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Digital Agriculture: A Literature Review of Social, Economic and Education Trends

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Abstract
Agriculture is the main source of food in the world. Stable agricultural sector ensures food security for countries, and it is the most important domain in the economic and social development of any country. With the increase in population density, the need for food increases, which leads countries to find quick solutions to meet the food needs of their population and provide security. And the world today is facing the challenge of global greenhouse gas pollution, Therefore, digital agriculture is considered necessary and inevitable in the near future, especially with the tremendous technological development in various technical and economic fields, knowing that traditional agriculture is financially costly due to the absence of modern technologies that provide accurate information and digital statistics that markets and production process need, while Relying on digital farming techniques will inevitably contribute to the development of local production at a lower cost, which will contribute to the high competitiveness of local agricultural production and thus achieve structural and sustainable economic growth, and farmers urgently need to prepare to embrace the coming digital change and must increase or acquire new skills and capabilities in the field of information and communication technology. This paper points out the gap on how to build the current body of knowledge about digital agriculture. With the aim of bridging this gap, our paper presents a review of the digital agriculture literature that helps realize the importance of enhancing research capacity and socioeconomic transformation by enhancing the connection with agricultural research knowledge in the field of agricultural informatics and the impact of these technological innovations on society.

Keywords: Agriculture, Digital, Sustainable, Agricultural informatics, Global greenhouse.

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1. introduction

Agriculture plays a critical role in the global economy. With the continued growth of the human population, pressure on the agricultural sector will increase. Agri-technology and precision farming, now also termed digital agriculture, have arisen as new scientific fields that use data intense approaches to drive agricultural productivity while minimizing its environmental impact. **[1].**

In 2015, the United Nations Agenda for Sustainable Development and the global local area focused on finishing hunger (Transforming Our World: The 2030 Agenda for Sustainable Development). In any case, how close would we say we are to accomplishing the objective? The short response is: We are not close by any means, nearly 800 million individuals experience in All over the world are going hungry, and under the "Business

Continuing" situation To no one's surprise, eight percent (or 650 million individuals) of the total populace will stay undernourished by 2030. The use of contemporary equipment, computerized tools, and information and communication technologies (ICTs) to enhance decision-making and production is altering agriculture as part of THE DIGITAL REVOLUTION. The spread of several cutting edge technologies, from GPS and remote sensing to big data, artificial intelligence and machine learning, robotics, and the Internet of Things (IoT), to agriculture is producing higher yields, lower prices, and a smaller environmental effect. Data-driven solutions are releasing production potential in a way that is resource-saving and sustainable **[2].**

In each instance,. We introduce digitalization, look at why it already has and will continue to have an increased impact on the agricultural sector, and explain why it is urgent to look at how a digital agricultural socio-technical transition is facilitated. Digitalization is the term for the effects of digital technology on daily life, including how we interact with our environment, interact with one another, and how economies operate and is said to be one of the most significant trends globally at present [3]. It has been argued that there is no single definition for digitalization, it rather encompasses growth in human-computer or human-information and communication technologies interaction **[4].**The use of precision agricultural technology, which largely lower costs connected with inputs or work, is typically one of the present effects of the digitalization of agriculture that is most frequently mentioned to increase yield and/or productivity **[5][6][7][8].** For instance, auto-steering tractors with GPS units that use satellites to reduce overlap and driver fatigue in cropping industries, together with related yield mapping and variable rate input application **[9][10].** Recent developments have enabled this technology to be used autonomously, thus the farmer is (technically) no longer required to sit in the tractor seat for extended periods of time **[11].**It has been stated that new digital technologies have enabled and will continue to enable significant changes in agricultural systems.
This literature also explores the role that transdisciplinary science can play in supporting integrative solutions that look at a combination of technological, social, economic challenges **[12].** This study, which focuses on three goals and examines the supply side of digital agriculture, tries to fill this knowledge gap. The first is to concepts of economic opportunities and challenges of supplying digital technologies to farmers. **[13]**. The second objective is to assess major trends in the social in digital agro_ technologies. The third objective of this article is to analyze the education skills of digital tools.

