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A Systematic Literature Review on Impact of Industrial Revolution 4.0 in Indonesia's Agriculture Sector

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Abstract

Technology always plays a significant role for humans in simplifying and optimizing tools and ideas to solve problems. When the first society was created began with foraging and livestock, the population increased. The Industrial Revolution 4.0 significantly impacted agriculture at the country level in a tolerable and understandable way. This paper aims to assess the implementation of preparation IR. 4.0 in Indonesia achieved its objectives or could be optimized. The previous research was in general and mainly focused on technological factors. . Indonesia is the fourth most populous country globally, and many of its citizens depend on their livelihood from the agriculture sector (Badan Pusat Statistik / Central Bureau of Statistic, 2021). Based on the national policy of Making Indonesia 4.0 and programs implemented in The Ministry of Agriculture, This research employs both quantitative and qualitative methods. A systematic review was conducted to check published articles regarding the topic from Food and Agricultural Organization (FAO) and Indonesian Governmental Institutions. To fully understand the topic, four research sources were used to find relevant data published between 2000 and 2021. The inclusion criteria were related to the IR 4.0 impact on the agriculture sector, original research, and published in English. Thirty articles have met the criteria. The findings have shown that IR 4.0 has revolutionized agriculture to become Agriculture 4.0, and various innovations are taken to increase the productivity of food production. Applications also built a stepping stone but yet worked for one purpose only.

Keywords
Industrial Revolution 4.0; Agriculture 4.0 Indonesia

I. Introduction

Technology always plays a significant role for humans in simplifying and optimizing tools and ideas to solve problems. When the first society was created began with foraging and livestock, the population increased. They build factories with intensive labor and more advanced technologies (Federico, 2005). The world population will reach 8.5 billion in 2030, based on the United Nations prediction in 2019. Meanwhile, there are critical issues concerning food security. The rise of the population will try to live from the agriculture sector, climate changes that affect on-farm agriculture, and over-exploited water scarcity (FAO & WWC, 2015).

Technology was used to increase productivity while facing limitations mentioned before at the same time. With the invention of electricity, Robots, Artificial Intelligence (AI), the industrial sector reached its status as Industrial Revolution 4.0 (IR 4.0). The Phenomenon changes all sectors, including agriculture. The agriculture sector evolved into Agriculture 4.0. The transformation is being carried out in many countries.

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Many researchers have shared their findings of IR 4.0 and agriculture in different ways. The previous research was in general and mainly focused on technological factors. Indonesia is the fourth most populous country globally, and many of its citizens depend on their livelihood from the agriculture sector (Badan Pusat Statistik / Central Bureau of Statistic, 2021). Based on the national policy of Making Indonesia 4.0 and programs implemented in The Ministry of Agriculture, this paper will try to answer three research questions (RQ's) as follows:

1. RQ1: What are the impacts of Agriculture 4.0 on the agriculture sector?
2. RQ2: What are the steps taken by the Ministry of Agriculture in Indonesia to prepare for Agriculture 4.0?
3. RQ3: Is the step taken effective and efficient to achieve organizational purposes?

II. Research Method

This research employs both quantitative and qualitative methods. In order to gather data accordingly with the systematic review standards offered in (Alleman, 1990) (Chin, 2006) and (Machi & McEvoy, 2016), the authors searched for sources of Information in various portals in Science Direct, IEEE, Sage, FAO, and Indonesia Government Institutions. The keywords used in the quest are "Industrial Revolution 4.0" and "Agriculture," also documents and articles published from 2000 until 2021. The search came with 60 articles and then filtered. Based on Petticrew and Roberts (2008) sequencing method using "Hierarchy of Evidence" with a systematic review and meta-analysis on titles and abstracts, the final results are up to 18 articles.

