agronomy

MDPI

Review

Can the Adoption of ICT and Advisory Services Be Considered as a Tool of Competitive Advantage in Agricultural Holdings? A Literature Review

Georgios Kountios [1,*], Christos Konstantinidis [2] and Ioannis Antoniadis [3]

[1] Department of Agricultural Economics and Entrepreneurship, School of Agriculture, International Hellenic University, Sindos, 57400 Thessaloniki, Greece
[2] Department of Management, School of Business Administrator, International Hellenic University, End of Magnesias Street, 62100 Serres, Greece
[3] Department of Management Science and Technology, School of Economic Sciences, University of Western Macedonia, Koila, 50100 Kozani, Greece
* Correspondence: gkountios@agro.ihu.gr

Abstract: Knowledge of better farming methods has been a crucial step upon which agriculture has grown over time. Knowledge, on the other hand, is a currency transferred from one person to another with the vision to improve the quality of life of the other person. Agricultural knowledge has been transferred from one generation to the next based on the experience of one society and whatever knowledge they have developed in their existence. This shows that possession of a better and deeper understanding of agricultural processes and strategies is vital in developing the agricultural sector within a particular society. Therefore, better ways of acquiring agricultural knowledge together with improved methods of transmission of the same knowledge is primary in the advancement of agriculture within a group of people. In the last years, farming and agriculture have made significant strides in utilizing Information and Communication Technology (ICT), particularly in the realm of growers' reach to market-based knowledge. Information and communication technology is being incorporated in several interventions that aim to properly educate producers about agriculture. In this context, ICT also helps them hold a competitive advantage in the process. This article addresses numerous cutting-edge initiatives that use Information and communication technology's purpose of providing agricultural knowledge to farmers. Its assessment focuses primarily on answering the question of the intensity of change brought about by ICT and advisory services in agriculture. This focus enables this review to give a clear and conclusive view of how the two factors are creating a competitive advantage amongst different farmer groups and localities.

Keywords: knowledge; agriculture; advisors; ICTs; sustainability; competitive advantage

Citation: Kountios, G.; Konstantinidis, C.; Antoniadis, I. Can the Adoption of ICT and Advisory Services Be Considered as a Tool of Competitive Advantage in Agricultural Holdings? A Literature Review. *Agronomy* **2023**, *13*, 530. https://doi.org/10.3390/agronomy13020530

Academic Editor: Valerio Cristofori

Received: 31 December 2022
Revised: 6 February 2023
Accepted: 10 February 2023
Published: 12 February 2023

1. Introduction

ICT has a significant impact on the growth of agriculture. It can be used in almost every aspect of agricultural production and farm management, and it has the potential to revolutionize marketing, display information, and, most significantly, the exchange of data and expertise inside the industry of agriculture. At every point in the value chain, farmers acquire physical inputs. However, they also require knowledge, which may be obtained more efficiently or effectively through ICT advancement. This dictates that the various agricultural branches and activities can benefit from ICTs' transformative potential, which develops a competitive advantage altogether [1].

Therefore, new and effective digital production methods such as machine influence in planting, weeding, and harvesting are easily shared amongst farmers leading to increased productivity, better utilization of available factors of production, and more significant profit margins [2]. Effective flow of agricultural knowledge educates farmers on using chemicals

more wisely. In return, it reduces environmental residues, quickly and effectively treating plant and animal illnesses. Digital techniques and instruments from ICT advancement may further improve agriculture viability.

There is still a lack of solid proof regarding the alleged advantages of introducing ICTs in the agriculture sector, even though studies have acknowledged the potential of ICTs for increasing efficiency in preproduction in natural resource management and even though some of research activities have been successful in measuring such impacts [3].

ICT adoption hurdles in the most agricultural-underdeveloped areas must be removed to rotate environmental sustainability and reverse trends of uneven growth in the region's agriculture. One method to achieve this objective is to locate effective programs and policies in nearby nations. It can also extend to other continents with comparable economic and social variety patterns. Thereafter, the countries noted can be nurtured with the aim to adapt them to the region's member states. This review paper aims to identify successful and published agricultural trials carried out to encourage the application of ICTs in farming.

The definition of "success" is based on the opportunities for widespread adoption of ICT by farmers, sharing of the agricultural knowledge acquired from one farmer to another, longevity, and the capacity to improve economic and social participation, the sector's environmental footprint, or both [4]. For that reason, this review holds particular importance and fills the existing gap in the literature as it examines the role of ICT as an agricultural breakthrough for effective information flow through relevant stakeholders and innovative capacity established by ICT in agriculture [5]. In a general overview, ICT in agriculture also helps policymakers, academic researchers, and managers make relevant decisions [6].

The lack of a coherent agricultural policy and strategy in agriculture, despite multiple attempts by policymakers over the last few decades, prevents it from evolving and ensuring conformity with the EU Agricultural Policy (EU CAP) [7,8]. In rural areas, achieving more sustainable agriculture is particularly challenging [9]. A significant factor behind sustainable agriculture is creativity. The digitization of agriculture must, therefore, be a primary concern for all parties involved in the global digitalization of society, as demonstrated by several others. It is a fact that they substantially affect the evolution of society and the economy. Information and communication technology (ICTs) serve as the foundation of economic growth [10].

One technique to boost agricultural output with high technology is precision agriculture [11], which aims to improve harvests, monitor soil conditions, and use less energy while also focusing on cultural factors. Progress in agricultural and developing rural areas can be anticipated without consulting the government service, which is set up in a contemporary manner. The main goal of such a well-organized public service in agriculture is to facilitate the knowledge transfer process [12,13]. The agricultural advisory service's duties are measures that help the organization reach its objectives. These initiatives are concentrated on occupations that enhance many aspects of agricultural production, including fruit and wine production, crop yields, animal production, plant health, automation, and farmland quality.

This systematic review sets to investigate the incorporation of ICT into agriculture as a move to improve the precision level in agriculture as well as set automated systems for effective and efficient agricultural practices. ICT by itself is seen to be crucial, enabling effectiveness in maintaining sustainable agricultural information flow from agriculture researchers to farmers. The promptness of advanced communication systems in ICT act as beneficial factors in communication management sustainability.

One of the main findings is the emerging need for future research agenda on digital agriculture, smart farming, and agriculture 4.0, along with the lack of bibliometric studies that do not fully exploit the complementarity of different modern bibliometric tools regarding the agriculture 4.0 thematic field [14,15].

It was also noted that agriculture 4.0 can, indeed, absolve the role of the enabler in sustainability agri-food, providing to the company a set of data and technological

sustainable oriented innovations. The question, though, about how specifically agriculture 4.0 can support a better supply chain decision-making process, or how it can help to save time for farmer to make effective decisions based on objective data still remains [16,17].

This review explores the topic of smart farming with the aim of exposing the benefits reaped from this kind of farming. The report further explores the comparison of ICT agriculture and traditional types of agricultural services. This investigation is decentralized other than localized. The review considers agriculture in European countries, American agricultural practices, and a few African countries together with some of Asian countries. The main objective, however, is the beneficial aspect of ICT in agriculture through creation of effective and efficient communication channels used to sustain the flow of agricultural knowledge from the intellectual problem researchers to practitioners. Therefore, ICT is scrutinized as the bridging factor that smoothens communication in the agricultural sector, hence enabling growth in knowledgeable farming practices as well as through another crucial agricultural knowledge.

This study is also resourceful in trying to establish the current state of ICT synchronization with agriculture. This discovery also touches on the expected levels of ICT involvement in agriculture in future time. This acts as the gauge upon which the utility of ICT is analyzed when incorporated in agriculture. As a result, the dependence of ICT is determined in agricultural practices as well as farmer satisfaction all along.

