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PERSPECTIVES OF SUSTAINABLE USE OF TECHNOLOGIES: AN APPROACH TO AGRICULTURE 4.0

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ABSTRACT

The sharp population has driven the demand for more food, fiber, water, and energy, which is associated with the increased need to use natural resources more sustainably. Agriculture 4.0 has become the agenda of public organizations worldwide since there is unanimous concern about feeding the population in the future. Studies are being conducted bringing the importance of Agriculture 4.0 and the different technologies that are being applied or under development, public policies, food security, and sustainability, the latter two as a watershed between "traditional agriculture" and Agriculture 4.0, linked to the internet of things, robots, sensors, blockchain, vertical agriculture, among others that, to be effective, need to be within everyone's reach. The results show that in the context of the insertion of technologies, they tend to meet the demand of medium and large producers, especially those who work with large-scale production, and this does not guarantee food security, nor does it ensure that 4.0 technologies will end world hunger, as the family producer does not have the same accessibility and knowledge to use them.

Keywords: Agriculture 4.0; Sustainable development; Food safety; Technology

RESUMO

O crescimento populacional tem impulsionado a demanda por mais alimentos, fibras, água e energia, o que está associado ao aumento da necessidade da utilização de recursos naturais de maneira mais sustentável. A agricultura 4.0 tornou-se pauta das organizações públicas mundiais, uma vez que é unânime a preocupação em alimentar a população no futuro. Estudos estão sendo realizados, trazendo a importância da agricultura 4.0 e as diferentes tecnologias que estão sendo aplicadas ou em desenvolvimento, as políticas públicas, a segurança alimentar e a sustentabilidade, essas últimas como um divisor de águas entre a “agricultura tradicional” e a agricultura 4.0, atrelada a internet das coisas, robôs, sensores, *blockchain*, agricultura vertical entre outros que para serem realmente eficazes precisam estar ao alcance de todos. Os resultados mostram que no contexto de inserção de tecnologias, elas tendem a atender a demanda do médio e grande produtor, principalmente aqueles que trabalham com produção em grande escala e isso não garante a segurança alimentar, nem se assegura que as tecnologias 4.0 irão acabar com a fome mundial, pois o produtor familiar não possui a mesma acessibilidade e conhecimento para utilizar-se delas.

Palavras-chave: Agricultura 4.0; Desenvolvimento sustentável; Segurança alimentar; Tecnologia

Código JEL: O13; O31

INTRODUCTION

Digital transformations in agriculture and their applicability on rural properties are shown to be a political priority on a global scale. According to Rijswijk et al. (2021), Digital Agriculture, also known as Agriculture 4.0 or Intelligent Agriculture, allows the implantation of new opportunities and interconnected technologies, which enables taking more assertive decisions, resulting in less costs and more profits for those who use it. Discussions on digital technologies are expressively regarded as an opportunity to open a sustainable future in agriculture and rural properties (RIJSWIJK et al., 2021). Connectivity rising in the countryside, and its larger integration with data from remote sensors, sensor systems, equipment, and smartphones, opened the way for new concepts of Agriculture 4.0 or Digital Agriculture (BOLFE et al., 2020).

Particularly, according to Trivelli et al. (2019), matters on environmental sustainability related to the gradual rising of the worldwide population, as well as the market demand for agricultural products - which is compounded by more and more challenging customers, who are aware of cultivation and improvement techniques, interested in healthy and high-quality products - are two of the main challenges agriculture is about to face next years.

It is essential to understand that land resources are limited about the population problem of food security, which cannot be solved by increasing arable land, but rather by increasing the efficiency of agricultural production (LEZOCHE et al., 2020). Given the current stage of development, Klerkx and Rose (2020) corroborate that increased efficiency and the use of resources in agriculture depend on the need to develop precision agricultural systems that streamline operational management processes that respond to changes in natural, market, and sustainability conditions. However, the implementation of technologies by farms has different contexts, such as lack of skills in their operations or even the feasibility of acquisition and other obscure impacts or effects that must also be foreseen (KLERKX; ROSE, 2020).

Agriculture 4.0 emerges to provide advanced technologies to farmers to challenges of agrifood production and to achieve more affordable prices for open market and the minimum cost for farmers (LEZOCHE et al., 2020).

Processes that make the results predictable are desirable because of the need to produce more in smaller spaces. Therefore, the use of technology 4.0 helps in this field, assuming that there are productivity gains in agriculture. However, it is necessary to assess in which areas this technology is being used more and if it favors and extends to all rural properties since commodity producers have a greater advantage over small producers or family farmers.

