and stores data on agricultural income, costs, and holdings from approximately 6000 different enterprises.

The Integrated Control System Department also serves as the liaison with the Digital Transformation Office and the Science, Technology, and Innovation Board. Most recently, the Integrated Control System Department has pioneered the establishment of the Smart Agriculture Platform, which includes research institutions, universities, and professional associations.

Although Turkish universities are generally quite active in terms of digital innovations, research into digital agricultural solutions is limited to date. Nevertheless, several promising projects are under development, including Intelligent Field Sprayer Design, Multi-copter Prototype Development for Pesticide Application, Nitrogen Reflection Indices Optimization through the Use of Yield and Sugar Quality Sensors for Variable Rate Fertilizer Application in Sugar Beet, and Multi-Conditioning Greenhouse Technology Development.

Digital agricultural services and applications available

There are already a number of digital agriculture solutions that exist in the country. Digital solutions help facilitate Turkish financial services for agricultural stakeholders. Banks, and more recently start-ups, have been setting up digital loan application systems, as well as partnerships with local retailers, to facilitate loan application for farmers in more remote areas. Risk assessment models accounting for the benefits and losses of farm management systems are also being digitized. Banks accept contract agreements as collateral; these contracts can now be digitized, and assets, such as tractors and land, can be digitally registered and made accessible for the financers.

Turkish agriculture is generally well mechanized; medium and large farmers, as well as smaller fruit farmers, have access to advanced machinery with sensors and precision agriculture capabilities. Market information, including prices, types and quality of crops, alternative crops, and current campaigns are also available through SMS,[45] Internet, and smartphone application services. Nutrition information is easily accessible to consumers through digital channels.

In addition, various precision agriculture services, management and support systems, and online communication platforms are available (Table 1). Many of these services are broadly applicable, including phytobiological image detection, remote sensing, fertilization application controls, plant protection, and information management. Additionally, several services are specialized in systems such as aquaculture and greenhouse, or projects such as barn design and micro-environment management.

Challenges for digital agriculture

The country's digital infrastructure is more than adequate to accommodate growth in the digital ecosystem. However, mechanisms to access and analyze data from various sources in order to inform the development of value-added services is lacking. As a result, business and research innovators find it challenging to understand and fully address end user needs.

Many Turkish producers do not invest in novel farming technology. On the contrary, they tend to rely on credit systems, even for predictable annual input costs. Financial literacy education would prepare farmers for the up-front investments necessary for many digital solutions. The current gender power dynamics in the agricultural sector may also hinder the scale-up of innovations and technologies.

The Turkish educational system is relatively advanced in terms of computer science, and there are many highly skilled individuals in the digital sector. Nevertheless, the digital workforce available to develop and manage digital solutions is lower per capita than the global average and is highly centralized in the largest cities. As such, there is significant opportunity for growth of the digital workforce, particularly in rural areas and the agricultural sector.

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Similarly, one of the greatest barriers to large-scale adoption is digital literacy. All four hubs highlight digital literacy of end-users as a key constraint. There is high connectivity throughout the value chain, and the majority of stakeholders have access to an Internet-enabled device. Nevertheless, the usage of innovative features beyond SMS[46] remains low. The primary determinant of digital literacy seems to be geography (urban versus rural) and is related to education and income levels. The limitations of digital literacy are most pronounced in the producer hub, and are marked by a generation gap: the average farmer is about 56 years of age. Ironically, the Producer hub requires the most sophisticated levels of information to make informed management decisions and identify deviations from historical trends. In order to access this level of information, comparably sophisticated digital literacy levels are required. Digital literacy is perhaps the first step toward a digital transformation of Turkish agriculture, as it enables or prevents the success of most digital solutions.

Enabling Digital Agriculture

An important first step in leveraging digital agriculture to solve real-world problems is identifying the most promising technologies across multiple end user barriers.[47] This enables investors and implementers to focus their efforts on areas of highest impact. Identifying and understanding these enabling factors will lay the foundation for effective mainstreaming of digital agriculture.