This study can benefit any agriculture-related practitioner looking to increase the level of automation within their operation. Furthermore, content coverage can be useful in improving sustainability within most agricultural systems. The sustainability discussed can be in the form of better agricultural knowledge sharing, which in turn leads to better farming practices, reducing the amount of wastages through water and soil maintenance in farming and the general maintenance of natural resources that interact directly with agriculture.

In the following sections, a thorough literature review will be presented regarding the role and the adoption of ICTs and the Advisory Services as a form of competitive advantage and the data and methods to perform this systematic review. The paper's main results were presented in Section 4, along with the discussion in Section 5. The body of the article is completed in Section 6, which discusses the proposal for the extension of this work and future research.

2. Theoretical Background

The optimal productivity of farmers is constrained in less developed nations by high costs for transactions and information-sharing limitations. Farmers must have precise and reliable data to make wise decisions in the face of rapid technological development connected to the global climate. If an acceptable reaction to each challenge is desired, the information demands at each step of the cycle of agriculture must be observed. Many studies have started to examine the effect of smartphones on rural and agricultural development since they have become the primary tool for providing advice to farms and increasing their competitiveness [17,18]. Additionally, mobile phones, according to Srinivasan and Burrell, are critical to enhancing relationships between various market participants and streamlining collaboration in the event of adverse situations [19]. Sherman can maximize profits by marketing catches in several marketplaces due to the coastal region's geographic position and vast financing prospects. Research published in 2012 [20] described the implementation of the Agricultural Management System based on smartphone technology in isolated communities. This system was locally marketed as Pallinet [21]. The study examines how information and communication technologies impact underprivileged populations in remote Lesotho. It highlights how expenses, illiteracy, availability, infrastructural facilities, and a shortage of necessary expertise limit the positive impact and possibility of boosting living circumstances in rural areas even though technologies concerning information and socioeconomic issues may be addressed via the interaction of farmers. The supply of data has become a significant objective of most developmental activities since rural areas typically need to be more informed [22]. Due to this, the most critical data and

communication services depend on farmers' capacity to obtain pertinent data for living and livelihood opportunities.

To identify the potential uses for information and communication technologies, several studies have examined the information demands of farmers. For instance, three kinds of statistics that farmers require were discovered by a national survey of Indian farmers: (1) Knowledge that helps them select which crops to grow and which species to select; (2) business data, which includes costs and measures of price; and (3) relevant data, which includes weather patterns and practice guidelines [23]. Various stages of the agricultural life cycle, such as growing crops, planting, developing, reaping, and marketing after acquiring seeds and other supplies, call for using this information [24]. The most critical information farmers value is climate, information on controlling pests and diseases, data on seeds, and commodity prices.

There are instances of initiatives based on interactive approaches. At the same time, the uses of technologies for information and communication in agriculture are centered on using cell devices to convey information. These strategies use the Internet, portable electronics such as portable projectors and TVs, and equipment for producing and distributing agricultural information [25]. This a very informative example of digital green, which facilitates the matching and collaboration of local farmers with agricultural specialists through brief videos with instructions. Videos are captured locally using tiny video cameras and are shown on-site with a micro projection. Interactive Voice Response is used to obtain input from farmers. Farmers who are promptly updated about the market's current condition might seek the cheapest market entrance. With the use of mobile telephone networks, existing information may be quickly received from a variety of traders of commodities via SMS messages, emails, and phone calls. Access to mobile phones can sometimes result in more income. According to a World Bank investigation done in the Philippines, purchasing a mobile phone is linked to higher income, which ranges from 11% to 17% [26]. In this research, they investigated the essential metrics required for the adoption and growth of smart farming ideas in the agriculture industry, particularly from the perspective of applicable digital technology. It was also demonstrated how nations with the highest investment in ICT in the agriculture industry might significantly enhance the value of production. This growth leads to a rise in the agricultural sector's level of production nationally as a proportion of GDP.

The literature review presents the findings of year-long research by the International Telecommunication Union (ITU) and FAO that aimed to address various topics related to current policies and strategies in e-agriculture in Europe, and the Community of Independent Nations was the most valuable source for the authors. It includes national experiences in their ongoing attempts to create and implement a digital agricultural plan [5]. The conceptual framework also continues to draw on assessments of the literature on environmental advancement [27,28], ICT scientific research on agriculture [29], principles of partners' participation in policy-making and development work [30], and ideas for sociocultural collaborations and inter-organizational collaboration [31], among many other easily accessible resources.

Only cutting-edge agricultural technology is featured in this literature/study. Instead of detailing programs encouraging knowledge transfer amongst scholars and educators, it concentrates on activities and initiatives that integrate agricultural training and knowledge for farm owners using information communication technology (ICT). Additionally, it excludes organizations or programs whose exclusive concentration seems to be on creating connections between supply sources, credit companies, or marketplaces using information and communication technologies, as well as the numerous academic activities currently underway that look into the potential agricultural applications of information and communication technologies.

Initiatives leveraging information and communication technology alternatives and putting them into practice, organizations or parties conducting business utilizing ICTs, in addition to global and subnational ICT solution technology companies have been included

in the records. Although several accounts seem to be activities with definite beginnings and ends, others may be statewide or local information systems that use ICTs to offer a wide range of allied activities. Because specific initiatives seem more complicated to classify than others, four classes have been established for the context of this study as a context for holding a competitive advantage:

2.1. Voice Information Delivery Services

For the gains of remote agricultural communities, it also incorporates a voice information exchange provider that gives guidance about agriculture activities, including free trade. Many of those same issues seemed to have solutions online. However, the great majority of landowners are not likely to have access because of network issues, illiteracy issues, or linguistic hurdles. In assistance with agricultural production, many people employ phone centers. Whereas modern telecommunication innovation and data processing systems are already provisioned at the rear launch pad for the delivery of the required resource center, quite complicated speech technologies employ simple voicemail—society remedied device or phone—as the channel of exchanging data.

2.2. Radio-Dial up (Agricultural Information on Demand) and Regular Radio Broadcasts

Traditional radio transmissions offering market forces or even other farming knowledge are included, as are keypad FM stations with this number of short radio segments that give the farming community internet access to detailed data via an autonomous speech system. Broadcasting serves as a central data source with a varied selection of farming programming, which is routinely upgraded. Specific initiatives that meet our innovation criteria were preserved for this study, including letting producers send queries via Text and disseminating data obtained by comprehension coupons or some cutting-edge methods [32].

2.3. IT Application for Traceability

Traditional agri-food logistics pattern can no longer match the needs of the market, so building an agri-food supply chain traceability system is becoming more and more urgent [33]. As a result, ICTs can be used as a primary component of establishing traceability within the agricultural sector [34,35]. Food companies can adopt traceability systems and are able to collect various types of information along the food supply chain, to satisfy regulation but also to make their work transparent [36]. Additionally, although the design of complex systems is an extremely complex and multi-dimensional effort [37], a low-cost and very successful framework for food traceability, for the remote monitoring of air, water, soil parameters, and herbicide contamination during the farming process has been developed and verified in real crop environments. [38]. The increased, on the other side, rates of food poisoning and food growth contamination have raised the need to have a management system that is viable to redraw the food production line. This way, any point of contamination can be traced and acted upon to curb any further health risks coming from the agricultural food production process. Most cases of agricultural food contamination are seen in improper pesticide application, and the use of inorganic methods of farming such as the application of inorganic fertilizers to boost production [39].

2.4. Extension Services Based on Mobile Phone and Database Monitoring

Using this media source, everyone could disseminate domain expertise through portable devices and the web. This platform transforms into a functional element for segmentation, enterprise analytics, or marketing by keeping records of actions and accounts. The solution may drastically reduce potential losses by concentrating on description, providing some financial solutions, and generating income by allowing branding and database mining [40]. The majority of operators up to this point were sponsored initiatives.

2.5. Link with Agriculture 4.0 and Industry 4.0 Paradigms

The Agriculture 4.0 paradigm is viewed as the advancement from precision farming to the use of technology in most farming procedures [41]. The fourth revolution is mainly the removal of intensive labor force from the farms and replacing it with cheaper and more effective technological appliances.