Facing it, this study approached, through a literature review, the conceptual theme of Digital Agriculture, Agriculture 4.0 or Intelligent Agriculture, aiming to identify in which conditions technologies are playing an essential role in the development of the field and if there are public policies that encourage the idea to make knowledge and accessibility possible for all farmers. For this, from now on, we will only use the Agriculture 4.0 nomenclature.

This paper presents perspectives on the use of Agriculture 4.0. The research hypothesis is that the insertion of technologies and agriculture 4.0 in agricultural farms is important for promoting global population nutrition, sustainability, and food security but does not guarantee food security. It is believed that there is resistance from farmers to its insertion and application due to a lack of knowledge and access to technologies, in addition to cultural and social issues in the countries.

The researcher's objective is to answer which technologies are used in agriculture 4.0, their impacts in different countries, and the results obtained through studies on the subject. In other words, it's the context of the insertion of technologies.

This article consists of four sections. The first section consists of the introduction, which presents the context and guidelines from which the research was carried out and which this paragraph integrates. The second section shows the methodological procedures referring to the whole set of decision-making and actions regarding the choice of techniques and research method. In the following section, the results and discussions of the study are presented and, finally, section four discusses the final remarks.

METHODOLOGICAL PROCEDURES

In order to achieve the proposed objectives of the work, it is necessary to present the methodological procedures that were used. Having agricultural sciences as an area of knowledge and interdisciplinarity as an epistemological approach to scientific research, it was decided to carry out a study with a qualitative approach. The focus of the qualitative method is to provide a better view and understanding of the context under study, giving greater familiarity to a problem (VIEIRA; TIBOLA, 2005).

Regarding nature, research is of a basic nature, where the researcher intends to know, seeking to satisfy an intellectual need through knowledge (MARCONI; LAKATOS, 2009). Still, the research was framed, based on its objectives, in a methodological category called exploratory study, which allowed researchers to increase their experience around a given problem (TRIVIÑOS, 1987). Therefore, about technical procedures, the exploratory phase took the form of bibliographic research.

Hair Jr. et al. (2005) state that this type of research is helpful when the researcher has little information. Therefore, this type of research was used to gather relevant information about state of the art since the bibliographic survey is a previous investigation of the literature review, developed from the narrative method (non-systematic), but following a set of keywords selected from the databases.

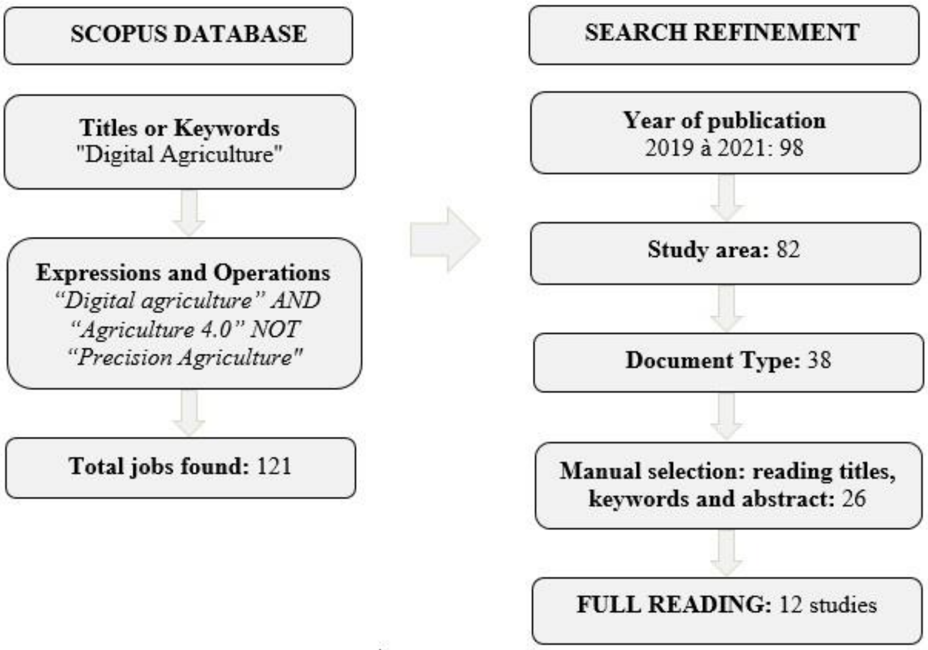
Therefore, the origin of the collected data was secondary, and the search for the material was carried out in the Sciverse Scopus data source. This choice was made for the fact that this is the major data source of reviews and quotes revised by pairs, contemplating more than 21.500 periodicals and more than 5.000 international publishers from different areas of knowledge (PALOMO; FIGUEROA-DOMECQ; LAGUNA, 2010). These expressions were used: "digital agriculture", "agriculture 4.0", "precision agriculture" with AND and NOT boolean operators. Scopus base showed 121 papers, limited from 2019 to 2021, generating 98 results.