2. The digital agriculture revolution

Agriculture has historically experienced a number of revolutions that have increased productivity, yield, and profitability to previously unimaginable heights. Market forecasts for the next decade suggest a 'digital agricultural revolution' by this changes so dramatic will be the newest shift which could help ensure agriculture meets the needs of the global population into the future. Development of smart agricultural production into four stages, as follows below **[1].**

2.1. The Agriculture 1.0: up to the 1950 decade, was characterized by a relatively low energy intensity, low productivity **[14].** Use of animal force of agriculture1.0, Moreover, given the low technological availability, hand tools were widely used both in land preparing for planting or for harvesting. The most used tools were the hoe, the manual plow, the pitchfork, the rake and the scythe **[15].**

2.2. The Agriculture 2.0: The use of fossil energy (agrochemicals, machinery, fertilizers), and the first-generation genetics and hybridization emerged in the Agriculture 2.0 stageor the British agricultural revolution, in the 1960s, which resulted in a significant productivity increase **[14].** According to **[16].** The biological nitrogen fixation was also an important advance in the second stage of agricultural evolution**. [17]**. The expansion of the use of agricultural machinery also marked Agriculture 2.0 for the most diverse operations such as soil preparation, planting, cultivation, harvesting, threshing, and etc. Thus, combustion engine tractors have gained worldwide prominence for their versatility, as they can be coupled to the most diverse implements, such as the plow, planter, cultivator, harvester, among others **[15].**

2.3. Then, Agriculture 3.0, which stretched from the end of the twentieth century to the beginning of the twenty first century, were essentially recognized by the development of knowledge in all areas, such as biology and various engineering disciplines. The convergence between digitalization and knowledge was the basis for the development of productive strategies that effectively combined the demands for higher productivity, efficiency, and sustainability **[14].** Agricultural machinery gains a new innovation at this stage, as it is equipped with a hydraulic system by which the operator performs heavy tasks, such as displacing large volumes and and blowing the seeds' straw **[15].** Agriculture 3.0 had a particular focus on the balance between high agricultural productivity and better environmental performance. The bio economy and sustainable development emerged in this stage **[14].**

2.4. Agriculture 4.0 or digital agriculture, Promising digital tools exist not only for farmers in industrialized countries but also for farmers, including smallholders, in developing countries.

This is especially true for digital tools like applications and digital platforms that run on smartphones that are not integrated with agricultural machinery **[18].** Given its transformational potential, digital agriculture is not without its share of worries. Digital gaps between urban and rural locations, large and small farms, male and female farmers in industrialized and developing nations are all raised as concerns by critics. **e.g., [19].**Digitalization as transformative force in agricultural production systems, value chains and food systems Digitalization, In the agricultural sector, Different types of digitalization in agricultural production systems, value chains, and more broadly food systems are expressed by a number of ideas. These include Decision Agriculture **[20].** Smart Farming **[21][22],** Precision Agriculture or Precision Farming **[23][24].**and Digital Agriculture. **[12][25].**Agriculture 4.0 **[26]** or what is referred to in French as Agriculture Numérique i.e. Numerical Agriculture **[27].**

Digitalization comprises technologies such as big data, internet of things (IoT),augmented reality, robotics, sensors, 3D printing, system integration, ubiquitous connectivity, artificial intelligence, machine learning, digital twins, and block chain among others **[28][29][30].** Digitalization is anticipated to significantly alter daily life **[31].** Agricultural production processes, and related food, fiber, and bioenergy supply chains and systems **[29].**

3.Applications of digital agriculture technologies

Digital Agriculture paradigm occurs five core technologies covering sensors and robotics, Internet of Things, cloud computing, data analytics, decision support system. Figure1 shows core technologies and connections among them. **[32].**

