Tiwari, S.P. (2023). Towards INDUSTRY 4.0: Increasing efficiency and effectiveness through technology integration in Agriculture. Management and Entrepreneurship: Trends of Development, 2(24), 17-25. https://doi.org/10.26661/2522-1566/2023-2/24-02

ECONOMICS

RECEIVED:
20 April 2023
ACCEPTED:
20 May 2023
RELEASED:
20 June 2023

UDC 338.43:330.342.2

DOI 10.26661/2522-1566/2023-2/24-02

TOWARDS INDUSTRY 4.0: INCREASING EFFICIENCY AND EFFECTIVENESS THROUGH TECHNOLOGY INTEGRATION IN AGRICULTURE

Siddhartha Paul Tiwari*
Google Asia Pacific, Maple Tree Business City,
Singapore
ORCID ID: 0000-0003-1596-1501

**Corresponding author email:* sidpaultiwari@gmail.com

Abstract. Agricultural industries, as well as other industries, are experiencing profound changes as a result of Industry 4.0. A key enabler technology that is becoming increasingly incorporated into agricultural equipment is a combination of cyber-physical systems, machine learning, the Internet of things, robots, artificial intelligence, the cloud, and cognitive computing, which are all key enabler technologies that allow the agricultural sector to achieve this transformation. The study involved interviews and surveys of 250 professionals from a cross-section of the agriculture industry and emerging technologies. According to the results, advances in machinery have led to a considerable increase in the scale, speed, and productivity of farm equipment, which has resulted in more efficient farming. A significant improvement has also been made in the quality of seeds, resources, irrigation, and fertilizer used by farmers over the years, allowing them to increase their yields. As a conclusion, the concept of artificial intelligence (AI) is at the heart of Industry 4.0. AI has an important role to play in agriculture.

Keywords: technology integration and agriculture, agriculture industry, sustainable development, technology and agriculture
JEL Classification: O14, O32, O33

INTRODUCTION

'Industry 4.0' stands for the industrial revolution of the 21st century, a revolution that is embracing and changing the technology landscape of all industries including the agricultural sector, and in essence it is about the future. As a result of new technologies such as cloud computing and analytics, artificial intelligence, the Internet of Things, and other advanced tools, automation, enhanced productivity, lowered costs, and streamlined operations are being achieved with new technologies. In the modern world, digitalization has become a catalyst for change. In terms of agriculture, digital transformation brings a lot of benefits that are expected from the Industry 4.0 era in terms of productivity growth, resilience, and sustainability. In terms of the agricultural regulatory sector, it brings the tools necessary to evolve economies in the digital age, and to create greener, safer, and more inclusive communities in today's society. As agricultural sectors strive to make high-performance connectivity more ubiquitous and accessible, they are also helping to secure the development of networks for innovation and collaboration in order to fuel the ongoing digitization of governments, societies, and businesses across all sectors.

With regard to the agricultural industry, Industry 4.0 refers to the next big trends that will impact the agricultural industry in the future, including a greater focus on precision agriculture, artificial intelligence (AI), machine learning (ML), and the use of big data for the purpose of improving the efficiency of businesses in a world where populations are increasing and climate change is on the rise.

Agricultural production in the 21st century is facing multiple challenges such as the reduction of resources, the rise in demand, and the increase in costs. Despite the fact that researchers have already identified that the world is not on track to accomplish the Sustainable Development Goals by 2030, the COVID-19 pandemic has made it even more difficult to achieve these goals and to monitor the progress being made on these goals. As the term Industry 4.0 is applied to the agricultural industry, it refers to the next big trends facing the agricultural industry, including a greater focus on precision agriculture, artificial intelligence (AI) and the use of big data to drive greater business efficiencies in a time of rising populations and climate change. There has been a long-standing trend among farmers to strive for better methods of enhancing productivity, preventing waste, and reducing the environmental impact for several decades. There has been a great deal of research and testing over the past few years, and it has become evident that the same methods used for optimizing manufacturing can also be applied to farming to enhance its growth and ensure its sustainability.