Refining it to only studying areas and articles resulted in 38 articles. Those passed by a manual selection by the reading titles, abstracts, and keywords, totalizing 26 articles. Finalizing the selection process, it was made the complete reading of those 26 articles, resulting in 12 studies that were deepened and analyzed, discussing the information obtained based on the intellectual knowledge of the authors for a better understanding of the reader about the inserted subject.

However, the sum of the usable material collected will provide adequacy according to the abilities of the investigators, their experiences, and abilities to discover the contributions and the important clues for the present article, serving as an overview of the main works already carried out, being important for providing current and relevant data related to the topic, representing an indispensable source of information (MARCONI; LAKATOS, 2007).

Figure 1 shows the scheme from the referred phases to the sample selection. Throughout the data analysis, Microsoft® Excel™ software was used. The same ones will be presented in tables and graphic shapes.

Figure 1: Criteria for the sample selection



Source: The authors.

RESULTS AND DISCUSSIONS

Agriculture 4.0 is made by different technologies which are already being operated or in development, Klerkx and Begemann (2020) cites robotics, nanotechnology, synthetic protein, cell agriculture, gene edition technology, artificial intelligence, blockchain, and machine learning, which may provide positive results in agriculture and the future of feeding systems with great transforming potential. These technologies contemplate perceptions from vertical agriculture and feeding systems, digital agriculture, bioeconomy, circular agriculture, and aquaponics, which are developed for more sustainable agriculture (KLERKX; BEGEMANN, 2020).

Thereby, in Agriculture 4.0, technology is used not only as a matter of innovation but also to attend better the real needs of customers (INSHAKOVA et al., 2020). So, the Internet of Things (IoT), through its spreading, provided the rise of the Agriculture 4.0 concept as an evolution of Precision Agriculture (PA) (MONTELEONE, 2020). However, it's worthwhile to highlight that each one of those has its peculiarities and may complement themselves, even though being mentioned as synonyms many times. In this sense, one may infer that the technological advance, which has recently happened in the global economy and its digital modernization, led to the transition to Industry 4.0 (INSHAKOVA et al., 2020), boosting Agriculture 4.0 as well.

The selected studies approach the referred elements in varied countries, showing a chronological order, in which, every year, Agriculture 4.0 theme and its technologies are shown in different proportions, regarding both reality and culture where they are applied. Frame 1 shows the deepened articles dynamic.

Frame 1 has 3 columns showing the article's titles, places or characteristics of the research, and the year they were made. It is confirmed that the search only refined publications from the last three years. In Europe, second Rijswijk et al. (2021), the European Commission established as one of its objectives to totally connect agriculturists and the countryside to the digital economy in order to reach a much more intelligent, modern, and sustainable future of food in agriculture. The study presents a concept that it is necessary to better comprehension of technologies and innovations users, which are unknown most of the time.

In this sense, it was considered important to understand the conceptions between the social, cybernetic, and physical, aspects related to a description of digital transformation conditions in agriculture. Results show that the implantation of technologies modifies the costs and responsibilities distribution in the system, which demands the involved ones to act on the possible effects of negative costs as well as the benefits. Nevertheless, writers reverberate that digital transformations in agriculture and on countryside properties are not motivated by technology but by problems that must be conducted through different ways and transitions (RIJSWIJK et al., 2021).

Frame 1: Titles of selected articles, countries, and year of publication.