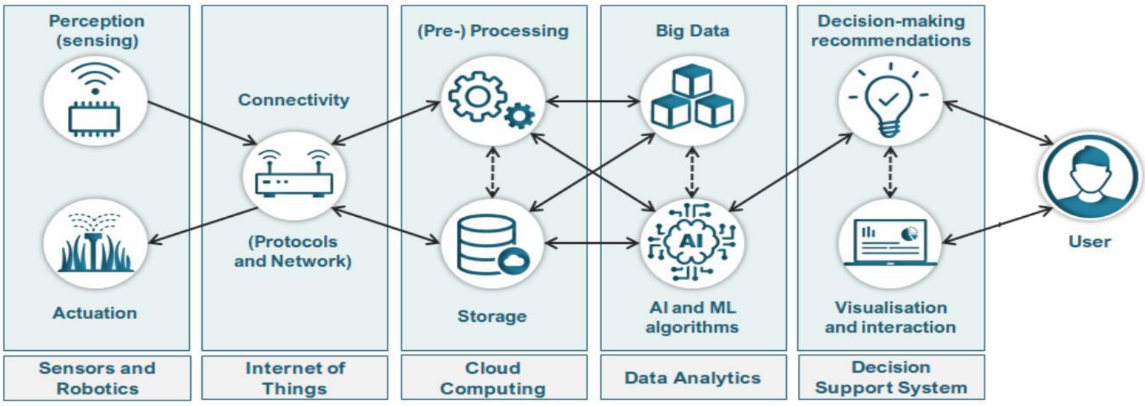

Figure 1: Digital Agriculture core technologies and connections [33].

3.1. REMOTE SENSING: A variety of remote sensing technologies, from proximal sensors (within 1 m distance from the monitoring object), to drones, to satellites are used by the agricultural sector, providing insight to tackle the uncertainties coming from the variations of weather conditions and management strategies **[2].**

3.2. ROBOTIC SYSTEMS TO AUTOMATE MONOTONOUS FARM OPERATIONS

Robotic systems have found fertile ground in agriculture tasks, due to the progress of ICT technologies, mainly advanced sensing, actuation, and AI. The increasing demand for accurate field operations, while reducing the farming inputs and environmental impact, constitute robotic platforms as the alternative of conventional tractors and implements. **[2].**

Agricultural robots can be used for crop monitoring and plant phenotyping, yield estimation, soil sampling, smart irrigation, smart spraying, dairy milking, sorting tasks, disease detection, weed and pest control, planting, harvesting, environmental monitoring and pruning. Robots called UAVs and UGVs are employed in agriculture both on land and in the air.

3.3. Drones : A number of researchers have reported the application areas of drones in supervision or precision agriculture, crop monitoring, harvest prediction or estimation and optimization, yield forecast and management, vegetable indices extraction, and variable rate prescriptions in agriculture **[34][35][36].** The application of drones in crop spraying or sprinkling (fertilizers, pesticides, herbicides), **[37].**
Over the past few years, drone-based imaging in Pennsylvania has developed quickly. Current drone imaging favor's usage of smaller farms where satellite imagery is not cost effective. With the improvements in satellite technology described above, however, drone-based imaging may be limited to certain conditions such as heavy cloud cover or difficult terrain. With regards to precision spraying, however, drones may prove to be a significant advantage as payload capacity continues to increase. **[23].**

3.4. The Internet of Things (IoT) Internet of Things
Refers to the system of intelligent, networked items and services that can detect or even hear demands. The Internet of Things (IoT) is a collection of endpoints that can all be uniquely identified and that use automated connectivity to exchange messages back and forth via a network.. The IoT enables based on networked sensors to remotely connect, track and manage products, systems, and grids. **[32],** many businesses may ponder their actions as a result of smart and linked devices. According to **[38].**

3.5. Cloud computing: includes the use of tools and applications such as data storage, servers, databases, and software based on a network of remote servers through the Internet. Cloud computing services enable users to store files and applications in a virtual place or the cloud and access all the data via the Internet. Public cloud services are available on public networks and open to a widely unlimited cosmos of potential users, designed for a market, not a single enterprise. **[32].**
A technique known as cloud computing, also referred to as "the cloud," was introduced in the early to mid-2000s **[39]** to supply hardware, software, and storage computer resources as a service across a private or public network like the Internet. In particular, cloud computing combines an ideal system, capable of dispersing on-demand computing services to the end users by fusing highly powerful computing, storage, and network technologies with regard to load balancing and re-utilization **[39][40].**

3.6. Big Data
is one of the pillars of digital agriculture, as it enables the practical collection, analysis, and dissemination of data; thus, producers can increase productivity at rates never observed since the mechanization process **[41].**Big Data is a term describing the continuous increase in data, and the technologies needed to collect, store, manage and analyze it. It is a complicated and multifaceted problem that affects technology, business operations, and people. Big Data is usually characterized by "four Vs ": Volume (size of the data sets), Velocity (high speed of data processing), Variety (different types and sources of data used), and Veracity (high quality of analyzed data), **[32].**
Farmers can monitor all production parameters of current activities using big data, which enhances decision-making **[42].** The Big Data are being used in intelligence agriculture, remote sensing, crop yield prediction and crop selection **[43][44].**