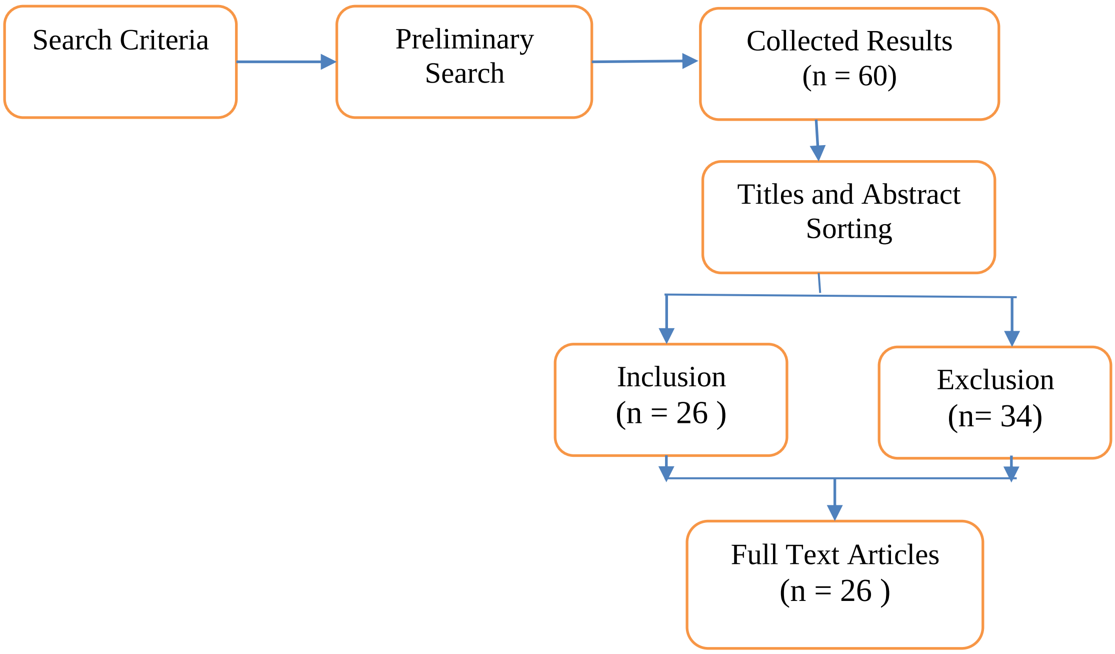

Figure 1. *Flow Diagram for systematic review*

III. Results and Discussion

3.1 Industrial Revolution 4.0

The rise of technological advancement was changing manual labor by hand and livestock to factories in the Industrial Revolution 1.0 in the 17^{th} century. After the invention of electricity which upgraded into Industrial Revolution 2.0 in the early 19^{th} century. Adding Computer systems and Robots to make autonomous and rapid production evolves to become Industrial Revolution 3.0 in the 1970s. In 2011, Klaus Schwab devised IR 4.0 in The World Economic Forum at Hannover Fair in Germany (Klaus Schwab, 2016). The differences between IR's can be seen below:

Table 1. History of Industrial Revolution

No	Subject	Year	Locus	Keyword	Tools
1	Industrial Revolution 1.0	1760 – 1840	England	Mechanization	Factory, Steam power, weaving loom
2	Industrial Revolution 2.0	1900 –1920	America	Mass Production	Electric Engine
3	Industrial Revolution 3.0	1960's	America, Japan	Automation	Computers, Electronics, Robot
4	Industrial Revolution 4.0	2011 – until now	Hannover Fair, Germany	Interconnected	Augmented Reality (AR), Artificial Intelligence (AI), Internet of Things (IoT), Big Data, Cloud Computing, Integrated System, 3D Printer, NanoTech, Biotechnology, Material Science, Advanced Robotics

Source : (Klaus Schwab, 2016)

Smart factories are made with combined functions of the Internet of Things (IoT), Big Data, Sensors, and Artificial Intelligence (AI). Those smart factories exist in every sector of life, such as social media, transportation, education, etc. It was supported with the existence of smartphones which send data of mobility, interest, and others. The process produces Big Data. Laney (2001) has done research on Big Data that contains three V's. Data Velocity is the speed of point-of-interaction (POI), Data Variety is the type of profiling data, and Data Volume is the quantity of the interactions (Laney, 2001).

The research then was developed by Patgiri and Ahmed (2016), which finds the V family ($V_3^{11}\ C$). Which are (1) Variety, (2) Veracity is the accuracy data; (3) Validity is the data that have worthiness, (4) Value is the sets of data that give worthiness, (5) Visibility / (6) Visualization is data ability to be shown, (7) Virtual is data efficiently and effectively to be managed in a virtual process, (8) Variability / (9) Volatility is the sudden changes of data, (10) Vendee defines the client size is associated with the big data, and (11) Vase is the receptacle that holds the data. Complexity is the pure form of a computational term. The term volume is redefined into a) Voluminosity is the size of the volume, b) Vacuum is data without volume, and c) Vitality is the activity of the data (Patgiri & Ahmed, 2016).