	Article	Country/Characteristic	Year
1	Digital transformation of agriculture and rural areas: A socio-cyber-physical system framework to support responsibilisation	European Union	2021
2	Advanced solid state nano-electrochemical sensors and system for agri 4.0 applications	Ireland	2021
3	Foresighting Australian digital agricultural futures: Applying responsible innovation thinking to anticipate research and development impact under different scenarios	Australia	2021
4	Framework for agricultural e-trading platform adoption using neural networks	Germany	2021
5	Agriculture 4.0: An Implementation Framework for Food Security Attainment in Nigeria's Post-Covid-19 Era	Nigeria	2021
6	Demand prognosis of industry 4.0 to agriculture sector in India	India	2021
7	Irrisens: An iot platform based on microservices applied in commercial-scale crops working in a multi-cloud environment	Australia	2021
8	Exploring the adoption of precision agriculture for irrigation in the context of agriculture 4.0: The key role of internet of things	Brazil and Italy	2021
9	Industry 4.0 versus agriculture. Development perspectives of agriculture in the republic of Moldova by assimilating digital technologies	Moldavia	2021
10	Precision and digital agriculture: Adoption of technologies and perception of Brazilian farmers	Brazil	2020
11	Feature extraction for cocoa bean digital image classification prediction for smart farming application	Indonesia	2020
12	Farmers' knowledge, attitude, and adoption of smart agriculture technology in Taiwan	Taiwan	2020
13	The future(s) of digital agriculture and sustainable food systems: An analysis of high-level policy documents	International actors	2020
14	Supporting food systems transformation: The what, why, who, where and how of mission-oriented agricultural innovation systems	Literature revision	2020
15	The model of distribution of human and machine labor at intellectual production in industry 4.0	Countries of "W. R. of Digital Competitiveness 2018"	2020
16	Dealing with the game-changing technologies of Agriculture 4.0: How do we manage diversity and responsibility in food system transition pathways?	State of art	2020
17	Enclosure 4.0: Seizing data, selling predictions, scaling platforms	Germany	2020
18	Agro 4.0: Enabling agriculture digital transformation through IoT	Brazil	2020
19	Computer vision applied to food and agricultural products	Literature revision	2020
20	Technological trends in digital agriculture and their impact on agricultural machinery development practices	Literature revision	2020
21	Digitization as politics: Smart farming through the lens of weak and strong data	Empirical studies in various countries and locations	2020
22	Precision Techniques and Agriculture 4.0 Technologies to Promote Sustainability in the Coffee Sector: State of the Art, Challenges and Future Trends	Systematic Literature Review	2020
23	The BonaRes metadata schema for geospatial soil-agricultural research data – Merging INSPIRE and DataCite metadata schemes	Germany	2019
24	Is the trend your friend? An analysis of technology 4.0 investment decisions in agricultural SMEs	Italy	2019
25	From precision agriculture to Industry 4.0: Unveiling technological connections in the agrifood sector	State of art	2019
26	Creation, storage and presentation of information content - semantics, sharing, presentation, and archiving	Interviews with web professionals	2019

Source: The authors.

Facing results, the study by Oruma, Misra, and Fernandez-Sanz (2021) also runs about Agriculture 4.0 importance for food safety, population growth, unsafety, and about environmental challenges and climate changes. It points out that public policies in Nigeria still go through safety and financial support for a few locations of cash crops, disfavoring millions of small agriculturists. As an alternative to food safety and sustainable development of the studied location, it is important that the policies are turned to adequate, cheap and sustainable energy provision, availability of communication and information technology (CIT) and modern infrastructure for the Agriculture 4.0 implementation to be a success. According to the writers, Nigeria cannot implement Agriculture 4.0, facing extreme hunger, poverty, and underdevelopment prevailing in its countryside, since violence, insurgency, and insecurity are fundamental requirements for the development and investment in any part of the world.

On the same line of reasoning about public incentives and food safety, Chuang, Wang and Liou (2020) provide a preliminary comprehension of the relation between psychological factors and the adoption of intelligent technology innovations in an economic context of small scale agriculture, in which it was investigated how the agriculturists' knowledge and attitudes in relation to Agriculture 4.0 interfere on the intelligent technologies adoption in Taiwan. Discoveries suggest that policy formulators and research and development institutes must concentrate on improving access to the Agriculture 4.0 market.

Taiwan's agricultural sector is characterized by small-scale properties, and it was identified as a global disaster hotspot (for instance, hurricanes and floods). It was launched by Taiwan Agriculture Council (AC) the Agriculture 4.0 Project, in 2017, according to Industry 4.0 development and climate change risks. Results revealed that knowledge, importance perception, and adoption behavior correlate. Therefore, lower levels of intelligent agriculture adoption may be attributed to inadequate information, lack of knowledge, technological consciousness, and lack of received practical value (CHUANG; WANG; LIOU, 2020).

Referring to the international actors who are able to influence the future food systems, the study by Lajoie-O´malley et al. (2020) investigated which roles are being imagined for these technologies by the same through an analysis of political documents internationally turned, as well as conferences annals about digital agriculture produced by the World Bank, Food and Agriculture Organization of the United Nations (FAO), Organization for the Economic Cooperation and Development (OECD).

These organizations glimpse future food systems which prioritize food production maximization by technology. This vision reflects a long-term narrative about the role of technology in food systems innovation, which makes the controverted supposition that food production rise leads to improvements in food safety. Analyzing these digital agriculture future views articulated by FAO, OECD, and World Bank, writers presuppose that technologies take shape in complex social contexts and the predominant narrative is the one of digital technology as a solution to the long-term problem of food scarcity (LAJOIE-O´MALLEY et al., 2020).

However, the study by Perciun, Amarfii-Railean, and Nataliia (2020) present a positive and, at the same time, cautious scenery of technology implementation theme which extends to the agricultural midst. Juncture changes turned to agricultural production and management technologies must be accessible and meet some criteria, which include the one of economic viability. It still highlights that environmental accessibility is another factor to be considered, which must make rational ecological handling possible, reducing harmful substances concentration in soil. Human criterion is also emphasized once it results in employees' capability to use technology in the process of production and management, in high qualification presence, continuity of technical education, college, and continuing education.