Most farmers are seen to use technology in prime farming activities such as planting, weeding, pruning, harvesting, transportation, and packaging [42]. These insights showcase the intensity at which most farmers have incorporated technology into their daily farming activities. These steps answer the questions of efficiency and sustainability.

First, technology is effective when applied to farms. It is also the use of machines that lacks the human nature to become fatigued, hence, can work at any required time so long as they are well maintained. The nature of this dependency that can be attained by technology enhances efficiency of the same. Secondly, technological application in agriculture through ICT incorporation increases the rates of sustainability in agriculture [43]. Technology, as discussed above, is highly effective in performing all farming practices. Hence, the same technology prevents great losses that can be experienced through traditional farming methods. This is seen in better water maintenance, proper soil maintenance, and maintenance of other natural resources associated with agriculture.

When seen from this point, technology creates a greater chance of establishing sustainability in agriculture.

2.6. E-Learning for Basic Skills, Farming Education, and the Video-Connectivity Approaches

The dissemination of knowledge and instructional materials regarding farming expertise belongs to this group. The particular multimedia strategy seems to have several significant benefits over standard types of farming information that is generally nonexistent in the native languages, are aimed at just an educated listener, use specialist terms, lacks village-level essentials, and continues to stay unreachable in some ocean of dispersed news. This assessment has sixty records and includes four tools in group 1, five for group 2, 16 for group 3, and thirty-five for group 4. Benin (1), Burkina Faso (3), Cameroon (1), Egypt (1), Ethiopia (2), Ghana (6), Kenya (9), Malawi (1), Mali (5), Nigeria (1), Senegal (2), South Africa (1), Tanzania (7), Uganda (9), Zambia (4), Zimbabwe (1), as well as portfolios working in more over three nations [10] are indeed the nations that are depicted.

It also refined the theoretical knowledge of the societal impact of these kinds of activities, including the associated potential economic burden to develop innovative agricultural advice and consultation employing information technology. The corresponding survey reveals that many remote ICT Investment projects and the usage of digital phones in farming require a particular competence for using content and stresses the difficulties of ramping up such activities.

Both for implementation and usage of basic information techniques, it is necessary to have a deeper awareness of the producers' setting to track the effects of remote telecommunication services on the farming industry. Information and communication technologies, plus smallholder businesses, are the subject of numerous efforts throughout the continent. Nevertheless, programs frequently need more coordination. Thus, data about the many projects are not readily available, leaving details on their effects. To ensure that cellphone technological progress for producers is "correct", study and advancement are needed, particularly regarding sustainable livelihood and improving quality of life. While it is acknowledged that the accessibility and operation of the main supply, credit systems, communal land accommodations, agency of sales promotions, equitable sharing of benefits arising, and so forth, could all have a significant impact on the absorption of viable technological advancement, including rural mobile communications, these ideologies had also primarily been viewed as factors that hinder or facilitate the adjustment of remote telephone services.

A farming industry may expand and prosper using intelligent technologies (ICT) effectively. Among nations or industries in which these technologies are effectively utilized,

information and communication technology have contributed significantly to economic expansion and social progress, as reported by the Organization for Food and Agriculture [4]. Both efficiency and effectiveness of the agricultural value chain have significantly risen due to the incorporation of technology in the farming industries of nations in America and Europe. For example, by monitoring and analyzing foods from farm to plate, tracking systems such as blockchain technology or wireless network tagging (RFID) have made the supply chain transparent and efficient. If a food security concern arises, now it is feasible to pinpoint the cause of every occurrence involving food. Nevertheless, Africa has yet to experience this kind of change.

This industry has been transforming recently, spreading numerous smartphone technologies and application services.

According to the Technical Centre for Agricultural and Regional Cooperation's latest digitalization study, around thirty-three million small business farmers already have access to mobile apps, with a predicted estimate of reaching up to 200 million by 2024. Ref. [44] claims that strengthening connections or improving accessibility of exact and up-to-date farming knowledge, information, and communication technology solutions may enhance sheltered lives and boost farm owners in emerging economies. These latest developments in information technology include cutting-edge innovations such as cryptography, machine learning, virtualization, the Internet of Things (IoT), and big data analytics, in addition to revolutionary communications technology such as workstations, radios, tv, and cell devices [45]. Ref. [44] contends that that same transformative action information has had the opportunity to assist throughout the shift to environmentally friendly farming by boosting efficiency, visibility, and predictability. Big data analytics could also be applied to restructure corporate procedures, make real work choices, or deliver actionable intelligence into agricultural production [46–48].

Agricultural production, which uses a broad range of tools including Geolocation (Location services), Geoinformation (Geospatial), computational science, innovative pattern recognition, and applications, has the potential to gather statistics on development variations throughout both time and place [49–51]. Information technology has already received more interest across many emerging economies due to the recognition of technology as little more than a crucial component in upgrading farming [52].

3. Data and Methods

3.1. Methodology

3.1.1. Search Criterion

The articles considered in this systematic review were pre-agreed to cover the last two decades on this topic together with other close associations. Most of databases used to acquire useful informational articles were open source. The databases include Google scholar, SCOPUS database, and other beneficial databases such as Elsevier. Some web articles were also incorporated to supplement the entire information. Relevant past newspaper articles took the role of promoting the article information extracted.

A specific procedure was applied to cover the search and retrieval of relevant articles to be used in this review (Figure 1).

Firstly, the process followed a pattern of specific keywords to enhance the search of quality information articles. The keywords used included "the role of ICT in agriculture," "sustainability in agriculture through ICT advancement," "Importance of ICT in advisory services of agriculture," and "hindrances of ICT in agriculture".