The rise of IR 4.0 brings opportunities and threats to the world. For example, the world witnessed the birth of new kinds of professions like data engineers. But ethics on data collection also carry concerns such as privacy, anonymity, transparency, trust, and responsibility. This includes lifecycle data, from collection to curation to manipulation and use (Klaws Schwab & Davis, 2018).

3.2 Agriculture Impacts

The combination of agriculture and digitalization has made a significant impact. As stated by Fielke et al. (2020), digitalization has made a turning point in the agriculture sector. Agriculture 4.0 is an integrated set of innovations spanning precision agriculture, IoT, and big data. This is intended to produce agricultural products and achieve greater production efficiency (FAO, 2020). The process has made the interconnectivity between humans and technology increased. It also increases transparency between agricultural stakeholders, such as farmers, government, and consumers. The IR 4.0 has made data sharing in the agricultural sector evolve to Agriculture 4.0 (Spanaki et al., 2021). The origin of Agriculture 4.0 is the development of ICT in agriculture, which develops into Precision Farming, Digital Agriculture, Smart Farming (Klerkx et al., 2019). Sensors, such as position, pressure, flow, temperature, and force, help create better decisions (Haleem et al., 2020).

Technological advancement influences the transformation of agriculture that happened at the periods. After industries flourished, agriculture also began to thrive. The development phase can be seen below:

Table 2. Phases of Agriculture Technology

No	Subject	Year	Keyword	Tools
1	Agriculture 1.0	1784 – 1870	Traditional Agriculture	Simple tool and manual labor
2	Agriculture 2.0	1901 - 2000	Mechanized Agriculture	Resources inefficient use
3	Agriculture 3.0	1992 – 2017	Development automatic agriculture	Low level of intelligence
4	Agriculture 4.0	2017 – until now	Smart Agriculture	Data Sensor, Autonomous Tractors, Smart Soil fertilization, spraying and irrigation, disease prediction and detection, vertical farming

Source : (Yang et al., 2021)

The progression in Agriculture 4.0 has many benefits. Vertical and smart farming increase production in a small area and limits land and water resources, such as urban farming. The sensor is used to support the technologies to better supply chain management to make better decisions (Lezoche et al., 2020). The implementation of Agriculture 4.0, besides increasing productivity but also adds value by reusing materials for animal feed production or an energy generator (Braun et al., 2018). As a result of implementing

Agriculture 4.0 in the food industry, now there are innovations such as lab-grown meat (Galanakis et al., 2021).

Some countries in Asia have started to adopt IR 4.0 into their agriculture policies. Thailand 4.0 began in 2016, involving the agriculture sector in a value-based economy (Kohpaiboon, 2020). In 2018, The Malaysian Government established "Industry 4WRD: National Policy on Industry 4.0 Policy to increase agricultural productivity after the industrial sector (Tambi & Dardak, 2020) and (Bujang & Bakar, 2020).

The Indonesian government has set Indonesia 4.0 policy as a national policy to use IR 4.0 to increase government growth. The policy focused on five sectors with regional competitiveness like food and beverages, textiles and apparel, automotive, electronics, and chemicals (Ministry of Industry Republic of Indonesia, 2018). Agriculture is the primary raw source for the food and beverages industries.

In line with the national policy, The Ministry of Agriculture has implemented in the Minister of Agricultural Decree No. 259/Kpts/RC.020/M/05/2020 about Strategic Plans of The Ministry of Agriculture of The Republic Indonesia Year 2020 - 2024 acknowledges IR 4.0 as potential impact (Ministry of Agriculture Republic of Indonesia, 2020). Since the 2000s, the MoA has made applications to optimize their work for internal and external purposes. Until 2021, 808 applications have been made, and some have been deactivated. From that number, 399 applications still exist. The application was made from 11 departments in MoA, which are shown below:

Table 3. Application in The Ministry of Agriculture of The Republic of Indonesia

No	Working Unit	Quantity
1	Secretariat General	124
2	Directorate General of Agricultural Infrastructures and Facilities	15
3	Directorate General of Food Crops	19
4	Directorate General of Horticulture	26
5	Directorate General of Estate Crops	23
6	Directorate General of Livestock and Animal Health	51
7	Inspectorate General	13
8	Indonesian Agency of Agricultural Research And Development	49
9	Agency for Agricultural Extension and Human Resources Development	29
10	Food Security Agency	11
11	Indonesia Agricultural Quarantine Agency	32
12	Others	7
	Total	399