Technologies with greatest potential and their impact[48]

Cross-cutting issues include a lack of decision support tools, poor market linkages, and limited product traceability. These issues span all four end-user hubs, and the solutions would have significant implications throughout the value chain. **Database, mobile phone** applications, and **blockchain** technologies show the greatest promise for addressing these obstacles. Effective decision support systems, strong market linkages, and product traceability all improve productivity, national stability, export capacity, and GDP. Providing such services through digital channels greatly reduces cost, enables equity for small-scale farmers, and increases reach. Digital literacy is key to the success of any endeavor.

In the short term, mobile technology is particularly important to ensure end user interface with decision support systems at all points in the value chain. This could be either through SMS / IVR[49] or smartphone application technologies. Many farmers already use SMS systems. Smartphone applications are currently under development. However, even upon release, they will still be out of reach for those with low digital literacy.

In the medium term, there is a significant opportunity for improvement in terms of value chain transparency. Blockchain enables secure, efficient, and equitable value chain traceability. Transparent information on product source also allows producers of organic, local, and other niche products to advertise as such; this supports greater profits, environmentally sustainable practices, and agricultural innovation. Nevertheless, the feasibility of blockchain tracing is low given the current digital environment; an initial step into a full bar-coding system would help pave the way.

Database technology will enable back-end operations of any complex digital system in both the short and medium term, including decision support programs and product traceability.

The **Input hub** struggles with increasing prices of imported raw materials, unreliable demand, and scant information on farmer demands. All of this leads to insufficient production. Given the appropriate policy environment, there is strong potential for transformation of input supply chains. In the short to medium term, **advanced analytics** and **database technologies** have the greatest potential for supporting these changes through e.g. the traceability of farm products, information sharing systems, bulk purchasing mechanisms, and financial support systems. A platform for equipment, tractor, and harvester sharing in particular would have great short and medium term potential; many farmers already own this machinery,

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47 In this analysis, we focus on identifying, for each of the end user hubs, the main challenges confronting the agriculture sector. We then identify, using participatory methods, a set of technologies and associated functions and outcomes. Table 1 shows the results of the technology prioritization across hubs. Next, each technology was assessed across six dimensions: Progress (the current degree of development, use, maturity, scaling, uptake, and profitability of the technology), Policy and enabling environment (the degree to which policy, programs, and investments enable further development, adoption, and impact of the technology), Potential impact (the expected uptake and return on investments of the technology over the next decade), Efficiency (the extent to which the technology enhances food systems efficiency in terms of labor, inputs, yield, transport, and transaction cost reduction), Equity (the degree to which the technology breaks down barriers to equity, particularly in terms of youth and gender inclusivity), and Environment (the extent to which the technology supports environmental sustainability through waste reduction, greenhouse gas intensity reduction, and improved natural resource use efficiency). Each of these is assessed using a number of indicators. The results of the technology identification and assessment are described below, followed by a discussion of the policies, the role of the public and private sector, and the financing options available to support the promotion of the most promising technologies.

48 These results are based on a combination of desk research and stakeholder consultation. The latter included 8 interviews with representatives of government, academics, farmer groups, and start-ups, as well as a one day workshop with 25 key experts in the field of Digital Agriculture.