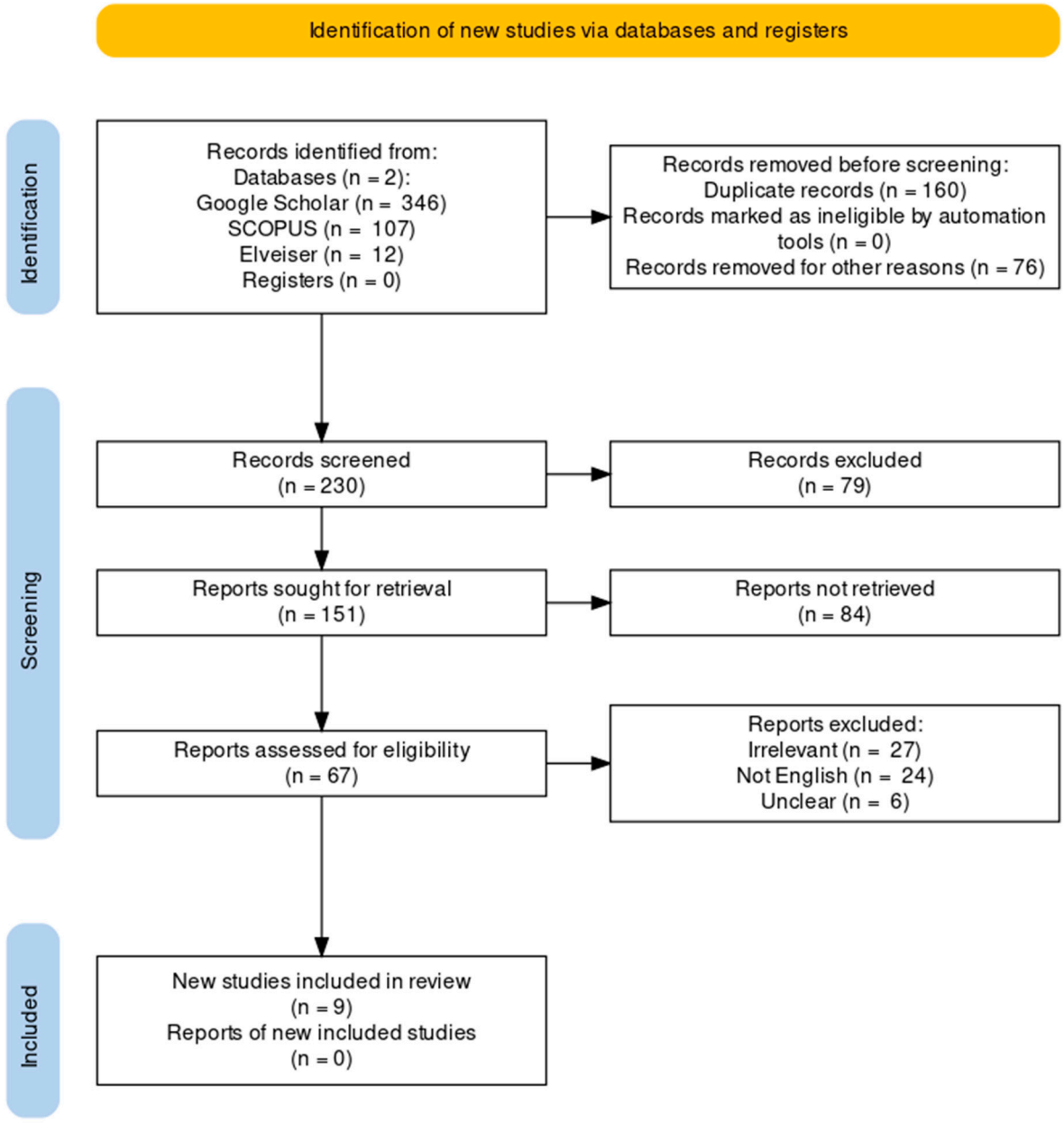

Figure 1. Research methodology flowchart.

3.1.2. Eligibility Criteria

The articles retrieved were potentially screened by the sole researcher behind this systematic review. In addition, criteria for inclusion and one for exclusion were put in place to standardize the quality of the literature considered. The laws binding the criteria are listed below:

- The inclusion criteria
  - The literature should mostly report on European countries but also worldwide
  - The articles should uphold a two-decade period since publication to date
  - The articles should incorporate a transparent methodology and data processing steps
  - The studies should be published in English
  - Studies covering a direct subject matter as the study primary objective of study.
- The exclusion criteria
  - Outdated articles—older than two decades

- Studies concentrating mostly on other countries and territories other than Europe
- Studies lacking proper online naming system as well as incomplete names of all the authors.

3.2. Data Analysis

This review adopted the use of sequential narration as the main method of informational data analysis. This method allows for the denotation of specific literature subtopics, noting down the main information points below the subtopics. The synopsis approach was also included to illuminate the study compositions. The synopsis highlighted the important points from the other chunks of information within specific articles.

The reports used were seen to touch on ICT viability to be joined with agricultural practices for beneficial outcomes. This review revealed the nature of ICT in its attempt to be involved with agriculture. There is a deep scrutiny carried out on the main idea of incorporating ICT in agricultural practices. It stretches to uncover the foreseen beneficial results expected to be reaped from this operation. The systematic review also digs for the current situation of ICT in enhancement of agricultural practices, especially in sustaining the flow of agricultural knowledge from researchers to farmers. There is an additional investigation of multiple levels of information flow and how they are influenced by the availability of ICT technology at its disposal.

4. Results

Below is a table (Table 1) with the main information of papers that have been used for this review (year of publication, types of ICTs used, country/regions where the research was conducted, basic findings, etc.

Table 1. A comprehensive description of the main references.

Article ID	Article Url/DOI	Results Analysis
1. [41]	10.1016/j.ijin.2022.09.004	• Covers the fourth evolution of agriculture (agriculture 4.0) that is associated with usage of digital technologies. • The current agricultural technology that is in operation today has been proven to bring sustainability in agriculture. It is also responsible for innovative procedures that results in effective farming methods. • This step has brought about automation and digitalization in agriculture. • Technological advancement has grown precision agriculture, which is strategic for efficient growth and maintenance of crops. • Daily agricultural operations are resulting in large volumes of data that are difficult to process by human help only. Big data technology, on the other hand, has made it easy. Now every knowledge point is assessed and implemented for better productivity. • Big data technology can specify the environmental conditions necessary to specific crops to help them grow perfectly and productively. • Agriculture 4.0 is associated with yield estimation, market demand assessment, and crop growth sustainability. It is also beneficial for crop monitoring, crop, soil and water maintenance, weather assessment, future prediction of weather, and other agricultural aspects based on data. Moreover, agriculture 4.0 helps in knowledge on irrigation sustainability, pest control, and harvesting together with yield transportation, storage, and distribution.

Table 1. *Cont.*

	Article ID	Article Url/DOI	Results Analysis
2.	[11]	10.1504/ijsami.2022.124577	• Covers good agricultural practices. • Protecting genetic resources and the natural biodiversity, soil, water, and landscape are considered good agricultural practices. • Agricultural consultants (advisory services) are considered as essential role players in spreading knowledge on the importance and benefits of incorporating ICT technologies into agriculture. • The paper also points out the importance of advisory services in educating farmers on precision agriculture. • ICT technology is crowned as the major factor of promoting a wider adoption of good agricultural practices by farmers for sustainability in agriculture as a whole.
3.	[53]	10.3390/environments4030050	• Improved efficiency for agricultural sustainable development. • Advanced farms are able to access electronic knowledge banks. • ICT e-agricultural infrastructure are composed of ICT and blockchain technology for security in safeguarding agricultural environmental data and maintaining its integrity and transparency. • Blockchain technology itself offers a safe channel for agendas, environmental protection organizations, fraudulent scientists, and large publishing institutions. This raises the need to safekeep trusted information data and keep a keen eye on data presentation to standardize its quality and truthfulness. • Environmental monitoring and management is mentioned as essential as well as sharing of any data acquired from these processes. • Blockchain acquires its power from its nature of decentralization, which is different from traditional cloud centralized systems. • Blockchain immutability with agriculture is still a technological milestone. However, results from this paper suggest that the idea is a socially preferred activity, especially when there is a social and technical change from the current systems. • Results prove that it is welcomed technology advancement for environmental and agricultural data monitoring.

Table 1. *Cont.*

Article ID	Article Url/DOI	Results Analysis
4. [32]	10.1177/02666669211064847	• Small scale farmers produce between 60–80% of food produced in Sub-Saharan Africa. • The productivity of these small scale farmers is mostly infested with multiple challenges that cut down their productivity levels. • Most challenges noted include poor decision making and late response to opportunities as a result of a general lateness in accessing agricultural information. • Recent introduction of ICT technologies in the area has increased their chances of accessing essential agriculture information and services. • Knowledgeable farmers that are emerging from the area are responsible for transformation of the productivity levels in this area. • Better productivity from the farmers has led to improved farmer lifestyles in the area. • The current situation of usage of mobile phone devices has increased favorably, presenting analog and smart device usage within the most used mobile applications for farming information, including Esoko, iCow, Community knowledge workers, WeFarm, and DigiFarm. • These mobile applications have enhanced curated skill sharing among farmers, which has resulted in better farming and better production.
5. [34]	10.3390/su12083497	• Food production traceability. • There have been increased threats of food security and contamination. The increase has called for an effective traceability system. The system is meant to maintain a sufficient food supply chain that ensures food safety for human consumption. • A blockchain based solution is put in place that eradicates the need for a centralized structure of security and multiple intermediaries. • This solution also optimizes the performance of the system and heightens the level of integrity and trust. • An investigation with the proposed model amongst all stakeholders showed verification of all transactions. The records were further recorded and stored centrally in a database filesystem handling interplanetary data. • The proposed system proved to be cost effective, accurate, and generally traceable.

