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Farming Of The Future: How Tech Companies Triggers a Farming Revolution

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ABSTRACT

Advances in technology in communication currently have a significant change throughout all sectors. Agriculture especially in Indonesia has a big potential to apply this 4.0 technology that will drive a significant output and productivity in crops production. The world's population is projected to rise from 7.4 billion currently to 8.1 billion in 2025, according to the UN's Food and Agriculture Organization. The UN food agency's latest annual agricultural outlook, produced alongside the OECD, forecast that 80% of the increase in crop output needed to feed this population would come from yield improvements. The main idea of this paper is twofold: the first one is to Understand how agriculture 4.0 could take place and improve the productivity of a crops production with a descriptive approach. And the second one is to Understand what the gaps of Indonesia as 3rd are ranked rice producer in the world to deploy the agriculture 4.0.

INTRODUCTION

Agriculture has played a significant role in human history, providing food, fiber, and other essential resources for the survival and well-being of communities. Over the years, agricultural practices have undergone several transformations, driven by technological advancements and the changing needs of society. Industry 4.0 or the fourth industrial revolution has brought new changes in agriculture which are commonly referred to as Agriculture 4.0. Agriculture 4.0 no longer relies on the application of water, fertilizers, and pesticides across the land. However, farmers use very specific targets and the minimum amount needed and farming is possible in arid areas where abundant and clean resources are utilized such as sun and sea water. Technological advances such as temperature, humidity, automatic devices, machines, robots, GPS and information technology cause agriculture and agricultural operations to be run very differently. Precision farming and advanced devices and robotic systems will enable farming to be more efficient, safe, environmentally friendly, and profitable.

Indonesia in the other hand is one of the biggest producers of crops, especially rice, corn, and cassava. As a country that depends on the agriculture, Indonesia indeed has a potential of technology application. The adaptation of technology in Indonesia especially in agriculture is least compared to another developing countries. Indonesia mainly relies on a manual labor, conventional technology, manual activities, and interpretation that happens to cause an inefficient process across the cultivation cycle.

Despite the potential benefits of Agriculture 4.0, its implementation faces several challenges. These challenges include the high cost of technology adoption, limited access to digital infrastructure

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in rural areas, and concerns around data privacy and security. Addressing these challenges will require a collaborative effort from stakeholders in the agricultural sector, including farmers, technology providers, policymakers, and researchers. Investment in machine plays the least amount of significancy compared to the preparation in the land field itself. Thus, causing a major problem in technology adaptation. For examples, the land profile that causing a trouble on machine operation, minimum technology infrastructure in a pilot area that mostly produces highest crops output. For that in this paper will present an overview of Agriculture 4.0 review in Indonesia.

METHODS

Research and development (R&D) in agriculture in investment is closely related to agricultural productivity growth and rural poverty reduction. Investment in technology is important for food availability and access shown in global research on the relationship between R&D and productivity (Muller, 2020). Investment experienced a shortage in the agricultural sector. FAO estimates $83 billion of additional investment is needed to feed more than eight billion people by 2025. Some countries rely on imports for more than half of their food supply (Basso, B., Cammarano, D., Carfagna, E. ‵). According to research from the Indonesian Ministry of Agriculture, Forestry and Fisheries, the level of food self-sufficiency has been around 40% for several years, thus occupying the lowest position among developed countries. Cycle of Farm mainly consist of multiples approaches that defined as preparation, main activities, and post farm activities. This paper will mainly focus on main activities that consist of Planting, Growing, and Harvesting, since these three main activities technology adaptation plays a significant role in overall success of a farm cycle.

Planting

Traditionally, rice planting has been a labor-intensive process, requiring significant manual labor (Basso, B., Cammarano, D., Carfagna, E. ‵). However, the advent of automated rice planting machines has transformed the process, making it faster and more efficient. These machines use a combination of seed drills, fertilizers, and water management systems to automate the planting process, reducing labor costs and increasing accuracy.

