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Digital Agriculture in the Present Scenario

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ABSTRACT: Digital agriculture, sometimes known as smart farming or e-agriculture,[1] is tools that digitally collect, store, analyze, and share electronic data and/or information in agriculture. The Food and Agriculture Organization of the United Nations has described the digitalization process of agriculture as the digital agricultural revolution.[2] Other definitions, such as those from the United Nations Project Breakthrough,[3] Cornell University,[4] and Purdue University,[5] also emphasize the role of digital technology in the optimization of food systems.

Digital agriculture includes (but is not limited to) precision agriculture. Unlike precision agriculture, digital agriculture impacts the entire agri-food value chain — before, during, and after on-farm production.[6] Therefore, on-farm technologies, like yield mapping, GPS guidance systems, and variable-rate application, fall under the domain of precision agriculture and digital agriculture. On the other hand, digital technologies involved in e-commerce platforms, e-extension services, warehouse receipt systems, blockchain-enabled food traceability systems, tractor rental apps, etc. fall under the umbrella of digital agriculture but not precision agriculture.

KEYWORDS: digital agriculture, smart, revolution, GPS, yield mapping, FAO, United Nations Project, food

I.INTRODUCTION

Digital agriculture encompasses a wide range of technologies, most of which have multiple applications along the agricultural value chain. These technologies include, but are not limited to:

- Cloud computing/big data analysis tools[21]
- Artificial intelligence
- Machine learning
- Distributed ledger technologies, including blockchain and smart contracts
- The Internet of Things, a principle developed by Kevin Ashton that explains how simple mechanical objects can be combined into a network to broaden understanding of that object
- Digital communications technologies, like mobile phones
- Digital platforms, such as e-commerce platforms, agro-advisory apps, or e-extension websites[1]
- Precision agriculture technologies, including
  - Sensors, including food sensors and soil sensors
  - Guidance and tracking systems
  - Variable-rate input technologies
  - Automatic section control[2]
  - Advanced imaging technologies, including satellite and drone imagery, to look at temperature gradients, fertility gradients, moisture gradients, and anomalies in a field
  - Automated machinery and agricultural robots[24]

To produce a “sustainable food future,” the world must increase food production while cutting greenhouse gas emissions and maintaining (or reducing) the land used in agriculture. Digital agriculture could address these challenges by making the agricultural value chain more efficient, equitable, and environmentally sustainable. Digital technology changes economic activity by lowering the costs of replicating, transporting, tracking, verifying, and searching for data. Due to these falling costs, digital technology will improve efficiency throughout the agricultural value chain.[3] On-farm, precision agriculture technologies can minimize inputs required for a given yield. For example, variable-rate application (VRA) technologies can apply precise amounts of water, fertilizer, pesticide, herbicide, etc. A number of empirical studies find that VRA improves input use efficiency. Using VRA alongside geo-spatial mapping, farmers can apply inputs to hyper-localized regions of their farm — sometimes down to the individual plant level. Reducing input use lowers costs and lessens negative environmental impacts. Furthermore, empirical evidence indicates precision agriculture technologies can increase yields. By facilitating a market for equipment sharing, digital technology ensures fewer tractors sit idle and allows owners to make extra income. Furthermore, farmers without the resources to make big investments can better access equipment to improve their productivity.[4]

Digital agriculture improves labor productivity through improved farmer knowledge. E-extension (electronic provision of traditional agricultural extension services) allows for farming knowledge and skills to diffuse at low cost.[23] For example, the company Digital Green works with local farmers to create and disseminate videos about agricultural best practices in more than 50 languages. E-extension services can also improve farm productivity via decision-support services on mobile apps or other digital platforms. Using many sources of information — weather data, GIS spatial mapping, soil sensor data, satellite/drone pictures, etc. — e-extension platforms can provide real-time recommendations to farmers. For example, the machine-learning-enabled mobile app Plantix diagnoses crops' diseases, pests, and nutrient deficiencies based on a smartphone photo[5]

II.DISCUSSION

Besides streamlining farm production, digital agriculture technologies can make agricultural markets more efficient. Mobile phones, online ICTs, e-commerce platforms, digital payment systems, and other digital agriculture technologies can mitigate market failures and reduce transaction costs throughout the value chain.[22]