Likewise, in Brazil, analyzing the main agriculturist's perception, the study by Bolfe et al. (2020) describes the Agriculture 4.0 use benefits are linked to productivity rise, more considerable potencial product sales, better planning, and production systems management. As a result, 95% of the agriculturists emphasized their wish to learn more about new technologies and strengthen their applications because 85% of the interviewed productors used at least one digital technology in their production system, and it is according to the technological complexibility, machines acquisition costs, equipment, softwares, and connectivity.

Therefore, it is argued Klerkx and Begemann (2020) that more attention is necessary to the inclusion and exclusion effects of Agriculture 4.0 technologies and to meditate on how they relate to varied ways of transitioning to agricultural and food sustainable systems motivated by innovation systems. Nowadays, the agricultural system has faced great challenges to sustainably feed a global population in growth, whereas it deals with large crises, like climate change, and resources ending. In meanwhile, there are significant advances in the areas of robotics, nanotechnology, gene technology, artificial intelligence, machine learning, energy generation, among many others.

These new technologies will lead to what commentaries call the 'fourth agricultural revolution'. It is noticeable that many countries have adopted approaches turned to missions in their agricultural innovation systems, bearing in mind future food systems and how they contemplate matters like food, nutritional safety, and environmental integrity (KLERKX; BEGEMANN, 2020).

Facing new technologies, there is artificial intelligence management according to Inshakova et al. (2020), which will allow mass production of exclusive industrial products by individual orders, based on the modified production process (with manipulators and robots help). Another advantage is the complex implementation of global aims in the sustainable development sphere. High-precision production (including nanotechnology) will allow resource expenses to be reduced in the industry. The attraction basis of this advantage is the intellectual production, to which human work (digital person) and machine (AI, robotics, etc.) will be used.

It must be concluded that the developed model of great distribution of human and mechanical labor force in Industry 4.0 intellectual production will allow to reducing disproportions in the efficiency of many business processes and in the development of many spheres of economy and growth rate of developed and underdeveloped countries. This explains its contribution to the balanced development of the modern global economic system (INSHAKOVA et al., 2020).

The industry 4.0 paradigm aims to integrate digital technologies into business processes to raise productivity levels and develop new business models. The study by Reis et al. (2020) investigates how the two domains of Industry 4.0 and precision agriculture are interconnected, analyzing the most used technologies in both fields in order to highlight common patterns and technological superposition. Results show how the two domains in the analysis are directly connected and describe the most important technologies to leverage when approaching digital transformation processes in the agricultural sector. Besides, belonging technologies to both domains allow us to represent these relations and identify how belonging technologies to Industry 4.0 paradigm are implemented into precision agriculture (RQ2).

In this sense, Monteleone (2020) discusses the elements which promote precision agriculture adoption in the Agriculture 4.0 context, approaching the agriculturist’s behavior and operations management, emphasizing the importance of knowledge and management from agriculturists so as to implement precision agriculture. Writers consider a result from this is Agriculture 4.0, through the conscient implementation of technologies.

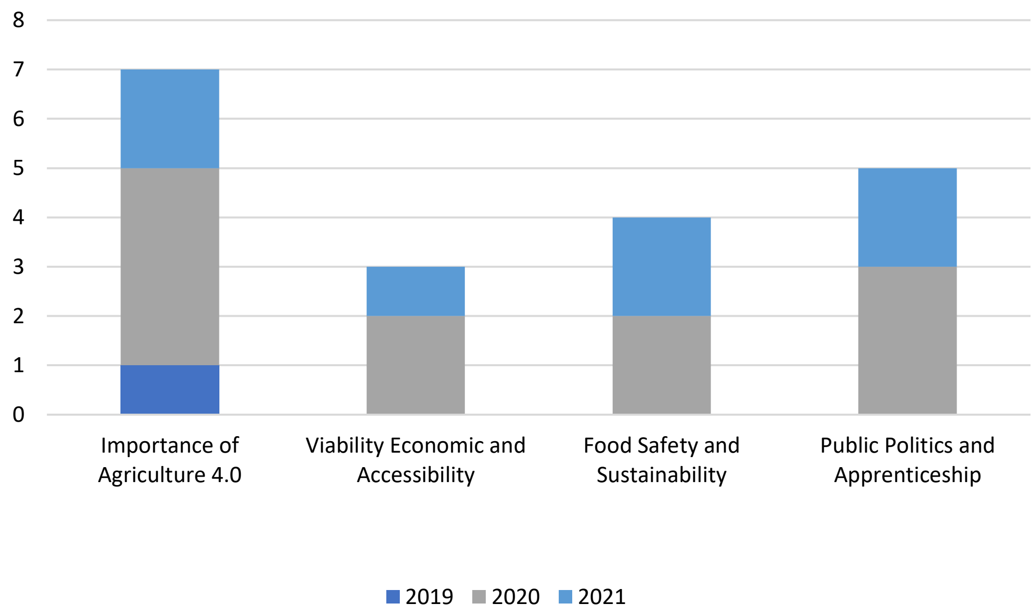
Nowadays, the Internet of Things (IoT) is already a mature technology, evidenced by successful large-scale implementation of this technology in agricultural production. However, the combination of this technology with others still opens many opportunities, enhancing even more the chances of adding value to the agricultural production chain. The study by Lima et al. (2020) exposes that the focus on innovation and technological developments for tropical agriculture has been a relevant factor for Brazilian agribusiness performance in the last decades. Next years, new challenges are to be expected to accelerate even more countryside digital transformation, starting with sectors such as agricultural machinery, which represents an important part of investments and operational costs in a high level of mechanization harvests.