One such machine is the Rice Transplanter, which can plant several rows of rice seedlings simultaneously, increasing planting speed and accuracy. The machine also ensures proper spacing between the seedlings, leading to uniform growth and better yields. In addition, these machines can be programmed to plant rice in different soil types and terrains, making them highly versatile.

Growing

Automation and machinery have also transformed rice growing, making it more efficient and precise. One of the most significant advancements in rice growing technology is the use of sensors and drones to monitor crop health and growth. These sensors can collect data on soil moisture, nutrient levels, and pest infestations, allowing farmers to adjust their farming practices in real-time to optimize growth and yields.

The use of a precise irrigation system is another innovation in growing rice. An automated system is used in the system to monitor soil moisture levels and adjust irrigation, ensuring rice plants receive the right amount of water at the right time. This reduces water waste, saves water resources, and increases crop yields.

Harvesting

The traditional method of harvesting rice involves manual labor, with workers using hand tools to harvest the crops. However, automated rice harvesters have revolutionized the process,

making it faster and more efficient. These machines use a combination of threshers, cleaners, and sorters to automate the harvesting process, reducing labor costs and increasing yields.
One example of a rice harvester is the combine harvester, which can harvest and thresh rice in a single pass. The machine can also clean and sort the rice grains, removing any impurities or foreign objects. In addition, these machines can be programmed to harvest rice in different soil types and terrains, making them highly versatile.

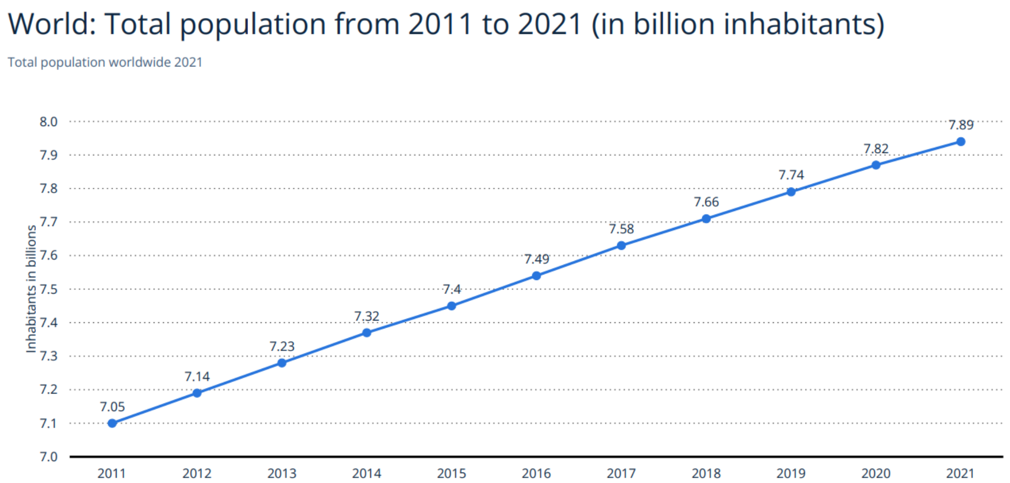
Agricultural Challenges

Challenges faced by the agricultural sector. Food security and sustainability of food and agriculture systems are significantly affected by the number of items (Christoph Kubitza1, 2020).

Population

Challenges faced by the agricultural sector. Food security and sustainability of food and agriculture systems are significantly affected by the number of items.The population is increasing rapidly. By 2025, the world's population is expected to grow by 33% to exceed 8 billion, up from 7.6 billion in October 2017. The actual fertility rate may be understated by this figure. The demand for food in a modestly growing economy increases with population growth. When compared with agricultural output in 2013, it increased by around 50%. The existence of demographic shifts causes changes in global diets.

Figure 1. World Total Population from 2011 – 2021(https://Statista.com)



Urbanization

Now and 2050, global urbanization could see an additional 2.4 billion people move to megacities (Hastuti, 2019). Urbanization is driving infrastructure improvements, increasing incomes, demand for processed foods and animal-sourced foods as part of a wider dietary transition.
Simply put: "more people mean greater demand and that demand in turn requires increased output so that farmers must produce 70% more food by 2050.".

