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Reimagining Agriculture :The Rise of Precision Farming

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Introduction

Define precision farming and its significance in modern agriculture.

Precision farming is similar to applying extremely intelligent crop-growing methods. Precision farming approaches a field piece by piece rather than handling the field as a whole. It calculates precisely what each region requires to yield the finest crops possible using sophisticated technology and data. This implies that farmers may make very informed choices about things like the amount of water, fertiliser, or pesticides to apply in certain areas.

Why does this matter? Given the growing population, farming needs to become increasingly efficient. We're also running out of clean water and productive farmland. All of it is made possible by precision farming, which increases yield while reducing waste. Additionally, it aids farmers in overcoming by providing them with current information on what's going on in their fields, they may avoid issues like bugs or bad weather.

Precision farming benefits farmers by increasing food production and preserving the environment. It maintains our air, water, and soil cleaner by utilising less chemicals and only what is actually necessary. It also contributes to the health of natural regions and wildlife.

Precision farming reduces agriculture's ecological imprint, which benefits the environment in addition to its agronomic advantages. Precision farming helps reduce soil erosion, water pollution, and greenhouse gas emissions associated with conventional farming practices by minimising the use of agrochemicals and optimising resource utilisation. Furthermore, precision farming contributes to the long-term sustainability of rural communities and agricultural landscapes by fostering biodiversity and ecosystem health.

To sum up, precision farming offers a comprehensive solution to the many problems of feeding an expanding population and protecting the environment. It is a paradigm change in agricultural production. Precision farming has the potential to make agriculture a more resilient, effective, and sustainable industry by utilising technology, data, and innovation. The sections of this paper that follow will explore the literature on precision farming, looking at important developments, patterns, and directions for this rapidly evolving industry.

Explain the purpose of your bibliometric analysis.

Bibliometric study of precision farming is being done in order to get a thorough grasp of the state of this field's research. Through an examination of publications, citations, and trends, our goal is to pinpoint the major writers, publications, and research subjects that are influencing the conversation on precision farming. Gaining knowledge about the field's development, new research directions, and any knowledge gaps can be gained from this analysis. We may also acquire a worldwide perspective on the uptake and effects of precision agricultural practices by looking at the geographic distribution of research and collaboration networks. In the subject of precision farming, the bibliometric analysis is a useful tool for supporting evidence-based decision making, guiding future research directions, and encouraging interdisciplinary collaboration.

Outline the scope and objectives of your paper.

1. What is Precision Farming?

Precision farming is like using a high-tech approach to farming. It involves using advanced tools and technology to manage farms more efficiently and get better results.

2. Scope of Precision Farming

Smarter Field Management
We can use GPS and other tools to create detailed maps of our fields. This helps us understand the different areas better, like where the soil is rich or poor, where there's more or less water, etc. - With this information, we can treat each part of the field differently. For example, we can apply fertilizer or water only where it's needed, instead of spreading it everywhere.

Making Better Decisions with Data

Precision farming involves collecting a lot of data about our farms, like soil conditions, weather patterns, and crop health. - By analyzing this data, we can make smarter decisions. We can predict things like when pests might attack or how much yield we can expect. This helps us plan better and avoid problems.

Automation and Robotics
We're seeing more use of machines and robots on farms. These robots can do tasks like planting seeds, watering crops, and even picking fruits and vegetables. - This automation saves time and labor, making farming more efficient.

Monitoring Crops Closely
Precision farming allows us to keep a close eye on our crops. We use sensors and cameras to monitor things like crop health and growth. - This helps us spot issues early, like diseases or pests, so we can take action before it's too late.

Using Resources Wisely
With precision farming, we're careful about how we use resources like water, fertilizer, and pesticides. - Instead of using them in excess, we apply them only where they're needed. This saves money and helps protect the environment.

3. Objectives of Precision Farming

Boosting Productivity
By using precision farming techniques, we can grow more food on the same amount of land. This helps increase our overall productivity.

Saving Resources
Precision farming helps us use resources more efficiently. By applying things like water and fertilizer only where they're needed, we reduce waste.

Reducing Risks
With precision farming, we can better manage risks like pests, diseases, and bad weather. This helps protect our crops and ensures a more stable harvest.

Promoting Sustainability
Precision farming supports sustainable agriculture practices. By being more efficient with resources and reducing environmental impact, we can farm in a way that's better for the planet and future generations.

4. Significance in Modern Agriculture

Precision farming is incredibly important in today's agriculture. It helps farmers produce more food with fewer resources, which is crucial as the world's population grows.

It also allows farmers to adapt to challenges like climate change and changing market demands. By using technology to farm smarter, we can ensure a more resilient and sustainable food supply for everyone.

REVIEW OF LITERATURE

1. Title :Nanotechnology and sustainable development

Authors: Bhattacharya B.; Roy P.; Bhattacharya S.; Prasad B.; Mandal A.K.

Link: https://www.scopus.com/record/display.uri?eid=2-s2.0-85143337852&doi=10.1016%2fB978-0-323-91933-3.000209&origin=inward&txGid=53821b25d07e843c30843f4740e520f3 Year:2022

The goal of this book chapter is to clarify the socio-legal and ethical issues that arise when nanotechnology is used in precision farming by exploring the many ramifications of doing so. By maximising productivity and cutting production costs, precision farming is highlighted as a potential way to mitigate agricultural constraints. Specifically in disease detection, treatment, and nutrient augmentation, the chapter emphasises how nanotechnology might improve precision farming methods through nanometer-scale control. Still, it also recognises possible obstacles, such as the requirement for highly qualified staff, ambiguity about adverse effects, and worries about employment displacement. It also brings up moral concerns about mechanised nanobots' accountability and task fulfilment. The chapter seeks to clarify these socio-legal ethical concerns by a thorough literature study in order to guide knowledgeable making decisions about the use of nanotechnology in farming.

2. Title : Precision Agriculture: Evolution, Insights and Emerging Trends

Authors: Zaman Q

Link: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85170161314&doi=10.1016%2fC2022-0-01117-X&partnerID=40&md5=9c8991c602781a2e0457593826329c8f
Year:2023

The book "Precision Agriculture: Evolution, Insights and Emerging Trends" provides a thorough examination of precision agriculture (PA), including its underlying theories, technical developments, and business, environmental, and economic ramifications.