Connectivity is an essential factor in the use of these technologies. Brazil faces a substantial challenge of habilitating connectivity in the country and remote areas. The immense territorial extension, scenery diversity, and balance between supply and demand in the current business models of internet suppliers’ service hinder the technical and economic viability to implement and operate a connectivity infrastructure with the necessary scope and quality. Technologies’ introduction may maximize profits and minimize costs through transparent information (LIMA et al., 2020).

Thus, it is necessary to encourage meditation from technology researchers and developers about present innovations and future potentials in agriculture digital technology, whether they are efficient and result in social consequences and negative ethics. The latest study by Lajoie-O'malley et al. (2020) reports results from a process of participative preview made with a varied group of scientists and engineers who work as a part of Digiscape, a research and development initiative of national importance in Australia's digital agriculture. The process of preview explored the future of digitalization mainly in agriculture, but not exclusively, at the end of agriculture production. Impacts on customers, retailers, distribution, and societies were also considered widely.

Each one of the scenarios showed that investment is necessary to build a capacity for future technology use. Access to the internet and infrastructure foundations are a central matter of equity and innovations that must be addressed. Actively learning with technology use is a key component. Digital innovations bring the capacity to better monitor farms with much lower costs. Results reflect the rise of availability and accessibility to technologies. Therefore, it is important to consider policies of access and control of data and information. Lastly, it is emphasized the importance of abilities and capacities development as crucial components (LAJOIE-O´MALLEY et al., 2020).

Graphic 1: Grouping of articles according to approaches presented in the selected studies



Source: The authors.

It is noticed in Graphic 1 that most of the studies about Agriculture 4.0 context knowledge about "Agriculture 4.0 Importance" (seven from twelve articles), "Public Policies", and "Learning" (five from twelve articles). Four studies approached the themes "Food Safety", and "Sustainability". Thus, according to Trendov, Varas and Zeng (2019), it is perceived it is noticed an advance in agriculture expansion and digital transformation process, even though there is a gap in researches with economically viable solutions, being necessary to include some intense and accessible manner small agriculturists and underdeveloped countries in this process, aiming production maximization and economic and social integration (GRIMBLATT et al., 2021).

Perciun, Amarfiian and Nataliia(2020) corroborate the thinking of 2020 new management models in sustainable technologies and, when reflecting on sustainable development, develop that these technologies develop new areas, still of production in an auxiliary area, even greater of the production while conserving soil and biodiversity. Trivelli et al. (2019) confirm in their results the connectivity between precision agriculture and the elements of Industry 4.0. The relationship between the two demonstrates the diligence of implementing technologies in rural areas and the development of all sectors of the chain.

However, really understanding what Agriculture 4.0 can lead to arouses attention in the studies discussed, which present the intensity of problems in the agricultural sector, including different climatic conditions, the need for innovation, and the lack of manpower, especially in small businesses. properties caused by migration, refers to the consequences of the problems and which contrast with the need to leave the countryside in search of better living conditions. (KLERKX, BEGEMANN,2020; PERCIUN, AMARFII-RAILEAN AND NATALIIA, 2020).

Although numerous studies understand digital transformation as the solution to the challenges that agriculture faces and although they consider it a transition to 'Agriculture 4.0' of great significance for the development and transformation of agrifood systems (TRENDOV; VARAS; ZENG, 2019; KLERKX; ROSE, 2020), Fleming et al. (2021) in their results observe different scenarios of the implementation of Agriculture 4.0, where it reproduces farmers who try to preserve traditional values with subsistence agriculture, because without available capital they cannot invest in technologies, having to adapt to low-cost solutions.

