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Open Access Journal of Agricultural Research
ISSN: 2474-8846

Sustainable Food Agriculture Utilizing Industry 4.0: A Short Note on the Impacts on Human Resources

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Review Article

Volume 9 Issue 1

Received Date: January 02, 2024

Published Date: January 29, 2024

DOI: 10.23880/oajar-16000348

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Abstract

This brief essay explores the correlation between Industry 4.0 (I4.0) and the agricultural sectors and the benefits they offer. Agriculture 4.0, the use of I4.0 technology in agriculture, has the potential to bring about a profound transformation in the agricultural sector by fostering sustainability. The advantages encompass catering to the increasing food requirements resulting from the rising human populace, attaining sustainable economic savings over time, improving food safety, and optimizing human resources. Integrating I4.0 into agriculture would improve productivity by reducing unnecessary workforce and addressing occupational health risks. Hence, implementing I4.0 technologies has considerable promise in promoting sustainable food production by leveraging data-driven decision-making, optimizing resource management, and improving efficiency in agricultural practices. In the age of I4.0, human resources (HR) 4.0 is crucial in utilizing digital technology to manage human resources efficiently and achieve organizational success, particularly in the agriculture industry.

Keywords: Industry; Food Agriculture; Human Resources

Introduction

If our lives could not go without our smartphones, then the agricultural sectors could not go without implementing Industry 4.0 (I4.0). The agricultural sectors would face many difficulties surviving without I4.0 technologies. The I4.0 has gained significant attention in various industries, including agriculture. Agriculture 4.0 or Agri-Food 4.0, applies I4.0 [1] principles and technologies in the agricultural sector to optimize and improve farming practices. By integrating advanced technologies such as sensors, robots, artificial intelligence, and machine learning into farming operations, Agriculture 4.0 aims to achieve precision agriculture and sustainable food production. Within Agriculture 4.0, one of the key focuses on food agriculture sustainability utilizing the capabilities of I4.0 to address the challenges and needs of the agricultural supply chain [2]. By utilizing technologies such as the Internet of Things (IoT), cloud computing, and big data analytics, Agriculture 4.0 enables farmers and food producers to make data-driven decisions in real-time, resulting in increased efficiency, reduced waste, and improved resource management [3].

The literature on sustainable agriculture is available within the range of references [1-9]. Nevertheless, not all papers explicitly reference using I4.0. Nevertheless, the components of I4.0 are suggested and put into practice in precision agriculture's (PA) sustainability [10-25].

This short note discusses the connection between I4.0 and agricultural sectors and their advantages. The discussion of using I4.0 technologies to be part of AS can be highlighted in the following sections [2-5].

To Cater for the Need for Food Supply with the Ever-Increasing Human Population

Integrating I4.0 technologies with the agricultural sector's needs can revolutionize sustainable food agriculture [4]. Integrating I4.0 technologies in the agricultural sector through Agriculture 4.0 presents a transformative opportunity for sustainable food agriculture [3]. It can potentially revolutionize how food is produced, consumed, and distributed by leveraging emerging technologies such as the IoT, artificial intelligence (AI), machine learning, and robotics. These technologies can enable farmers to monitor and manage their crops more effectively, optimize resource use, reduce waste, and improve overall productivity. Furthermore, Agriculture 4.0 can help address the challenges posed by climate change by providing real-time data on weather patterns and environmental conditions [5]. With this information, farmers can adjust their practices accordingly, such as implementing irrigation systems based on precise moisture levels or using predictive models to plan planting and harvesting timelines.

The primary agricultural objectives are cultivating nourishing crops while mitigating the adverse impacts of crop production on land, water, and climate [15]. Managing plant infections is crucial in addressing these issues as plant diseases significantly diminish agricultural yield and economic viability, which sustains a substantial amount of the world's population. Novel methodologies and advanced technologies are required to ensure the long-term viability of agricultural production systems and effectively control plant diseases [16]. Many farmers own on-site equipment, although they need help to utilize it, resulting in limited I4.0 utilization [17]. Sahoo, et al. [18] asserted that sustainable agriculture is important for the survival of all species on Earth as the globe continues to require sustenance. Sustainable agriculture encompasses comprehensive practices in livestock, crop, and fisheries management to enhance the long-term self-sufficiency of farming [19].