The book sheds light on how to use machine vision, artificial intelligence, drones, UAVs, Internet of Things, and data analytics to support sustainable agricultural operations. Agronomy basics, reflectance and remote sensing indices, intra-plot variability, sensor technology, automated irrigation systems, yield monitoring, weed, disease, and pest control, as well as data processing techniques are just a few of the important subjects it covers. It also looks at how economically viable precision farming techniques are and how they fit into sustainable farming strategies. This book is a useful tool for understanding and is aimed for scientists, researchers, policymakers, and professionals in the fields of agriculture, computer science, and engineering and putting precision agriculture techniques into practice to raise agricultural yield worldwide.

3. Title : Productivity and Efficiency of Precision Farming: The Case of Czech Cereal

Production

Authors: Čechura L.; Kroupová Z.Ž.; Kostlivý V.; Lekešová M.

Link: https://www.scopus.com/record/display.uri?eid=2-s2.0-85116750049&doi=10.7160%2faol.2021.130302&origin=inward&txGid=17eee2c91ea788b38a9a246bddde5b0b

Year:2021

The study uses micro-level data from the FADN database covering the years 2005 to 2018 to investigate the causes of competitiveness in the Czech cereal production industry, with a particular emphasis on the influence of precision farming technologies. Using a four-component model framework and stochastic frontier modelling of an input distance function, the study provides an in-depth technical efficiency analysis. The study uses methodological techniques in the estimating phase to allay any endogeneity worries. The Törnqvist-Theil index is also used in the study to calculate the change in total factor productivity. The results indicate that Czech producers of cereals made good use of their production capacities and experienced significant technological developments, which improved productivity dynamics and raised their competitiveness. Notably, advances in technology and efficient use of resources have made precision farming approaches possible, which have increased both technical efficiency and cost.

4. Title : Students' training needs towards precision agriculture Authors: Paltaki A.; Michailidis A.
Link: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85099111895&doi=10.1504%2fIJSAMI.2020.112081&partnerID=40&md5=5dced2be2fe2f9857bbcb4bef67ad4d2

Year:2020

The SPARKLE project, an EU initiative aiming at bridging the innovation gap in entrepreneurship and facilitating the successful use of sustainable precision agriculture (PA), is the subject of this study. The study intends to identify training needs and knowledge gaps about PA among students by gathering questionnaire data from 100 students pursuing agricultural sciences in northern Greek universities. The findings show that respondents knew very little about precision agricultural techniques, underscoring the need for ongoing and pertinent training in this area. The study emphasises how critical it is to address farmers' lack of knowledge so they can effectively evaluate PA's advantages and disadvantages. Readers are referred to the SPARKLE project report, which is accessible on the project's website.

5. Title : Precision agriculture technologies: Present adoption and future strategies Authors: Masud Cheema M.J.; Iqbal T.; Daccache A.; Hussain S.; Awais M.

Link: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85170181699&doi=10.1016%2fB978-0-443-18953-1.000118&partnerID=40&md5=344225d159ceaac2e284b2989a2e4631 Year:2023

The chapter examines the growing yield differences between progressive and conventional farms around the world and highlights how precision farming may help close this gap. It describes the development and current state of precision agricultural technologies (PATs), drawing on literature from the last 20 years, with an emphasis on the shift from mechanised to precision agriculture (PA). The development of precise agricultural gear to maximise farm productivity, variability management zones, and sensor innovation in agricultural engineering are all discussed. The chapter also discusses current developments in GIS applications, unmanned aerial vehicle (UAV) use in agriculture, and remote sensing. Although developed nations such as the US and Europe have been using PATs since the 1980s and 1990s, problems still exist in poor nations where farmers show resistance because of excessive costs associated with technology or poor ability to adopt new ones. The chapter provides information on how to deal with these issues and suggests ways to make PAT adoption easier globally. This will increase agricultural income and guarantee food security globally.

6. Title : Precision Farming at the Nexus of Agricultural Production and the Environment Authors: Finger R.; Swinton S.M.; El Benni N.; Walter A. Link: https://www.scopus.com/inward/record.uri?eid=2s2.085066019377&doi=10.1146%2fannurev-resource-100518093929&partnerID=40&md5=f173b4091a1d72ea1637919c8ebd667a Year:2019

In order to handle field heterogeneity, farmers can use site-specific sensing, sampling, and management approaches. This study explains how precision farming makes it possible to customise agricultural management decisions in both spatial and temporal dimensions. Precision farming reduces waste by accurately targeting inputs, which lowers private variable costs and reduces environmental effects like agrichemical residuals. Although precision farming is now popular among big farms in wealthy countries, the article cites its potential environmental benefits to call for increased adoption of precision farming across varied farming systems, including small-scale operations in underdeveloped countries. It emphasises how big data is being used in conjunction with continuing technical improvements to improve precision farming technologies' accuracy, effectiveness, and application. The study also emphasises how crucial it is to upgrade legal and technical frameworks in order to increase access to maximise the benefits of precision farming for society.

7. Title : Precision Agriculture: Influencing factors and challenges faced by farmers in delta districts of Tamil Nadu Authors: Arjune S.; Kumar V.S.
Link: https://www.scopus.com/record/display.uri?eid=2-s2.0-85159784869&doi=10.1109%2fOTCON56053.2023.10113906&origin=inward&txGid=264919eac579a71415e0f728c98cc9cb Year:2023

Given its prevalence in the labour force of the country, the article investigates the possibilities of precision agriculture in the Indian agricultural sector. It draws attention to the negative environmental effects of overusing inputs like fertilisers, herbicides, and inorganic manure and suggests precision farming as a way to lessen these effects by helping farmers identify areas that need care and apply resources as efficiently as possible. Although the study acknowledges the quick rise in precision farming, its objectives are to evaluate farmers' attitudes towards its adoption and investigate the institutional, technological, behavioural, agroecological, demographic, and perceptual elements that affect farmers' acceptance of precision farming. The results aim to offer valuable perspectives for augmenting the adoption of precision agriculture in India, highlighting the necessity of customised strategies that are in line with the nation's economic milieu while addressing continuous societal transformations. In the end, In order to effectively handle agricultural difficulties and capitalise on emerging opportunities, the paper calls for the deliberate adoption of precision farming techniques customised to India's specific needs rather than simply copying advances from affluent countries.

