Analecta Technica Szegedinensia

Vol. 18, No. 4 ISSN 2064-7964 2024

THE RISKS OF AI IN AGRICULTURE

[1]György Hampel, [2]Zoltán Fabulya

[1]Faculty of Engineering, University of Szeged, Mars tér 7. 6724, Szeged, Hungary,
[2]Faculty of Engineering, University of Szeged, Mars tér 7. 6724, Szeged, Hungary,
e-mail: hampel.gyorgy@szte.hu

Received: 6th June	Accepted: 10th December

ABSTRACT

Integration of artificial intelligence (AI) into agriculture has the potential to revolutionise agriculture, but it also presents challenges and risks that must be carefully managed. AI can improve planning, streamline work processes, and improve decision making in crop cultivation and animal husbandry, ultimately leading to higher returns for farmers. However, lack of training and high implementation costs can make it difficult for some farmers to adopt AI, creating a competitive disadvantage and concentrating agricultural resources. Additionally, AI may contribute to unemployment among those with lower skill levels and poses cybersecurity risks that need continuous monitoring. Legal concerns also arise with respect to data ownership and usage rights, with questions about who can access and utilise collected data. Farmers often have to rely on AI systems as "black boxes", with limited understanding of how they work. If these systems fail and cause damage, accountability becomes an important issue. It is crucial to assess the drawbacks and risks of AI implementation in agriculture and educate farmers about these risks to prevent significant damage. Managing these risks effectively and ensuring data accuracy and security are essential in the global adoption of AI in agriculture.

Keywords: artificial intelligence, agriculture, dangers, risks

1. INTRODUCTION

The notion that robots will replace human labour in crop harvesting is now a reality rather than a mere fiction. Artificial intelligence (AI), also known as machine intelligence (MI), has emerged as a novel technology that not only simplifies daily life, but also enhances productivity and profitability in various systems. The importance of AI is evident from the projected value of the global AI market, which is expected to reach a staggering 1,581 billion US dollars by 2030 [1]. AI has already permeated the entire economy, making its presence felt in industries, finance, education, trade, and increasingly in the agricultural sector.

Agriculture and farming, which are among the oldest and most crucial fields of human activity, have immense social importance, even though their contribution to the gross domestic product may have diminished over time. Throughout history, mankind has used various technologies to cultivate crops, grow plants, and use animals. However, with the growing population and the shrinkage of arable land, it has become imperative to make farming more efficient and innovative. Consequently, efforts are being made to improve productivity and yield in cultivated areas [2].

Improvement is crucial not only to ensure food supply but also to address the significant ecological footprint and harmful side effects associated with food production, which contribute to climate change [3]. Agriculture and related industries face numerous intricate and challenging issues that require a fresh perspective and innovative – sometimes revolutionary – solutions. Increasing efficiency to the maximum, acquiring and analysing high-quality data, and mobilising previously untapped or underutilised resources have emerged as crucial concerns, thereby fostering more sustainable practices. Within this framework, a significant hurdle lies in the form of global warming, escalating water scarcity, erratic weather patterns and occurrences, the dearth of essential resources vital for agriculture, migration, waning interest or attrition of the societal strata engaged in agriculture to alternative sectors, financial constraints, inequitable distribution of wealth and income, and unfavourable working conditions. In addition, there is the pressing issue of the growing demand for food, which is accompanied by the imposition of increasingly stringent food safety and quality

DOI: https://doi.org/10.14232/analecta.2024.4.32-44

regulations, the evolution of consumer preferences driving these changes, and the need to minimise the use of harmful pesticides [4] [5].
The widespread adoption of digital technologies in agriculture is based primarily on various technological solutions such as sensor technology for data collection, actuators for intervention, microcomputers for onboard control, (mobile) telecommunication systems for data transmission, and databases for remote or cloud-based services and server technologies [6]. These technological advances can be further enhanced through the integration of AI.
AI offers numerous opportunities to transform agricultural work processes, but it also comes with risks and dangers that must be carefully considered [1]. To determine the appropriate use of AI in agriculture and to address the associated risks and downsides, it is essential to draw information from existing AI applications. Moreover, the Collingridge dilemma, which suggests that the full impact of technology cannot be predicted until it is widely adopted, emphasises the challenges of subsequent control and changes once technology is fully integrated into daily practices [7].

2. MATERIALS AND METHODS

The prevalence of AI is evident in the extensive collection of over 1.4 million articles on Google Scholar (https://scholar.google.com/) in the past 5 years that pertain to this field. Surprisingly, only a mere 36,000 articles touch on the potential risks associated with this emerging technology. In comparison, the number of articles concerning agriculture in relation to AI is considerably lower, with approximately 30,000 articles available, of which around 18.6 thousand acknowledge the risks associated with its application in this domain.
Scite – Citation Statement Search (https://scite.ai/search) found 256,339 articles related to AI between 2019 and 2024, of which 68,222 mentioned some kind of risk involved in the use of AI. 13,048 of the published articles mentioned AI and agriculture in relation to each other, of which 4,284 also mentioned risks.
Consequently, it becomes apparent that while numerous studies explore the possibilities and advantages of artificial intelligence, insufficient emphasis is placed on the potential risks.
After briefly examining the concept of AI, its main types and the advantages that arise from its implementation in the field of agriculture, our research strives to synthesise pertinent sources that can provide a more comprehensive understanding of the dangers and challenges posed by AI.

