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# How Technologies are Working in the Coffee Sector

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**Abstract.** The world's population is estimated to exceed 9 billion people by 2050. A rapid and safe increase in food production associated with the use of agro-industrial technologies is necessary. The aim of this article is to investigate the use of technologies in the coffee sector. Recognizing the need for a concise and accessible source of literature to disseminate the findings about the coffee sector regarding new technologies. It collects abstracts of articles from 2017 up to 2022 systematically raising important issues to be studied. The coffee sector brings proposals on the use of different technologies and how to use them. A gap is evident for studies. The quality of the grains is emphasized, but no studies which corroborate to the competitiveness of the segment are presented. The results suggest investments in the agro-industrial sector to promote competitiveness and offer products with higher quality and competitive prices.

**Keywords:** Coffee, 4.0 Industry, Market Competition

## 1 Introduction

The United Nations estimates that by 2050 the world population will exceed 9 billion people [1]. Therefore, it is necessary a quick and safe increase in food production [2]. It leads to the use of technologies which are essential for farmers who have as their only source of income their agricultural crops.

A challenge faced by the agricultural sector is the climate conditions which affect production and cause environmental changes. To monitor environmental variables and create large database is of paramount importance for producers to make assertive decisions. In this sense, Smart Farming (SF) is considered by several authors to be the best solution for data-driven monitoring and decision-making issues. It is the use of information and communication technologies to identify, monitor, analyse and represent the characteristics of agricultural production and support decision-making [3, 4].

Wolfert et al. [5] proposes a flexible architecture for the management of agricultural chains. Popović et al. [6] presents a private platform for IoT which meets different stakeholders. Colezea et al.[7] feature a cloud web service platform which improves product quality and stimulates agricultural business development.

In the coffee sector, there is an effort to monitor climatic conditions which affect harvesting. The grain harvest is done in months of drought, preferably not on rainy days. Excess water can deteriorate the grain. In Brazil, it is common to use adapted technologies which help small producers during plantations and crops. Large producers, who are in the minority, have access and structure to use specific machinery.

Another point is the use of technologies aimed at grain processing. The processing phase consists of sorting and separation for transferring to the coffee industry afterwards. At this stage, the grains will be prepared for roasting in the industry. Grain roasting guarantees all grain qualities. There are not many reports on the use of available technologies in this segment.

To fill this gap, this article aims to investigate the use of technologies in the coffee sector. It is recognized the need for a concise and accessible source of literature to disseminate the findings about the growing knowledge in the coffee sector according to new technologies. This review brings together abstracts of articles from different sources in a systematic way, and presents the chosen ones as having relevance in the coffee technology sector.

## 2 Methodology

This review was provided as follows using articles between the years 2017 and 2022:

1. Literature Search: Indexed databases were used as Science Direct, Emerald, Web of Science, Taylor and Francis and others. Articles were selected in English. Terms such as drones, IoT, Big Data, Blockchain, artificial intelligence, Cloud and cloud computing associated with agribusiness were used;
2. Article screening: The titles and abstracts of the articles selected were based on their relevance to the subject and technological innovations used. Articles related to the studied pillars were included to show the scenario. Therefore articles dealing only with technologies were excluded;
3. Full article review: The articles chosen were summarized, highlighting the main findings and strengths of each one, so that it was possible to present an overview of the sector.

## 3 Literature Review

### 3.1 Smart Farming

Smart farming or precision agriculture covers the use of new agricultural technologies which emerged at the beginning of the fourth industrial revolution to increase quantity and quality of production, minimizing environmental impact and increasing food safety [8, 3, 4].

It consists of applying personalized treatments to each portion of production area to get the most out of it. Some technologies stand out : drones, IoT, Big Data, Blockchain, artificial intelligence (AI), Cloud and cloud computing [8].

Drones are remotely commanded aircrafts of various sizes. They are used for image capture, image transmissions, object delivery and fun [9]. In the agricultural environment, they facilitate the supervision of farms, can cover hundreds of hectares in a single flight, gather images from different angles and collect a wide variety of information of land conditions, need to irrigation, crop growth and possible pathogens [10].

Big Data is a huge collection of online databases, to be used anywhere in the world and for different purposes[11]. Farmers can manage the information obtained by drones, IoT and other measurement instruments and integrate them with historical farm information and weather data in order to optimize production steps [12].

Blockchain is a network of distributed information records that change through encryption-protected transaction blocks and cannot be changed or deleted after their verification [13]. Technology makes it possible to monitor growth crops delivery to suppliers, improving supply chain traceability[14].