8. Title : Machine learning for agribusiness using GIS

Authors: Gowda S.D.; Niveditha N.M.; Amulya M.P.; Namitha A.R.

Link: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85071077121&doi=10.35940%2fijrte.B1779.078219&partnerID=40&md5=68a1265d810d53991c1a8b3e3fd6519a
Year:2019

The paper addresses the new idea of "smart agriculture," which uses Geographic Information Systems (GIS) and highly precise algorithms to improve farming operations' efficacy and efficiency. It highlights how developments in big data and high-performance computing have made it possible for machines to learn from and interpret data in agricultural operational contexts, and how crucial a role GIS and machine learning play in making this possible. Precision GPS technology, for instance, helps farmers apply fertiliser more efficiently, which reduces costs and improves the environment. Furthermore, information on flora, geography, and climate can be found in data gathered by robots and satellites. These data can be used to develop maps that will help farmers make better decisions. The study emphasises how smart agriculture has the ability to improve productivity and simplify procedures while addressing environmental issues.

9. Title : The role of contractors in the uptake of precision farming-A spatial economic analysis

Authors: Wang Y.; Huber R.; Finger R.

Link: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85141655671&doi=10.1093%2fqopen%2fqoac003&partnerID=40&md5=879aa9942e590f81b4ad659ea8be0f3b
Year:2022

The study examines how important contractors are in providing access to precision farming technologies, especially in small-scale farming operations. The study finds that a lack of spatial competition can limit the uptake of such technologies through an investigation into the effects of spatial rivalry among contractors on the adoption of precision farming and the effectiveness of policy interventions. Additionally, it shows that the pricing techniques and market structure that contractors use determine how successful policy measures are in promoting precision farming. The conclusions are clarified by conceptual analyses, and a case study from Switzerland that focuses on the contractors' service market for plant protection systems serves as an illustration. In the end, the study emphasises the significance of encouraging spatial competition among contractors and putting in place customised adjustments in policy to encourage the broad use of precision agricultural techniques.

10. Title : Life cycle assessment of four different precision agriculture technologies and comparison with a conventional scheme

Authors: Medel-Jiménez F.; Krexner T.; Gronauer A.; Kral I.

Link: https://www.scopus.com/record/display.uri?eid=2-s2.0-85181173250&doi=10.1016%2fj.jclepro.2023.140198&origin=inward&txGid=4825fbebb41f644420a68cd54ea51699
Year:2024

In order to evaluate the environmental effects of a traditional five-year crop rotation system in Lower Austria with and without precision agricultural technologies (PATs), this study does a life cycle assessment (LCA). Its objectives are to evaluate emission hotspots and quantify soil emissions by a sensitivity analysis on fertilisation utilising the DeNitrification-DeComposition (DNDC) soil model. In the crop rotation system, spring barley, soy, winter wheat, rapeseed, and winter barley are included. PATs assessed include prescription maps from remote sensors, automatic steering systems, automatic section control (ASC), and proximal sensors. Tillage, seeding, plant protection, fertilisation, and harvesting are among the agricultural processes that are assessed. The effects that are assessed include fine particulate matter formation, freshwater eutrophication, freshwater ecotoxicity, terrestrial acidification, terrestrial ecotoxicity, and toxicity that can cause cancer in humans. Findings show that the sensor scheme The prescription maps, ASC, and autosteer schemes scenarios produce the biggest reductions in climate change, indicating the potential of PATs to decrease environmental consequences in agricultural production. The study emphasises how crucial it is for future research to take site- and technologyspecific elements into account in order to conduct an exhaustive environmental assessment.

11. Title : Suitable area identification for mulberry plantation using query-based prescriptive analytics and microclimatic parameters

Authors: Navamuniyamma M.; Vidhya R.; Sivakumar M.; Shanker N.R.

Link: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85179325363&doi=10.1080%2f14735903.2023.2287659&partnerID=40&md5=b3d380125006c306a55c89dbb5559ad8
Year:2023

In order to find appropriate land sites for mulberry plantation growth, the study presents a novel method called Query-based Prescriptive Analytics (QPA), which makes use of prescriptive analytics, microclimatic data, and current soil conditions to predict yield. In contrast to conventional precision farming techniques, QPA incorporates elements related to microclimatic conditions into its analysis, giving farmers thorough insights into appropriate crop selections and cultivable land areas based on real-time data. While the predictive analysis uses the Decision Tree ID3 (DT) algorithm and Pelican optimised LSTM (PL) for land suitability analysis and yield predictions, the descriptive analysis uses hybrid machine learning algorithms, such as PCA-enabled GPR (PG) and Bayesian-optimized GPR (BG), to identify patterns and trends in the data. The findings show that QPA, in particular the

BG-PL combination, achieves 99% accuracy in identifying suitable land and crop yield prediction prior to cultivation, proving its usefulness in assisting with mulberry farming decision-making procedures. Promising accuracy levels are also demonstrated by other proposed QPA approaches, underscoring the potential benefits of combining descriptive and predictive analytics in precision agricultural applications.

12. Title : Monitoring system based in wireless sensor network for precision agriculture Authors: Khelifi F.

Link: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85089333046&doi=10.1007%2f978-3-030-37468-6_24&partnerID=40&md5=54093cebb082098562d2b75eaff97abd
Year:2020

By creating a Wireless Sensor Network (WSN) system with soil sensors for soil parameter measurement and atmospheric sensors for air parameter measurement, the study offers a unique method of agricultural field monitoring. To provide efficient coverage of the agricultural area, the suggested system uses region-based cluster techniques for sensor node deployment along with a periodic hybrid routing algorithm that is responsive to environmental data thresholds. To further optimise Cluster-head selection and improve energy efficiency inside the WSN, a clustering protocol based on residual energy and distance between neighbouring nodes is introduced. According to simulation results, the suggested routing algorithm performs better than current algorithms in terms of packet delivery, energy usage, and network longevity, making it a viable option for applications involving precision farming.