Primarily, sustenance is derived from the practice of agriculture. Extensive research and discussions have been conducted on implementing I4.0 in the agricultural sector to enhance food security for the expanding population. That was an intelligent decision. The increasing demand for agricultural commodities, mainly processed meals, meat, dairy, and seafood, will pressure food production and transportation networks. Digital technologies provide a comparable purpose. Agriculture and related activities must support all human endeavors for future food security. Nevertheless, the ongoing growth in population and the resulting rivalry for resources persistently jeopardize agricultural supply networks, posing a significant danger to the sustainability of agriculture.

With the help of sensors and AI, Agriculture 4.0 can monitor and analyze various environmental factors such as soil quality, water usage, and weather conditions. These technologies provide farmers with real-time data and insights, allowing them to make informed decisions about crop planting, irrigation, fertilization, and pest control. By optimizing these practices, Agriculture 4.0 can help reduce resource waste, minimize environmental impact, and increase overall productivity in the farming process.

Reduction of Cost in the Long Run

However, there are challenges in implementing I4.0 technologies into the agricultural sector, such as access to reliable internet connectivity in rural areas and the cost of implementing these technologies. Despite these challenges, integrating I4.0 technologies in agriculture is crucial for the future of sustainable food production [4]. By harnessing the power of I4.0 technologies, Agriculture 4.0 has the potential to revolutionize the agricultural sector, making it more sustainable and efficient.

Farmers may anticipate increased profitability from implementing PA technologies. The PA should enhance the sustainability of society [10]. PA is gaining increasing global popularity as a dynamic production technique. When evaluating this method's environmental and economic sustainability, we considered its capacity to decrease pesticide usage by regulating the application of pesticides at the level of individual land parcels while also increasing profitability and income. PA has been associated with social collective action. However, there needs to be more understanding of actors' roles and education in this context [11].

One of the concerns related to agriculture's sustainability is nitrogen control. Implementing PA techniques instead of traditional tillage methods can enhance the efficiency of the nitrogen cycle, resulting in environmental, agricultural, and soil benefits [12]. Nanomaterials are employed in agriculture for many purposes, such as enhancing crop output, managing soil and water, conducting diagnostic tests, regulating chemical usage, and protecting plants. These applications are made possible by nanomaterial's unique characteristics, small size, and high surface-to-volume ratio

[13]. Pennsylvania's use of nanotechnology has progressed via the development and implementation of pesticides, herbicides, fertilizers, and early disease diagnostics based on nanotechnology [13]. Agriculture is the primary means by which a nation sustains itself and achieves economic progress. The rapid progress of PA has facilitated the adaptation of agriculture and its associated sectors to big data and machine intelligence. Machine learning provides valuable analytical and computational methods for combining datasets from several sources [14].

Increase Food Safety

The food industry is currently facing the challenge of transitioning its business model from one based on supply to one based on demand, particularly in light of the disruptions caused by the COVID-19 pandemic. To address this challenge and enhance the sustainability of the food production sector, there is a growing need for digitalization and I4.0 [26] technologies. These technologies can provide innovative solutions to improve food safety by enabling real-time monitoring, traceability, and quality control throughout the supply chain. By leveraging technologies such as AI, the IoT, and data analytics, I4.0 can help modernize the agricultural supply chain, ensuring better management and control of food safety-related issues [27]. This includes optimizing farm handling and management practices, improving post-harvest operations, storage, transportation, and enhancing product traceability.

Furthermore, big data analytics and cloud computing can ensure compliance and product provenance, addressing concerns such as food authenticity [28]. Integrating I4.0 technologies in the food industry can significantly enhance food safety measures, allowing for greater transparency and accountability throughout the supply chain [29]. In summary, the emergence of I4.0 and its associated technologies presents a unique opportunity for the food industry to revolutionize its approach to food safety.

Agriculture 4.0 can also enhance traceability and transparency in the food supply chain, ensuring food safety and quality for consumers. Furthermore, Agriculture 4.0 can empower farmers with real-time monitoring and analytics, allowing them to detect and respond to potential crop diseases or pests before they cause significant damage [2]. By embracing Agriculture 4.0, farmers can improve their decision-making process and reduce risks, leading to more sustainable agricultural practices and long-term food security.

Improvement of Human Resources

As we delve deeper into the implications of I4.0, it becomes evident that the role of human resources (HR) is pivotal in driving the successful implementation of technological advancements within organizations. The adoption of new technologies brings forth a spectrum of challenges for HR management, and it is essential to emphasize the strategic role of HR in fostering a positive mindset for digital transformation.