Natural-Resources

Production is increasingly not suitable to use agricultural land. Based on certain metrics, as much as 25% of all agricultural land is assessed as highly degraded (Bruno Basso, 2019). More than 40% of the world's rural population is pressured by water resources.
The main cause and indirect victim of agricultural land degradation is agriculture. Given the different agricultural effects, excessive cutting of vegetation leads to soil erosion (Damak, 2018).

Climate-Changes

One of the main GHG producers is agriculture. Greenhouse gas emissions resulting from agriculture, forestry and other land uses have almost doubled over the last 50 years. A side effect of this is also a significant reduction of a productivity. And this will also affect significantly on food production, and food insecurity (K. Riahi, 2018).

Agriculture 4.0

While technology assessment studies have evolved, their approach to measuring the impact of interventions has had limitations and has remained largely unchanged over time [7]. The key to increasing agricultural productivity in developing countries and to reducing potential negative externalities is the development and dissemination of sustainable practices (C. Brown, 2019). A fundamental transformation is being experienced by the traditional approach to the food industry. Agriculture 4.0 will utilize science and technology by ignoring the calculated data on the value chain, the food scarcity equation, by meeting customer needs (Revolution., 2017).

Industry 4.0 is "a concept of chain organization and technologies terms, based on radio frequency concept, cyber physical system, the internet of things, service internet, and data mining, it is a new form of personalization". Industry 4.0 can be used to adjust products in a short time and at a lower price than companies who are doing the standardization, so that producers and customers create new value together with the aim of filling gaps (Y. Wang., 2017). Produce crops differently using new technology means bringing food production to consumers, increasing efficiency in the food chain using new technologies, and combining Cross-Industry technologies and applications (Schuh, 2014).

Table 1. Todays and Future Agriculture Advancement

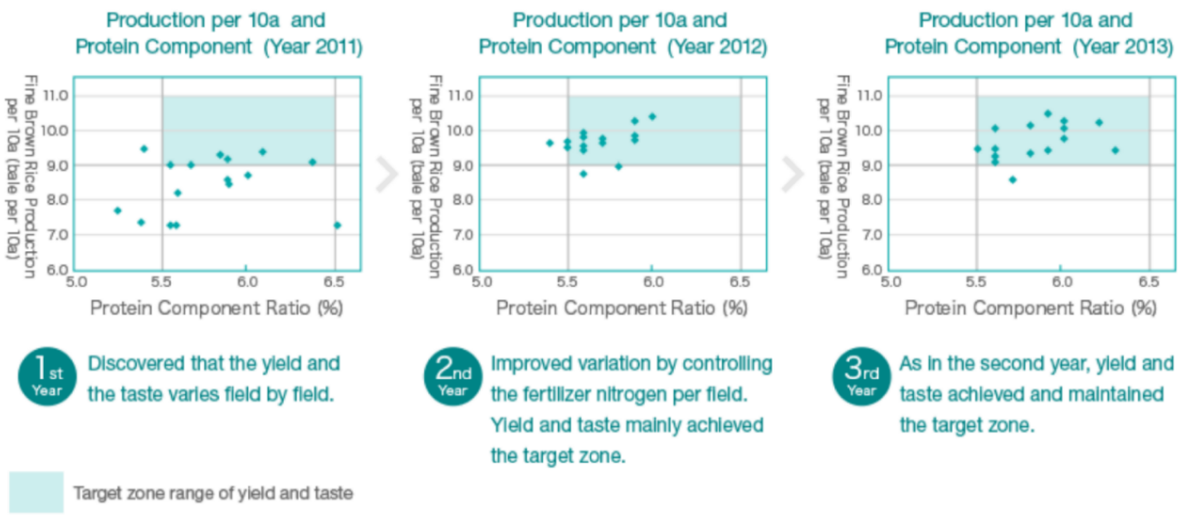
	Today		**Future**	
"Produce Differently Using New Techniques"	Hydroponics	Bioplastics	Desert Agriculture	Sea Water Farming
"Use new technologies to bring food production to consumers, increasing efficiencies in the food chain"	Urban Farming	Genetic modification	Advanced Genetic modification	Cultured Meats
"Incorporate Cross-Industry technologies and application"	Drone Technology	Data analytics on Crops	Nanotechnology	AI
	Internet of things	Precision Agriculture	Blockchain	Crowd Farming