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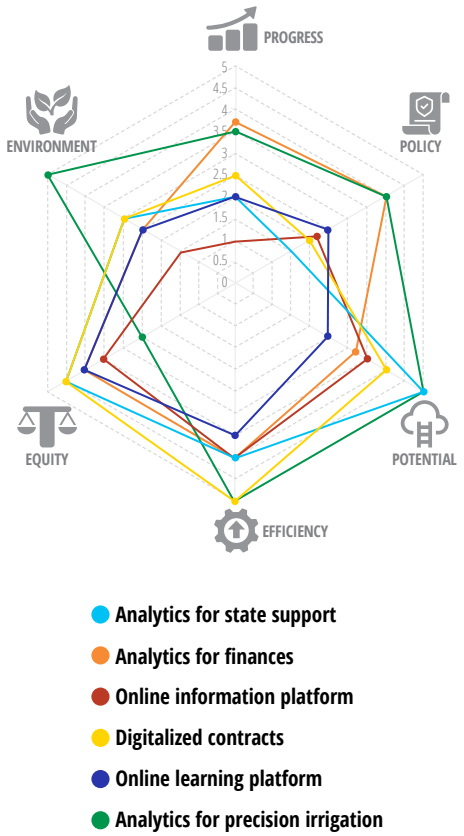
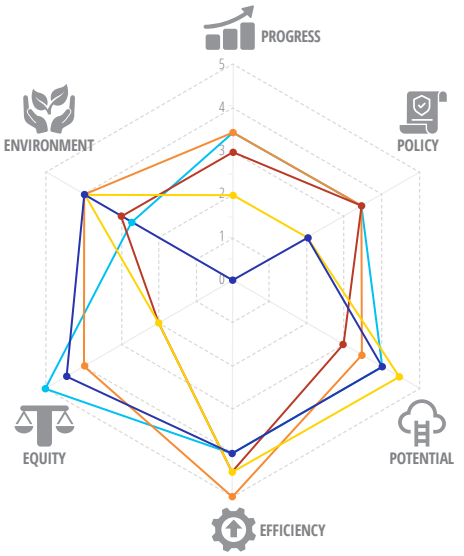
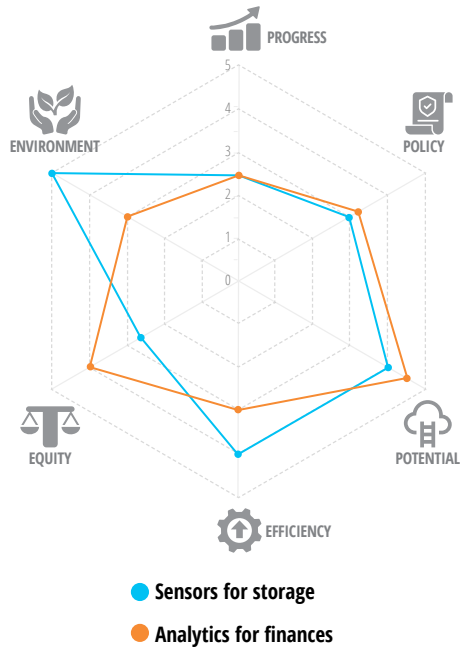
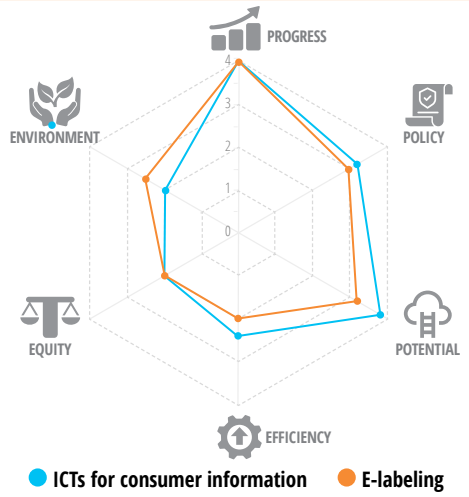
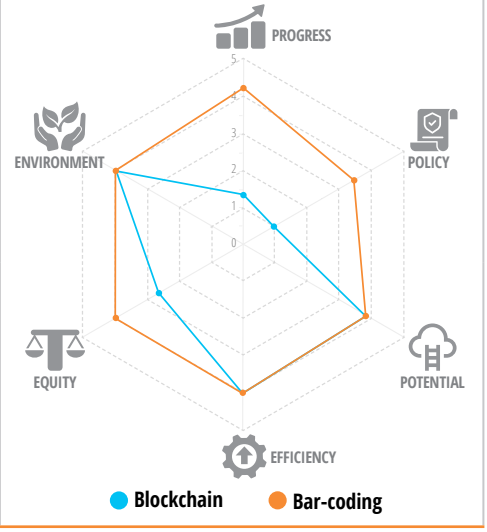
Table 1: Prioritized technologies