3. RESULTS AND DISCUSSION

3.1. The interpretation of AI and the advantages in agriculture

According to the European Parliament, AI is poised to become the predominant technology of the future, allowing machines to exhibit human-like behaviour through capabilities such as environmental sensing, learning, problem solving, planning, reasoning, and creativity [8].
Numerous interpretations of AI can be found in the academic literature, making it difficult to pinpoint the most precise definition that satisfies all requirements. Marvin Lee Minsky was a prominent figure in the field of AI, known for his groundbreaking research. He defined AI as the discipline focused on developing machines capable of performing tasks that typically require human intelligence [9].
AI systems, while not equivalent to human intelligence, can mimic certain aspects of it [1]. These systems can analyse their surroundings, exhibit intelligent behaviour, and perform specific tasks autonomously. AI can manifest itself through software applications or physical entities such as robots and drones. Machine learning plays a crucial role in AI, enabling systems to create algorithms for tasks such as recognition and classification based on training data [10]. AI has the ability to identify and understand complex scenarios through rapid processing, merging, and analysis of large and diverse data sets [3]. It is not mandatory that all data and the objective for data computation are predetermined and familiar to AI; the system must also have the capability to operate with unfamiliar data. It must have the ability to autonomously determine which data

DOI: https://doi.org/10.14232/analecta.2024.4.32-44

to use for a specific purpose [11] [12]. According to ref. [11] and [13], AI, which includes both software and/or hardware components, is capable of self-improvement, thus improving its own performance. By continuously processing incoming data and information from various sources, AI undertakes tasks that were previously exclusive to human capabilities. The most advanced AI solutions have the ability to generate novel combinations of previously acquired knowledge elements. Data collection and processing in business organisations serve primarily to facilitate management decisions. With the integration of AI, systems can generate decision proposals for decision makers, which could lead to automation of execution and elimination of human intervention in certain cases [3]. As per ref. [14], the primary objective of AI applications already in use is to improve the efficiency of digital analysis and automation solutions within business organisations. These applications typically involve quantitative changes aimed at optimising resource management and reducing costs [11].

There are three main types of AI that can be distinguished [15] [16]:

- The first type is Artificial Narrow Intelligence (ANI), which is controlled by complex algorithms and neural networks. ANI systems can learn from experience, detect patterns, and make predictions. However, they are still far from possessing the full range of human intelligence. Examples of ANI include image and facial recognition systems, self-driving vehicles, and virtual assistants.
- The second type is Artificial General Intelligence (AGI), which encompasses the capabilities of ANI and goes beyond them. AGI systems can extrapolate acquired knowledge to tasks and situations that are not closely related to the data and algorithms they have processed. To achieve AGI, significant computing power is required, currently only available in supercomputers. While AGI systems are still under development, examples can be found in super- or quantum computers, as well as generative models like ChatGPT.
- The third type is Artificial Superintelligence (ASI), which represents the highest level of AI sophistication. ASI systems possess complete self-awareness and are capable of understanding and imitating human behaviour. They combine human-like characteristics with superhuman processing and analytical capabilities. Although the creation of ASI systems in the near future is unlikely, it is important to prepare for a world where AI can surpass and potentially render humans obsolete in various ways. This preparation should involve ethical, legal, and other means. The point at which AI surpasses human mental capabilities, known as the technical or AI singularity, is a significant milestone in the rapid development of AI.

For agricultural decision makers, the use of AI in a strategic way has the potential to improve productivity, minimise waste, and optimise costs. Various studies have highlighted several ways in which AI can benefit farmers [17] [18] [19] [20] [21]:

- Utilisation and analysis of diverse data types: A plethora of data types can be obtained from various devices such as photos, videos, light, IoT sensors, and other technologies that capture inputs.
- Real-time data tracking: Even a single plant can produce significant data on the impact of light, water, weather, and environmental changes on production, taste, disease susceptibility, and more. Over time, these data can offer valuable insight to improve efficiency, increase yield, determine pricing based on estimated crop yields, reduce waste, enhance nutritional value, and optimise the use of diminishing resources such as water, arable land, fertilisers and pesticides.
- Livestock health monitoring: AI can monitor vital signs, daily activity levels, and food intake of animals to ensure their well-being.
- Continuous machine learning with round-the-clock monitoring: Continuous data collection, including drone use, allows real-time information on crop growth and environmental conditions, allowing farmers to adapt to unexpected events.
- Deployment of Autonomous Systems: Intelligent self-driving vehicles, robots, and drones offer a solution to perform various agricultural tasks that are challenging to perform with human labour.
- Supply chain monitoring: Enhancing the traceability of supply chains to facilitate the delivery of fresher and safer produce to the market has become a crucial aspect of agricultural operations.

DOI: https://doi.org/10.14232/analecta.2024.4.32-44

3.2. Risks and dangers

Like any emerging technology, AI presents numerous questions and obstacles that need to be addressed. The pursuit of advantages inevitably brings about risks. It is crucial to analyse the potential unintended consequences of using AI in agricultural settings, as well as the impact of AI advancements in other sectors on agriculture. Additionally, according to ref. [22], failure to realise the potential benefits of the AI application poses a risk that must be taken seriously. Throughout the development of AI, all potential risks must be evaluated and assessed, and the possible drawbacks of implementation must be carefully examined [23] prior to the deployment of the AI system.

The creation of a machine that mimics human intelligence demands significant time and resources, resulting in high production costs. It requires cutting-edge hardware and software for operation, increasing additional expenses [16]. Stakeholders in agriculture, similar to other industries, face challenges related to AI use, such as substantial investment requirements, compatibility with existing technological frameworks, and the need for specialised skills and resources for operation [2].