Table 1. *Cont.*

Article ID	Article Url/DOI	Results Analysis
6. [39]	10.1007/978-3-030-41552-5_1	• Inorganic and organic fertilizers are the sources of nutrients for agricultural crops. • When applied wrongly, these two can act as contaminants of both food and natural resources, such as water and air. • The easy nature of inorganic fertilizers to breakdown within the soil is responsible for contamination of the soil, water, and air especially nitrogenous and phosphatic fertilizers. • Nitrogenous and phosphatic fertilizers are carried by runoff water, causing a pollution scene to nearby waterbodies. They are also viable for distracting particular soil properties, whereas some contents escape as gases contributing to climate change by increasing levels of greenhouse gases. • Nutrients from both organic and inorganic fertilizers may escape through runoff and soil erosion, causing eutrophication of water bodies. • Organic and inorganic fertilizers cause a high build-up of heavy metals within the soil, hence creating an imbalance of soil components.
7. [54]	10.1016/j.csi.2012.09.002	• Traditional agricultural systems applied more of human labor and less mechanization. • Today most of the farming practices apply technological inputs in order to carry out agricultural procedures. This includes planting, weeding, and harvesting, among others. • Moreover, the most recent activities in agriculture have involved the application of robotics, computing, GIS, and wireless technology.
8. [44]	10.1016/j.inpa.2018.06.006	• Covers the role of ICT in promoting food sustainability. • ICTs can contribute to agro-food sustainability transition by increasing resource productivity. • Decreasing management costs. • Improving food chain coordination system. • Reducing common inefficiencies such as water wastage and pollution of natural resources. • Global food systems need a heavy transformation in order to become sustainable. • Recent ICT technologies promote greater efficiency in resource usage; hence, digital technologies are potentially effective in reducing inefficiencies along the food supply chains. • This paper discovers potential setbacks brought about by ICT integration with agriculture. As a result, more research is needed on the impacts of ICT on the agriculture sector.
9. [55]	10.3390/app10124113	• Blockchains are advantageous in achieving traceability. This is done by irreversibly and immutably storing data. • The research unearthed multiple global regulations, directives, and traceability of agricultural food products. • Implementation of blockchain in agriculture traceability systems has been put to use recently despite its mention and research activities on the subject matter over decades. • However, there is an increasing trend on the same startups and pilot applications. • Blockchain technology creates higher levels of credibility, bringing more sustainability to the food industry.

The main finding of the authors is that internet and communications technology (ICTs) can speed up the spread of a wide range of systems, services, and platforms across

agriculture. Eighty-one (81) percent of farmers listed equipment cost as the top barrier to adopting intelligent farming technologies, according to research, which shows that only 14 percent of farmers had done so [6].

The findings demonstrated that a new approach to agricultural research tends to put the farmer first, embraces interactive techniques, gives farmers access to relevant information, weather alerts, and mobile banking, connects them to clients of commodities, and acknowledges the challenges of a situation that is becoming more uncertain and difficult. Advisors have three primary duties to perform in upcoming functions to encourage agricultural producers to be more committed to agriculture practices resulting in increased competitive advantage.

The overall results of the initial research are presented in the section. Initially, pertinent qualitative data for the 23 articles chosen are offered. The part also contains relevant findings that relate to the broad study topic. Numerous publications from various sources have been found. Whereas a few magazines covered many nations, many concentrated on particular settings. A perspective article solely seeking to publish in emerging countries seems to be the "Digital Journal of Data Systems in Emerging Markets." The "Electronic Journal of Information Systems in Developing Countries" also generated the most original research. "Information Technology for Development," which generated three primary pieces of research, seems to be the second most common network (see Table 2).

Table 2. Main publication sources.

Publication Source	#
Progress in Development Studies	1
Telecommunications Policy	1
Electronic Journal of Information Systems in Developing Countries	6
Information Technology for Development	3
Journal of Agricultural Education and Extension	1
Journal of Enterprise Information Management	1
Technological Forecasting & Social Change	1
South African Journal of Information Management	1
Computers and Electronics in Agriculture Information	1
Processing in Agriculture	1
African Journal of Agricultural Research	1
International Journal of Agricultural Sustainability	1
Journal of Rural Social Sciences	1
Society and Business Review	1
Journal of Agricultural & Food Information	1
Journal of Agricultural Informatics	1

Consequently, after reviewing the detailed literature research on the group of references regarding ICTs as a competitive advantage, it has been found that the essential factors influencing the use of ICT in agriculture carrying a competitive advantage, especially for poor farmers, have been five main trends:

a. affordable and pervasive connectivity,
b. flexible and more moderately priced tools,
c. advances in sharing data and preservation,
d. creative commercial arrangements and partnerships, and
e. the liberation of data, including the open access movement using social media.

These trends are explained below:

(a) Affordable and pervasive connectivity: Connectivity's widespread use—for portable devices, the internet, and other wireless devices—is facilitated by several factors, including slowing growth, more competitiveness, and infrastructural expansion for the final mile. Several tendencies are ICT equipment, and applications are becoming more affordable in parallel. Regarding methods that also increase slight producers' access in terms of ICT use in agriculture, mobile phones are in the lead, with about

six billion mobile phone subscribers recorded at the end of 2011. SIM cards, or more specifically, subscriber identification modules, were anticipated to be employed on a global scale. The involvement of mobile phones in developing nations is also a factor, with more than two memberships now accessible for every three persons, fueled by the growth of networks in Africa and Asia. The availability of inexpensive mobile phones has increased due to the upgrading of communications network. Most nations today have a cell service that reaches more than 90% of their population, including covering rural regions. Because favorable laws encourage competition in the communications industry and the considerable interest in subscriptions for mobile phones, broadband internet's accessibility and cost-effectiveness are also drastically improving—though slightly and gradually in the process. The number of internet users in 2010 was approximately 2 billion, more than half of whom are now in developing nations. Global availability of the internet has increased dramatically after 2000, gaining more than 480 percent. The cost of bandwidth has grown. Additionally, the price of expanding connections to remote villages is still decreasing. Telecenters and other local amenities can offer access to the internet in areas where bandwidth is too costly for personal usage by people. Internet access is further predicted to rise because of the ongoing use of prominent and influential party (4G) mobile networks, which substantially increase data-holding capabilities.

(b) Flexible and more moderately priced tools: The usefulness of ICT to smallholder agriculture has also expanded with the advent of adaptive and more reasonably priced technology and gadgets. Technology has steadily decreased the cost of buying phones, computers, and scientific equipment, and specific programs developed by agricultural innovation countries have improved its ability to meet the demands of emerging nations. Individuals with little academic education or technology experience can benefit from many technologies because of their intuitive design and ability to communicate information visually or vocally. Cellphone apps are becoming increasingly useful for isolated and underprivileged populations, especially with feature phones. Service providers can offer mobile banking, other transactional services (like selling inputs, for instance), and information services by utilizing straightforward, readily available technology such as SMS (market price alerts). Extension and advisory services, among other publicly and privately offered services, are provided through mobile devices, which are becoming not merely "Cellphones," but are essentially multipurpose wireless devices. As mapping applications such as Microsoft Earth or Google Maps (picture 1.2) deliver geographic data material to non-specialist users, geospatial data is simpler to obtain and utilize. Through more accessibility, usable geographic information systems that are accessible on regular desktops and smartphones using web-based tools, scientists and development organizations have produced significant sets of georeferenced data on inhabitants, deprivation, shipping, and a variety of other standard utilities and factors. The clarity and richness of satellite photos and other pictorial elements have increased tremendously. Compared to earlier years, these instruments and monitoring devices use fewer resources and need fewer people's interaction.