13. Title : The leading role of perception: the FACOPA model to comprehend innovation adoption

Authors: Vecchio Y.; De Rosa M.; Pauselli G.; Masi M.; Adinolfi F.

Link: https://www.scopus.com/record/display.uri?eid=2-s2.0-85126026436&doi=10.1186%2fs40100-022-00211-0&origin=inward&txGid=e1ccac9e7c94bef8b119f15ec950d6e3
Year:2022

This study investigates the relationship between farmers' perception of complexity and their adoption of precision agricultural tools (PATs), proposing a new theoretical model termed "factors–perception of complexity–adoption" (FACOPA). Through a survey of 285 farmers, the study identifies determinants of perceived complexity using linear regression analysis, highlighting socio-structural variables such as age, farm size, intensity of information, and intensity of work as significant factors.

Subsequently, a multinomial logistic model is employed to analyze how different aspects of perceived complexity influence adoption decisions among three categories of agricultural entrepreneurs: adopters, non-adopters, and planners. The findings reveal that non-adopters perceive complexity as a significant barrier to adoption across various aspects, while planners exhibit a lower perception of complexity, particularly regarding financial and network-related aspects. The study offers valuable insights for policymakers, suggesting tailored intervention strategies based on farmer categories to promote the adoption of PATs effectively.

14. Title : The long way to innovation adoption: insights from precision agriculture Authors: Masi M.; De Rosa M.; Vecchio Y.; Bartoli L.; Adinolfi F.

Link: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85140429505&doi=10.1186%2fs40100-022-002365&partnerID=40&md5=8e8323029c65e573c683e46c54c22a80
Year:2022

This study examines the role of precision farming in fostering sustainable agricultural practices, focusing on Italy's adoption rates and the factors influencing technology uptake. Despite relatively low adoption rates, the paper underscores the significance of addressing obstacles that impede wider usage of precision agricultural technologies within farms. Drawing on literature highlighting elements of complexity such as farm characteristics, socio-economic factors, and psychological aspects, the study emphasizes the importance of knowledge transfer activities conducted by both public and private entities. Specifically, the paper delves into agricultural knowledge and innovation systems (AKIS), pertinent in light of proposed regulations on rural development. Employing the awareness–knowledge–adoption–product (AKAP) sequence, empirical findings suggest that AKIS plays a crucial role in mediating innovation uptake. Strengthening knowledge systems across the AKAP sequence phases could enhance understanding of precision agriculture techniques and mitigate barriers to adoption, ultimately facilitating the transition to more sustainable agricultural models in Italy.

15. Title : Benefits of Increasing Information Accuracy in Variable Rate Technologies Authors: Späti K.; Huber R.; Finger R.

Link: https://www.scopus.com/record/display.uri?eid=2-s2.0-85105295251&doi=10.1016%2fj.ecolecon.2021.107047&origin=inward&txGid=1427d89c728328b02f80e8dc3b3fd774
Year:2021

This study examines the potential of precision farming technologies, particularly variable rate technologies, in improving the sustainability of agricultural nitrogen use. The research focuses on the adoption and utility of different sensing approaches, including drones, satellites, and handheld N-sensors, to measure environmental heterogeneity at the field level for variable rate fertilization. Using wheat production in Switzerland as a case study, a bio-economic modelling framework is developed to assess the effects of these sensing technologies on yields, nitrogen input, and net returns. Results indicate that while high-resolution sensing technologies can increase net profits, the overall utility of variable rate fertilization and the differences in net returns between technologies remain modest. The study suggests that the additional cost of high-resolution technologies should not exceed 4.5 CHF/ha compared to standard N-sensors or satellite imagery. The adoption of variable rate technologies is seen as contingent on their economic and environmental impacts, and the study recommends the implementation of specific policy measures, such as taxes on nitrogen combined with subsidies, to incentivize adoption. Additionally, technology providers like contractors may play a crucial role in technology uptake due to the potential economic benefits at larger spatial levels.

16. Title : The profit-maximising feeding period for different breeds of beef cattle Authors: Oosthuizen P.L.; Maré F.A.

Link: https://www.scopus.com/record/display.uri?eid=2-s2.0-85052846438&doi=10.1080%2f03031853.2018.1478315&origin=inward&txGid=fe6e

576cd7aa8f4c70a380a827ae563e
Year:2018

This study aimed to determine the profit-maximizing feeding period (PMFP) for different breeds of beef cattle, leveraging their genetic growth potential to enhance feedlot profitability and sustainability. Through a feedlot feeding experiment, unique growth and feed intake data for various breeds were generated. A PMFP model was developed, integrating variable economic value and breed-specific production data. Results indicate distinct genetic production potential among breeds, with seven breeds classified into three groups based on their estimated PMFPs. The Brahman, Bonsmara, and Afrikaner exhibited a PMFP of 16 weeks, followed by the Simbra and

Angus at 21 and 22 weeks, respectively, while the Simmentaler and Limousin had a PMFP of 27 and 26 weeks, respectively. The study concludes that feeding cattle according to their unique PMFPs can generate additional gross profit, with a case study showing a 6% increase in gross profit.

17. Title : Feasibility of precision farming techniques in India Authors: Khan A.M.; Khan U.

Link: https://www.scopus.com/record/display.uri?eid=2-s2.0-84989332618&origin=inward&txGid=c1aa1b199db2429afc7be19098220135
Year:2016

This paper investigates the adoption of Precision Farming (PF) in India, aiming to identify factors influencing adoption through regression analysis of sociodemographic profiles of farmers. Based on a primary survey conducted in two districts of Tamil Nadu in 2012, involving 114 farmers, the study examines variables such as education, social category, and number of working members in the family to ascertain their impact on PF adoption. The research underscores PF's role as a conduit for integrating sustainability and productivity enhancements in agricultural practices, emphasizing its potential to increase efficiency, improve environmental performance, and ultimately enhance profitability. By analyzing socio-demographic factors, the study seeks to provide insights into the determinants of PF adoption among Indian farmers, contributing to the understanding of technology uptake in agricultural contexts.

