SMART AGRICULTURE, DATA AND AI IN THE CONTEXT OF COBIT 2019: ANALYSIS OF POTENTIALS AND RISKS[1]

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Abstract

Modern agriculture, which is becoming an increasingly interesting topic in scientific circles, has been commonly linked to widely widespread application in practice. Actually, it represents a comprehensive integration of smart solutions in agriculture, dominantly driven by progress in data analysis and artificial intelligence, and as such represents a direct and unambiguous significant shift in modern agricultural structures. The aim of the paper is to consider the potential benefits and associated risks in the implementation of smart agriculture. By presenting the essential elements of smart agriculture, and above all the decision-making process with the application of artificial intelligence and large-scale data management, the paper aims to provide a balanced perspective on how these technologies can improve business success in agriculture. At the same time, the subject of the work is consideration of the challenges of managing information technologies in smart agriculture. The results of the work provide a significant contribution to risk management using the various possibilities of smart agriculture. Derived conclusion shows that the main risks in new technologies use in agriculture in many countries is insufficient knowledge towards technology and high costs of its use, while its greatest potential is increasing the incomes with the less engagement of human factor.

Key words: Smart agriculture, COBIT 2019, artificial intelligence.

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Introduction

Sudden transformation that haven't bypass the sector of agriculture was caused by digital technologies, among which tools for the analysis of large amounts of data, as well as artificial intelligence (AI), stand out. Modern, smart agriculture (Photo 1.), which is actually the application of modern technology to traditional agricultural activities, brings increased productivity and efficiency, followed by increased volume and gained quality of agri-food outputs (products), while preserving the sustainability of the environment and applying the smart management under the scarce resources (Paarlberg, 2009; Subeesh, Mehta, 2021; Audia, Sugiantoro, 2022). By basing their activity on real-time data and numerous activities driven by advanced digital technologies and AI, agricultural producers can optimize crop yields, eliminate or decrease environmental impact and improve overall operational efficiency (Javaid et al., 2022; Haidar, 2024).

Photo 1. Smart agriculture

Source: Authors by https://create.microsoft.com/en-us/features/ai-image-generator

However, implementation of the concept of modern, smart agriculture accelerates new challenges, such those created in data management, application costs, data sorting, or data storage, but also these linked to cyber security and compliance with legal regulations and international food safety practices (Zhu et al., 2018; Osinga et al., 2022).

The sheer volume of data generated by the application of modern tools, which combined with the complexity of AI algorithms, requires very extensive governance to address the risks and provide all benefits of used technologies are fully realized (Kallem, 2012). Among them, one of the most relevant is COBIT 2019, a globally well-known management framework, which enables structured approach to solving previously mentioned challenges (De Haes et al., 2020; Amorim et al., 2021). It offers principles, practices and tools that can contribute to better data management when applying the concept of smart agriculture, primarily in the protection of applied information technologies from cyber security and related risks (Rupnik et al., 2021).

Methodological Framework

Performed research encompasses methods commonly used in social sciences, such as desktop research, as well as analysis and synthesis, which facilitate a better understanding of the observed topic, while drawing appropriate conclusions. Methods used are supported by theoretical perception and understanding of "Smart Agriculture" data and AI in the context of COBIT 2019, identifying key segments and impacts of mentioned framework on current state of agriculture. Writing the paper involved the use of available scientific and professional literature sources.

This research aims to analyze the potentials and risks towards the integration of smart agriculture in the context of COBIT 2019. By exploring the interconnections and entanglements between AI, data analytics and governance patterns, paper aims to secure unique, contemporary, and comprehensive insight and understanding how these elements can be aligned to improve agricultural production while mitigating occurred risk.

Results and Discussion

COBIT 2019

COBIT 2019 in its title corresponds to Control Objectives for Information and Related Technologies. It is a complex framework established to help organizations to manage applied information technology. It is designed by the Information Systems Audit and Control Association (ISACA). It is built on previous versions of COBIT, providing updated management guidance (Thabit, 2021; Kesuma et al., 2022). COBIT 2019 is very applicable in various activities, including agricultural production, ensuring that applied information systems, involving AI and other processes, support business goals, while they are subject to effective risk management, complying with relevant legislation and regulations. COBIT 2019 is designed to be adaptable, allowing agricultural producers to adapt the framework to their activities, offering a clear and measurable approach to management (Birkstedt et al., 2023; Smit, 2023).