(c) Advances in sharing data and preservation: A vastly increased capacity for data storage and the capability to remotely access data and simple data sharing have enhanced agriculture's usage of ICT. The ability to network and develop the e-learning environment has allowed it to incorporate more partners in agricultural research. Information may now be shared and exchanged across departments and levels of government. Data sharing and storage advancements have fundamental causes. Hard disk capacity and processor performance have increased over time, as has the cost of storing data. Cloud computing provides access to the internet; several shared computer resources consist of services, tools, and intelligently connected information. These innovations deal with some of the agriculture industry information and communication restrictions from government agencies, cooperatives, and research

institutions, and the formation of personality, which are advantages of improved data. The benefits of increased data capacity include specific targeting of agricultural development initiatives and improving the management of farm-level surpluses or deficits.

(d) Creative commercial arrangements and partnerships: Many different forms of ICT were first developed and used in the public sector, but as their financial potential became evident, the private sector swiftly took over. The public sector continues to be very interested in ICT to improve public services with an impact on agriculture (for example, agricultural extension services, property registration, and forest management), as well as for interacting with residents and controlling internal matters. The role of the private sector in some of these initiatives has improved the availability, affordability, and flexibility of ICT for development. Development plans utilizing ICT have benefited from increased private sector engagement and public demand, in contrast with other strategic planning, which frequently has difficulty surviving or expanding since the public sector cannot pay them. Many different forms of ICT were first developed and used in the public sector, but as their financial potential became evident, the private sector swiftly took over. The public sector continues to be very interested in ICT to improve public services with an impact on agriculture (for example, agricultural extension services, property registration, and forest management), as well as for interacting with residents and controlling internal matters. The entrepreneurial aspect of ICT draws new business relationships and investment opportunities. Only a small portion of the potential is represented by mobile phone applications, software development, local language adaptation, and remote transaction services to support ongoing innovation. Private businesses that have made technology and software investments frequently want to collaborate with the public sector to offer their goods and services to smallholders. Cellular network operators can invest, for instance, by providing more extensive text products at a cheaper cost, gathering premiums, dispersing payments, or taking part in network expansion into remote regions. Commercial businesses, including processors, input providers, and exporters, are also encouraged to engage in ICT since it frequently results in greater productivity and earnings and furthermore extends to clientele groups like lone farmers [14]. There is the ability to layer geographical data that includes socioeconomic and climatic facts, in that there are multiple choices for analyzing biophysical trends (such as erosion or the movement of pathogens), forecasting (about the consequences of climate change or the proper place of wholesale markets in regards to transportation infrastructure), and picking specific populations to test new technologies or farming methods (for example, recognizing growers who are particularly likely to profit from using e-vouchers, to Buy fertilizer).

(e) The democratization of data, including the open access movement using social media and related industry 4.0 technologies: ICT-enabled democratization of research and information is also advancing rural and agricultural development more widely. New technologies such as the Internet of Things (IoT) and blockchain are expected to push this trend further, enabling farmers to actively participate in the governance of agrifood supply chain networks [55–57]. Through the open-access movement, enormous amounts of information held by people and organizations have become viewable, accessible, and maintainable. These deeds have enhanced accountability and visibility while also encouraging the public, private, and research sectors to take part in the solution of long-term economic challenges, including those involving agriculture. Additionally, the growth of freely accessible software and open source blockchain solutions makes it possible for local community organizations to share information. Social media, formerly just used for pleasure, now possesses enormous potential for usage in knowledge exchange and cooperation, even in farming, even though Facebook, the most widely used social network, was estimated in 2010 as only having 3 percent usage in Africa and over 4 percent in Asia against 10.3% (more than

500 million users) worldwide. Fundraising, which involves scientists, governments, and other development groups asking producers and consumers for input using tools such as cell devices, also supports the expansion of agriculture. Farmers may now share crucial local information on agriculture via SMS, such as insect incidences or agricultural production, which was formerly easier to collect with costly research surveys. Additionally, farmers in less developed countries can use innovative funding tools such as microloan crowdfunding platforms that use the internet and social media. Consumers may also inform companies about altering purchasing preferences and habits using technological tools.

5. Discussion

This paper aims to bring attention to the role of ICTs and agricultural advisory services in fostering more sustainable agriculture, helping them create a competitive advantage. This is done by emphasizing the role that agricultural advisors play in encouraging agricultural producers to use ICTs and, thus, to participate in the procedure of cultivating agricultural production more fully [11,52], making them able to gain a competitive advantage, which constitutes the research contribution of this paper for academics, managers, and policymakers.

Therefore, the study considered earlier studies on the methods used by agricultural producers to get pertinent information, and the channels via which they attempt to receive new information for their future work, etc. All information is based on the work of the eleven agricultural advisors in charge of such activities.

Also establishing a system of long-term relationships based on trust between agricultural advisors and producers is the most crucial prerequisite for the success of their work. To utilize new findings related to ICTs, policymakers must incorporate traditional knowledge to foster the growth of more sustainable agriculture. Both types are derived from human experiences and observations, and are verified, replicated, and distributed across the relevant society through social institutions and procedures intended for that goal [11].

In this context and after reviewing the literature thoroughly, we must recognize the complicated debate on digitalization and sustainability. This debate has clearly shown that (a) digitalization is only sustainable under certain conditions and that (b) economic growth and sustainability are in obvious tension, resulting in a competitive advantage for their users [42,43,58–60]. The debate mentioned above may not be adequately and fully addressed in this review paper, nevertheless, it provokes the extension of this work for future research.

Even though ICTs standardize and regulate agricultural processes while shrinking the wide gap between farming researchers and farmers, their integration faces additional challenges such as a shortage of data, poor skills, a poor state of infrastructure, and restricted accessibility, especially in rural areas.

Several suggestions are made based on the gained knowledge.

- Direct interactions with farmers, farm tours, lectures, and other informal educational activities highlight the special significance of advisors' work.
- Educational centers for counseling and communication and information systems had to play a more central role.
- The significance and the value of agricultural advice in village life and the nation are emphasized.
- The farms that produce necessities, as well as family farms that may be seeking to develop more creative goods, should be able to receive guidance from the agricultural consulting company.

6. Conclusions

Future agricultural growth has significant opportunities due to the fourth industrial revolution, especially in less developed, emerging economies. Additionally, ICT usage has

gradually improved in developing countries, presenting a unique opportunity to transfer essential data to different locations and to various individuals who formerly could not obtain such details, as well as significantly lowering the cost of implementing innovative features that carry a competitive advantage.

As mentioned above, the main findings of the author are that information and communications technologies (ICTs) can accelerate the spread of a wide range of systems, services, and platforms across agriculture. According to the research, a significant percentage of farmers listed equipment cost as the top barrier to adopting intelligent farming technologies, which shows that only 14 percent of farmers had done so.

The Smart Specialized Strategy's publications include the Rural Development and Agriculture Policy 2014-2024 comparison. It is consistent with the research and development in the FOOD FOR THE FUTURE priority area. Even though several efforts were made, more advancement in technology adoption is needed. Most agricultural farmers acknowledged the necessity for subsidies to embrace high-tech technology. Using ICTs in agriculture necessitates the development of new skills, which takes time to develop and calls for adjustments to education and vocational training.

This study is limited to the current and already studied technology in the agricultural sector. However, technological advancement is a rapid and continuous process. Therefore, any further progression of agriculture technology is not considered within the boundaries of study consideration. This limitation ends up yielding a narrowed vision of the nature of technological advancement in the agricultural sector.

Future studies on this ICT involvement with agriculture should consider any technology under development and how the same technology is due to bring development on current agricultural setbacks on the journey to increase sustainability in the agricultural sector.

Finally, although the primary goal of this review paper was to determine whether ICT and agricultural advisory is a tool of competitive advantage, during the literature research, the social impact of ICTs and the complicated debate on digitalization and sustainability arose. This leads to the emerging need for future and more thorough analysis of these topics from the writers. As a final and comprehensive outcome, it can quickly be concluded that when using smart technologies (ICT) effectively, even the ones with a small cost, the farmer and the farming industry may expand and prosper.