FINAL REMARKS

Agriculture 4.0 is understood by different technologies. The advancement of technologies was fundamental for its insertion. The objective of this research was to answer which technologies are used in agriculture 4.0, in addition to their impacts in different countries, and the results obtained through studies on the subject. Thus, it was verified that agriculture 4.0 has different technologies, with characteristics that depend on each location where it is inserted. While there are positive effects of inserting technologies in agriculture, such as increased productivity, there may also be disadvantages that small farmers may have compared to commodity producers. Therefore, the characteristics are different in each country.

It was observed that the culture and reality of each country are important and influence the use of agriculture 4.0. However, it is important to better understand some issues, such as the economic viability.

By understanding the main changes, it is possible to identify gaps, risks, and opportunities, propel new business models, adopt technologies, and finally change the economic, social, and environmental aspects facing the digital era elements. Thereby, aiming to identify which technologies are assuming an important role in countryside development, the present study contributes to agricultural production, pointing to convenient attitudes and technologies to solve one of the planet's greatest problems, population's future feeding.

In this context of insertion of such technologies, it appears that they tend to meet the demand of medium and large producers, especially those who work with large-scale production, an example of which are rural properties producing commodities or even integrated ones. It appears that these rural companies use high technologies, from software and applications for management and organization, to accurately check diseases and pests, as well as for nutritional monitoring of animals. They use the most modern agricultural and livestock implements, such as robots, to ensure greater efficiency and productivity, to mitigate climate change such as irrigation, or even genetic changes in plants and animals that are more resistant to the environment in which they are inserted.

However, this does not guarantee food security, nor does it guarantee that 4.0 technologies will end the world hunger that is rising, as the family producer does not have the same accessibility and knowledge to use them. Family farming tends to be resistant to technology 4.0, since many are "useless" to the rural property model that has family labor, little land area, precarious roads to transport production, lack of credit lines that allow investments in technologies that contribute to their production activities, which are generally diversified.

Nonetheless, efforts are needed so that Agriculture 4.0 can be inclusive to all rural properties of small or large-scale agricultural activities to feed the world population that has been increasing sharply. With the help of software, it is possible to identify specific deficiencies in exclusive areas. This makes decision-making more accurate. In the same way, when identifying a certain problem, it is possible that Public Policies are created with the purpose of meeting a specific demand, a fact that, consequently, may result in the reduction of transaction costs.

REFERENCES

ADHITYA, Yudhi et al. Feature extraction for cocoa bean digital image classification prediction for smart farming application. *Agronomy.* v. 10, p. 1642, 2020.

ANNOSI, Maria Carmela et al.. Is the trend your friend? An analysis of technology 4.0 investment decisions in agricultural SMEs. *Computers in Industry.* v. 19, p. 59-71, 2019.

ARORA, Dhruv. Demand prognosis of industry 4.0 to agriculture sector in India. *International Journal of Knowledge-based and Intelligent Engineering Systems*. v. 25, n. 1, p. 129-138, 2021.

BOLFE, Édson Luis. et al. Precision and digital agriculture: Adoption of technologies and perception of Brazilian farmers. *Agriculture.* v. 10, n. 12, p. 653, 2020.

CAROLAN, Michael. Digitization as politics: Smart farming through the lens of weak and strong data. *Journal of Rural Studies,* 2020.

CHAUDHARY, Sanjay; SURI, P. K. Framework for agricultural e-trading platform adoption using neural networks. *International Journal of Information Technology.* v. 13, p. 501–510, 2021.

CHUANG, Jui-Hsiung; WANG, Jiun-Hao; LIOU, Yu-Chang. Farmers' knowledge, attitude, and adoption of smart agriculture technology in Taiwan. *Int. J. Environ. Res. and Public Health.* v. 17, p. 7236, 2020.

FLEMING, Aysha et al. Foresighting Australian digital agricultural futures: Applying responsible innovation thinking to anticipate research and development impact under different scenarios. *Agricultural Systems.* v. 190, p. 103-120, 2021.

FRACAROLLI, Juliana Aparecida et al. Computer vision applied to food and agricultural products. **Revista Ciência Agronômica.** v. 51, 2020.

GRABHER, Gernot. Enclosure 4.0: Seizing data, selling predictions, scaling platforms. *International Journal for Sociological Debate.* v. 14, n. 3, 2020.

GRIMBLATT, Victor et al.. How to Feed a Growing population – An IoT Approach to Crop Health and Growth. *IEEE Journal.* p. 2156-3357, 2021.

HAIR, JR., Joseph. F. et. al. *Fundamentos de métodos de pesquisa em administração.* Porto Alegre: Bookman, 2005.

INSHAKOVA, Agnessa O. et al. The model of distribution of human and machine labor at intellectual production in industry 4.0. *Journal of Intellectual Capital.* v. 21 n. 4, p. 601-622, 2020.