The framework defines management as a system of setting goals, assessing risks and ensuring mutual compliance, clearly identifying the components that make up the management system (Figure 1.). COBIT 2019 framework is based on result management system that can significantly help agricultural producers to assess and improve the maturity of their data management practices, risks and potentials. It provides detailed guidelines for implementing appropriate performance metrics and very clear and unambiguous maturity models for monitoring progress. It includes a design guide and implementation guide, which offer practical advice on how to adapt and apply the framework within someone who owns farming system. These guides help align the framework with business goals and address specific management challenges (Nachrowi et al., 2020; Rusman et al., 2022).

Figure 1. COBIT 2019. elements

Processes	• Describe how information processes should be structured and subject to management.
Organizational structures	• Define roles and responsibilities within organization (farm, agricultural company).
Principles, policies and frameworks	• Provide guidance on decision-making.
Culture, ethics and behavior	• Relate to human resource management and cultural aspects of management.
Information	• Ensure that accurate and timely information is available for decision making.
Services, infrastructure and applications	• Refers to the technology and tools needed to support management.
People, skills and competences	• Focuses on ensuring that farm or agricultural company have necessary skills and expertise.

Source: ISACA, 2018.

COBIT 2019. emphasizes understanding all stakeholder imperatives, ensuring that information technology management in agricultural production is aligned with business goals and provide added value. This includes balancing stakeholder expectations and effective risk management (Chawviang, Kiattisin, 2022). Agricultural producers can use COBIT 2019 to establish robust management framework that aligns application of new technologies and AI with production goals, while providing tools and processes to identify, assess and mitigate different risks (De Goede et al., 2022). System supports agricultural producers to understand the complexity of regulatory environment by ensuring that implemented processes and related information technologies in agriculture complying with relevant laws and agricultural products safety standards (Audia, Sugiantoro, 2022; Radjulan et al., 2024).

Potentials

Smart agriculture, through its integration of contemporary technologies, as are the new digital tools, use of drones, application of AI, big data analysis and numerous other innovative technologies, offers a wide range of advantages that transform traditional agricultural activities by giving them a new, modern meaning (Goel et al., 2021; Fuentes Peñailillo et al., 2024).

These benefits affect not only the efficiency and productivity of agricultural operations, but also contribute to environmental sustainability, economic growth and food security. Smart agriculture enables precise application of inputs as are water, mineral and organic fertilizers, agro-chemicals, or animal feed. Using system data and AI-driven analysis, farmers can use and apply inputs exactly where and when they are required, decreasing waste and optimizing their use. Involvement of autonomous machines, drones and robots reduces the need for manual labor, what is surely useful in remote areas or areas facing labor shortage (Shafi et al., 2019; Shaikh et al., 2022). Activities such as planting, weeding, fertilizing, irrigating, or harvesting can be automated, saving time and reducing labor costs (Subić et al., 2017).

By applying modern AI-assisted data analysis techniques, it is possible to analyze the state of soil and crops' health, weather patterns, etc. to enable insight that optimizes planting and irrigation schedules, and nutrient management (Javaid et al., 2023). This leads to higher crop yields and better products' quality. Continuous monitoring of crops and livestock using smart sensors and drones provides real-time data, allowing farmers to make informed decisions quickly. This can prevent crop losses due to pests, diseases or adverse weather conditions. On the other hand, precision farming techniques minimize the excessive use of chemicals, which leads to a reduction in environmental pollution and a lower risk of chemical residues in food (Bongiovanni, Lowenberg Deboer, 2004; Liang, Shah, 2023). Smart irrigation systems use data sets and predefine procedures to apply water just where and when it is required, decreasing water loss and helping to conserve this highly sensitive resource, especially in agricultural production. This is especially important on agricultural arable land that faces water shortages (Bwambale et al., 2022).