Funding: This research received no external funding.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Sachitra, V.; Choy Chong, S. Firm Level Competitive Advantage in the Agricultural Sector: A Research Agenda. *J. Econ. Manag. Trade* **2016**, *12*, 1–12. [CrossRef]
2. OECD. The Impact of Digitalization on Productivity: Firm-Level Evidence from The Netherlands. Available online: https://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=ECO/WKP(2021)31&docLanguage=En (accessed on 28 December 2022).
3. Al Zubi, M.; Radovic, V. *SDG11-Sustainable Cities and Communities-Towards Inclusive, Safe, and Resilient Settlements*, 1st ed.; Emerald Publishing Limited: Bradford, West Yorkshire, UK, 2016; pp. 32–36.
4. United Nations. *Transforming Our World: The 2030 Agenda for Sustainable Development*; United Nations: New York, NY, USA, 2015; pp. 7–32.
5. Popescu, G.H.; Sima, V.; Nica, E.; Gheorghe, I.G. Measuring sustainable competitiveness in contemporary economies—Insights from European economy. *Sustainability* **2017**, *9*, 1230. [CrossRef]
6. Food and Agriculture Organization of the United Nations (FAO); The International Telecommunication Union (ITU). *Status of Digital Agriculture in 18 Countries of Europe and Central Asia*; FAO: Geneva, Switzerland, 2017; pp. 1–5.
7. World Bank. Competitive Agricultural Project (SCAP). Report No. PAD 3446. Available online: http://documents1.worldbank.org/curated/en/961711573843471628/pdf/Serbia-Competitive-Agriculture-Project.pdf (accessed on 14 December 2020).

8. Đurić, K.; Cvijanović, D.; Prodanović, R.; Čavlin, M.; Kuzman, B.; Lukač Bulatović, M. Serbian Agriculture Policy: Economic Analysis Using the PSE Approach. *Sustainability* **2019**, *11*, 309. [CrossRef]
9. Dimitrovski, D.; Leković, M.; Joukes, V. A bibliometric analysis of Crossref agritourism literature indexed in Web of Science. *Hotel. Tour. Manag.* **2019**, *7*, 25–37. [CrossRef]
10. Spasić, T.; Georgijevski, M. Application of modern information technologies in agricultural development. In Proceedings of the 18th International Scientific Conference "Regional Development and Demographic Flows of Southeast European Countries", Niš, Serbia, 6–8 June 2013; pp. 759–771.
11. Kountios, G. The role of agricultural consultants and precision agriculture in adopting good agricultural practices and sustainable water management. *Int. J. Sustain. Agric. Manag. Inform.* **2022**, *8*, 144–155. [CrossRef]
12. Simonović, Z. Development policy advisory public service in agriculture in Serbia. *Ekonomika* **2016**, *62*, 59–68. [CrossRef]
13. Ammann, K. Reconciling traditional knowledge with modern agriculture: A guide for building bridges. In *Intellectual Property Management in Health and Agricultural Innovation: A Handbook of Best Practices*; Krattiger, A., Mahoney, R.T., Nelsen, L., Thomson, J.A., Bennett, A.B., Satyanarayana, K., Graff, G.D., Fernandez, C., Kowalski, S.P., Eds.; Centre for the Management of Intellectual Property in Health Research and Development (MIHR): Oxford, UK, 2007; Volume 1–2, pp. 1539–1559.
14. Klerkx, L.; Jakku, E.; Labarthe, P. A review of social science on digital agriculture, smart farming and agriculture 4.0: New contributions and a future research agenda. *NJAS Wagening. J. Life Sci.* **2019**, *90–91*, 100315. [CrossRef]
15. Latino, M.E.; Menegoli, M.; Corallo, A. Agriculture Digitalization: A Global Examination Based on Bibliometric Analysis. *IEEE Trans. Eng. Manag.* **2022**, *1*, 1–16. [CrossRef]
16. Lezoche, M.; Hernandez, J.E.; del Mar Eva Alemany Díaz, M.; Panetto, H.; Kacprzyk, J. Agri-food 4.0: A survey of the supply chains and technologies for the future agriculture. *Comput. Ind.* **2020**, *117*, 103187. [CrossRef]
17. Latino, M.E.; Corallo, A.; Menegoli, M.; Nuzzo, B. Agriculture 4.0 as Enabler of Sustainable Agri-Food: A Proposed Taxonomy. *IEEE Trans. Eng. Manag.* **2022**, 1–20. [CrossRef]
18. Molina-Maturano, J.; Verhulst, N.; Tur-Cardona, J.; Güerena, D.T.; Gardeazábal-Monsalve, A.; Govaerts, B.; De Steur, H.; Speelman, S. How to Make a Smartphone-Based App for Agricultural Advice Attractive: Insights from a Choice Experiment in Mexico. *Agronomy* **2022**, *12*, 691. [CrossRef]
19. Srinivasan, J.; Burrell, J. Revisiting the fishers of Kerala, India. In Proceedings of the Sixth International Conference on Information and Communication Technologies and Development: Full Papers—Volume 1 (ICTD '13), Cape Town, South Africa, 7–10 December 2013; Association for Computing Machinery: New York, NY, USA, 2013; pp. 56–66.
20. Islam, S.M.; Grönlund, Å.G. Factors influencing the adoption of mobile phones among the farmers in Bangladesh: Theories and practices. *Int. J. Adv. ICT Emerg. Reg.* **2012**, *4*, 4–14. [CrossRef]
21. Ruiz-Garcia, L.; Lunadei, L.; Barreiro, P.; Robla, R. Review a review of wireless sensor technologies and applications in agriculture and food industry: State of the art and current trends. *Sensors* **2009**, *9*, 4728–4750. [CrossRef] [PubMed]
22. Chapman, R.; Slaymaker, T. *ICTs and Rural Development: Review of the Literature, Current Interventions and, Opportunities for Action*; Working Paper; Overseas Development Institute (ODI): London, UK, 2002; pp. 30–34.
23. Mitrović, D.; Škrbić, N.; Ogrizović, B. Review of the role and importance of the agricultural professional service from the point of view of mechanics. *Poljopr. Teh.* **2009**, *25*, 23–31.
24. Filipović, J.; Stanković, S.; Beskorovajni, R.; Tolimir, N.; Popović, N.; Pešić, B.; Jovanović, V. Diary production in Pomoravlje region, Serbia. In Proceedings of the VIII International Scientific Agriculture Symposium "AGROSYM 2017", Jahorina, Bosnia and Herzegovina, 5–8 October 2017; pp. 2575–2579.
25. Janković, S.; Novković, N.; Vasiljević, Z. Agroeconomic knowledge in the function of agricultural extension in Serbia. In Proceedings of the Sixth International Scientific Agricultural Symposium AgroSym, Jahorina, Bosnia and Herzegovina, 15–18 October 2015; University of East Sarajevo: Jahorina, Bosnia and Herzegovina, 2015; pp. 69–77.
26. Labonne, J.; Chase, R. The Power of Information: The Impact of Mobile Phones on Farmers' Welfare in the Philippines. Policy Research Working Paper No. 4996. Available online: athttp://econ.worldbank.org/external/default/main?pagePK=64165259&theSitePK=478060&piPK=64165421&menuPK=64166093&etityID=000158349_20090716115612 (accessed on 22 December 2022).
27. Antholt, C.H. *Getting Ready for the Twenty-First Century: Technical Change and Institutional Modernization in Agriculture*; World Bank Technical Paper 217; Asia Technical Department Series; World Bank: Washington, DC, USA, 1994.
28. Radović, V.; Pejanović, R.; Marinčić, D. Extreme weather and climatic events on agriculture as a risk of sustainable development. *Econ. Agric.* **2015**, *62*, 181–191. [CrossRef]
29. Pedersen, S.M.; Fountas, S.; Have, H.; Blackmore, B.S. Agricultural robots-system analysis and economic feasibility. *Precis. Agric.* **2006**, *7*, 295–308. [CrossRef]
30. Emerson, K.; Nabatchi, T. *Collaborative Governance Regimes*; Georgetown University Press: Washington, DC, USA, 2015; pp. 132–144.
31. Seitanidi, M.; Koufopoulos, D.N.; Palmer, P. Partnership Formation for Change: Indicators for Transformative Potential in Cross Sector Social Partnerships. *J. Bus. Ethics* **2010**, *94*, 139–161. [CrossRef]