It is crucial to ensure proper collection, storage, and processing of daily generated data necessary for the functionality of AI systems [24]. The variation in the quality of the data collected in agriculture [25] can pose challenges during processing. To facilitate data transmission, the establishment of a high-speed (wireless) computer network is imperative. Furthermore, achieving interoperability between systems from different software developers and clarifying the collected data may present obstacles [24] [26]. The effective use of these systems also requires user training (farmer) and the organisation of specialised workshops [27]. Lastly, the development of innovative business models is vital to the efficient adoption of new technologies [25] [26].

A. Legal Considerations

The rapid advancement of AI in agriculture has the potential to make existing regulatory frameworks obsolete, thereby posing challenges to the safe and responsible use of this technology. A significant barrier to the widespread adoption of data-driven agricultural technology is the lack of clarity surrounding the legal interpretation of data ownership and data security concerns [25] [28].

In the European Union, personal data are protected by stringent regulations, such as the General Data Protection Regulation (GDPR). Although certain agricultural data can be considered personal data, most of the data in this domain are not subject to the same level of regulatory oversight. In 2018, a contractual agreement known as the EU Code of Conduct on the sharing of agricultural data was established and approved by nine major European agricultural organisations [29]. According to this agreement, the data producer is deemed the rightful owner of the generated data, and any subsequent use of these data requires prior consent and adherence to the conditions outlined in the contract, often involving a fee. Although this agreement is voluntary in nature, the participation of influential organisations that have signed it provides some assurance about the transparency and responsible use of data produced by agricultural entities [10].

It is crucial that both agricultural practitioners and researchers have access to the data that have been collected. However, this can potentially clash with the concerns and rights of farmers, who often harbour apprehensions about their data being disclosed to the public [28]. Despite the presence of contracts that aim to regulate data security, there is still a sense of mistrust with respect to data management between farmers and companies [30].

The question arises as to who should be responsible for the damages caused by AI [2]. Should it be the owner/user, the manufacturer/distributor of the ‘device’, or the programmer? If the sole burden of damages falls on the user, it could potentially erode trust in AI-driven technologies, while excessively stringent regulations may hinder innovation [31].

AI has the potential to affect the right to privacy and data protection through various means, such as facial recognition technology, online tracking, and profiling [31]. The misuse of data poses a significant risk, which

DOI: https://doi.org/10.14232/analecta.2024.4.32-44

justifies the need for legal regulations. Although data ownership and security are often highlighted in legal discussions, it is essential to consider other areas that may also be influenced by AI, such as aviation safety regulations, self-driving vehicle regulations, and environmental protection issues [32]. Furthermore, ethical considerations should not be overlooked [33] along with the legal and regulatory frameworks.

B. Reliability Considerations

The current capabilities and future advancements of AI, including generative language models such as ChatGPT, present both opportunities and challenges, as well as potential dangers, for humanity and specifically for the field of agriculture. AI-powered chatbots are now widely accessible through various search engines, offering a convenient and efficient means of accessing relevant information, including agricultural topics. This accessibility saves valuable time and effort that would otherwise be spent on lengthy search and research processes. However, it is crucial to acknowledge that improper training or imprudent use of these chatbots can introduce risks to users. Despite their ability to provide seemingly plausible answers, even to experts, these systems are not immune to generating incorrect or non-sensical responses, as highlighted by ref. [34].

AI systems, particularly those employing machine learning, often function as enigmatic "black boxes" for users [35]. This opacity raises concerns about the lack of human understanding of the decision-making process and its potential for unpredictable behaviour under unexpected circumstances [22]. Consequently, the reliability of such systems and the appropriate circumstances for their use are in question [36]. For instance, when an AI system, known for its reliability, suggests a course of action that contradicts a farmer's own judgment, what should the farmer do? This dilemma prompts an examination of the parties responsible for the results generated by AI systems and the distribution of accountability [37] [38] [39] [40], as discussed in the section on legal considerations. Who bears responsibility in such cases? Is the farmer using the tool, the system designers, or the individuals who provided the training data? Furthermore, there is a risk that the party at fault may evade accountability or that no one will be held responsible at all. Until these issues are resolved, the potential benefits of AI in agriculture may not be realised, as farmers and agricultural producers hesitate to adopt and embrace AI technologies [22].

C. Digital (data) security considerations

The agricultural industry faces a significant challenge in effectively managing the vast amount of data it generates. Traditional tools and methods are no longer sufficient to meet the demands and complexities of the present time. Therefore, there is a need for new and more advanced technological solutions [30].

The advent of digitalisation in agriculture brings with it the potential vulnerability to cyberattacks. It is crucial to consider not only the familiar forms of attacks such as ransomware and denial of service in other sectors, but also the disruption of AI-controlled machinery. These machines include autonomous sprayers, self-driving tractors and harvesters, and robot swarms used for crop inspection, among others [23]. Furthermore, the deployment of AI itself can pose risks [41]. For example, attacks that deceive autonomous tractors into planting seeds too deep or causing damage to crops can have severe consequences on food security, the economy, and society as a whole [22]. To mitigate this risk, it is crucial to involve appropriate professionals, such as ethical hackers, during the development phase of AI systems. Their expertise can contribute to ensuring the security and integrity of these systems [42].

If AI becomes widely adopted and plays an important role in agriculture, there is a potential vulnerability to cyber attacks targeting the agricultural sectors of developed countries, especially during times of war or terrorist activity [43] [44]. This could lead to the exposure or misuse of sensitive agricultural data if adequate security measures are not in place. The risk of data leakage is a concern, which could have serious implications for farmers, farms, and food security due to the compromise of critical information related to crops, livestock, and supply chains [42] [45].