	Challenge	Technology	Outcome	Analysis
INPUT HUB	State support payments do not result in anticipated efficiency gains	**Database technologies and advanced analytics for design and monitoring of agriculture state support**	More efficient agriculture state support system	
	Lack of financing mechanisms for inputs	**Advanced analytics for financial support systems**	Additional options for farmers to buy inputs	
	High input costs	**Online platforms for information sharing and joint purchasing**	Accurate information on necessary farm inputs available; Reduced input prices via bulk purchasing	
	Lack of finance mechanisms for farm investments	**Digitized contracts and risk assesment models for optimal financial systems**	Financial services available to farmers at prices that accurately reflect their objectively quantified risk	
	Low farmer financial literacy	**Online learning platform for financial literacy training**	Increased financial literacy across a broad population at great cost-effectiveness	
	Regional low water supplies	**Advanced analytics for precision irrigation systems**	Reducing environmental impact and improving long term sustainability of water supplies	
PRODUCER HUB	Ineffective and/or inefficient farming systems without a quantitative base	**SMS / IVR decision support systems for lower-tech farmers**	Improved decision support to enhance efficiency and thus farmer income	
		Computer / smartphone applications for farmer decision support		
		Sensors and applications for real-time livestock location/health information		
		Internet of Things and advanced analytics for decision support		
	Excessive cost of mechanization	**Digital platform for equipment sharing**	Machinery easily available at low cost to farmers	

	Challenge	Technology	Outcome	Analysis
DISTRIBUTION HUB	Poor storage conditions	**Internet of Things and advanced analytics to enhace storage conditions**	Automated and optimized storage conditions for reducing food waste	
	Poorly functioning financial systems	**Advanced analytics for integrated finance solutions**	Faster and more reliable financial transactions across the value chain	
CONSUMER HUB	Lack of market information to support decision-making	**Website, smartphone application, or SMS to inform consumers**	Improved market transparency for end users across the value chain	
	Lack of nutritional and food source information	**Smartphone application for e-labeling and nutritional information**	Consumers make informed purchasing decisions; niche producers market and price products based on unique characteristics	
CROSS-CUTTING HUB	Lack of traceability across the food chain	**Blockchain for traceability** **Bar-coding for traceability**	Product sources, processes, and pathways are transparent to all stakeholders for marketing and trouble-shooting purposes	

and the platform could be easily generalized by farm size. In addition to positive economic impacts, these technologies will pave the way to higher equity levels, and, in combination with sustainable intensification methods, reduce environmental impacts.

Within the **Production hub**, water shortages are a problem in some parts of the country. Farmers with greater digital literacy and financial means would benefit greatly from the use of **sensors, Internet of Things,** and **advanced analytics** for direct decision support via precision agriculture or programs such as Bayer's Fieldview. These services are already in place, and may be further scaled across the medium-term. In the interim, SMS / IVR[50] are good short term fits for farmers with less investment capacity. Further public investments in advisory systems and precision irrigation technologies, in combination with sustainable intensification methods, will show tremendous promise for increasing efficiency and environmental sustainability.

Reliable credit systems are already in place for Turkish producers; these could be further improved by accepting warehouse-registered crops as collateral and facilitating the partnership economy model for production financing. Both of these would be readily facilitated in the short to medium term by digital channels. Digitized contracts and risk assessment models would enable more accessible and more equitable financial service systems.

The **Distribution hub** faces significant challenges in terms of monitoring, sorting, storage, and transportation. Traceability, the automation and interoperability of systems, and faster, more reliable financial transactions through the use of **sensors** and **advanced analytics** would help address these issues in the short to medium term. Although this requires significant up-front investment, the return over time will be remarkable, most notably in reducing waste and inefficiency costs. Accurate and timely market information through data collection, data analytics, and communication platforms will ensure more equitable market access and higher efficiency for smaller retailers.