INDUSTRY 4.0 AND THE AGRICULTURAL SECTOR: THE KEY ASPECTS

By using the new technologies, the data extracted by the new technologies can be processed in several ways that are already known to be effective. Through these methods, it is possible to obtain relevant information in an automated way, which would otherwise be invisible to the human eye, and which would otherwise be overlooked by the human eye. A variety of purposes can be served by data gathered through agriculture 4.0, such as soil study, task execution, etc.

As part of the implementation of Industry 4.0 in the agricultural industry, there needs to be a transition towards precision farming on the farm, which is beneficial to reach its full potential. There are several factors that determine whether or not a connected farming infrastructure needs to use real-time data or span a vast geographic area, depending on the farm's requirements and the purpose for implementing the technology. All management elements are handled by the robot, from planting and growing to watering, fertilizing, and harvesting according to the needs of the plant. It may be possible for farming bots to work in a small garden bed, greenhouse, or indoor greenhouse. In order to provide access to services in conditions of limited or non-existent coverage, cloud-based services are able to provide access to the services, given the previously mentioned obstacle of the availability of connection to high-capacity mobile communication networks. A high level of empathy is also necessary in order to be able to overcome the psychological barrier that has always existed among the agricultural industry when it comes to the adoption of new technologies into their daily jobs in order to create experiences that are tailored to their needs and working circumstances.

Increasingly, it is becoming evident that FAO, UN, and governments are advocating for the implementation of technology-driven agriculture (industry 4.0) within the agricultural sector, which is becoming increasingly accepted. There is also an increase in labor costs and a shortage of skilled workers in the agriculture industry that are contributing to a higher demand for Industry 4.0 technology in the field. There is a plummeting cost of connected devices, as well as a growing availability of automation technologies such as artificial intelligence (AI) and machine learning (ML), which are accelerating the process of increasing the financial feasibility of more technology in the agricultural industry.

INDUSTRY 4.0 AND SUSTAINABILITY IN THE AGRICULTURAL SECTOR

Agricultural enterprises have become increasingly concerned with sustainability because it is an environmental as well as financial imperative. It is not just a matter of avoiding costly fines from regulators that is at stake. By supporting new business models in the agricultural sector, companies that reach sustainability targets are able to unlock growth and unlock their potential. Also, the

agricultural sector tends to be more attractive to customers who wish to partner with suppliers that can help them meet their own sustainability commitments in a cost-effective way.

As a result of digitization, there are paths to sustainability that can be taken through such tools as pervasive connectivity, cloud computing, advanced analytics and industrial automation. It is imperative that digitalization is fueled by the Industry 4.0 goals of efficiency, productivity, and agility. Through digitalization, organizations can connect their employees with their workplaces in new ways, improve their sustainability practices, and measure their environmental impact with greater intelligence built into the entire process with greater insight. The green agricultural sector cannot exist without the use of digital technology. There are more than 13% of greenhouse gas emissions attributed to agriculture around the world. Consequently, this share of the agricultural output could grow as a result of the need for mechanization and the adoption of green farming practices in order to fill the gap in agriculture output. There will be a significant role for Industry 4.0 Technologies in ensuring that emission levels are measured before and after mechanization is implemented. The amount of emissions caused by technological intervention should be measured and kept under control in order to prevent any increases in emissions. A report by Boston Consulting Group claims that green farming practices will result in a loss of 43 million jobs existing by 2030, but will generate 80 million new jobs by 2050. In order for Industry 4.0 to be applied to the agricultural industry, farmers will require innovation and government support in order to automate and develop skills.

There has been a lot of focus on identifying technologies for sustainability and climate resilience in several industries, but the agricultural industry has not yet been able to do so at scale. As a result of the fragmented nature of the agricultural industry, a significant proportion of the global population is going to have to adopt green farming practices in order to ensure a sustainable future. The technological intervention occurring in the agriculture sector is generally occurring through a combination of physical paths such as automation of tasks through the use of machinery or artificial intelligence, and digital paths such as providing information flows that assist timely and effective decision making. There are many types of data that can be used to help farmers determine how to take actions that will result in an improvement in efficiency and yields, such as soil parameters, weather patterns, and commodity prices.