There is a hope that has perplexed mankind since the dawn of agriculture, namely perfect knowledge of the yield before harvest. This is because seasonal forecasts of crop yields play an important role in decision-making by stakeholders – from farmers to policy makers to governments for food security, to commodity traders. To predict the results with different levels of detail, accuracy, and time, different methods have been used.

The value of accurate and reliable forecasts of seasonal yields cannot be underestimated. Over time, many methodologies have been developed to perform forecasting analysis of results. Historically, there has been a combination of historical perspective and on-the-field evaluation of crops i.e., forecasting seasonal yields. According to experts and experienced growers, crop performance throughout the season (plant size, tiller number, spikelet count, disease, pests and weeds, and correlated damage) when combined with previous years' observations provides data for making informed decisions.

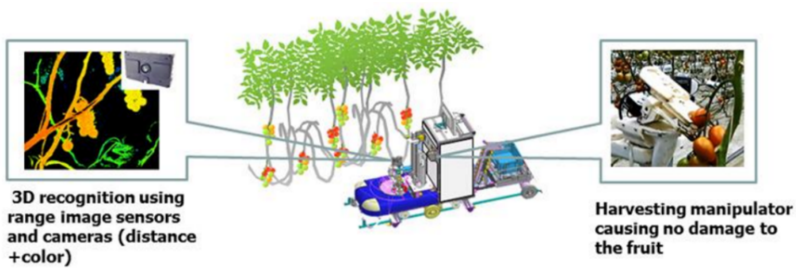
Kubota is a Japanese company that provides agricultural machinery, including tractors and combine harvesters, as well as precision farming technologies. One of its products is the Kubota Smart Agriculture Cloud (KSAC), a cloud-based platform that allows farmers to collect and analyze data about their crops using sensors and other IoT devices (‵, 2017).

Figure 3. Japanese company attempt on taste monitoring according to Grain Content



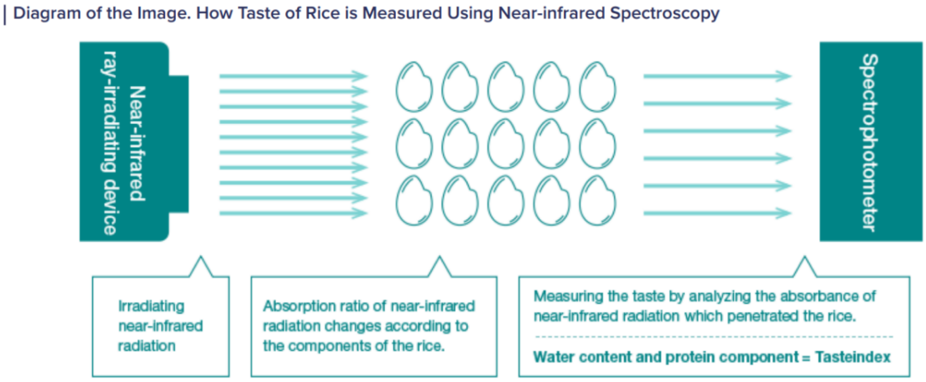
According to Kubota, some farmers in Japan have reported significant improvements in their rice yields after using KSAC. For example, one farmer in Hokkaido saw a 14% increase in his rice yield, while another farmer in Niigata saw a 7% increase.