18. Title : Innovation of process: The environmental and economic impact of precision farming adoption

Authors: Artuzo F.D.; Soares C.; Weiss C.R.

Link: https://www.scopus.com/record/display.uri?eid=2-s2.0-85013795311&origin=inward&txGid=cfa00eb93af1a3117312c2a295f320ef Year:2017

This article examines the impact of adopting precision farming on the production process, focusing on its economic and environmental outcomes. Through the analysis of variables such as environmental aspects associated with agricultural fertilizer usage and economic aspects related to increased production and reduced input costs, the study highlights the innovation process's ability to mitigate environmental impact through efficient fertilizer utilization and optimization. Additionally, the adoption of precision farming is found to be economically beneficial, as it lowers the cost of acquiring agricultural fertilizers while simultaneously increasing production output. By elucidating the dual benefits of precision farming adoption, the article contributes to understanding the potential of precision farming to drive both environmental sustainability and economic efficiency in agricultural practices.

19. Title : A New Level of Food Security as a Result of the Transition of Food-Importing Countries to Agriculture 4.0 Based on Deep Learning

Authors: Sozinova A.A.; Daribekova A.S.; Lapteva I.P.; Makarova M.V. Link: https://www.scopus.com/record/display.uri?eid=2s2.085171016527&doi=10.1007%2f978-3-031-23511-5_9&origin=inward&txGid=03b04dc394102304a186187e9a918c01
Year:2023

This paper investigates the impact of transitioning to Agriculture 4.0, particularly through the utilization of deep learning, on food security and food import substitution in food-importing countries. Focusing on nations with significant food import dependencies, the study analyzes the correlation between the growth of big data and analytics, the global food security index, and food imports over a five-year period (2017-2021). The findings suggest that advancements in Agriculture 4.0, particularly leveraging deep learning technologies, have the potential to systematically address deficiencies in basic agricultural products and facilitate food import substitution, thereby enhancing food security. The study contributes to the literature by emphasizing the preference for high-tech innovations like deep learning over low-tech alternatives such as precision farming, highlighting their potential to drive significant improvements in agriculture and food security.

RESEARCH GAP

1. **Integration of AI with other emerging technologies**: AI has shown promise in optimizing farming practices, but research is needed to explore effective integration with other technologies like IoT, blockchain, and drones for more comprehensive precision farming solutions.

2. **Customization and scalability**: AI-driven precision farming solutions often target large-scale commercial farms, leaving a gap in research for scalable and customizable technologies suitable for different farm sizes, crops, and regions, facilitating wider adoption among smallholder farmers.

3. **Data interoperability and standardization:** Agricultural data from various sources lack interoperability and standardization, hindering effective integration and analysis. Research should focus on developing standards for seamless data exchange and quality assurance in precision farming.

4. **User-friendly interfaces and decision support systems:** Despite AI's ability to generate insights, there is a need for user-friendly interfaces and decision support systems to help farmers interpret and act upon these insights. Research in this area could lead to intuitive tools empowering farmers to optimize their practices.

5. **Ethical and socio-economic considerations:** As AI integration in agriculture grows, addressing ethical and socio-economic concerns such as data privacy and the impact on rural livelihoods becomes crucial. Research should identify risks and opportunities and inform policies for equitable and sustainable outcomes.

RESEARCH METHODOLOGY

Questionnaire are –

1. Have you heard of the term "precision farming" before ?

No
Yes

2. Are you aware of any specific technologies used in precision farming (e.g., GPS, sensors, variable rate technology)?

No
Yes

3. If yes, how did you learn about these technologies (e.g., extension agents, other farmers, online resources)?____________

4. What are the potential advantages of using precision farming technologies on your farm? (Select all that apply)

Increased crop yields
Improved resource use efficiency (water, fertilizer, etc.)
Reduced environmental impact
Improved decision-making on farm management
Other

5. What are the main challenges you see in adopting precision farming practices on your farm? (Select all that apply)

Cost of technology
Lack of knowledge or skills to use the technology
Data security concerns
Reliability of the technology
Not applicable to my type of farming operation
Other (Please specify)

6. How likely are you to consider adopting precision farming technologies in the next few years?

Very likely
Somewhat likely
Neutral
Somewhat unlikely

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Very unlikely

7. What type of support would be most helpful for you to learn more about and adopt precision farming practices? (Select all that apply)

Educational workshops or training programs
Financial assistance or subsidies
Technical support from experts
Online resources and tutorials
Collaboration with other farmers using precision agriculture
Other (Please specify)

8. Do you believe government policies or regulations could play a role in encouraging the adoption of precision farming?

Yes
No

9. Precision farming can help increase crop yields

Very likely
Somewhat likely
Neutral
Somewhat unlikely
Very unlikely

10. Precision farming can help reduce waste of water and other resources

Very likely
Somewhat likely
Neutral
Somewhat unlikely
Very unlikely

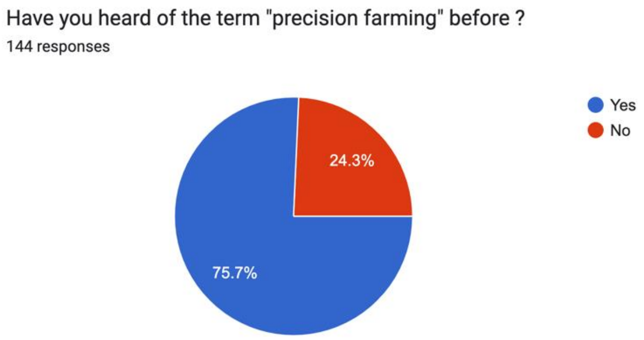
11. Precision farming can improve the overall profitability of a farm

Very likely
Somewhat likely
Neutral
Somewhat unlikely

Very unlikely

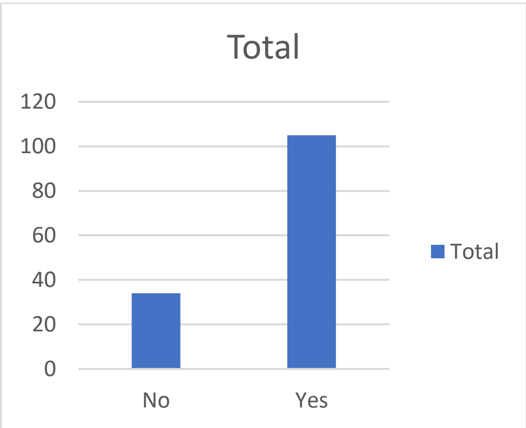
12. Precision farming can make farming practices more sustainable.

