Integrated-Smart Agriculture

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Definition

The targets that smart agriculture tries to reach and respond to encompass not only the climate effects, but also other environmental factors as well as social and economic aspects linked with the life of farmers and rural communities all over the world. Hence, the concept of smart agriculture shall be expanded to include all these dimensions.

1. Overview

The innovative technologies developed in the different fields of science (nanotechnology, artificial intelligence, genetic modification, etc.) opened new and infinite possibilities for the several stakeholders that carry out their activities in the different economic sectors. For agriculture, these new approaches are particularly relevant and may bring interesting contributions, considering the specificities of the sector, often dealing with contexts of land abandonment and narrow profit margins. Nonetheless, the question in these unstopped evolutions is about the interlinkages with sustainability. In this context, the objectives of this study are to highlight the main insights from the available scientific literature about the interrelationships between the new trends in the agriculture and the sustainability. To achieve these aims, a search on the Web of Science Core Collection (WoS) and Scopus databases was carried out, on 15 May 2021, for the topics ‘smart agriculture’ and ‘sustainability’. A total of 231 documents (102 from WoS and 129 from Scopus) were obtained, remaining 155 documents after removing the duplicated, which were surveyed through systematic review following the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) approach. As main insights, the concerns of the researchers with the impacts on the sustainability from the transformations in the farming organization are highlighted. On the other hand, it was shown the relevance and the new opportunities, including in terms of food supply, arising from the precision agriculture, agricultural intelligence, vertical/urban farming, circular economy, internet of things, and crowdfarming. We suggest the new and wider concept of ‘integrated-smart agriculture’, better than ‘climate-smart agriculture’.

2. Agricultural Digitalization

The technological progress opens several opportunities for the different socioeconomic sectors, including the farming sector, in a perspective of smart agriculture, but brings, also, various challenges [1] threats that may compromise the sustainability of the development process worldwide. One example of this paradigm is the internet of things (IoT). The concept of IoT refers to the digital interconnection of everyday objects with the Internet, connecting objects instead of than people, allowing the intercommunication of data between sensors and digital controllers, for example. IoT is a set of networks which connect things capable of processing and communicating data between each other [2]. Hence, the IoT may contribute to increase the agricultural efficiency in the use of soil, water and energy (some agricultural resources where an efficient management is crucial); however, it also creates new risks associated with confidentiality and integrity [2].

In any case, the agriculture is faced with new challenges, such as the population rising, the urban agglomeration, scarcity of resources, climate change, and waste management. These tasks call for pioneering solutions. The technological development may play here a relevant and determinant role, namely with innovative practices associated with, for example, the vertical/urban farming, seawater and desert farming [3], as well as smart agriculture [4]. The literature highlights the relevance of the smart agriculture concept and practices to increase the sustainability in the farms. Smart agriculture practices are envisaged as the most appropriate adaptation strategies that will allow achieving food security, while at the same time being able to mitigate climatic changes. This is achieved through the preservation of

natural resources and sustainability of vital ecosystem services. Smart agriculture refers to a number of tools that help the management of agricultural resources and crop production. Smart agriculture is relating to the utilization of technologies such as the Internet of Things, sensors, geospatial location, robotics, and artificial intelligence.

Specifically, the artificial intelligence may be crucial for a more efficient use of the resources, but also, for a better disease and pest control, data analysis, productions' management and fill the gap between farmers and knowledge, allowing in this way higher productivities and competitiveness [5]. In general, the scientific community interlinks the artificial intelligence with sustainability and a more circular economy [6]. Potentialities of the artificial intelligence are referred for decades by the researchers [7]. The smart agriculture aims to promote more sustainability, increasing the farming productivity, dealing with the climate change implications and reducing the greenhouse gas emissions [8]. For these aims the artificial intelligence may bring interesting contributions, as well as, other new approaches and technologies, such as the IoT. In the current contexts of climate change [9], the innovation [10] is crucial to achieve sustainable development goals (SDGs) [11]. The agricultural institutions, namely the cooperatives, are fundamental to support the farmers in the process of agricultural digitalization [12] that is in course in the sector [13] in the different world countries. The cooperatives and the associations are important institutions in the farming sector, considering their proximity with the several agricultural stakeholders. To improve the sustainability in the agricultural sector through a smarter agriculture, the institutions (namely the associations and cooperatives) play a determinant role. The adaptability of farmers to the new technological demands might be difficult, especially for small dimension farms and family farmers. Hence the role of cooperatives might be of great help to connect them to the new technological demands. Other dimensions are related with the commitment of the farmers and the design of adjusted policy instruments to promote the adoption of innovative approaches in a sustainable perspective. Indeed, the agricultural policies and planning impact significantly the structure of the farms and the evolution of the sector, namely in the European Union through the CAP (Common Agricultural Policy). In fact, the CAP is the main driver of the European farming structures, including in the sustainability dimensions [14].