Artificial intelligence has potential to modify the way organizations operate. It goes beyond mechanical automation, encompassing cognitive processes which generate learning capacity. This system is capable of performing repetitive, numerous and manual activities and also performs activities that require analysis and decision making [15, 16]. In agriculture, artificial intelligence and robotization are used in interpretation of field images and in application of fertilizers and pesticides with surgical precision or to deal with weeds [15].

Cloud transforms the IT framework into software which performs tasks on the computer. It is possible to connect it to a structure over Internet and use its resources without having to install resources on physical equipment [17, 18].

### 3.2 State of the Art Smart Farming in Agricultural Sector

Here, some papers on the technologies used in the agro-industrial sector which are considered part of Industry 4.0 are presented.

A field-focused study on Agro-gain brings an end-to-end platform for data-driven agriculture, collecting data from different sources such as drones, cameras, and sensors. It uses weather forecasts to click work of different components of base station [19].

Another point is the study on the implementation of industry 4.0 strategies in companies, enabling them to improve efficiency and keep growing in face of international competition. It was a survey via mail to collect information about people's knowledge about technologies in the primary products industry in the case of wood. The knowledge of technologies is low. The main limiting factor for implementation of technologies is lack of skilled workers, outdated facilities and unclear financial benefits [20].

Use of smart farming for sustainable agricultural systems is a competitive advantage for farmers, extension services, agribusiness, and policymakers. Other authors claim to be the best solution, but do not bring recommendations on how to elect the best and most appropriate IoT technology and do not provide options for managing IoT. This study brings the implementation of a Smart

Farming System based on three layers (Agriculture Perception, Edge Computing and Data Analytics). SF increases farmers' profits by improving product quality; coffee value chain model provides usability and farm management; data analysis favors implementation of machine learning algorithms; Edge Layer is able to detect discrepancies by avoiding use of unreliable data; Perception Layer compares technologies by performance, usability and price [2].

Carraro et al.[21] bring a study on the applicability of terms of industry 4.0 in Brazilian agribusiness, ascertaining whether its use can be a mechanism for reducing production costs.

This review shows the trajectory of industrial and agricultural revolution, analysing challenges faced by agriculture along supply chain, to allow implementation of industry guidelines 4.0 and how to improve these techniques to be relevant to agricultural sector [22].

The article brings a systemic vision on how to learn to manage all processes that characterize agricultural chain from production to sale to the final consumer. It investigates the use of digital technologies to boost agribusiness supply chain [23].

Colezea et al.[7] comes up a web service platform based on cloud. It increases quality of products and supports development of agricultural businesses. It is related to providing detailed information to elect the most appropriate IoT technology, IoT infrastructure management and agricultural production estimation.

Strozzi et al.[24] puts on scene an overview of scientific literature on the concept of smart farming, which remains in focus in academic and professional environment due to innovations in manufacturing sector.

Rodríguez et al. [25] bring an estimate of coffee production based on computer vision techniques that deal with rust, a disease that affects plants, but smart farming techniques are not implemented because there are few sample data.

Kouadio et al. [26] proposes an extreme learning machine model to analyze soil and its fertility properties with the intention of generating an accurate estimate of robust coffee production based on environmental, climatic and soil fertility conditions.

Bergier et al. [17]bring the use of a cloud mobile app. This connects landowners and slaughterhouses; it is a point-to-point network. They bring the perspective that livestock farming is associated with unsustainable land use and climate change. Moreover, the use of geolocation and traceability can promote sustainable meat markets. A digital market has been designed to produce reliable data, generating big data. This big data analysis has potential sustainability compliance.

Debauche et al. [27] bring the perspective that smart farming is at the origin of producing a large amount of data that must be collected, stored, and processed quickly. For processing to be performed, a specific infrastructure \*which uses adapted IoT is needed. They offer a comparison of Central Cloud, Distributed Cloud Architectures, Collaborative Computing Strategies, and new trends used in the context of Agriculture 4.0.

Guo [28] understands that knowledge of agricultural cycle of current agribusiness is concerned with information, veracity, and perspectives. With the use of IoT, innovations quickly overhauled all sectors, including smart agribusiness, transforming their business. It provides the description of remote sensor and functions of Horticulture IoT and how to handle applications related to remote sensors experienced in agriculture.

Sreeja et al. [29] show that IoT is moving forward with various technologies to renew agriculture and increase crop efficiency and yields. They focus on an IoT-based crop monitoring system with three sensors, a WiFi module and a DC engine that measure and display the different parameters for the crop, promote intelligent agricultural monitoring by providing water and air to the system. It provides real-time assistance to farmers using an IoT platform.