32. Mapiye, O.; Makombe, G.; Molotsi, A.; Dzama, K.; Mapiye, C. Information and communication technologies (ICTs): The potential for enhancing the dissemination of agricultural information and services to smallholder farmers in sub-Saharan Africa. *Inf. Dev.* **2021**, 026666692110648. [CrossRef]
33. Tian, F. An agri-food supply chain traceability system for China based on RFID & blockchain technology. In Proceedings of the 2016 13th International Conference on Service Systems and Service Management (ICSSSM), Kunming, China, 24–26 June 2016. [CrossRef]
34. Prashar, D.; Jha, N.; Jha, S.; Lee, Y.; Joshi, G.P. Blockchain-Based Traceability and Visibility for Agricultural Products: A Decentralized Way of Ensuring Food Safety in India. *Sustainability* **2020**, *12*, 3497. [CrossRef]
35. Chryssochoidis, G.; Karagiannaki, A.; Pramatari, K.; Kehagia, O. A cost-benefit evaluation framework of an electronic-based traceability system. *Br. Food J.* **2009**, *111*, 565–582. [CrossRef]
36. Latino, M.E.; Menegoli, M.; Lazoi, M.; Corallo, A. Voluntary traceability in food supply chain: A framework leading its implementation in Agriculture 4.0. *Technol. Forecast. Soc. Change* **2022**, *178*, 121564. [CrossRef]
37. Hughes, T.; Martin, C. Design traceability of complex systems. In Proceedings of the Fourth Annual Symposium on Human Interaction with Complex Systems, Dayton, OH, USA, 22–25 March 1998. [CrossRef]
38. Radogna, A.V.; Latino, M.E.; Menegoli, M.; Prontera, C.T.; Morgante, G.; Mongelli, D.; Giampetruzzi, L.; Corallo, A.; Bondavalli, A.; Francioso, L. A Monitoring Framework with Integrated Sensing Technologies for Enhanced Food Safety and Traceability. *Sensors* **2022**, *22*, 6509. [CrossRef]
39. Rashmi, I.; Roy, T.; Kartika, K.S.; Pal, R.; Coumar, V.; Kala, S.; Shinoji, K.C. Organic and Inorganic Fertilizer Contaminants in Agriculture: Impact on Soil and Water Resources. In *Contaminants in Agriculture*; Springer: Cham, Switzerland, 2020; pp. 3–41. [CrossRef]
40. Ajah, I.; Nweke, H. Big Data and Business Analytics: Trends, Platforms, Success Factors and Applications. *Big Data Cogn. Comput.* **2019**, *3*, 32. [CrossRef]
41. Javaid, M.; Haleem, A.; Singh, R.P.; Suman, R. Enhancing smart farming through the applications of Agriculture 4.0 technologies. *Int. J. Intell. Netw.* **2022**, *3*, 150–164. [CrossRef]
42. Garske, B.; Bau, A.; Ekardt, F. Digitalization and AI in European Agriculture: A Strategy for Achieving Climate and Biodiversity Targets? *Sustainability* **2021**, *13*, 4652. [CrossRef]
43. Heyl, K.; Ekardt, F.; Sund, L.; Roos, P. Potentials and Limitations of Subsidies in Sustainability Governance: The Example of Agriculture. *Sustainability* **2022**, *14*, 15859. [CrossRef]
44. Hamid El Bilali, H.; Allahyari, M.S. Transition towards sustainability in agriculture and food systems: Role of information and communication technologies. *Inf. Process. Agric.* **2018**, *5*, 456–464. [CrossRef]
45. OECD. Consumer Policy and the Smart Home. Available online: https://one.oecd.org/document/DSTI/CDEP/CISP/MADE(2017)1/en/pdf (accessed on 20 December 2022).
46. Wolfert, S.; Cor Verdouw, L.; Bogaardt, M. Big data in smart farming—A review. *Agric. Syst.* **2017**, *153*, 69–80. [CrossRef]
47. Ahoa, E.; Kassahun, A.; Tekinerdogan, B. Business processes and information systems in the Ghana cocoa supply chain: A survey study. *NJAS-Wagening. J. Life Sci.* **2020**, *92*, 100323. [CrossRef]
48. Kassahun, H.T.; Jacobsen, J.B.; Nicholson, C.F. Revisiting money and labor for valuing environmental goods and services in developing countries. *Ecol. Econ.* **2020**, *177*, 106771. [CrossRef]
49. Köksal, Ö.; Tekinerdogan, B. Architecture design approach for IoT-based farm management information systems. *Precis. Agric.* **2019**, *20*, 926–958. [CrossRef]
50. Verdouw, C.; Sundmaeker, H.; Tekinerdogan, B.; Conzon, D.; Montanaro, T. Architecture framework of IoT-based food and farm systems: A multiple case study. *Comput. Electron. Agric.* **2019**, *165*, 104939. [CrossRef]
51. Papadavid, G.; Kountios, G.; Michailidis, A. Monitoring and determination of irrigation demand in Cyprus. *Glob. Nest J.* **2013**, *15*, 93–101.
52. Kountios, G.; Papadavid, G. The Adoption of Information and Communication Technologies in Farmers and the Emerging Need for an Integrated System of Agricultural Advisory and Training. In Proceedings of the CEUR Workshop Proceedings, Athens, Greece, 22–25 September 2022; Volume 3293.
53. Lin, Y.-P.; Petway, J.R.; Anthony, J.; Mukhtar, H.; Liao, S.-W.; Chou, C.-F.; Ho, Y.-F. Blockchain: The Evolutionary Next Step for ICT E-Agriculture. *Environments* **2017**, *4*, 50. [CrossRef]
54. Suprem, A.; Mahalik, N.; Kim, K. A review on application of technology systems, standards and interfaces for agriculture and food sector. *Comput. Stand. Interfaces* **2013**, *35*, 355–364. [CrossRef]
55. Demestichas, K.; Peppes, N.; Alexakis, T.; Adamopoulou, E. Blockchain in agriculture traceability systems: A review. *Appl. Sci.* **2020**, *10*, 4113. [CrossRef]
56. Serdaris, P.; Antoniadis, I.; Tomlekova, N. Supply chain management: A view of the distribution channel. *Bulg. J. Agric. Sci.* **2014**, *20*, 480–486.
57. Anshari, M.; Almunawar, M.N.; Masri, M.; Hamdan, M. Digital marketplace and FinTech to support agriculture sustainability. *Energy Procedia* **2019**, *156*, 234–238. [CrossRef]
58. Stubenrauch, J.; Ekardt, F.; Heyl, K.; Garske, B.; Schott, V.L.; Ober, S. How to legally overcome the distinction between organic and conventional farming Governance approaches for sustainable farming on 100% of the land. *Sustain. Prod. Consum.* **2021**, *28*, 716–725. [CrossRef]

59. Weishaupt, A.; Ekardt, F.; Garske, B.; Stubenrauch, J.; Wieding, J. Land Use, Livestock, Quantity Governance, and Economic Instruments—Sustainability Beyond Big Livestock Herds and Fossil Fuels. *Sustainability* **2020**, *12*, 2053. [CrossRef]
60. Verhoef, P.; Broekhuizen, T.; Bart, Y.; Bhattacharya, A.; Qi Dong, J.; Fabian, N.; Haenlein, M. Digital transformation: A multidisciplinary reflection and research agenda. *J. Bus. Res.* **2021**, *122*, 889–901. [CrossRef]