In parallel to this process of agricultural digitalization to promote smarter and sustainable farming practices, the public institutions should be able to implement strategies that increase the organization of the sector, improve the sills of the farmers and encourage the technological transfer from the scientific community to the farms and the sector. The organization of the sector and the skills of the farmers are, indeed, determinant for a more sustainable farming development [15]. These three dimensions will be crucial for an effective modernization of the agricultural sector in a perspective of a more sustainable development.

In this perspective, the main objective of this study is to highlight the main relationships between the smart agriculture (modern agricultural practices based on the new technologies, such as the IoT [16], that combine scientific research and innovation) and the sustainability (capacity to meet the present needs without compromise the future generations [17][18]). In practice the main question here is the following: what are the main relationships between the smart agriculture and the sustainability? Is the concept of 'climate-smart agriculture' (CSA) in general considered in the scientific literature sufficiently broader to capture the several interrelationships among the smart agriculture and the sustainability? CSA is a concept introduced by FAO (Food and Agricultural Organization) in 2010 and is known as the "triple win" approach [19]. CSA is an approach to the management of landscapes with the purpose of adapting crop and animal production to the climate changes originated by the human action on the planet. However, some researchers argue that the CSA concept is a narrow approach about the current farming contexts and a broader statement [20], involving interdisciplinary dimensions [21], and using recent sustainability indicators [22] is needed. For that, a systematic literature review was carried out based on the PRISMA approach and on a preliminary bibliometric analysis. The PRISMA statement consists on a checklist with several items and on a flow diagram with few phases [23]. PRISMA is used as a guiding methodology for conduction reviews, in many fields of science, however with some degree of subjectivity. In fact, the scientific research involves always decisions that depend on the authors' perspective. Nonetheless, in

order to deal with this subjectivity the PRISMA statement suggests transparency in the description of the decisions made. The literature review reveals that there are not many studies (or none) that consider the topics here addressed jointly with the PRISMA approach or bibliometric analysis, highlighting the novelty of this research.

3. Conclusions

The main conclusions point out to the necessity to face the present and future challenges of the agricultural sector in a more effective way and making use of the technological possibilities that smart agriculture brings. The challenges linked to providing food to the growing world population while at the same time guaranteeing the sustainability of food supply chains must be addressed and looked at as new opportunities to use technology to the service of mankind and the planet. The efficient use of resources, the improvement of the input/output balance of agricultural systems, the mitigation of climate change effect or the socioeconomic impact over rural populations, all are, but not exclusively, part of this global approach. The conceptualization of an integrated approach where all aspects of the problem are included is urgent and therefore we are led to suggest that the somewhat limited concept of climate-smart agriculture could be expanded to a broader concept of ‘integrated-smart agriculture’.

In terms of practical implications, the main insights obtained with this research suggest a more effective involvement of the stakeholders in the processes of decision and design of agricultural policy instruments. The participation of the women may be important, considering their concerns with the sustainability and the wellbeing of the family members. In these contexts, the contributions of the different institutions are determinant, specifically through services of extension to involve and support the farmers. Educational programs and vocational training courses are also determinant for an effective implementation of the Integrated-Smart Agriculture practices.

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Keywords

agriculture;new technologies;sustainability;systematic review;PRISMA