3.7. Artificial Intelligence (AI) and Machine Learning (ML)
Agriculture has a variety of difficulties since it is characterized by uncertainty in many processes, including seed planting, pesticide control, weed management, crop disease infestations, lack of irrigation and drainage systems, or even poor storage management. Artificial Intelligence (AI) and Machine Learning (ML) techniques offer intelligent software applications and systems that are capable of performing knowledge work operations involving subtle judgments and unstructured commands, enabling efficient risk management, reducing prediction costs on decision making, and ultimately improving agricultural accuracy and increasing productivity **[45].**
(AI) is a term used to define machines achieving human-like cognitive functions such as learning, understanding, reasoning, or interacting. It consists of many cognitive processes and methods for

comprehending meaning (such as speech recognition and natural language processing) as well as human interaction. (E.g., signal sensing, smart control, simulators). In terms of its technology base AI is a very heterogeneous field. While some aspects like sensors, robots as well as certain applications like autonomous driving, logistics, or medical instruments refer to hardware components, a relevant part of AI is rooted in algorithms and software **[32].**

3.7. Blockchain is a distributed, digital, immutable ledger that makes it easier to track assets and record transactions in a corporate network. Shared ledgers technology allows new transactions to be added to an existing chain of transactions using a secure, digital or cryptographic signature. Assets can be tangible (house, car, cash, and land) or intangible (intellectual property, patents, copyrights, and brand. Blockchain protocols collect, verify, and transmit transactions over the network of blockchains. On a Blockchain network, almost item of value may be recorded and exchanged, lowering risk and all business expenses. Blockchain is excellent for presenting information because it offers instantaneous, shareable, and fully transparent data that is kept in an immutable ledger and accessible to authorized network users only. Orders, payments, accounts, production, and many other things may all be tracked via a blockchain network. As members share a single view of the truth, all the details of a transaction can be seen from start to finish; thus, creating new efficiencies and opportunities as well as greater confidence. **[32].**Blockchain technology has been mainly applied in food and agricultural traceability, smart contract and crop insurance, food trade, land governance and registries, financial services in agriculture, transport and agro-logistics, and agricultural supply chain supervision and management (informative) **[46][47][48].** In addition, blockchain has been applied to waste reduction, environmental awareness, and food safety **[49][37].**

3.8. Industrial Biotechnology is the application domain of biotechnology for the industry in the production and processing of chemicals, materials, and fuels. This technology involves the practices related to using microorganisms or enzymes to generate industrially useful products in a more efficient way (e.g. less energy use, or fewer by-products) without conventional petrochemical processes.

3.9. Nanotechnology is an umbrella term that covers from the design to structural application and production, to devices, and systems by controlling shape and size at a nanometer scale. Nanotechnology has revolutionary the potential for the development of smart Nano and micro-devices and systems in fields such as agriculture, healthcare, energy, environment, and manufacturing. Nanotechnology use in agriculture allows smart solutions for nutrients, pesticides, and genetic materials for improved soil fertility and soil protection, thanks to better stress tolerance. Nano-based sensors can be used for monitoring whole factors that affect productivity in smart farming. Moreover, nanotechnology can be used in post-harvest food processing and packaging to reduce food contamination and waste.

3.10. Photonics is a multidisciplinary field related to light including energy generation, detection, and process management, devices such as electronic components, and photodiodes, lasers, and LEDs. It allows the technological basis for the economic conversion of sunlight to electricity for solar-powered systems.

3.11. Satellite tech for agriculture

Among PA technologies, satellite technology has made major advancements for imaging applications.For example, remote sensing (RS) is used successfully to detect variability in soil and crop conditions and to match inputs such as water, seed, and fertilizer via variable rate technology. Currently, satellite-imaging technology is more suitable for large areas due to its cost effectiveness in comparison to drone-based imaging. However, with a number of high-precision satellite launches being planned, that precision capabilities will improve significantly to enable usage for medium-sized and small fields **[32].**