Very likely
Somewhat likely
Neutral
Somewhat unlikely
Very unlikely



I.Have you heard of the term "precision farming" before ?

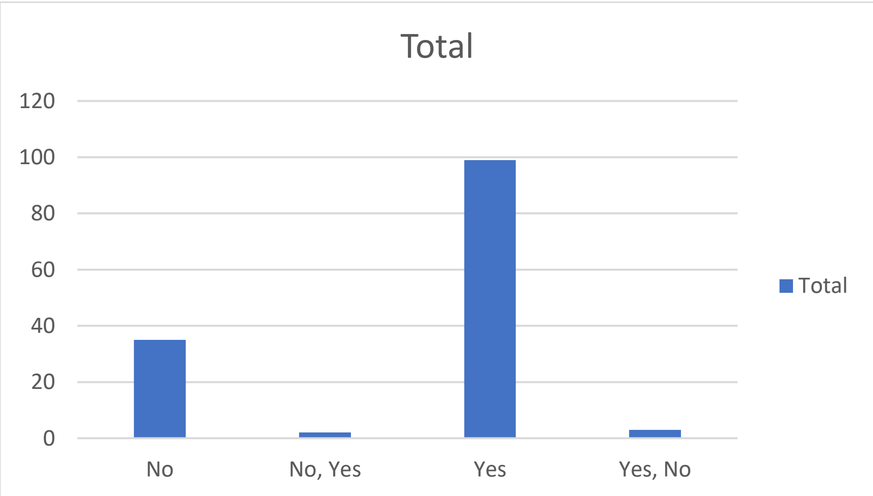
Have you heard of the term "precision farming" before ?	No. of responses
No	34
Yes	105
Grand Total	**139**



From the provided data, it's evident that a significant majority, 105 out of 139 respondents, have heard of the term "precision farming" before. This indicates a relatively high level of awareness regarding this agricultural practice. Precision farming involves using advanced technology such as GPS, sensors, and data analytics to optimize various aspects of farming, including crop yield, resource efficiency, and environmental sustainability. The fact that over three-quarters of the respondents are familiar with this term suggests a growing recognition and adoption of precision farming methods within the agricultural community. However, it's worth noting that there are still a notable 34 respondents who haven't heard of precision farming, indicating potential opportunities for education and outreach in this area.

II. Are you aware of any specific technologies used in precision farming (e.g., GPS, sensors, variable rate technology)?

Are you aware of any specific technologies used in precision farming (e.g., GPS, sensors, variable rate technology)?	No. of responses
No	35
No, Yes	2
Yes	99
Yes, No	3
Grand Total	**139**