Finally, a lack of product origin, processing, and nutrition information is the primary issue facing the **Consumer hub**. E-labels with nutritional value, environmental footprint, and origin information increase the marketable value of high-quality and niche products and support consumer purchase decision-making. Such systems employ **data collection, bar-coding, database technologies,** and **smartphone applications**. E-labeling system development is already underway in urban areas, and may continue to scale up in urban areas on the short term. E-labeling has the potential to expand into rural areas on the medium term. The remaining long term challenge is greater adoption and shifting mindsets. Such systems can also assist in monitoring and tracking food waste and environmental impacts. The potential environmental impact and policy support for these technologies are both currently limited.

Potential avenues for the public sector

The government already has a strong foundation in place for digital agriculture, and is significantly investing in further transforming the sector; approximately US$26.5 million of the 2019 budget has been dedicated to digital agriculture solutions. These governmental investments and development plans will benefit all stakeholders along the value chain by increasing efficiency, equitability, and profitability of food systems while simultaneously reducing environmental impact.

There is enormous opportunity to further leverage existing databases of information on nearly all farmers in Turkey. These data can be used to identify farmers' needs and reach them through SMS / IVR,[51] smartphone applications, or web platforms–as well as through tailored in-person extension services. Further development of data collection and advanced analytics would enable forecasting of supply, shortages, and market prices to increase farmer resiliency. Significant opportunity also exists to empower start-ups, for example through grants, that work in niches that otherwise would find little development support.

The digital transformation of the agricultural sector will require a substantial digital workforce to develop digital solutions. Similarly, the digital literacy of users across the country is crucial to the success of any digital solution. As such, educational programming at all levels, including for the use, design, and development of digital solutions, is crucial to moving such solutions forward. In the meantime, offering solutions for clients across the digital literacy spectrum will enhance uptake and return on investments. Piloting, demonstration plots, and public awareness campaigns will help ensure that all stakeholders hubs and entrepreneurs are familiar with the digital innovations, solutions, and opportunities available to them.

Potential avenues for the private sector

The private sector's position at the cutting edge of Turkish digital innovation will continue to be crucial in popularizing

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and monetizing new technologies. Within the private sector, diverse organizations are developing and adapting digital agricultural solutions for all stages of the value chain. Turkey has over 2.3 million farmers, the majority of which belong to at least one farmer organization. These organizations play an extremely important role in market access, traceability, and branding. As such, private sector entities that choose to work with these organizations to identify and implement digital solutions will have a significant advantage in terms of economies of scale. Similarly, marketing to cooperatives rather than individual farmers represents a marked reduction in advertising costs.

The private sector has indicated that the entrepreneurial enabling environment in Turkey is not as supportive as in other countries. As such, ensuring the availability of investment funds, incubators, and accelerators is key. These types of support will help ensure that innovation and strong business solutions to agriculture's most pressing issues continue to emerge. Investing in the development of mobile technology is particularly important in terms of end-user interfaces at all points in the value chain. Given the low digital literacy in the producer group, it will likely be in the hands of the private sector to spearhead capacity building as they move such technologies forward.

The private sector's monetization of digital solutions plays a significant indirect role in catalyzing public sector establishment of nationwide mobile and broadband services. Additionally, public-private partnerships with organizations such as the World Bank, NARES,[52] FAO,[53] and CGIAR,[54] with a focus on pre-competitive research, will be particularly helpful in developing strong business models and quickly scaling innovative digital agriculture solutions.

Outlook / synthesis of recommendations

Turkey has laid a strong foundation for digital agricultural solutions, and the digital agriculture ecosystem is growing rapidly. Connectivity and subscription rates are high, and digital solutions within the agricultural and food sector have been met with significant success. A number of digital agricultural solutions, such as precision agriculture, have been in place for years, and others, such as smart agriculture, are now being successfully piloted. This suggests important opportunities for digital solutions to the challenges that the Turkish agricultural sector faces, including a lack of access to financial and decision support services, market information, and supply chain traceability and management.