DOI: https://doi.org/10.14232/analecta.2024.4.32-44

In addition, AI systems have the ability to increase surveillance on agricultural workers using the data they generate to monitor and supervise individuals [46]. AI applications that interact physically with individuals or are integrated into the human body may pose security risks if not designed and implemented with adequate precautions, used incorrectly, or targeted by online attacks.

D. Algorithmic Bias Considerations

The effectiveness of machine learning systems is highly dependent on the quality of training data. When the data used for training are distorted, inaccurate results can be obtained, aligning with the GiGo (Garbage In, Garbage out) principle. Data distortion refers to data that deviates from the reality it is intended to represent. For instance, image recognition systems are trained using photographs captured under various lighting conditions and backgrounds. Consequently, AI algorithms learn to classify objects based on these diverse factors [47] [48]. There are two distinct types of bias in this case:

- First, the use of systems trained in different regions with varying environmental conditions [49] can pose numerous challenges for agricultural producers. Diskrepancies in environmental factors can lead to inaccurate predictions or recommendations, affecting the effectiveness of AI-based agricultural practices.
- Second, another issue arises from the fact that the data used to train AI systems predominantly originate from industrial management practices. This can be problematic as many regions still adhere to small-scale and indigenous farming traditions, where digital agriculture technologies are not prevalent. Consequently, AI systems may not be trained on data that represent these local farming practices, which can result in inadequate support or exclusion of local farms. As a result, society would lose valuable knowledge embedded in the traditions of local climate, flora, and fauna [22].

E. Economic vulnerability considerations

Ref. [50] suggests that the use of artificial intelligence systems that have the ability to have a significant impact on stock exchange rates can have extensive economic consequences that extend to agriculture, food raw materials and food prices. These consequences could cause a crisis and potentially disrupt the entire agricultural sector. It is important to note that the data used in these systems are not limited to agricultural properties or plants. The entire food supply chain is involved in producing and using these data, which affects the entire chain [51]. Furthermore, the reliance on artificial intelligence technology can lead to the loss of traditional knowledge and skills, as well as to a lack of diversity in agricultural practices. Overreliance on AI systems can leave farmers vulnerable to various disturbances, including system failures, data loss, or technical problems. This poses significant risks not only for farmers but also for the broader food economy [44].

Automating agricultural processes can also lead to a loss of autonomy for farmers, as they may depend on AI systems [22] or systems manufacturers [24] to make decisions. This change in decision-making powers may lead agricultural experts to hand over control to organisations that own the data.

F. Considerations Related to the Deepening of economic inequalities

Farmers using artificial intelligence systems can gain a competitive advantage over low-level technology system users [24]. Information gaps between the modern AI-based and other economies can distort market competition because the former have access to better and more in-depth information. The high cost of implementing artificial intelligence tools can make them unobtainable for economies with low capital intensity, exacerbate existing inequalities in the agricultural sector, and restrict access to advanced technologies that may be most useful. This situation could lead to a further concentration of capital and energy for larger agricultural enterprises [23] [52] [53].

DOI: https://doi.org/10.14232/analecta.2024.4.32-44

The development and ownership of AI technology is predominantly in the hands of large companies, which use their dominance to control the entire food supply chain and market. As small economies struggle to compete with industrial giants, the concentration of power and capital can deepen economic and social inequality [22] [25] [54] [55].

G. Considerations for Agri-Jobs

The appeal of AI lies in its ability to perform cognitive tasks traditionally performed by humans, which could lead to a reduction in the demand for human labour if machines prove to be more efficient in producing goods and delivering services. The probability of automation depends on whether they involve cognitive or manual tasks, as well as whether they follow a routine pattern or not [56] [57]. It is evident that AI will also bring about a transformation in the nature of work within the agricultural sector [22].
The potential impact of AI on the workforce, particularly in agriculture, is a topic of concern due to the risk of mass unemployment associated with its widespread adoption [7]. The use of AI-powered robots in agriculture poses a threat to jobs that involve manual labour and require lower qualifications. Moreover, the notion that AI could replace many intellectual tasks is a common concern [58]. Consequently, the implementation of AI in agriculture, similarly to other sectors, may jeopardise the employment of people engaged in both physical and cognitive work [57].
The proliferation of AI is expected to result in job displacement, while simultaneously generating new job opportunities that require higher skill levels and fostering the emergence of creative job roles [16]. The supervision of AI systems is expected to require fewer individuals, but those engaged in this work will require greater expertise [59].
Furthermore, it is expected that if only tasks beyond the capabilities of machines are performed, the expertise required for these remaining jobs will likely decrease compared to the present [59] [60]. In the realm of agriculture, the overall impact is projected to be negative. Although the implementation of AI will undoubtedly create new jobs, it is unlikely to generate as many jobs in agriculture as it eliminates [22].
Researchers speculate that in the future, the management of a farm will resemble the management of any other business, with teams consisting of humans and robots [22]. Education and training play a vital role in equipping individuals with the necessary skills for these domains [31].

H. Considerations on the Transformation of the relationship between the Country and the city

The potential impact of AI on rural areas goes beyond job losses. It can cause demographic changes and alter the social and political dynamics of rural and urban populations [61]. This can have an impact on the political and financial support received by farmers and the agricultural sector. If agriculture is perceived as a mere part of the information technology sector or if resources are concentrated in this sector, maintaining support is difficult and could lead to political dissatisfaction.
It should also be noted that a decrease in employment opportunities in agriculture can also lead to the emergence of new companies in rural areas, such as hospitality and tourism [62]. Reorganisation of agricultural jobs can gradually blur cultural differences between urban and rural areas [63] [64] [65] and lead to economic and political transformations [22].