Figure 4. 3D sensors to action generated Machine Learning on Urban Plantation (lab Scale)



A robotic field test using cameras and image sensors to detect ripe tomatoes on the vine was conducted by Panasonic. Basically, Panasonic imitate human activities in a form of robot. Replacing with a sensor for a similar function such as Eyes to a camera to detect color, shape, position, and possibly other information that could be obtained through this device. Once those steps are complete, a "harvest manipulator" is deployed to efficiently pick tomatoes and carefully harvest them free of damage at the rate of about one every 20 seconds.

Figure 5. Machine learning on Grain properties towards its homogeneity to Tastiness

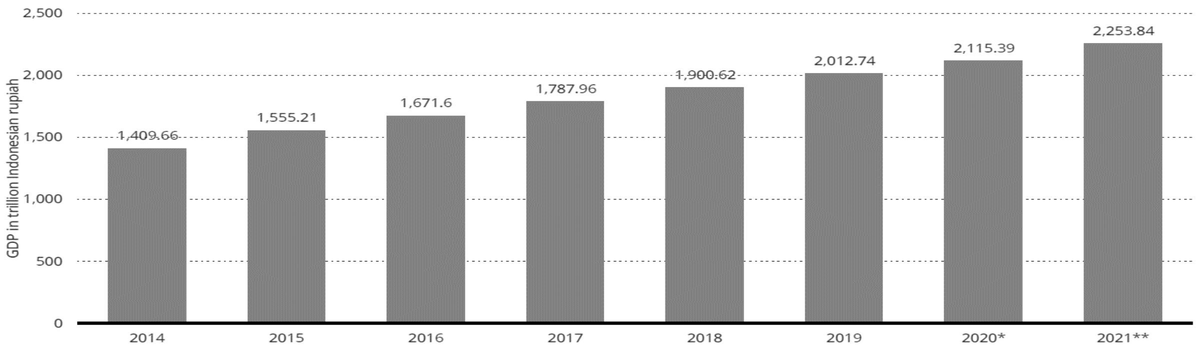


Results of rice yields with farms using Kubota's cloud service which utilizes farming data, work records, machine, and crop information to drive up yields and taste. The above is a demonstration sample at Niigata Prefecture (individual test executed by Kubota from 2011 to 2013). Kubota's programs link food production technology with bi-directional ICT.

Indonesia's Economic Outlook

Indonesia's GDP targeted to reach higher as the technology innovation takes place. But according to a survey conducted in 2019 by *McKinsey&Co*, as many as 79% of surveyed companies including agriculture in Indonesia are in the pilot stage of implementing Industry 4.0 principles. Industry 4.0 was first introduced at the Hannover Fair in 2011. Industry 4.0 described as an automated manufacturing and industrial process that uses modern technology such as IoT (internet of Things). According to the characteristics of decision-making, the rate of adoption varies as much as risk aversion. This causes household-level impacts to require a heterogeneity model of agents that is relevant at the individual or typological level (Jan, 2022).

Figure 6. Gross domestic product (GDP) from agriculture, forestry, and fishing in Indonesia (https://Statista.com)

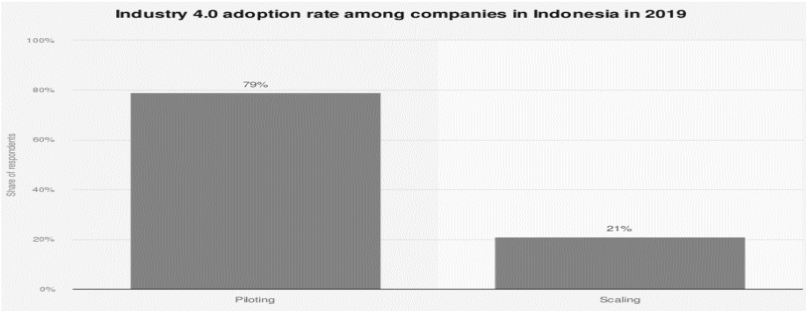


Indonesia has a significant agricultural sector that contributes to its Gross Domestic Product (GDP). According to the World Bank, in 2020, Indonesia's GDP in agriculture was approximately 13.8% of its total GDP (Mutia, 2023).