- Reducing information asymmetry: Price information affects competitive markets' efficiency because it impacts price dispersion, arbitrage, and farmer and consumer welfare. Since the marginal cost of digitally delivering information approaches zero, digital agriculture has the potential to spread price information. Aker and Fafchamps find that the introduction of mobile phone coverage in Niger reduced spatial price dispersion for agri-food products, especially for remote markets and perishable goods.[6]
  - Matching buyers and sellers: E-commerce lowers the search costs of matching buyers and sellers, potentially shortening the value chain. Rather than go through dozens of intermediaries, farmers can sell directly to consumers Market access services can also solve the matching problem without necessarily hosting online transactions. For example, Esoko sends market information (prices for specific commodities, market locations, etc.) to agents and farmers, connecting them to commodity buyers.[21] All of these matching platforms help smallholders coordinate with buyers and enter both regional and global value chains. Finally, it's important to note that digital technologies can also facilitate matching in financial and input markets, not just producer-to-consumer output sales.
  - Lowering transaction costs in commercial markets: Digital payments — whether integrated in e-commerce platforms or in mobile money accounts, e-wallets, etc. — reduce transactions costs within agricultural markets[7]. The need for safe, rapid monetary transactions is particularly apparent in rural areas. Plus, digital payments can provide a gateway to bank accounts, insurance, and credit Using distributed ledger technologies or smart contracts is another way to reduce trust-related transaction costs in commercial markets. Many retail and food companies have partnered with IBM to develop blockchain pilots related to food safety and traceability, and Alibaba is testing blockchain to reduce fraud in agri-food e-commerce between China and Australia/New Zealand.
  - Lowering transaction costs in government services: Digital payments can also streamline government delivery of agricultural subsidies.[20] In 2011, the Nigerian Federal Ministry of Agriculture and Rural Development started delivering fertilizer subsidy vouchers to e-wallets on mobile phones; by 2013, they had reached 4.3 million smallholders nationwide.Compared to the previous program, the e-vouchers cut costs — from 2011 to 2013, the cost per smallholder farmer receiving fertilizer went from US$225–300 to US$22. The e-vouchers also reached more smallholders, increasing from between 600,000-800,000 in 2011 to 4.3 million in 2013.[8] In the second phase of the program, the Nigerian government developed the Nigerian Agricultural Payment Initiative (NAPI), which distributed PIN-enabled ID cards that hold subsidy information and provide access to loans and grants. Other e-wallet/e-voucher systems for agricultural subsidies exist or have been piloted in Colombia, Rwanda, Zambia, Mali, Guinea, and Niger. Besides reducing subsidy costs, governments can harness digital technology to save time. When Estonia implemented their e-ID and X-Road system, time spent applying for agricultural subsidies decreased from 300 minutes to 45 minutes per person.[9]

Rarely does one single digital agriculture technology solve one discrete market failure. Rather, systems of digital agriculture technologies work together to solve multifaceted problems. For example, e-commerce solves two efficiency issues: difficulty matching buyers and sellers, especially in rural areas, and the high transaction costs associated with in-person, cash-based trade.[19]

III.RESULTS

Digital agriculture technologies can expand farmers' access to credit, insurance, and bank accounts for a number of reasons. First, digital technology helps alleviate the information asymmetry that exists between farmers and financial institutions. When lenders decide a farmer's credit ceiling or insurance premium, they are usually uncertain about what risks the farmer presents.[18] Digital technology reduces the costs of verifying farmers' expected riskiness. Digital technology facilitates trust between farmers and financial institutions. A range of tools create trust, including real-time digital communication platforms and blockchain/distributed ledger technology/smart contracts[10]. In Senegal, a digitalized, supply-chain-tracking system allows farmers to collateralize their rice to obtain the credit necessary for planting. Lenders accept rice as collateral because real-time, digital tracking assures them the product was not lost or damaged in the post-harvest process.[17] Off-farm, digital agriculture has the potential to improve environmental monitoring and food system traceability. The monitoring costs of certifying compliance with environmental, health, or waste standards are falling because of digital technology. For example, satellite and drone imagery can track land use and/or forest cover; distributed ledger technologies can enable trusted transactions and exchange of data; food sensors can monitor temperatures to minimize contamination during storage and transport. Together, technologies like these can form digital agriculture traceability systems, which allow stakeholders to track agri-food products in near-real-time. A wide gap exists between developed and developing countries' 3G and 4G cellular coverage, and issues like dropped calls, delays, weak signals, etc. hamper telecommunications efficacy in rural areas. Even when countries overcome infrastructural challenges, the price of network connectivity can exclude smallholders, poor farmers, and those in remote areas. Similar accessibility and affordability issues exist for digital devices and digital accounts. According to a 2016 GSMA report, of the 750 million-plus farmers in the 69 surveyed countries, about 295 million had a mobile phone; only 13 million had both a mobile phone and a mobile money account.[11]

The significance and structure of a country's agricultural sector will affect digital agriculture adoption. For example, a grain-based economy needs difference technologies than a major vegetable producer.[16] Automated, digitally-enabled harvesting systems might make sense for grains, pulses and cotton, but only a few specialty crops generate enough value to justify large investments in mechanized or automated harvesting. In order to benefit from the advent of digital agriculture, farmers must develop new skills. As Bronson (2018) notes, "training a rural work-force in Internet technology skills (e.g., coding) is obviously a key part of agricultural "modernization." Integration into the digital economy requires basic literacy (ability to read) and digital literacy (ability to use digital devices to improve welfare). In many instances, benefiting from digital content also requires English literacy or familiarity with another widely spoken language.[15] Digital agriculture developers have designed ways around these barriers, such as ICTs with audio messages and extension videos in local languages. However, more investment in human capital development is needed to ensure all farmers can benefit from digital agriculture. In order for digital agriculture to spread, national governments, multilateral organizations, and other policymakers must provide a clear regulatory framework so that stakeholders feel confident investing in digital agriculture solutions. Policy designed for the pre-Internet era prevents the advancement of "smart agriculture.[12]

IV.CONCLUSIONS

According to Project Breakthrough, digital agriculture can help advance the United Nations Sustainable Development Goals by providing farmers with more real-time information about their farms, allowing them to make better decisions. Technology allows for improved crop production by understanding soil health[14]. It allows farmers to use fewer pesticides on their crops. Soil and weather monitoring reduces water waste. Digital agriculture ideally leads to economic growth by allowing farmers to get the most production out of their land. The loss of agricultural jobs can be offset by new job opportunities in manufacturing and maintaining the necessary technology for the work. Digital agriculture also enables individual farmers to work in concert, collecting and sharing data using technology and The hope is that young people want to become digital farmers[13]

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