Additional investments in digital agriculture can lead to higher productivity and competitive market structures. Digital agricultural innovations can help address the core challenges of food production by supporting greater efficiency, knowledge sharing, networking, and informed decision-making. These, in turn, have the potential to reduce upward trends in food prices.

Our research suggests that stakeholders who focus their efforts on developing mobile and data analytics -based approaches are most likely to bring high-impact solutions to the Turkish agricultural sector. Medium and large scale farms with the means to invest in cutting-edge technologies can realize major gains from investments in weather stations, soil and livestock sensors, and Internet of Things. For small-scale and low-tech farms, SMS / IVR[55] and Application-based advisory systems to support decision-making and peer-to-peer knowledge sharing offer the greatest potential. In all cases, piloting, demonstration plots, and public awareness campaigns will help ensure that farmers remain abreast of the digital innovations, solutions, and opportunities available to them.

Supportive national policy, public-sector investment, and private sector engagement in innovation and monetization will be key. Research and development contributions from organizations such as the World Bank, CGIAR, FAO, and other international donors will be crucial to ensuring the success of such solutions.

52 National Agriculture Research and Extension Systems

53 Food and Agriculture Organization of the United Nations

54 Consultative Group on International Agricultural Research

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References

Anadolu Agency. "Turkey Goes Full Throttle in 5G Technology Tests." Hürriyet Daily News, February 12, 2019. http://www.hurriyetdailynews.com/turkey-goes-full-throttle-in-5g-technology-tests-141181.

Bahia, K. "State of Mobile Internet Connectivity." Connected Society. GSMA, 2018. https://www.gsmaintelligence.com/research/?file=c0bcc185be555f77478a8fdf986ea318&download.

BSA. "Global Cloud Computing Scorecard." The Software Alliance, 2018. http://cloudscorecard.bsa.org/2018/.

Caliskan, O., and Polat, A.A. "Fruit Set and Yield of Apricot Cultivars under Subtropical Climate Conditions of Hatay, Turkey." Digital Repository: Jomo Kenyatta University of Agriculture and Technology, February 2018. http://ir.jkuat.ac.ke/handle/123456789/4342.

CNNTurk. "Konya'da 6 Günde 3 Yeni Obruk Oluştu." CNNTurk.com, February 21, 2019. https://www.cnnturk.com/turkiye/konyada-6-gunde-3-yeni-obruk-olustu?page=1.

Connected Society. "Mobile Connectivity Index." GSMA, September 2017. https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2017/09/GSMA_Mobile-Connectivity-Index-Infographic.pdf.

Deveci, Hüsne Seda, A. Güne Koru, Ufuk Sakarya, İsmail Tevrizoğlu, Mustafa Teke, Ramazan Küpçü, Bülent Avenoğlu, et al. "The Benefits and Challenges of Having an Open and Free Basis Satellite Data Sharing Platform in Turkey: GEZGİN." The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Prague, Czech Republic, XLI-B8 (2016). https://doi.org/10.5194/isprs-archives-XLI-B8-1341-2016.

Doktar Digital Agricultural Solutions. "Doktar - Çiftçinin Nabzı." Data & Analytics, 12:38:17 UTC. https://www.slideshare.net/Doktar/doktar-ciftcinin-nabzi/Doktar/doktar-ciftcinin-nabzi.

Erdogan, C. "Turkey's Advanced Food Sector Provides Opportunities in Spite of Economic Downturn." Required Report. Global Agricultural Information Network. USDA Foreign Agricultural Service, March 29, 2019.

FAO. Food and Agriculture Organization of the United Nations. "National Gender Profile of Agricultural and Rural Livelihoods." Country Gender Assessment. Ankara, 2016. http://www.fao.org/3/a-i6192e.pdf.

Food and Agriculture Organization of the United Nations. "FAOSTAT," 2019. http://www.fao.org/faostat/en/#data/TP.