By optimizing the use of water and agro-chemicals, it is possible to further reduce input costs. Farmers can achieve better results with fewer resources, leading to higher yields per hectare. At the same time, timely detection of pests and other threats through real-time monitoring enables timely interventions, reduction in crop losses and general improvement in gained yields. The ability of smart agriculture to increase productivity ensures that more food can be produced on the same area of arable land. Simultaneously, it contributes to conversion of uncultivable land into arable land, capable for producing large quantities of quality agri-food products. Advanced technologies support farmers adapt to changing climates by providing data-driven insights into how best to manage crops in different weather conditions (Agrimonti et al., 2020; Maraveas et al., 2022).

Data analytics can optimize feeding schedules and breeding programs, ensuring livestock are healthier, facilitate grow, or reproduction more efficiently. Smart agriculture gives farmers access to vast amounts of data, which, when analyzed, can lead to better decision-making. Farmers can plan production cycle more effectively, or better predict outcomes and adjust their strategies based on data-driven insights. Historical data and predictive analytics enable long-term planning, helping farmers anticipate future challenges and opportunities, such as changes in market demand or climate change (Coble et al., 2018; Jakovljevic et al., 2024).

Smart agriculture technologies enable product tracking from farm to fork, increasing transparency in supply chain. This is very important for consumers who demand visibility of origin and quality of used food (Qureshi et al., 2022). Better planning and real-time data can help reduce post-harvest losses by ensuring crops are timely harvested, stored and transported under optimal conditions, reducing food waste. The adoption of smart agriculture technologies can stimulate economic growth in rural territories through the increase in farm productivity, creating new jobs opportunities in technology-driven agriculture, and attracting investment in agricultural technology. Farmers who adopt smart agriculture can produce higher quality and larger quantities of products at a lower cost, making them more competitive in local and global markets (Ranganathan et al., 2022; Franzel et al., 2019).

Smart agricultural technologies can be adapted to fit the specific needs of different crops, regions, or farming practices. This adaptability ensures that the benefits of smart agriculture can be realized in a variety of agricultural contexts, from large commercial farms to smallholder operations. So, smart agriculture offers a few benefits that advance the economic viability and overall sustainability of agricultural practices. By using advanced technologies, farmers can achieve greater control over their operations, decrease environmental impacts and support the worldwide food security, while improving their economic performances. As these technologies continue to develop, the potential for smart agriculture to revolutionize the agricultural sector will only increase (Mwongera et al., 2017; Birkstedt et al., 2023).

Risks

There are numerous risks that smart agriculture brings. These risks can have significant implications for agricultural producers, but also for consumers and real-life cycle of agri-food products. Understanding and managing risks is essential for the successful and sustainable involvement of smart agriculture (Komarek et al., 2020). Appliance of advanced technologies and connected systems produce huge datasets, including sensitive information. This data is vulnerable to cyber-attacks, what can lead to data breaches, theft or manipulation. Cybercriminals can target agricultural systems with malware or ransomware, potentially disrupting critical operations such as irrigation, fertilization, or harvesting. Such attacks can cause significant financial losses and downtime. These vulnerabilities can be exploited to gain unauthorized access to agricultural systems, leading to potential sabotage or data manipulation (Balyan et al., 2024; Ali et al., 2024).

Collecting data from various sources, including farmers, employees and customers, raises data privacy concerns. If personal information is not properly secured, it could be exposed or misused, leading to legal and ethical issues. In many cases, it can be unclear who owns the data, and disputes over data ownership and rights of use can arise, especially when third-party service providers are involved (Wiseman et al., 2019).