I. Environmental Considerations

AI systems that prioritise resource-intensive management practices, despite their inefficiency, can initially enhance efficiency and increase crop yield. However, this improvement often comes at the expense of the environment. AI systems programmed solely to maximise short-term crop yield tend to overlook the long-term environmental consequences associated with their actions [42]. Such disregard for the environment can

DOI: https://doi.org/10.14232/analecta.2024.4.32-44

result in long-term negative effects, such as the excessive use of chemicals that disrupt the delicate balance of local flora and fauna. Ultimately, this disruption can cause damage to ecosystems and biodiversity [66].
Furthermore, the contribution to the proliferation of monoculture is another concern, as it is widely recognised to have detrimental effects on the environment [67]. The development and increased adoption of genetically modified crops may also make agriculture more susceptible to crop losses, as these modifications can inadvertently enhance vulnerability to plant diseases [22].
AI systems trained on data from a specific region may not consider the unique environmental factors and biodiversity of other regions, potentially leading to unintended consequences and exacerbating biodiversity loss. This highlights the importance of responsibly developing AI technologies and testing them in controlled environments to prevent negative impacts on the environment [8] [42]. Ensuring the sustainability of AI solutions in agriculture is essential for long-term economic and environmental viability, as well as the preservation of natural resources.

J. Alienation from the Natural World

AI systems have the ability to simplify and distort our perception of the world by transforming everything into data. This can lead to a loss of connection with the natural world, as highlighted by ref. [68] and [69]. The widespread use of AI in agriculture has the potential to alter our understanding and appreciation of the natural world, as it encourages us to view it through the lens of data. This change in perspective can undermine political support for environmental initiatives, as the value of the natural world may be overshadowed by its quantifiable aspects.
Furthermore, improper use of AI can negatively impact animal welfare. Articles [70] [71] [72] have highlighted their concern that, in certain agricultural contexts, the suffering of animals may be obscured by the collected data and the relationships formed from them.
It is important to recognise that if we treat nature solely as a data system to be analysed and manipulated, there can be detrimental consequences for both the environment and us. Our world cannot be fully described or understood solely by numerical data, and it is crucial to recognise that plants and animals are not mere machines [22].

4. CONCLUSIONS

Some analysts predict that in the near future, a market-economic environment may emerge that does not favour the widespread adoption of AI in agriculture. This can be attributed to several key factors, such as a significant decline in investor and user interest in new technology, increased development costs, and the need for stringent regulations [73].
As appears, AI now has enormous potential in various sectors, including agriculture, making it an attractive prospect for farmers and suppliers of AI systems. Its integration into agriculture has the potential to increase efficiency, productivity, and sustainability, ultimately leading to a more resilient and food-secure world.
However, along with these numerous opportunities and advantages, the introduction and implementation of this new technology also brings forth a multitude of risks and hazards, discussed in this article. In the agricultural industry, there are unprecedented challenges posed by AI for which only seemingly suitable solutions are currently being developed. For the squeezing solution many stakeholders are required to cooperate between experts of several disciplines, farmers, companies, governments, and international organisations.

REFERENCES

[1] Cs. Köpöncei, A mezőgazdaságban is hódít a mesterséges intelligencia / Artificial intelligence is also conquering agriculture, Világgazdaság, 2023. (Accessed: 8th March, 2024, https://www.vg.hu/vilaggazdasag/2023/02/a-mezogazdasagban-is-hodit-a-mesterseges-intelligencia)