THE CHALLENGES FACED BY THE AGRICULTURAL SECTOR AS A RESULT OF INDUSTRY 4.0

While it appears that Industry 4.0 technologies, practices, and mindsets will be integrated into the agricultural domain eventually, the adoption of the technologies, practices, and mindsets will take some time. It is important to note that the sector faces a large number of challenges, such as standardisation of technology and the ability to invest in modernising the equipment and supporting infrastructure to address these challenges.

Farming, in order to become truly autonomous, will require the use of both physical and digital technologies. Over time, this will progress from manual to automatic to semiautonomous to, finally, fully autonomous operations, with continuous progression from manual to automatic to semiautonomous to altogether autonomous. There has been an increase in the expectations of customers in recent years regarding the traceability and transparency of the food they purchase. Aside from improving efficiency within the agri-food sector, Industry 4.0 provides a framework for proactive traceability within the supply chain in order to achieve a more sustainable agri-food sector as a result of increased traceability.

It is also important to recognise that challenges regarding the adoption of Industry 4.0 will be difficult for the agricultural industry if farmers are not able to invest and modernize their practices in the production process. They are often faced with a very hard economic environment due to a lack of investment ability and limited access to credit, and often face a very tight economic situation. As a result, the workforce in the agricultural industry has limited digital skills and as a result, we need to invest more heavily in training in order for them to be able to adopt new technologies in the future. In addition, there are a number of disparities between regions and

exploitations in terms of their willingness and ability to invest in new technologies, which can create significant gaps in the production capabilities between the regions.

THE BENEFITS THAT INDUSTRY 4.0 CAN BRING TO THE AGRICULTURAL SECTOR

There are a number of advantages that can be gained by integrating new technologies into agriculture 4.0. These advantages include a more efficient production process, lower production costs, and a greater quantity of food being collected. Sustainability can be achieved by making better use of data and by managing them better so that pesticides and fertilizers can be used more efficiently as a result of having a greater amount of data and better management of it. The availability of data is enabled by the digitalization of all information, which means that the necessary data can be accessed very quickly, and the crop status can be easily monitored. There is an increase in the speed at which various tasks can be completed as a result of automation and data management that allows these tasks to be completed more quickly and efficiently.

In Industry 4.0, artificial intelligence has the potential to benefit the entire supply chain of the agricultural industry, and it will play a greater role than ever before in transforming the agriculture industry as a whole. The advanced connectivity of a global agriculture network provides a vast number of benefits up and down the supply chain: By analyzing the data farmers gather, they can use the data to apply the right products, at the right rates, and at the right time to their crops, distributors can use the data to source inputs and position themselves to take advantage of the market the most; manufacturers can improve their methods of production and better target their customers.

Among the fields of agriculture that have suffered the greatest impact of the Fourth Industrial Revolution is the labor-intensive one. It is because of this revolution that two technologies have been developed: artificial intelligence, which provides decision makers with the ability to make better decisions, and big data, which provides analytical tools to analyze statistical data collected using a number of different methods, to provide decision makers with the ability to make better decisions. A number of high-tech organizations are developing these technologies as part of the precision farming sector, which is a field in which several hi-tech organizations are involved. As part of an agricultural operation, there are several sectors that are used there, such as the analysis of soil moisture, the detection of the healthiness of the crop, the prediction of the exact harvest time, and the scheduling of pest control activities. Through the use of a technology known as Internet of things (IoT), it is possible to operate a farm remotely from a mobile device, along with the ability to measure temperature, humidity, and the amount of sunlight in production farms, thereby increasing the yield as well as adding value to the production.