Foreign Agricultural Service. "Turkey Livestock and Products." Annual Required Report. Global Agricultural Information Network. USDA Foreign Agricultural Service, 2018. https://apps.fas.usda.gov/newgainapi/api/report/downloadreportbyfilename?filename=Livestock%20and%20Products%20Annual_Ankara_Turkey_9-7-2018.pdf.

Freedom house. "Turkey." Freedom on the Net, November 1, 2018. https://freedomhouse.org/report/freedom-net/2018/turkey.

General Directorate of Meteorology. "Yıllık Toplam Yağış Verileri," March 12, 2016. http://dmi.gov.tr/veridegerlendirme/yillik-toplam-yagis-verileri.aspx?

Giray, H. "Turkish Agriculture at a Glance." Journal of Food Agriculture and Environment 10 (July 1, 2012): 292–95.

Global Nutrition Report. "Turkey Nutrition Profile," 2016. https://globalnutritionreport.org/resources/nutrition-profiles/.

Gulter, S, Ozlem Y, and Murat B. "Çiftçilerin Bilgi ve İletişim Teknolojilerini Kullanma Eğilimleri: İzmir İli Menderes İlçesi Örneği." Tarım Ekonomisi Dergisi Turkish Journal of Agricultural Economics, 2018.

Huawei. "Global Connectivity Index," 2018. https://www.huawei.com/minisite/gci/en/country-profile-tr.html.

International Telecommunication Union. "Country Profile: Turkey." ICTEYE Key ICT Data & Statistics, 2017. https://www.itu.int/net4/itu-d/icteye/CountryProfile.aspx https://www.itu.int/net4/itu-d/icteye/CountryProfileReport.aspx?countryID=236.

International Telecommunications Union. "Economy Card: Turkey," 2017. https://www.itu.int/net4/ITU-D/idi/2017/index.html#idi2017economycard-tab&TUR.

Investment Support and Promotion Agency. "Why Invest in Turkish Agri-Food Industry." Republic of Turkey, n.d. http://www.invest.gov.tr/en-US/infocenter/publications/Documents/AGRI.FOOD.INDUSTRY.pdf.

Khan, B. "Turkey's Göktürk-1 Earth Observation Satellite Now in Orbit." Defense News & Analysis Group. Quwa (blog), December 6, 2016. https://quwa.org/2016/12/06/turkeys-gokturk-1-earth-observation-satellite-now-in-orbit/.

OECD. "Obesity Update," 2017. https://www.oecd.org/els/health-systems/Obesity-Update-2017.pdf.

Open Networking Foundation. "Turkey Will Become First to Field Test New Communication Technologies Developed at the ONF," March 9, 2018. https://www.opennetworking.org/news-and-events/press-releases/turkey-will-become-first-field-test-new-communication-technologies-developed-onf/.

Republic of Turkey. "Intended Nationally Determined Contributions." UNFCCC, September 30, 2015. https://www4.unfccc.int/sites/submissions/INDC/Published%20Documents/Turkey/1/The_INDC_of_TURKEY_v.15.19.30.pdf.

The World Bank. "Agriculture, Forestry, and Fishing, Value Added (% of GDP)." Data, 2017. https://data.worldbank.org/indicator/NV.AGR.TOTL.ZS.

Turkish Statistical Institute. "Communication Statistics." TurkStat. Accessed June 28, 2019. http://www.turkstat.gov.tr/VeriBilgi.do?alt_id=1062.

United Nations. "Digital Agriculture: Feeding the Future." Project Breakthrough, 2019. http://breakthrough.unglobalcompact.org/disruptive-technologies/digital-agriculture/.

United Nations Department for Economic and Social Affairs. "E-Government Survey." United Nations, 2018. https://publicadministration.un.org/egovkb/Portals/egovkb/Documents/un/2018-Survey/E-Government%20Survey%202018_FINAL%20for%20web.pdf.

United Nations Development Programme. "Gender Inequality Index." Human Development Reports, 2017. http://hdr.undp.org/en/composite/GII.

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