4. Taxonomy of Digitalization Impacts:

4.1. Economy impact

The global economy depends heavily on the agricultural sector. Pressure on the agricultural system will increase with the continuing expansion of the human population**[1].**however the agricultural nexus planning combined with digital technologies can be used to solve challenges related to water, energy, and food including the environment **[32].**In Europe, the European Commission set out as one of its objectives "fully connecting farmers and the countryside to the digital economy" in order to achieve a smarter, modern and sustainable future of food and farming**[32].**Agri-technology and precision farming, now also termed digital agriculture, have arisen as new scientific fields that use data intense approaches to drive agricultural productivity while minimizing its environmental impact**[50].**For instance, it is simple to imagine a scenario in which Apple eventually owns and controls almost all of the technological data platforms, tools, and resources available to agricultural producers in North America. As a result, some farmers may be "freed" to access and utilize their data in their interests by using open source or non-proprietary data and code. (e.g., to fix or modify their farm equipment**[51].** although stated that politicians and experts assume that smart farming technologies have a strong potential to improve the economic performance of farmers and that they will contribute to more sustainable agriculture**[37],**it is important for international research stakeholders to strategically reflect on and anticipate the potential implications of their work beyond the immediately obvious outcomes of increasing the economic competitiveness of export orientated agricultural production systems. Technological developments are already intermediating network interaction, for example, farmers utilizing WhatsApp group messaging or twitter hashtags **[2].**

4.2. Digital agriculture social systems conceptualizations:

By now, the meaning of term digital agriculture has expanded somewhat and has begun to include not only the technological component, but also the social, cultural and anthropological **[32].**

As a new technological revolution in agriculture is being backed by global policymakers. Critics claim that social ramifications are being neglected even while smart technologies like artificial intelligence, robotics, and the internet of things may be crucial in achieving more productivity and higher eco-efficiency. According to research, certain agricultural professionals are hesitant to use specific smart technology [2].

There is also scope for this methodological innovation, moving from an analogue social science to digital social science or social data science, because as **[52],** social science research in conjunction with natural or technical sciences can help to guide the development of digital agriculture in ways that consider and respond to social dynamics technologies **[53].**

The role of the digital sublime in supporting unsustainable socio-technical regimes Technological fetishism; that is, awarding special attributes to physical or virtual human creations, is not particularly new **[54],** noted how many of us and our institutions mystify technology in our day-to-day activities or in scholarly research at the turn of the century. The author claims that humans occasionally engage in a form of technical reductionism in which we link certain outcomes to specific gear, particularly hardware like computers or phones. **[54].**

Research has revealed that technology affects agricultural society on a variety of levels, both within farms and between farming and non-farming populations. **[24].**

Ignoring the very social relations that are necessary for technology to have any effect. Nevertheless, even if this causality is spurious, What Harvey called mentalities or ways of thinking associated with technologies still influence the way we ask questions and provide answers to problems like climate change. That is, it is not the technologies in themselves that determine certain effects. Rather, it is the social relations and assumptions that are embedded with those technologies that play an important role in structuring our thinking and actions **[54].**

Embedding innovation and technology acceptance frameworks to enhance discussion about social factors In order to present more meaningful findings and recommendations, researchers need to go beyond basic demographic data such as age and sex, to capture details about educational attainment, marriage status, and access to resources, including networks **[51].**Many companies are recognizing the benefit of social and human support, even if it adds to their costs. African digital data collection and services company Esoko introduced personalized calls to customers in an effort to build trust. This changed its business model, transitioning from being delivery-focused to service-focused. Importantly, overlapping social factors such as education, socioeconomic status, race, class and gender, can create interdependent systems of discrimination and disadvantage which reinforce the exclusion of some groups—particularly, but not only, women—from the benefits of digital technology and services. The ability to look at social factors as a system is essential to fostering greater understanding of use of Digitally-Enabled Agricultural Services and avoid tendencies to assign certain characteristics to everyone who may be classified into a particular category, such as elderly, youth or women **[55].**

On the other hand, several studies suggest that women's groups and social networks can help turn this around. Women tend to have stronger ties to their social networks than men, and these networks deliver important information channels that can significantly help in learning and using new technologies and farming practices **[56].**A study conducted in Northern Tanzania that examined the social networks and relationships amongst female rural agro-entrepreneurs suggests that the network improved sharing of market information, which had a positive impact on the sustainability and scalability of their enterprises. The study of 200 women in 20 villages found that many formed women's groups around the new techniques they learned through farmer-to-farmer videos, as well as collectives to gain access to credit, training on how to appeal to more buyers, and even to negotiate higher prices in the market for their rice **[57].**