Source: https://katalogapp.pertanian.go.id/dashboard

The function of the application can be deferred to four section as shown below:

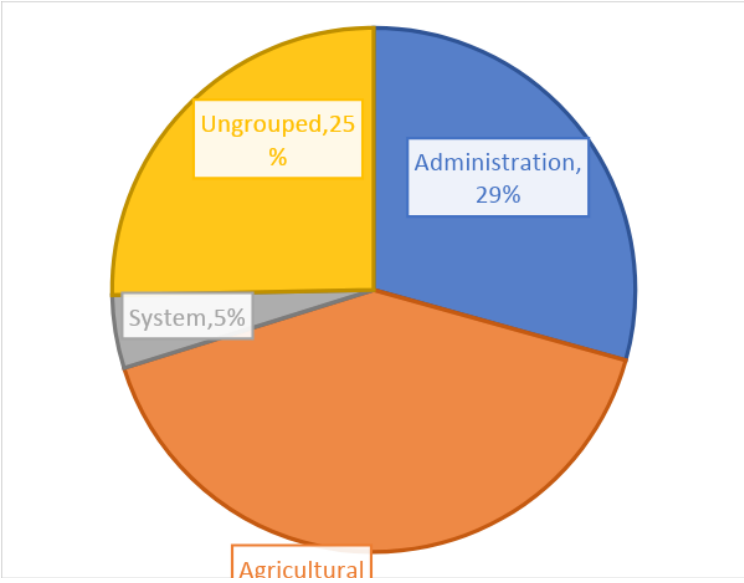

Figure 2. *Application by Function*
Source: https://katalogapp.pertanian.go.id/dashboard

The data above shows that 25% or 111 applications from 399 applications are not grouped based on their function. Based on the application, users can be divided into external and internal. The internal user is from the organization itself. Meanwhile, the external users are from Central and Local Go farmers, industries that need input from agriculture materials, foreign Non-Governmental Organizations (NGOs), International Organizations, and Countries as working partners. The type of users can look at below:

Table 4. Type of Application Users

No	User	Stakeholder	Purpose
1	Internal	Ministry of Agriculture	Distribute man, money, material and making policy internally
2	External	Government	Providing agricultural inputs and policy
		Industry	Provide raw materials
		Farmers	Training Requests
		People	Fulfilling the demand for food products and other agricultural products
		National and Foreign Educational, Government and Organization	Cooperation and Information about agricultural related issues

An interview with the Data and Information Center administrator was also conducted. It was about the purpose of the application, and it's only focused on one function, such as Kartu Tani to provide subsidized fertilizers, PasTani for Farmers' Markets, Agricultural Protection for Agricultural Insurance, and many others. To develop one application will take months of planning and funds, therefore it is very expensive. The interview also informs that the application only will be disabled after there is a request from the department users. The authors also find no or limitless coordination between departments if the business overlays between 2 departments or more such as Database Farmland Application (Directorate General of Estate Crops) with Registration FarmLand

Application (Directorate of Horticulture). Furthermore, there is no coordinator between the programs administered to achieve organizational goals. The purposes of The MoA are (1) Increasing food security, (2) Increasing agricultural added value and competitiveness, and (3) realization of the bureaucratic reform of the Ministry of Agriculture.

The MoA has built coordination centers called Agricultural War Room (AWR) in the Agriculture Training Center (ATC) that uses state of the art ICT. In addition, they encourage young farmers by giving training and coaching through the ATC across Indonesia. They have started with research to produce autonomous tractors, seeding drones, and Smart Farming projects in the Indonesian Center for Agricultural Engineering Research and Development.

IV. Conclusion

Research on IR 4.0 is not something new. Therefore, the authors recognize the limitations of this review. Firstly, the selected article might not be internationally indexed. In particular, the paper discusses the impact of IR 4.0 on the agriculture sector in Indonesia. Secondly, the selected search word might have all been comprehended for the literature review. Lastly, the tracing process could open a way for the author to bias.

In summary, the Industrial Revolution 4.0 has influenced the agriculture sector to transform into Agriculture 4.0. The Revolution has made agriculture projects more productive, added value, and innovations that could not achieve without IR 4.0. Indonesia has caught up with other countries that have implemented Agriculture 4.0. The Ministry of Agriculture implemented applications related to Agriculture 4.0 before IR 4.0 was formally initiated. Even though it lacks the coordination to achieve organizational purposes.

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