The agricultural sector in Indonesia is diverse and includes crops such as rice, palm oil, rubber, cocoa, coffee, and spices, as well as livestock and fisheries. Agriculture provides employment for a large portion of the population, particularly in rural areas, and is a crucial source of food and income for many households (Rauch, 2022).

However, the agricultural sector in Indonesia also faces several challenges, including land use issues, low productivity, climate change, and the need to balance economic development with environmental sustainability (Wiratama Putra, 2023).

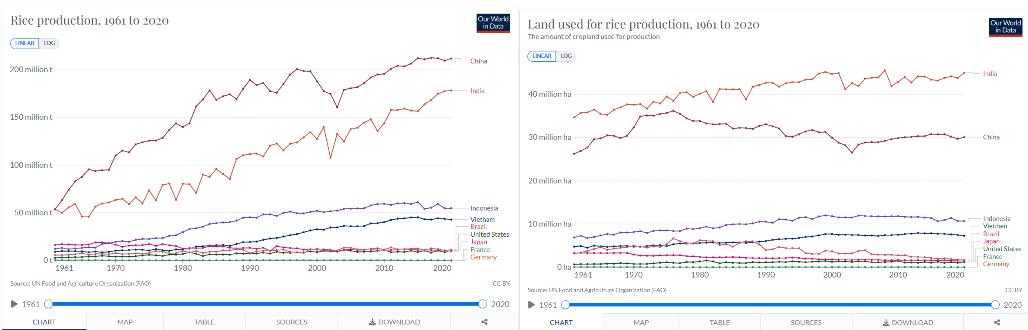
Figure 7. Industry 4.0 Technology adoption Rate (https://Statista.com)



The adoption of farming technology in Indonesia has been increasing in recent years, with the government and private sector investing in modernizing the agriculture sector to improve productivity, efficiency, and sustainability. But looking at the data above where the technology adoption rate in Indonesia is measured by 79% in plotting state, indicates that the state Indonesia technology adoption is relatively slow (Maqbool, 2019).

Indonesia's agriculture

Figure 8. Rice Production and Land Utilitzation on crops production in the world: *(https://ourworldindata.org/explorers/global-food)*



Data above is the rice production across the world from 1961-2022 specifically in a rice crop production. From the data above, we can see how Indonesia's main crops consumption placed 3rd in world comparison (Hakim, 2021). Seasonal yield varies across temporal and spatial scales. The variation mainly caused by geographical situation such as weather, temperature, humidity, and in the end, defined by productivity of a rice crops production (Parise, 2016).

RESULTS AND DISCUSSION

Looking at the land used for the rice production, by putting a comparison between land used that represented in hectare against the amount of production. By putting this formula for the big three rice crops producer, we may interpret the data below:

Table 2. Productivity Index Land to Crops Yield

Country	Productivity Index (Ha/mT of Crops Production)
China	0.14

India	0.2
Indonesia	0.2

Interpreting the data on the table above, we can see how Indonesia had 40% less of productivity compared to China which applies technology on their agriculture which nowhere close to Agriculture 4.0 yet. India production.

Figure 9. Aerial photo taken on June 2, 2020, shows harvesters working at the wheat fields in Zhoukou City, central China's Henan Province. (Xinhua/Li Jianan)

Table 3. Agriculture 4.0 Mapping on each step of deployment

			Outcome	**Resources & Infrastructure**	**Investment**
Agriculture 4.0 implementation	**Automation and Machinery**	Ha	Improve productivities by automate the cultivation chain process.	Land Profile *(That suitable with the machinery movement)* Line Size *(That suitable with the machinery movement)* Utility Resources *(Water supplies that adequate with the land size and resources)*	Plantation Machine
		Hb		Irrigation System	Fertilizer Automatic Equipment
		Hc		Packaging Facilities Warehouse	Bagging Machine
	Da ta An	Ha		People	