Social science researchers have recently started investigating different aspects of digital agriculture in relation to farm production systems, value chains and food systems. This has resulted in a growing yet dispersed amount of social science literature. There is hence lack of overview of how this field of study is developing, and what are established, emerging, and new topics on precision farming, digital agriculture, smart farming or agriculture 4.0 **[53].**

In addition, for understanding the use of mobile phones to aid in development requires an adequate knowledge of the current uses and perceived impacts of mobile phones, as well as an assessment of the opportunities and barriers reinforced by the local social structure. Interviews were conducted on 90 mobile phone owners who are holders of small to medium sized among the interviewees were 50 women and 40 men whom are actively involved in the district's farm groupings depending on agricultural development. Results of the interview showed that respondents indicated the use of mobile phones for coordinating access to market information, agricultural inputs, monitoring financial transactions, and consulting with agricultural experts **[58][59].**

Four other prospective new theme social science clusters are also found, however they now appear underdeveloped:

4.2.1. Digital agriculture socio-cyber-physical-ecological systems conceptualizations;

4.2.2. Digital agriculture policy processes;

4.2.3. Digitally enabled agricultural transition pathways; and

4.2.4. Global geography of digital agriculture development.

The scope for future interdisciplinary and transdisciplinary research on precision agriculture, digital agriculture, smart agriculture, and agriculture 4.0 is greatly expanded by this future research agenda.

The adoption of decision support tools, according to **[26],** would alter or "re-script" how farmers interacted with their land. (See also **Higgins et al., 2017)** on how technology "orders" agricultural society). Other studies have looked at the impacts of robotic milking technologies on-farm **[60][61][62][63].** Robotic technology, according to **[61],** may alter what it means to be a "good" farmer. Farming will become less "hands-on" as a result of the introduction of technologies to assist livestock management, which could alter the nature of stockmanship and the dynamics between animals and farmers **[61][63].** According to **[60],** these technologies may alter how people think about what it means to be a farmer or advisor in rural areas. Negative effects on the farm also have an impact on imaginations at larger scales. [26], found evidence that the requirement to use emergent technologies are mismatched with the exp of farmers about what farming is. [**64]** Suggested that the focus on big data could further transfer decision-making authority from farmers to private corporations with access to such data (see also **[65].** The usage of emerging technology may not align with social expectations of sustainable food production in terms of broader effects on society. If the opinions of the public are not sufficiently taken into account during this technological revolution, it is likely that comparable disputes may arise using GM and other emerging technologies as analogs **[66].**

This gap might be linked to an absence of studies that used technology acceptance models and innovation diffusion models, or other similar frameworks, in their study design. The application of these models enables researchers to qualitatively describe the intent to use, use behaviors, and even design challenges faced by the communities with whom they work. An evaluation of available frameworks, what they mean, and how they work to promote data collection of social factors, could encourage greater uptake in research. **[37].**

4.3.1. Digital education for digital skills

The ability to operate digital devices and use them to find, share and create information for everyday problems can be a big barrier to effective digital agriculture system implementation farmer's education level has a significant positive influence on the use of agricultural technologies **[67].**However, while researchers cite challenges of digital literacy, many farmers cite that services do not offer a compelling value proposition. We found that a lack of knowledge or digital literacy skills is not the main reason to preclude use; some studies suggest potential users will become motivated to learn how to use the service once they deem it sufficiently beneficial to be worth the effort. In addition, many users find ways to overcome barriers when services are worthwhile. For example, pastoralists in Ethiopia found user-driven digital services so useful to their grazing operations that they travelled to elevated areas to make calls and placed mobile phones on high objects in their homes to pick up better reception **[68].**

Estimates that globally, as much as 49 percent of current work hours could be technically automated according to existing technologies. Consequently, available estimates have proved that the growing demand for e-skills is a core trend in the labor market, and the agriculture labor market is no exception. That is why most of the contemporary occupations in agriculture are connected with developed ICT skills. Modern education technology makes it simpler to learn new ICT knowledge and abilities. These new learning opportunities are key aspects of lifelong learning by providing modularized approaches to education and for acquiring the multidisciplinary knowledge that new job opportunities will require. **[32].**

4.3.2. Digital education for inclusion?

It is common to hear that using digital education is a desirable strategy to reach more people more quickly and inclusively. Those who cannot physically access education can benefit from digital learning (e.g. learners in hospitals, prisons, remote areas) or who need flexibility in their attendance (e.g. those who study outside work hours). The current refugee and Ebola crises provide examples of the ways in which digital methods are a major delivery channel and can facilitate inclusion for large groups **[69].**

Digital skills will increasingly be needed for the jobs of the future

These new learning opportunities are for acquiring the multidisciplinary knowledge that new job opportunities will require. Regulated training programs should be flexible enough to take advantage of these new learning schemes; also, the development of multidisciplinary skills should be fostered. Infusing the curricula with digital learning from the earliest stages of formalized schooling throughout higher education also is key to address the digital divide.