One of the emerging concepts in this domain is HR 4.0, which has evolved in response to the technological revolution characterizing I4.0. With the integration of technologies such as the IoT, big data analysis, AI, and fast data networks, HR 4.0 aims to redefine employee management for the next generation.

Using I4.0 in the agricultural sectors is expected to increase labour efficiency by reducing unnecessary labour-related workforce and occupational health risks. Automation and robotics in Agriculture 4.0 can streamline labour-intensive tasks such as harvesting, sorting, and packaging. This improves efficiency and reduces reliance on manual labour, creating more sustainable and efficient food production systems. Overall, Agriculture 4.0, powered by I4.0 technologies, holds great potential for promoting sustainable food agriculture by enabling data-driven decision-making, optimized resource management, and increased efficiency in farming practices [2].

This transformative integration of digital technologies in agriculture has the potential to promote sustainable food production by reducing inputs and labour requirements, increasing productivity, and improving environmental health by minimizing waste and maximizing resource utilization. Agriculture 4.0 can also enhance traceability and transparency in the food supply chain, ensuring food safety and quality for consumers.

By harnessing the power of I4.0 technologies, Agriculture 4.0 has the potential to revolutionize the agricultural sector, making it more sustainable and efficient [2]. By leveraging advanced technologies such as IoT, cloud computing, big data, and machine learning, Agriculture 4.0 can enable farmers to make data-driven decisions, optimize resource management, and improve overall productivity [3]. This transformative integration of digital technologies in agriculture has the potential to promote sustainable food production by reducing inputs and labour requirements, increasing productivity, and improving environmental health by minimizing waste and maximizing resource utilization.

By integrating advanced technologies such as IoT, cloud computing, big data, and machine learning, Agriculture 4.0 can optimize resource management, increase productivity, improve traceability and transparency in the food supply chain, enhance real-time monitoring and analytics capabilities, and ultimately ensure long-term food security while minimizing environmental impact. Based on the research, it is evident that I4.0 technologies will significantly enhance agricultural productivity both presently and in the future. Therefore, they should be connected. Furthermore, the use of I4.0 and its associated technologies has the potential to enhance the competitiveness of food agricultural enterprises in the digital era. The increasing utilization of digital technologies in the food industry characterizes agriculture 4.0. Agriculture and livestock have a crucial role in maintaining social and economic stability. The administration of FSC gains advantages from enhanced visibility, traceability, digitization, removal of intermediaries, and use of smart contracts [20-25].

Scholars have emphasized that HR 4.0 should align with the human capital of version 4.0. This correlation underscores the essentiality of developing new approaches to HR branding and the strategic management of human resources to navigate the complexities of the industrial era 4.0. The evolving landscape of I4.0 implicitly necessitates organizations to prioritize human resource management to ensure sustainability and technological advancement. Furthermore, the I4.0 working group highlights the importance of adopting a socio-technical approach to work organization, empowering employees with greater responsibility and opportunities for personal development [30]. To adapt to the changes brought about by I4.0, HR professionals have integrated new technologies like IoT, AI, big data, and data analytics into their functions [31]. This integration has given rise to the "Smart HR 4.0." Smart HR 4.0 leverages digital technologies to transform essential HR functions, including recruitment, onboarding, learning and development, social sharing, and crowd-sourced feedback [32]. Technology integration in HR management has improved service delivery and cost savings, enabling effective management of the new generation of employees [31]. Therefore, in the era of I4.0, HR 4.0 plays a critical role in leveraging digital technologies to manage human resources and drive organizational success effectively [33].

Conclusion

Agriculture 4.0, driven by I4.0 technologies, holds immense potential for transforming the agricultural sector towards sustainability. The advantages are that it caters to the ever-increasing human population's need for food supply, reduces costs in the long run, increases food safety, and improves human resources. Using I4.0 in the agricultural sectors is expected to increase labour efficiency by reducing unnecessary labour-related workforce and occupational health risks. Hence, Agriculture 4.0, powered by I4.0 technologies, holds great potential for promoting sustainable food agriculture by enabling data-driven decision-making, optimized resource management, and increased efficiency in farming practices. HR 4.0 is of utmost importance in the agricultural sector, as it enables organizations to manage human resources effectively and propel success through utilizing digital technologies in the era of I4.0.

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