Agricultural automation driven by robots and machine learning has resulted in a significant increase in production and a significant reduction in the costs associated with manual labor in the agricultural industry. A farm automation process refers to the use of advanced technologies like robotics and artificial intelligence (AI) in order to automate and upgrade previously manual methods of farming. Using this method, farmers around the world have been able to reduce the number of man-hours and time-intensive processes involved in agriculture that have always been one of the biggest challenges for farmers. The combination of artificial intelligence (AI) and robotics will in the near future enable us to plant seeds, monitor the condition of crops, and even harvest them with the assistance of robotics once artificial intelligence (AI) and robotics are combined.

In order for the agricultural industry to benefit from Industry 4.0, currently applied systems and technologies need to integrate with AI, machine learning, connected services, and solutions integrated with smart, cloud-based systems for end-to-end workflow automation powered by artificial intelligence (AI), ML. With the automation of tractors and weeding equipment, humans will have less need to interfere with the process, errors will be eliminated, and energy will be saved. In the future, farming equipment that contains real-time location services as well as cloud networks will be able to spray, seed, cultivate, plow, and harvest crops utilizing real-time location services.

With the aid of artificial intelligence-based data analytics, farmers will be able to maximize the use of resources and reduce their total cost of ownership by using connected smart irrigation technologies to optimize the use of resources.

METHODOLOGY

During the course of this study, we interviewed and surveyed 250 people from a cross-section of the agriculture industry as well as new technologies from around the world. As a part of his study, the author conducted a series of surveys as part of an attempt to examine how scientists understand their own explanations and motivations for changing their practices in light of these changes. The author of this article has conducted a series of surveys in an attempt to gain a better understanding of how people interpret the changes in their practices as a result of the findings we have found in our study. The participants were asked to complete a survey in order to assess their attitudes towards the agricultural industry, and their perceptions of its benefits as well as their expectations regarding how technological advancement and newness of technology will affect the agricultural industry in the future, as well as their understanding of how it will affect them. Upon the completion of the implementation process, a survey was conducted in order to determine whether expectations had been met or not. The results were compared with those that had developed after the start of the implementation of the program, in order to formulate an opinion based on their comparison.

As a result of the introduction of new technologies into the agriculture industry, these technologies have had a significant impact on the agriculture industry as well as in a variety of other fields as well. A Likert scale of five points was used to ask respondents how strongly they agreed or disagreed with the questionnaire by rating it on a scale of 5 points (strongly agree) to 1 point (strongly disagree). Respondents have been asked to indicate their degree of agreement with this statement in accordance with the scale above, based on the scale above. As a tool for determining the validity of the measurement questions, we used Cronbach's alpha as a method of determining the validity of the measurement questions. The Cronbach's alpha of the 20 items in the questionnaire "Towards Industry 4.0: Increasing efficiency and effectiveness through new technologies integration in agriculture" was calculated by SPSS for the reliability statistics and it was calculated to be 0.723. It can be concluded from this result that the data is reliable and suitable for further analysis. There is no doubt that the value is well above the minimum value of 0.6 as can be sees from the graph above.

RELIABILITY TEST: Cronbach's Alpha		
Measure of internal consistency		
Cronbach's alpha tests to see if multiple-question Likert scale surveys are reliable. It will tell you if the test you have designed is accurately measuring the variable of interest.		
Cronbach's Alpha	INTERPRETATION	
α = k/k-1[1-Σs2y / s2x]	Interpreting ALPHA for dichotomous or Likert scale question.	
	CRONBACH'S ALPHA	INTERNAL CONSISTENCY
	0.90 and above	Excellent
	0.80 - 0.89	Good
Where	0.70 - 0.79	Acceptable
K is the number of test item	0.60 - 0.69	Questionable
Σs2y is sum of the item variance	0.50 - 0.59	Poor
s2x is the variance of total score	below 0.50	Unacceptable

Table 1

Reliability Statistics

Cronbach's Alpha	N of Items
.723	20

Data Collection

1. **Primary data:** Based on a questionnaire consisting of 20 questions asked by the participants closely related to the areas of agriculture industry and new technologies, the following primary data were collected from the selected samples.