Looking to the future, some estimate that as many as 65 per cent of children in primary school will have jobs which do not exist today **[70][71].**

Although traditional training continues to play an important role in the acquisition of new skills, the complementary role of self-directed learning in the acquisition of digital skills is also becoming increasingly important: for European workers aged 16-29. Approximately 72% of employees say they have acquired ICT skills through independent learning in practice, according to the latest Eurostat data. Similarly, nearly 40 percent of respondents in the 2015 Harvard Business Review said self-study was the preferred method of learning about new digital technology (Harvard Business Review, 2015). So, in 2015 about 32 percent of European Internet users aged from 16 to 74 have used online resources to obtain information about education, training, or course offers and this figure increased by 13 percentage from 2007 (19%) to 2015 (32%). **[72].** this data can confirm the increasing role and importance of digital education and life-long learning.

This access to technologies not only implies having access to infrastructure and hardware, but also having the right skills to exploit the benefits and avoid the pitfalls of this new way of living.

The Children and Parents: Media Use and Attitudes Report (2014) by Ofcom emphasizes how common digital use is among UK children aged 5 to 15 years old • Close to nine out of every ten children (88 per cent) have access to the Internet at home. • Seven in ten people (71%) use a tablet at home.

• Four in ten (41 per cent) have a mobile phone, and of these, 31 per cent have a smartphone. • Close to nine in ten (87 per cent) go online using any device; while laptops are still the most common way of using the Internet (66 per cent), tablets and smartphones are becoming more and more popular **[73].**

The ability to operate digital devices and use them to find, share and create information for everyday problems can be a big barrier to effective digital agriculture system implementation A farmer's education level has a significant positive influence on the use of agricultural technologies **[67].**However, while researchers cite challenges of digital literacy, many farmers cite that services do not offer a compelling value proposition. We found that a lack of knowledge or digital literacy skills is not the main reason to preclude use; some studies suggest potential users will become motivated to learn how to use the service once they deem it sufficiently beneficial to be worth the effort. And many users find ways to overcome barriers when services are worthwhile. For example, pastoralists in Ethiopia found user-driven digital services so useful to their grazing operations that they travelled to elevated areas to make calls and placed mobile phones on high objects in their homes to pick up better reception **[68].**

Estimates that globally, as much as 49 percent of current work hours could be technically automated according to existing technologies. Consequently, available estimates have proved that the growing demand for e-skills is a core trend in the labor market, and the agriculture labor market is no exception. That is why most of the contemporary occupations in agriculture are connected with developed ICT skills. Nowadays digital education makes it easier to acquire new knowledge and skills in ICT. These new learning opportunities are key aspects of lifelong learning by providing modularized approaches to education and for acquiring the multidisciplinary knowledge that new job opportunities will require. **[32].**

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Looking to the future, some estimate that as many as 65 per cent of children in primary school will have jobs which do not exist today **[70][71].**

Digital technology alone can provide an opportunity to transform education as games become more available in education. **[32].**However, Radio is still a relevant and popular technology, more formal learning is also possible over radio. The School on Air (SOA) **[75],** programme in the Philippines provides courses on crop production and natural resource management. At the end of each lesson, farmer-students submit their answers to a village SOA facilitator to demonstrate the practical skills they have learned. Certificates are issued to those who complete the sessions and practicum. An assessment showed that the students acquired knowledge, skills and self-confidence that contributed to improved farming and livelihood practices. Recommended investment areas include building a holistic strategy to address and strengthen human capital for participation in the digital ecosystem; improving technical education **[50].**

The increasing use of technology and the growth in connectivity is also disrupting the labor market of today and will continue to do so in the future – a phenomenon labelled the 'digitalization of work'. Gartner predicts one in three jobs will be converted to software, robots and smart machines by 2025 **[76].** This change, combined with the use of technology in our personal lives, requires the upskilling of the current workforce and wider population to adapt to an increasingly digital world and to lessen the chance that this transformation will result in the emergence of a new level of social isolation **[73].**