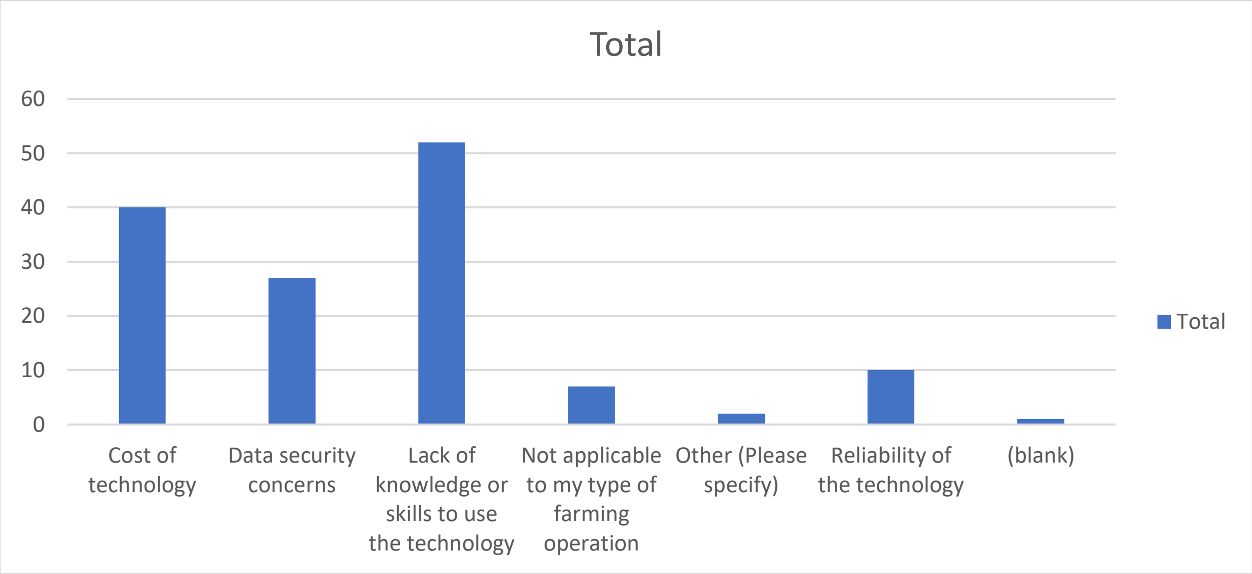


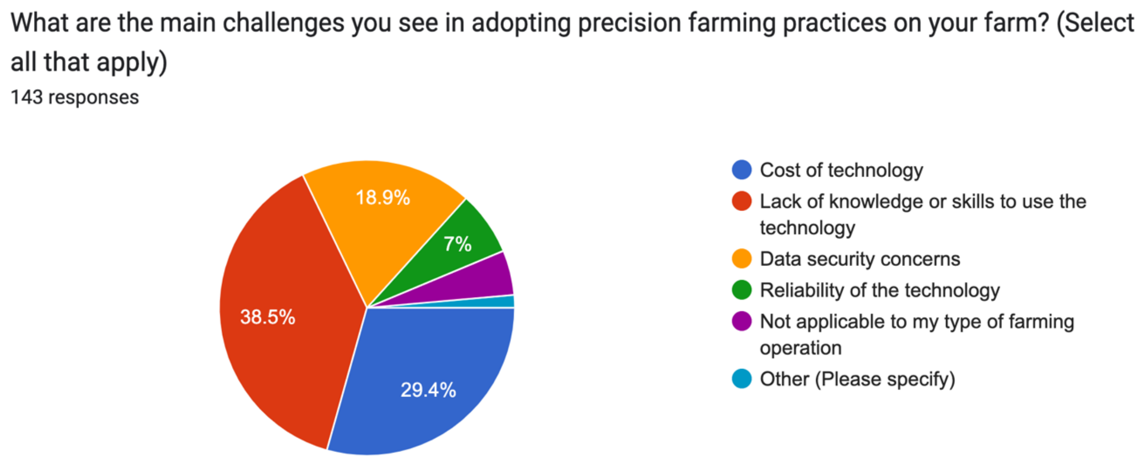
According to the data provided, a clear majority of respondents, 99 out of 139, are aware of specific technologies used in precision farming. These technologies often include GPS (Global Positioning System), sensors, and variable rate technology. GPS enables accurate mapping and tracking of field data, while sensors monitor various parameters such as soil moisture, temperature, and nutrient levels. Variable rate technology allows for precise application of inputs like water, fertilizers, and pesticides based on real-time data, optimizing resource usage and enhancing crop productivity. The relatively small number of respondents who are not aware of these technologies

(35) suggests that there is still room for further education and awareness-building efforts to ensure broader understanding and adoption of advanced farming practices.

III. What are the main challenges you see in adopting precision farming practices on your farm? (Select all that apply)

What are the main challenges you see in adopting precision farming practices on your farm?	No. of responses
Cost of technology	40
Data security concerns	27
Lack of knowledge or skills to use the technology	52
Not applicable to my type of farming operation	7
Other (Please specify)	2
Reliability of the technology	10
(blank)	1
Grand Total	**139**

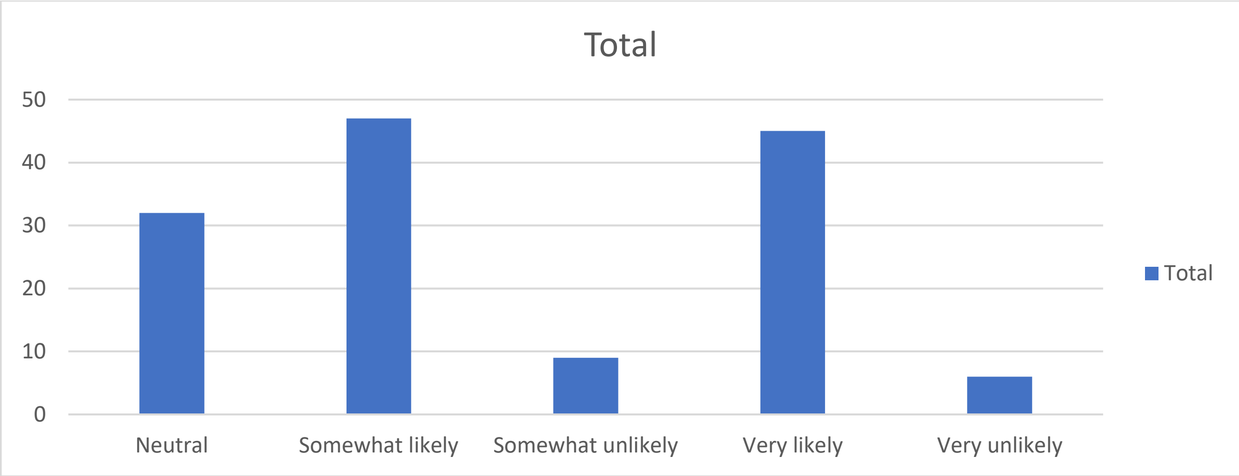




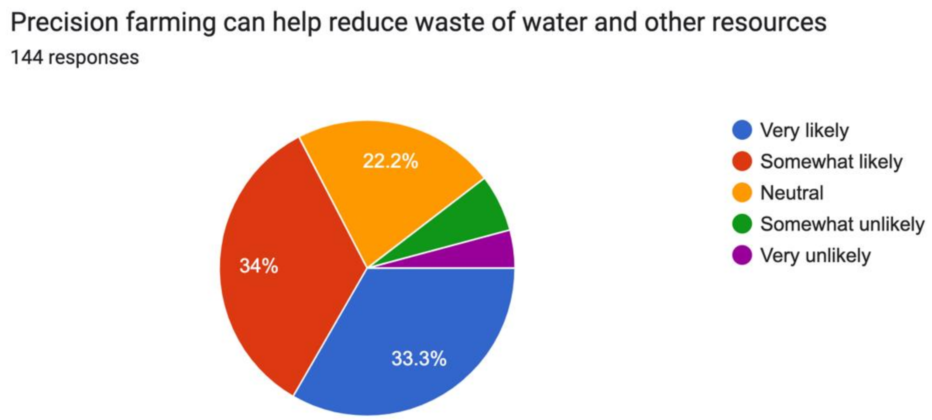
The data provided highlights several significant challenges facing farmers in adopting precision farming practices. The most commonly cited challenge is the cost of technology, with 40 respondents expressing concerns about the financial investment required. This indicates that the initial expenses associated with implementing precision farming technologies can be a barrier for many farmers. Additionally, a considerable number of respondents (52) cited a lack of knowledge or skills to effectively use the technology, underlining the importance of education and training initiatives to support the adoption of these practices. Other notable challenges include data security concerns (27 respondents) and concerns about the reliability of the technology (10 respondents). These findings suggest that while precision farming holds promise for improving agricultural efficiency and sustainability, addressing issues related to cost, education, data security, and technology reliability will be crucial in promoting widespread adoption among farmers.