2. **Linear Regression:** To further prove or disprove the relationship between agriculture industry and new technologies, the former was considered as an independent variable and the latter as a dependent variable. A relationship between the two variables was established using a simple linear method, a statistical method. The data from the designed questionnaire as well as the analysis in Excel helped to demonstrate a general flow of the points based on the x-axis and the y-axis, indicating a positive trend and placing the points close together, which indicates a strong and positive correlation between agriculture industry and new technologies, as indicated by the regression line, where the y-intercept is 0.005 and the m-intercept is 0.137. A slope is defined as the change between two points on the line divided by the change.

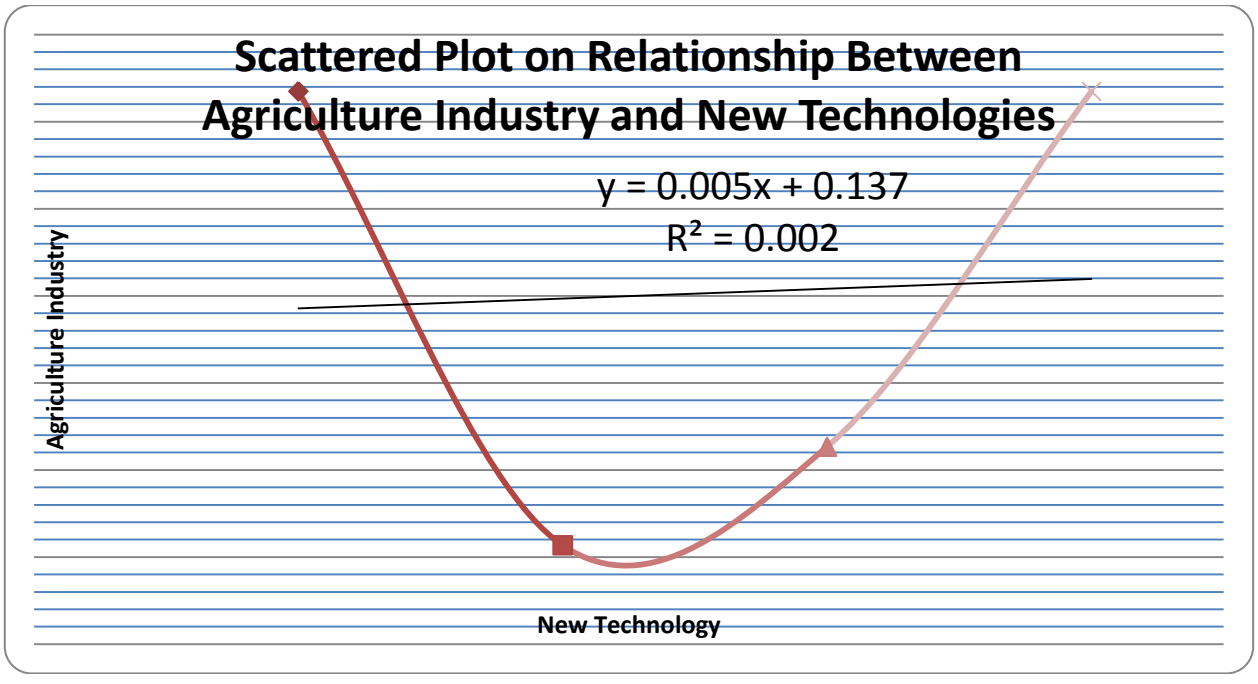

Figure1. Linear Regression

CONCLUSION

In today's world, when industry 4.0 is applied to the agriculture industry, it is more than just a trend. A broader sense of the term has come to be used to describe the next phase of agriculture as a catch-all term. To enhance the efficiency of the entire supply chain and end-to-end production

systems, artificial intelligence and new technologies need to be incorporated so that they can be smarter, more efficient, and more productive.