5. Challenge

In our opinion, the possible risks of the introduction of digitization in the agricultural sector will not stop its rapid progress, since the most important result for businesses is the growth of profits. That is why it is important at the present stage to develop various programs at different levels to minimize the negative effects of agricultural digitization and sustainable agricultural development in general **[77].**

It is undeniable that smart farming technology may contribute significantly to the sustainable production of food, yet the need for a technical revolution would be lessened if other societal improvements were made. Two Greater food and income security and environmental benefits could result from increased productivity because less land would need to be used for farming. To promote evidence-based decision-making, precision agriculture is used in conjunction with more productive crop and livestock varieties and decision support tools see **[78] [51],** believe that the agricultural industry is undergoing a digital revolution that will increase productivity and efficiency while lowering resource use. The creation of a high-/low-skill fork in the labor market and challenges with data control are some of the important societal issues that are simultaneously brought up by this. Other issues include growing land and automation costs. Using a responsible innovation framework that takes into account the ethical and social aspects of decision-making, primarily with regard to big data, **[79],** expanded on these worries. He recommended a responsible digital transition **[80].**

In general, expressing concern that the social and ethical implications of adopting such technologies have not received adequate consideration in the design and implementation processes [6, 13].Further, Due to ethical considerations associated with the use of such technology, these new technologies have the potential to cause more problems than they solve without a thorough knowledge of how agriculture 4.0 will effect populations, especially in lower-income nations. Therefore, in order to ensure that the advantages of this suite of technologies are not simply optimized for production and efficiency, it is necessary for policymakers and technology companies to collaborate with farmers and communities more generally. but that both environmental and social impacts are addressed explicitly.There is an alternative drive to promote agroecology principles that encompass both social and natural sciences that underscore systems philosophy and ecological thinking **[81]** This is supported by data showing that agroecological methods boost yields in a cost-effective and sustainable manner **[82][83].** Although agroecology principles have demonstrated significant promise for... sustained yield enhancement, this strategy is probably insufficient to meet the increasing population's demand for food.. Therefore it is imperative to identify and adopt suitable technologies that are context-specific and in line with current realities **[84]**

6. Conclusion:

This review has provided an overview of thematic clusters of: 1) digital agriculture social systems conceptualizations; 2) how the economic characteristics of new digital technologies may impact dynamic across agro-sector ;and 3) Education: Digital technology's role in enabling skills, The diversity of thematic presented in this article shows that there are many possible lines of enquiry across and between different social science and economic and technical science disciplines. As digital agriculture progresses past the prototype stage, . However, digital transformation in any sector can greatly contribute to increasing productivity, rationalizing and reducing financial burdens, increasing profitability and better knowledge of market needs according to consumption pattern, which contributes to increasing export opportunities, reducing local supply, increasing national income and farmers' income. This digital transformation includes the complete food system from Agriculture, animal husbandry and its derivatives. In addition, ICTs, technologies and digital services in agriculture are critical to increasing productivity and incomes on farms and along the food chain. He pointed out that more efforts should be made to support the connection of smallholders to the Internet, and to benefit from the advisory and extension e-agriculture solutions. Long-term support should be provided to farmers and digital entrepreneurs to develop and implement digital solutions in agriculture. Our study found that there were concerns raised about digital innovations to ensure that these technologies will result in positive social benefits to farmers' particularly small farmers, and deep engagement with critical social scientists. Whether digital or not an educational/training sector that recognizes the nuances of digital agriculture (the good, the bad, and the ugly) and challenges, is what is required to guarantee the creation of a fair and sustainable food system.. Education plays a critical role in achieving digital, social and labor market inclusion. However, does education today prepare young people for the jobs of tomorrow using the tools of yesterday?

While we have shown the diversity of social science perspectives employed so far, and their complementarity, we believe there is more scope for interdisciplinary as well as transdisciplinary work. The literature review performed in this work has unveiled that existing studies concerning digitalization in agriculture and rural areas do not provide an overall picture, thereby showing this is a burgeoning field that provides important insights for the practice of digital agriculture. Being an exploratory review, while summarizing earlier strands of work, this article has not systemically analyzed, compared, and synthesized the evidence in the different thematic clusters on digital agriculture. Future research should adopt a systematic review methodology in light of this.

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