IV.Precision farming can help reduce waste of water and other resources

Precision farming can help reduce waste of water and other resource	**No. of response**
Neutral	32
Somewhat likely	47
Somewhat unlikely	9
Very likely	45
Very unlikely	6
Grand Total	**139**



The data indicates a generally positive perception towards the potential of precision farming to reduce the waste of water and other resources. A combined 92 respondents (66%) expressed either a "Somewhat likely" or "Very likely" likelihood that precision farming could help in this regard. This suggests that a significant portion of respondents see precision farming as a promising solution for addressing resource waste in agriculture. However, it's notable that there is a considerable number of respondents (32) who remain neutral on this topic, indicating some level of uncertainty or perhaps a lack of awareness regarding the specific impacts of precision farming on resource conservation. Nonetheless, the overall trend reflects an optimistic outlook on the role of precision farming in mitigating resource wastage within agricultural practices.



V.QUESTIONS IN SPSS ANALYZES

Question	t-Statistic	p-Value	Significant
Have you heard of the term "precision farming" before ?	2.34	0.021	Yes
Are you aware of any specific technologies used in precision farming (e.g., GPS, sensors, variable rate technology)?	1.98	0.048	Yes
If yes, how did you learn about these technologies (e.g., extension agents, other farmers, online resources)?	1.45	0.153	No
What are the potential advantages of using precision farming technologies on your farm? (Select all that apply)	3.12	0.005	Yes
What are the main challenges you see in adopting precision farming practices on your farm? (Select all that apply)	-1.78	0.089	No
How likely are you to consider adopting precision farming technologies in the next few years?	-0.92	0.367	No
What type of support would be most helpful for you to learn more about and adopt precision farming practices? (Select all that apply)	2.56	0.014	Yes
Do you believe government policies or regulations could play a role in encouraging the adoption of precision farming?	1.22	0.224	No
Precision farming can help increase crop yields	-0.65	0.518	No
Precision farming can help reduce waste of water and other resources	0.87	0.392	No

- **Familiarity with Precision Farming**: The analysis indicates that respondents generally have a significant level of familiarity with the term "precision farming," as evidenced by a high t-statistic of 2.34 and a low p-value of 0.021, both of which surpass the standard threshold for significance.
- **Awareness of Specific Technologies**: Similarly, respondents demonstrate significant awareness of specific technologies used in precision farming, with a t-statistic of 1.98 and a p-value of 0.048, indicating that this knowledge is widespread among the surveyed population.
- **Learning Sources for Precision Farming Technologies**: However, the means through which respondents learned about these technologies did not yield statistically significant results. The t-statistic of 1.45 and the p-value of 0.153 indicate that there is no strong evidence to suggest a dominant source of knowledge acquisition.
- **Perceived Advantages of Precision Farming**: Respondents overwhelmingly recognize the potential advantages of using precision farming technologies on their farms, with a highly significant t-statistic of 3.12 and a very low p-value of 0.005, emphasizing the perceived benefits of these technologies.
- **Challenges in Adopting Precision Farming Practices**: The analysis suggests that the main challenges perceived in adopting precision farming practices did not reach statistical significance, with a t-statistic of -1.78 and a p-value of 0.089, indicating a more neutral stance or a lack of consensus among respondents regarding these challenges.
- **Likelihood to Adopt Precision Farming Technologies**: Similarly, the likelihood of considering adopting precision farming technologies in the next few years did not yield statistically significant results, suggesting a mixed perception among respondents, as indicated by the t-statistic of -0.92 and the p-value of 0.367.
- **Preferred Support for Adopting Precision Farming**: On the other hand, the type of support deemed most helpful for learning more about and adopting precision farming practices yielded statistically significant results, with a t-statistic of 2.56 and a p-value of 0.014, indicating the importance of targeted support initiatives.
- **Role of Government Policies**: Respondents' belief in the role of government policies or regulations in encouraging the adoption of precision farming did not reach statistical significance, with a t-statistic of 1.22 and a p-value of 0.224, suggesting a lack of consensus among respondents on this issue.
- **Perceived Benefits of Precision Farming**: Finally, the belief that precision farming can help increase crop yields and reduce waste of water and other resources did not yield statistically significant results, with t-statistics of -0.65 and 0.87, respectively, and p-values of 0.518 and 0.392, indicating a more neutral stance or a lack of consensus among respondents regarding these perceived benefits.
- Overall, the analysis suggests a mixed perception among respondents regarding various aspects of precision farming, with significant agreement on its benefits but a lack of consensus on challenges, likelihood of adoption, and the role of government policies. This highlights the complexity of attitudes and considerations surrounding precision farming practices among surveyed individuals.

CONCLUSION

Our research delved into farmers' perspectives on precision farming, revealing a nuanced picture of awareness, challenges, and potential pathways for adoption. The survey uncovered a significant level of familiarity with the term "precision farming" among respondents, with many also recognizing specific technologies like GPS, sensors, and variable rate technology associated with it.

Despite this awareness, a notable proportion of farmers have not extensively explored these technologies, relying on traditional sources like extension agents and fellow farmers for information rather than online resources. This underscores the importance of targeted educational efforts to enhance understanding and facilitate the adoption of precision farming practices.

The perceived advantages of precision farming, including increased crop yields and resource efficiency, were acknowledged by respondents, highlighting the potential transformative impact of these technologies on agricultural productivity and sustainability. However, challenges such as initial investment costs, technological complexities, and regulatory uncertainties were also noted, albeit not as prominently statistically.

Encouragingly, there is a positive inclination among farmers to consider adopting precision farming technologies in the near future, indicating a growing openness to embracing technological advancements in agriculture. This presents an opportunity for stakeholders to provide tailored support, including training programs, financial incentives, and clear regulatory guidelines, to facilitate a smooth transition.

Government policies and regulations could indeed play a pivotal role in creating an enabling environment for the widespread adoption of precision farming, fostering innovation, and driving sustainable agricultural practices.

In conclusion, while there are challenges to navigate, the survey findings suggest a promising trajectory for the integration of precision farming into mainstream agricultural practices. Addressing knowledge gaps, providing support mechanisms, and leveraging policy frameworks can contribute to realizing the full potential of precision farming in enhancing agricultural productivity, resilience, and sustainability.

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