As a result of climate change, volatility, shifting nutritional needs, and the scarcity of physical factors that impact production, we are at the threshold of a paradigm shift that is much needed in the agriculture industry. This shift will be crucial to adapting to the changes brought about by climate change, volatility, and changing nutritional needs. There is a needful paradigm shift that is on the way. As a result of the rapid development of technologies and applications in the agricultural sector, the productivity of this sector is positively impacted. It has been found that the introduction of Industry 4.0 technologies in several industries around the world is creating an efficient, cost-effective, and innovative future that can reduce costs and improve efficiency as a result of Industry 4.0 technologies. For the purpose of survival, the agriculture industry provides humans with food and raw materials that are necessary for their survival. The agricultural sector has undergone a variety of technological developments in the last several decades, becoming increasingly industrialised and technology-driven as a result. It is now possible for farmers to improve their control of animal production and crop production by utilizing intelligent agricultural technologies, making them more predictable and efficient in the farming process. In addition to this, an increase in consumer demand for farm products has played a significant role in the spread of smart farming technology around the world. In the near future, the author believes that Industry 4.0 will have a significant impact on the entire agriculture industry as a whole as a result of its big impact on the agricultural sector.

REFERENCES

Anderson, E., & Weitz, B. (1989). Determinants of continuity in conventional industrial channel dyads. Marketing science, 8(4), 310-323.

Bell, M. (1984). 'Learning'and the accumulation of industrial technological capacity in developing countries. Technological capability in the Third World, 187-209.

Biggs, S. D., & Clay, E. J. (1981). Sources of innovation in agricultural technology. World Development, 9(4), 321-336.

Blomström, M., & Persson, H. (1983). Foreign investment and spillover efficiency in an underdeveloped economy: Evidence from the Mexican manufacturing industry. World development, 11(6), 493-501.

Brown, R., Condor, S., Mathews, A., Wade, G., & Williams, J. (1986). Explaining intergroup differentiation in an industrial organization. Journal of Occupational psychology, 59(4), 273-286.

Chang, S. J., & Choi, U. (1988). Strategy, structure and performance of Korean business groups: A transactions cost approach. The journal of industrial economics, 141-158.

Dalenogare, L. S., Benitez, G. B., Ayala, N. F., & Frank, A. G. (2018). The expected contribution of Industry 4.0 technologies for industrial performance. International Journal of production economics, 204, 383-394.

De Brentani, U. (1989). Success and failure in new industrial services. Journal of Product Innovation Management: An International Publication of the Product Development & Management Association, 6(4), 239-258.

Evenson, R. E. (1985). Agricultural research policy.

Ghobakhloo, M. (2020). Industry 4.0, digitization, and opportunities for sustainability. Journal of cleaner production, 252, 119869.

Gliessman, S. R., Garcia, R. E., & Amador, M. A. (1981). The ecological basis for the application of traditional agricultural technology in the management of tropical agro-ecosystems. Agro-ecosystems, 7(3), 173-185.

Hermann, M., Pentek, T., & Otto, B. (2016, January). Design principles for industrie 4.0 scenarios. In 2016 49th Hawaii international conference on system sciences (HICSS) (pp. 3928-3937). IEEE.

Jarillo, J. C. (1989). Entrepreneurship and growth: The strategic use of external resources. Journal of business venturing, 4(2), 133-147.

Jandyal, A., Chaturvedi, I., Wazir, I., Raina, A., & Haq, M. I. U. (2022). 3D printing–A review of processes, materials and applications in industry 4.0. Sustainable Operations and Computers, 3, 33-42.

Kobrin, S. J. (1987). Testing the bargaining hypothesis in the manufacturing sector in developing countries. International organization, 41(4), 609-638.

Kogut, B. (1989). The stability of joint ventures: Reciprocity and competitive rivalry. The journal of industrial economics, 183-198.

Kuan, C., Hongchang, W., Yuxin, Z., Jefferson, G. H., & Rawski, T. G. (1988). Productivity change in Chinese industry: 1953–1985. Journal of Comparative Economics, 12(4), 570-591.