KLERKX, Laurens; BEGEMANN, Stephanie. Supporting food systems transformation: The what, why, who, where and how of mission-oriented agricultural innovation systems. *Agricultural Systems.* v. 184, p. 102901, 2020.

KLERKX, Laurens; ROSE, David. Dealing with the game-changing technologies of Agriculture 4.0: How do we manage diversity and responsibility in food system transition pathways? *Global Food Security.* v. 24, p. 100347, march. 2020.

LAJOIE-O'MALLEY, Alana et al. The future(s) of digital agriculture and sustainable food systems: An analysis of high-level policy documents. *Ecosystem Services.* v. 45, p. 101183, 2020.

LEZOCHE, Mario, et al. Agri-food 4.0: A survey of the supply chains and technologies for the future agriculture. *Computers in Industry*, v. 117, may. 2020

LIMA, Gustavo Correa et al. Agro 4.0: Enabling agriculture digital transformation through IoT. *Revista Ciência Agronômica,* v. 51, p. 1-20, 2020.

MAIA, Rodrigo Filev et al. Irrisens: An iot platform based on microservices applied in commercial-scale crops working in a multi-cloud environment. *Sensors.* v. 20, p. 7163, 2020.

MARCONI, Marina de Andrade.; LAKATOS, Eva Maria. *Técnicas de pesquisa.* 6 ed. 3 reimpr. São Paulo: Atlas, 2007.

MARCONI, Marina de Andrade; LAKATOS, Eva Maria. *Fundamentos de metodologia científica.* 6 ed. 7 reimpr. São Paulo: Atlas, 2009.

MASNER, Jan et al. Creation, storage and presentation of information content - semantics, sharing, presentation, and archiving. *Research in Agricultural & Apllied Economics*.**.** v. 11, n. 1, 2019.

MONTELEONE, Sergio. Exploring the adoption of precision agriculture for irrigation in the context of agriculture 4.0: The key role of internet of things. *Sensors.* v. 20, p. 7091, 2020.

ORUMA, Samson. O.; MISRA, Sanjay; FERNANDEZ-SANZ, Luis. Agriculture 4.0: An Implementation Framework for Food Security Attainment in Nigeria's Post-Covid-19 Era. *IEEE Access.* v. 9, p. 83592-83627, 2021.

PALOMO, J.; FIGUEROA-DOMECQ, C.; LAGUNA, P. Mulheres, paz e segurança estado da arte: uma análise bibliométrica em ciências sociais com base na base de dados SCOPUS. *Cientometria.* v. 113, p. 123–148, 2017.

PERCIUN, Rodica; AMARFII-RAILEAN, Nelli; NATALIIA, Shveda. Industry 4.0 versus agriculture. Development perspectives of agriculture in the republic of Moldova by assimilating Digital Technologies. *Multidisciplinary Research Journal.* v. 12, n. 4, 2020.

REIS, Angelo Vieira dos et al. Technological trends in digital agriculture and their impact on agricultural machinery development practices. *Rev. Ciênc. Agron.,* v. 51, 2020.

RIJSWIJK, Kelly. et al. Digital transformation of agriculture and rural areas: A socio-cyber-physical system framework to support responsibilisation. *Journal of Rural Studies*. v. 85, p. 79–90, jul. 2021.

SEYMOUR, Ian. et al. Advanced solid state nano-electrochemical sensors and system for agri 4.0 applications. *Sensors.* v. 21, n. 3149, 2021.

SOTT, Michele Kremer. et al. Precision Techniques and Agriculture 4.0 Technologies to Promote Sustainability in the Coffee Sector State of the Art, Challenges and Future Trends.

*IEEE Access***.** v. 8, 2020.

SPECKA, Xenia. et al. The BonaRes metadata schema for geospatial soil-agricultural research data – Merging INSPIRE and DataCite metadata schemes. *Computers & Geosciences.* v. 132, p. 33-41, 2019.

TRENDOV, F. M.; VARAS, S.; ZENG, M. *Digital technologies in agriculture and rural áreas* - Status Report. Food and Agriculture Organization of the United Nations. Rome, 2019.

TRIVELLI, Leonelo. et al. From precision agriculture to Industry 4.0: Unveiling technological connections in the agrifood sector. *British Food Journal.* v. 121, n. 8, p. 1730-1743, 2019.

TRIVIÑOS, Augusto N. S. *Introdução à Pesquisa em Ciências Sociais*: a pesquisa qualitativa em Administração. São Paulo, SP: Editora Atlas, 1987.

VIEIRA, Valter Afonso; TIBOLA, Fernando. Pesquisa qualitativa em marketing e suas variações: trilhas para pesquisas futuras. *Revista de Administração Contemporânea*, Curitiba, v. 9, n. 2, abr./jun. 2005.