Relf-Eckstein et al. [30] have the prospect that a new smart agricultural future is created as digital technologies meet with agriculture. It's a case study on an intelligent agricultural innovation of machines used in conservation crops. They find that knowledge and experiences of agriculture, coding skills and robotics generate innovations in problem solving. However, there is still a lack of evidence, mechanisms for assessing environmental and social benefits/risks.

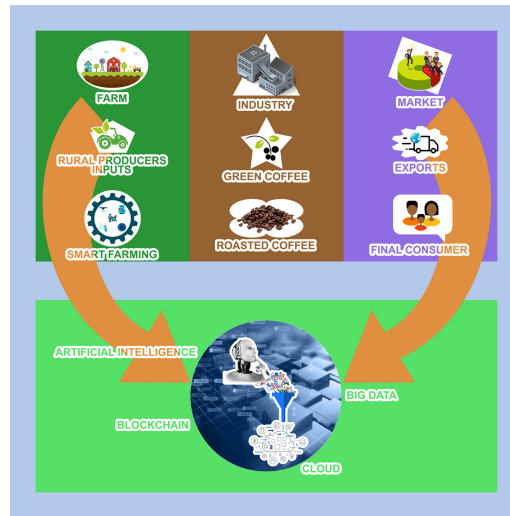
## 4 Results and Discussion

Figure 1 presents an overview of the scenario of the coffee bean production, industrialization and commercialization.

In Figure 1 it is possible to observe that in the first phase of production, the "Farm", the agricultural sector is influenced by Artificial Intelligence, Blockchain, Big Data and Cloud technologies. The same influence is perceived in the third phase "Market" of marketing. It is noted that the processing in the "Industry" phase is not influenced by the technologies used by the sector. However, these technologies could be used to increase the competitiveness of the sector.

The use of technologies significantly impacts the agricultural sector [28, 29]. It allows a controlled and monitored production, with correct use of pesticides and quality assurance. Consumers are increasingly concerned about environment. One way to minimize impacts and optimize results is to worry about shape of the planting and how this production was cultivated. In this sense, technologies such as drones, cameras and sensors which monitor and collect data for upcoming plantations stand out [19, 2, 7, 26–29]. A different view is brought to this study. It uses computational techniques to predict coffee production and possible pests but reinforces that these techniques are not used because there are few sample data [2]. The producer who perceives this new niche stands out and has advantage over others.

Investment in technologies is still an obstacle for small producers and beneficiaries. In general, coffee sector is made up of family producers and for producers to invest a large amount is not always an option. Public policies are necessary for agro-industrial coffee sector to transform Industry 4.0 and im-



**Fig. 1.** Technologies that may influence the coffee bean production, industrialization and commercialization

prove its competitiveness in the sector. A study shows that the applicability of Industry 4.0 can be a cost reduction mechanism [21].

Another important issue in the coffee segment is the scarcity of labor due to seasonal production and poor qualification of workers. A differential in the sector would be the use of technologies to monitor coffee production together with other crops for better utilization and adequacy of soil nutrients. In addition to investments in new technologies, producers should also qualify professionals who will make use of these technologies.

It was observed that most of the studies found are related to the use of technologies in the field and that the industry which benefits coffee beans do not suffer the same influence. Few works address Industry 4.0 technologies in the primary products industry. Legg et al. [20] brings a study on the subject and finds that about 77% of the surveyed group does not recognize the terms Industry 4.0 or Smart Manufacturing. Another review presents considerations on how technological development affects industry and agriculture in different ways but does not bring recommendations on how to apply such resources in practice [22].

## 5 Final Remarks and Outlook

This work aimed to explore how technologies that are part of Industry 4.0 work in coffee agro-industrial sector. A literature review showed an overview of the sector and brought important issues that inspire further studies.

The coffee agricultural sector has significantly contributed for studies. It brings some proposals on which technologies could be used and how each of



them could help during plantations and crops. The coffee industry has a gap for studies. The sector that emphasizes the qualities of grains does not present studies to improve its competitiveness and keeps doing its work without major innovations. One exception is the coffee industry in capsules, which is a specific market and differs from the proposal of this study.

Investments in the agro-industrial sector are needed in order to the sector to be competitive worldwide and to offer the consumer, who is increasingly demanding, a quality product with a better price. For future work, technical visits are suggested in the coffee bean processing industry to score the key points and propose the use of technologies that meet Industry 4.0.

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