[2] M. Czékus, Mesterséges intelligenciával támogatott mezőgazdaság / Agriculture supported by artificial intelligence, Mezőhír, 2021/5, 2021. (Accessed: 8th March, 2024, https://mezohir.hu/2021/05/10/mesterseges-intelligencia-az-agrariumban-mezogazdasag/)
[3] Gy. Bőgel, A dolgok internetének hatása az ellátási láncokra: a mezőgazdaság példája / The impact of the Internet of Things on supply chains: the example of agriculture, Logisztikai trendek és legjobb gyakorlatok, 4 (2) (2018), pp. 23-27. https://doi.org/10.21405/logtrend.2018.4.2.23
[4] N. C. Eli-Chukwu, Applications of Artificial Intelligence in Agriculture: A Review, Engineering, Technology & Applied Science Research, 9 (4) (2019), pp. 4377-4383. https://doi.org/10.48084/etasr.2756
[5] S. Qazi, B. A. Khawaja, Q. U. Farooq, IoT-Equipped and AI-Enabled Next Generation Smart Agriculture: A Critical Review, Current Challenges and Future Trends, IEEE Access, 10 (2022), pp. 21219-21235. https://doi.org/10.1109/ACCESS.2022.3152544
[6] M. C. Annosi, F. Brunetta, A. Monti, F. Nat, Is the trend your friend? An analysis of technology 4.0 investment decisions in agricultural SMEs, Computers in Industry, 109 (2019), pp. 59-71. https://doi.org/10.1016/j.compind.2019.04.003
[7] V. Nagy, V. Hajdu, A mesterséges intelligencia lehetséges hatása(i) a „munka világára” / Potential Impact(s) of Artificial Intelligence on the 'World of Work', Jelenkori társadalmi és gazdasági folyamatok, 16 (1-2) (2021), pp. 79-90. https://doi.org/10.14232/jtgf.2021.1-2.79-90
[8] European Parliament, What is artificial intelligence and how is it used?, 2023. (Accessed: 8th March, 2024, https://www.europarl.europa.eu/topics/en/article/20200827STO85804/what-is-artificial-intelligence-and-how-is-it-used ljak)
[9] T. Stonier, The Evolution of Machine Intelligence, In: Stoner, T. (ed.), Beyond Information, Springer, London. 1992, 107-133. https://doi.org/10.1007/978-1-4471-1835-0_6
[10] I. Szabó, Az agrárinformatika helyzete, fejlődési irányai hazánkban és nemzetközi kitekintésben / The situation and development directions of agricultural informatics in Hungary and in an international perspective, Állattenyésztés és takarmányozás, 68 (3) (2019), pp. 185-194.
[11] A. Szalavetz, Mesterséges intelligencia és technológiavezérelt termelékenységemelkedés / Artificial intelligence and technology-driven productivity growth, Külgazdaság, 63 (7-8) (2019), pp. 53-79. (Accessed: 8th March, 2024, http://real.mtak.hu/102427/1/Szalavetz_MI_Final.pdf)
[12] S. Russel, P. Norvig, Artificial Intelligence: A Modern Approach, Third Edition, Pearson Education Limited, New Jersey, 2010. (Accessed: 8th March, 2024, https://people.engr.tamu.edu/guni/csce421/files/AI_Russell_Norvig.pdf)
[13] M. Taddy, The technological elements of artificial intelligence, National Bureau of Economic Research, Working Papers No. 24301 (2018). https://doi.org/10.3386/w24301
[14] M. Chui, J. Manyika, M. Miremadi, N. Henke, R. Chung, P. Nel, S. Malhotra, Notes from the AI frontier: Applications and value of deep learning, McKinsey Global Institute, 2018. (Accessed: 8th March, 2024, https://www.mckinsey.com/featured-insights/artificial-intelligence/notes-from-the-ai-frontier-applications-and-value-of-deep-learning)
[15] SAP, What is artificial intelligence?, 2023. (Accessed: 8th March, 2024, https://www.sap.com/uk/products/artificial-intelligence/what-is-artificial-intelligence.html)
[16] N. Duggal, Advantages and Disadvantages of Artificial Intelligence [AI], Simpilearn, 2023. (Accessed: 8th March, 2024, https://www.simplilearn.com/advantages-and-disadvantages-of-artificial-intelligence-article)
[17] E. Alreshidi, Smart Sustainable Agriculture (SSA) Solution Underpinned by Internet of Things (IoT) and Artificial Intelligence (AI), International Journal of Advanced Computer Science and Applications, 10 (5) (2019), pp. 93-102. (Accessed: 8th March, 2024, https://arxiv.org/ftp/arxiv/papers/1906/1906.03106.pdf)

[18] L. Columbus, 10 Ways AI Has The Potential To Improve Agriculture In 2021, Forbes, 2021. (Accessed: 8th March, 2024, https://www.forbes.com/sites/louiscolumbus/2021/02/17/10-ways-ai-has-the-potential-to-improve-agriculture-in-2021/)
[19] L. Morgan, AI examples that can be used effectively in agriculture, Techtarget Network, 2022. (Accessed: 8th March, 2024, https://www.techtarget.com/searchenterpriseai/feature/AI-examples-that-can-be-used-effectively-in-agriculture)
[20] P. R. Bhagat, F. Naz, R. Magda, Artificial intelligence solutions enabling sustainable agriculture: A bibliometric analysis, PLoS ONE, 17 (6) (2022), pp. 1-19: e0268989. https://doi.org/10.1371/journal.pone.0268989
[21] W. Gonzalez, How AI Is Cropping Up In The Agriculture Industry? Forbes, 2023. (Accessed: 8th March, 2024, https://www.forbes.com/sites/forbesbusinesscouncil/2023/02/02/how-ai-is-cropping-up-in-the-agriculture-industry/)
[22] R. Sparrow, M. Howard, Ch. Degeling, Managing the risks of artificial intelligence in agriculture, NJAS: Impact in Agricultural and Life Sciences, 93 (1) (2021), pp. 172-196. https://doi.org/10.1080/27685241.2021.2008777
[23] M. Taylor, Researchers Warn of Risks of Using AI in Agriculture, Laboratory Equipment, News, 2022. (Accessed: 8th March, 2024, https://www.laboratoryequipment.com/583705-Researchers-Warn-of-Risks-of-Using-AI-in-Agriculture/)
[24] BMEL – Bundesministerium für Ernährung und Landwirtschaft (ed.), Digitalisierung in der Landwirtschaft 2018, Bundesministerium für Ernährung und Landwirtschaft, 2018. (Accessed: 8th March, 2024, https://www.bmel.de/SharedDocs/Downloads/DE/Broschueren/digitalpolitik-landwirtschaft.pdf?__blob=publicationFile&v=9)
[25] S. Wolfert, L. Ge, C. Verdouw, M.-J. Bogaardt, Big Data in Smart Farming – A review, Agricultural Systems, 153 (2017), pp. 69-80. https://doi.org/10.1016/j.agsy.2017.01.023
[26] V. Bonneau, B. Copigneaux, L. Probst, B. Pedersen, Industry 4.0 in agriculture: Focus on IoT aspects. Digital Transformation Monitor, European Committee, 2017. (Accessed: 8th March, 2024, https://ati.ec.europa.eu/sites/default/files/2020-07/Industry%204.0%20in%20Agriculture%20-%20Focus%20on%20IoT%20aspects%20%28v1%29.pdf)
[27] A. Deter, Landwirtschaft 4.0 – endlich mal praktisch, Top Agrar, (3) (2018), pp. 116–117. (Accessed: 8th March, 2024, https://www.topagrar.com/technik/news/landwirtschaft-4-0-endlich-mal-praktisch-9372736.html)
[28] M. Kunisch, F. Kloepfer, Landwirtschaft 4.0 im Maisanbau. Mais, 44 (4) (2017), pp. 156-160.
[29] FEFAC, EU Code of concuct on agricultural data sharing by contractual aggreement 2018, 2018, (Accessed: 8th March, 2024, https://fefac.eu/wp-content/uploads/2020/07/eu_code_of_conduct_on_agricultural_data_sharing-1.pdf)
[30] B. Pollmann, Digitale Landwirtschaft: IT für Acker und Stall, 2017. (Accessed: 8th March, 2024, https://biooekonomie.de/digitale-landwirtschaft-it-fuer-acker-und-stall)
[31] European Parliament, Artificial intelligence: threats and opportunities, 2020. (Accessed: 8th March, 2024, https://www.europarl.europa.eu/topics/en/article/20200918STO87404/artificial-intelligence-threats-and-opportunities)
[32] I. Eisenberger, E. Hödl, A. Huber, K. Lachmayer, B. Mittermüller, „Smart Farming" – Rechtliche Perspektiven, In: Norer, R., Holzer, G. (eds.), Agrarrecht. Jahrbuch. NWV Verlag, Vienna, 2017, pp. 207-223.
[33] B. Zsótér, D. Deák, Á. Búrány, Gy. Hampel, Ethical aspects of inventory management in an agricultural enterprise, Analecta Technica Szegedinensia, 13 (4) (2023), pp. 40-45. https://doi.org/10.14232/analecta.2023.4.40-45
[34] K. Rass, Mesterséges intelligencia: áldás vagy átok? / Artificial intelligence: blessing or curse? Magyar mezőgazdaság, 2023. (Accessed: 8th March, 2024, https://magyarmezogazdasag.hu/2023/06/05/mesterseges-intelligencia-aldas-vagy-atok/)