Lasi, H., Fettke, P., Kemper, H. G., Feld, T., & Hoffmann, M. (2014). Industry 4.0. Business & information systems engineering, 6, 239-242.

Lu, Y. (2017). Industry 4.0: A survey on technologies, applications and open research issues. Journal of industrial information integration, 6, 1-10.

Masood, T., & Sonntag, P. (2020). Industry 4.0: Adoption challenges and benefits for SMEs. Computers in Industry, 121, 103261.

McGahan, A. M., & Porter, M. E. (1997). How much does industry matter, really?. Strategic management journal, 18(S1), 15-30.

Porter, M. E. (1981). The contributions of industrial organization to strategic management. Academy of management review, 6(4), 609-620.

Rosin, F., Forget, P., Lamouri, S., & Pellerin, R. (2020). Impacts of Industry 4.0 technologies on Lean principles. International Journal of Production Research, 58(6), 1644-1661.

Rüßmann, M., Lorenz, M., Gerbert, P., Waldner, M., Justus, J., Engel, P., & Harnisch, M. (2015). Industry 4.0: The future of productivity and growth in manufacturing industries. Boston consulting group, 9(1), 54-89.

Scherer, F. M. (1982). Inter-industry technology flows in the United States. Research policy, 11(4), 227-245.

Sony, M., & Naik, S. (2020). Key ingredients for evaluating Industry 4.0 readiness for organizations: a literature review. Benchmarking: An International Journal, 27(7), 2213-2232.

Stigler, G. J. (1983). The organization of industry. University of Chicago Press.

Stentoft, J., Adsbøll Wickstrøm, K., Philipsen, K., & Haug, A. (2021). Drivers and barriers for Industry 4.0 readiness and practice: empirical evidence from small and medium-sized manufacturers. Production Planning & Control, 32(10), 811-828.

Xu, L. D., Xu, E. L., & Li, L. (2018). Industry 4.0: state of the art and future trends. International journal of production research, 56(8), 2941-2962.

INDUSTRY 4.0: ПІДВИЩЕННЯ ЕФЕКТИВНОСТІ ТА РЕЗУЛЬТАТИВНОСТІ ШЛЯХОМ ІНТЕГРАЦІЇ ТЕХНОЛОГІЙ У СІЛЬСЬКЕ ГОСПОДАРСТВО

Siddhartha Paul Tiwari
Google Asia Pacific, Maple Tree Business City, Singapore

Сільськогосподарські галузі, як і інші галузі, переживають глибокі зміни в результаті INDUSTRY 4.0**.** Ключова технологія, яка все більше впроваджується в сільськогосподарське обладнання, — це поєднання кіберфізичних систем, машинного навчання, Інтернету, роботів, штучного інтелекту, хмари та когнітивних обчислень, які є ключовими

Tiwari, S.P. (2023). Towards INDUSTRY 4.0: Increasing efficiency and effectiveness through technology integration in Agriculture. Management and Entrepreneurship: Trends of Development, 2(24), 17-25. https://doi.org/10.26661/2522-1566/2023-2/24-02

технологіями, які дозволяють сільськогосподарського сектору досягати трансформації. Дослідження включало інтерв'ю та опитування 250 професіоналів із різних галузей сільського господарства та нових технологій. Відповідно до результатів, прогрес у техніці призвів до значного збільшення масштабу, швидкості та продуктивності сільськогосподарського обладнання, що призвело до більш ефективного землеробства. За ці роки також було досягнуто значного покращення якості насіння, ресурсів, зрошення та добрив, які використовуються фермерами, що дозволило їм збільшити врожайність. Як підсумок, концепція штучного інтелекту (ШІ) лежить в основі INDUSTRY 4.0. Саме ШІ сьогодні відіграє важливу роль у сільському господарстві.

Ключові слова: технологічна інтеграція та сільське господарство, сільськогосподарська промисловість, сталий розвиток, технології та сільське господарство.