		Hb	Data record and monitoring of a crops for a data record and further technology usage as a data and automation input.	Electricity Supplies Security	Sensors (Temperature, Humidity) PLC Cloud Storage Access EIA investment Weather Monitoring
		Hc			
	Machine Learning	Ha	Obtain the best strategies on crops production from a machine learning data generated by sensors and computation.	Computation Facilities Urban Farming Facilities	Computation Unit Advance automation machine
		Hb			
		Hc			

Looking at **Table 3.** Agriculture 4.0 refers to the application of advanced technologies, such as Internet of Things (IoT), Artificial Intelligence (AI), Big Data, and Robotics, in agriculture. These technologies are aimed at improving efficiency, productivity, and sustainability of the agriculture industry (José Monteiro, 2021).

In the context of planting, harvesting, and growing in the cultivation process, Agriculture 4.0 can have a significant impact. Here is an explanation of the correlation between Agriculture 4.0 and these processes: **Planting:** Agriculture 4.0 technologies can improve planting in several ways. For example, sensors can be used to monitor soil moisture, nutrient levels, and temperature, which can inform decisions about planting schedules and irrigation. AI algorithms can analyze data from sensors and make recommendations for planting based on optimal conditions. Furthermore, precision agriculture techniques, such as precision planting and variable rate seeding, can be used to optimize seed placement, resulting in better crop yields. **Growing:** Agriculture 4.0 can also help optimize crop growth. AI algorithms can analyze data from sensors and weather forecasts to provide recommendations for fertilizer application, pest control, and irrigation. Drones can be used to monitor crops and identify areas that need attention. Robots can be used to perform tasks such as weeding and pruning, reducing the need for manual labor. **Harvesting:** Agriculture 4.0 can improve harvesting efficiency and quality. For example, AI algorithms can analyze data from sensors to predict optimal harvest times, resulting in better quality crops. Robotics can be used to perform tasks such as fruit picking and sorting, reducing the need for manual labor. Autonomous vehicles can be used to transport harvested crops, reducing the time and cost associated with manual transportation.

Overall, Agriculture 4.0 technologies can improve planting, growing, and harvesting in the cultivation process. By optimizing these processes, farmers can increase efficiency, productivity, and sustainability, ultimately resulting in better crop yields and profitability.

CONCLUSION

The results of this study show that in the agriculture 4.0, Indonesia's agriculture sector is poised for a major transformation with the adoption of Agriculture 4.0 technologies. These technologies promise to revolutionize the way farmers produce, manage, and market their crops, leading to increased productivity, efficiency, and profitability. However, the successful implementation of Agriculture 4.0 in Indonesia will require the government to address several challenges, such as improving digital infrastructure, promoting technology adoption among farmers, and ensuring data security and privacy. In addition, private sector participation and collaboration will be critical in driving innovation and scaling up the adoption of Agriculture 4.0 technologies. If these challenges are addressed effectively, Agriculture 4.0 has the potential to transform Indonesia's agriculture sector into a modern and sustainable industry that can contribute significantly to the country's economic growth and food security.

It is vital to remember, that in the advancement of Agriculture 4.0, technology implementation is indeed aligned with productivity improvement of a crops production which represent in both yield and land usage index. Indonesia for this case need to develop a comprehensive preparation to overcome these changes. As the Result addressed by the Author on Result and Discussion, China which had the first step of Agriculture 4.0 have 40% productivity higher in number compared to Indonesia. Japan that had applied the Data Analog and IoT (Which is not applicable yet for a crops) have a significant improvement on taste which equivalent to the product Yield and Quality. Lab Scale that had applied Machine Learning agriculture, could significantly reduce the cost of production by a conducting a specific soiling, watering, and any other activities that are sensors related across cultivation activities starting from how we produce, monitor, and harvest.

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