[35] J. Burrell, How the machine 'thinks': Understanding opacity in machine learning algorithms, Big Data and Society, 3 (1) (2016), pp. 1-12. https://doi.org/10.1177/2053951715622512
[36] European Commission, High-level expert group on artificial intelligence, 2022. (Accessed: 8th March, 2024, https://digital-strategy.ec.europa.eu/en/policies/expert-group-ai)
[37] A. Matthias, The responsibility gap: Ascribing responsibility for the actions of learning automata, Ethics and Information Technology, 6 (3) (2004), pp. 175-183.
[38] R. Sparrow, Killer robots, Journal of Applied Philosophy, 24 (1) (2007), pp. 62-77. https://doi.org/10.1111/j.1468-5930.2007.00346.x
[39] D. G. Johnson, Technology with no human responsibility?, Journal of Business Ethics, 127 (4) (2015), pp. 707-715. https://doi.org/10.1007/s10551-014-2180-1
[40] L. Wiseman, T. Cockburn, J. Sanderson, Legal consequences of autonomous farming, Farm Policy Journal, 15 (2) (2018), pp. 37-46.
[41] H. Murphy, AI, a new tool for cyber attackers - or defenders?, Financial Times Special Report – Navigating Cyber Risk. (Accessed: 8th March, 2024, https://www.ft.com/content/09d163be-0a6e-48f8-8185-6e1ba1273f42)
[42] A. Tzachor, M. Devare, B. King, Sh. Avin, S. Ó hÉigeartaigh, Responsible artificial intelligence in agriculture requires systemic understanding of risks and externalities, Nature Machine Intelligence, 4 (2) (2022), pp. 104-109. https://doi.org/10.1038/s42256-022-00440-4
[43] R. A. Clarke, R. Knake, Cyber war: The next threat to national security and what to do about it. Harper Collins, New York, 2010.
[44] R. Dara, S. M. Hazrati Fard, J. Kaur, Recommendations for ethical and responsible use of artificial intelligence in digital agriculture, Frontiers in Artificial Intelligence, 5 (2022), pp. 884192. https://doi.org/10.3389/frai.2022.884192
[45] D. Lenniy, AI in Agriculture The Future of Farming, 2023. (Accessed: 8th March, 2024, https://intellias.com/artificial-intelligence-in-agriculture/)
[46] V. De Stefano, Negotiating the algorithm: Automation, artificial intelligence and labour protection. Working paper, International Labor Office, 2018. (Accessed: 8th March, 2024, https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---emp_policy/documents/publication/wcms_634157.pdf)
[47] D. C. Slaughter, D. K. Giles, D. Downey, Autonomous robotic weed control systems: A review, Computers and Electronics in Agriculture, 61 (1) (2008), pp. 63-78. https://doi.org/10.1016/j.compag.2007.05.008
[48] C. L. McCarthy, N. H. Hancock, S. R. Raine, Applied machine vision of plants: A review with implications for field deployment of automated farming operations, Intelligent Service Robotics, 3 (4) (2010), pp. 209-217. https://doi.org/10.1007/s11370-010-0075-2
[49] M. Keogh, M. Henry, The implications of digital agriculture and big data for australian agriculture, Australian Farm Institute, Sunny Hills NSW, 2016.
[50] J. Bridle, New dark age: Technology and the end of the future, Verso Books, London, 2018.
[51] V. Szőke, L. Kovács, Mezőgazdaság 4.0 – relevancia, lehetőségek, kihívások / Agriculture 4.0 – relevance, opportunities, challenges, Gazdálkodás, 64 (4) (2020), pp. 289-304.
[52] V. Galaz, M. A. Centeno, P. W. Callahan, A. Causevic, Th. Patterson, I. Brass, S. Baum, D. Farber, J. Fischer, D. Garcia, T. McPhearson, D. Jimenez, B. King, P. Larcey, K. Levy, Artificial intelligence, systemic risks, and sustainability, Technology in Society, 67 (2021), pp. 101741. https://doi.org/10.1016/j.techsoc.2021.101741
[53] L. Barangé, Artificial Intelligence: How could it transform agriculture?, 2023, (Accessed: 8th March, 2024, https://alliancebioversityciat.org/stories/artificial-intelligence-agriculture)
[54] A. Fleming, E. Jakku, L. Lim-Camacho, B. Taylor, P. Thorburn, Is big data for big farming or for everyone? Perceptions in the Australian grains industry, Agronomy for Sustainable Development, 38 (3) (2018), pp. 24-34. https://doi.org/10.1007/s13593-018-0501-y