As farms rely more and more on technology, any malfunction or breakdown in mentioned systems can have serious consequences. The adoption of smart agriculture requires a certain level of technical expertise, which may be lacking in some farming communities. Farmers who do not possess the necessary skills to operate and maintain new technologies may struggle to realize their full benefits (Farooq et al., 2020). The effectiveness of smart agriculture depends mostly on the accuracy of data collected by smart devices. However, these devices can sometimes produce inaccurate or incomplete data due to technical problems, environmental factors, or calibration errors. Decisions based on faulty data can lead to suboptimal outcomes. The sheer volume of data generated by a smart agriculture system can be overwhelming, making it difficult for farmers to effectively process and act on the information. Agricultural producers may struggle to keep up with these changes, which can lead to non-compliance and associated penalties. The use of proprietary technologies and algorithms in smart agriculture can lead to intellectual property disputes, especially when third-party vendors are involved. Farmers may face legal challenges if they are deemed to be infringing patents or copyrights. Although smart agriculture aims to promote sustainability, there is a risk that over-reliance on technology can lead to unintended environmental consequences. Proper disposal and recycling of these devices are essential to prevent risks and threats to environmental sustainability (Issad et al., 2019; Sacco et al., 2021; Sinha, Dhanalakshmi, 2022).

The use of modern technologies can contribute to instability in agricultural products market. If many farmers adopt these technologies at the same time, it could lead to oversupply, falling prices and reduced profitability. The high cost of smart farming technologies can widen the gap between large, technologically advanced farms and smaller, traditional farms (Bashiru et al., 2024). This could affect increased economic disparities within the sector of agriculture, or to displacement of jobs, especially in regions where agriculture is the main source of employment. So, mentioned could have a significant social and economic impact on rural communities. AI-driven systems used in smart agriculture can inadvertently introduce biases into decision-making processes. As smart agriculture involves the use of complex technologies, determining liability in cases of system failures, data breaches or environmental damage can be challenging. Farmers and technology suppliers may face legal disputes over liability and compensation. In regions where, smart agriculture systems rely on cloud-based services, data may be transferred across borders, leading to legal issues related to data sovereignty and international data protection laws (Mayakannan et al., 2023; Naibaho, Cahyono, 2024).

The risks associated with smart agriculture are multiple and require careful consideration and management. An effective governance framework, such as COBIT 2019, generally plays key role in agri-business and significantly help agricultural producers to manage these risks, ensuring that adoption of smart agriculture technologies initiate sustainable and resilient practices. By addressing cybersecurity, data privacy, regulatory compliance, and other risks, stakeholders can maximize benefits of smart agriculture while minimizing potential negative impacts (ISACA, 2018).

Conclusion

COBIT 2019 is a powerful and flexible framework for managing innovations in agricultural production, and above all excellent tool that provides agricultural producers with the opportunities and guidelines needed to effectively manage their capacities. By aligning applied technologies with business goals, adequately managing risks and ensuring a satisfactory level of compliance, COBIT 2019 helps agricultural producers to navigate the complexities of the digital age, delivering value while maintaining control over their resource environment. Its adaptability and integration with other standards make it an essential tool for risk management in the digital world. The integration of smart agriculture, driven by data analytics and artificial intelligence, represents a transformative opportunity for the agricultural sector, offering significant potential to improve production outcomes in every sense.

Paper highlights the importance of structured approach to managing the risks and potentials of smart agriculture. By using the principles, processes and tools offered by COBIT 2019, agricultural producers can not only optimize the use of AI and data, but also protect themselves from the inherent risks associated with mentioned technologies. Effective governance, as outlined in COBIT 2019, ensures that the benefits of smart agriculture are realized while minimizing a several risks, including system failures and regulatory non-compliance.

However, successful implementation of smart agriculture requires a balance between innovation and risk management. In this context, COBIT 2019 represents the most interesting framework for achieving previously defined balance, enabling agricultural producers to exploit the full potential of AI and big data-based agriculture, while maintaining tight governance and control. As agriculture continues to evolve, adoption of a governance framework, such as COBIT 2019 could be crucial to ensure that technological advances result in improved quality of agri-food products (Sherly, Fianty, 2024).

In many countries there still exist insufficient knowledge related to new technologies, while high costs of their use as the main risks of utilization in agriculture. On the other side, their huge potential lies in increased incomes with less engagement of the human factor. Paper significance is in integration of smart agriculture and AI with risk management through the COBIT 2019 framework, facilitating efficiency, data security, and sustainability in agriculture. It also provides basic guidelines for responsible and secure implementation of emerging technologies in agri-business. In subsequent steps, research could be focused on assessing farmers' readiness to adopt advanced technologies underlying the smart agriculture and AI application.

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