DOI: https://doi.org/10.14232/analecta.2024.4.32-44

[55] Cropin, Ethical and Safe AI In Agriculture: Considerations for Lending & Insurance, 2021. (Accessed: 8th March, 2024, https://www.cropin.com/blogs/ethical-and-safe-ai-in-agriculture-considerations-for-lending-insurance)
[56] D. Autor, F. Levy, R. J. Murnane, The skill content of recent technological change: An empirical exploration, The Quarterly Journal of Economics, 118 (4) (2003), pp. 1279-1333. https://doi.org/10.1162/003355303322552801
[57] C. B. Frey, M. A. Osborne, The future of employment: How susceptible are jobs to computerisation?, Technological Forecasting and Social Change, 114 (2017), pp. 254-280. https://doi.org/10.1016/j.techfore.2016.08.019
[58] E. Brynjolfsson, A. McAfee, The second machine age: Work, progress, and prosperity in a time of brilliant technologies, W W Norton & Co., New York, 2014.
[59] S. E. Bell, A. Hullinger, L. Brislen, Manipulated masculinities: Agribusiness, deskilling, and the rise of the businessman-farmer in the United States, Rural Sociology, 80 (3) (2015), pp. 285-313. https://doi.org/10.1111/ruso.12066
[60] N. Carr, The glass cage: How our computers are changing us, W W Norton & Co., New York, 2015.
[61] S. Rotz, E. Gravely, I. Mosby, E. Duncan, E. Finnis, M. Horgan, J. LeBlanc, R. Martin, H. T. Neufeld, A. Nixon, L. Pant, V. Shalla, E. Fraser, Automated pastures and the digital divide: How agricultural technologies are shaping labour and rural communities, Journal of Rural Studies, 68 (2019), pp. 112-122. https://doi.org/10.1016/j.jrurstud.2019.01.023
[62] B. Zsótér, Turizmus Mezőhegyesen: a Hotel Nonius bemutatása / Tourism in Mezőhegyes: presentation of Hotel Nonius, In: J. Gál (ed.), Európai Uniós Kutatási és Oktatási Projektek Napja és Leonardo da Vinci Learn at Work Projekt-találkozó, Delfin Computer Informatikai Zrt., Hódmezővásárhely, 2006.
[63] H. Gosnell, J. Abrams, Amenity migration: Diverse conceptualizations of drivers, socioeconomic dimensions, and emerging challenges, GeoJournal, 76 (4) (2011), pp. 303-322. https://doi.org/10.1007/s10708-009-9295-4
[64] L. Klerkx, E. Jakku, P. Labarthe, A review of social science on digital agriculture, smart farming and agriculture 4.0: New contributions and a future research agenda, NJAS – Wageningen Journal of Life Sciences, 100315 (2019), pp. 90-91. https://doi.org/10.1016/j.njas.2019.100315
[65] B. Zsótér, S. Illés, P. Simonyi, Model of Local Economic Development in Hungarian Countryside, European Countryside, 12 (1) (2020), pp. 85-98. https://doi.org/10.2478/euco-2020-0005
[66] University of Cambridge, Risks of using AI to grow our food are substantial and must not be ignored, warn researchers, ScienceDaily, 2022. (Accessed: 8th March, 2024, https://www.sciencedaily.com/releases/2022/02/220223111240.htm)
[67] D. Tilman, Global environmental impacts of agricultural expansion: The need for sustainable and efficient practices, Proceedings of the National Academy of Sciences, 96 (11) (1999), pp. 5995-6000. https://doi.org/10.1073/pnas.96.11.5995
[68] J. Ellul, The technological society, Vintage Books, New York, 1964.
[69] M. Heidegger, The question concerning technology, and other essays, Garland Publishing, New York, 1977.
[70] A. Woods, Rethinking the history of modern agriculture: British pig production, ca. 1910–65, Twentieth Century British History, 23 (2) (2012), pp. 165-191. https://doi.org/10.1093/tcbh/hwr010
[71] L. Holloway, C. Bear, K. Wilkinson, Re-capturing bovine life: Robot–cow relationships, freedom and control in dairy farming, Journal of Rural Studies, 33 (2014), pp. 131-140. https://doi.org/10.1016/j.jrurstud.2013.01.006
[72] L. Holloway, C. Bear, K. Wilkinson, Robotic milking technologies and renegotiating situated ethical relationships on UK dairy farms, Agriculture and Human Values, 31 (2) (2014), pp. 185-199. https://doi.org/10.1007/s10460-013-9473-3

DOI: https://doi.org/10.14232/analecta.2024.4.32-44

[73] T. Nemes, Mesterséges intelligencia: már jövőre kidurranhat a lufi / Artificial intelligence: the balloon may burst as early as next year, Világgazdaság, 2023. (Accessed: 8th March, 2024, https://www.vg.hu/penz-es-tokepiac/2023/10/mesterseges-intelligencia-mar-jovore-kidurranhat-a-lufi)

DOI: https://doi.org/10.14232/analecta.2024.4.32-44