AI for Complex Adaptive Systems in Agric-Food Chains: Enterprise Architecture Perspectives

Ronald Tombe, Hanlie Smuts*
Department of Computing Sciences
Kisii University, Kenya
& Future Africa, University of Pretoria
Department of Informatics
University of Pretoria, South Africa
ronaldtombe@kisiiuniversity.ac.ke

Abstract

Enterprise architectures provide a structured framework for designing and managing complex organizational systems. In the context of agricultural food chains, integrating artificial intelligence (AI) can enhance the capabilities of complex adaptive systems in Agriculture (CASA). This paper explores the application of AI in agricultural food chains, focusing on how it can improve decision-making, optimize supply chain operations, mitigate risks, and promote sustainability within the context of enterprise architectures.

Keywords: Machine Learning, Deep Learning, Data Mining, Data Analytic,

1 Introduction

Agricultural food chains are complex adaptive systems characterized by dynamic interactions, interdependencies among stakeholders, and the effects of climate change. The CASA involves various stakeholders, processes, and resources wang (2005). Sensors usage in farmlands, mapping, and tracking technologies are revolutionizing farming systems and the management of the agricultural food system as it moves from farmers to consumers. The speedy growth of agricultural entities and their networks has attained the "5Vs" features of "Big-data," that is, Volume, Variety, Velocity, Veracity, and Value Coble (2018). Sensor technology, data mining, and analytics based on other industries now apply to agricultural applications Shanka (2020) Woodard (2018) Coble (2018). The computational capacity in terms of volume and speed enables novel analyses, for instance, the processing of extensive weather data for timely decision-making. Multiple data sources are sometimes integrated, including machine and sensor data, public data, and other private-entities held data. "Macro" level analysis applications that aggregate data to offer functional agricultural market-level analyses are possible, and this is true for "micro" level applications. Agricultural social networks occur in the agricultural value chain (AVC) tombe (2023) , implying obtaining 'stakeholder specific context data'. Coble (2018) define "Agricultural Big Data" as large, complex, diverse, longitudinal datasets generated from sensors, internet activities, emails, academic publications, videos, satellites, and other digital sources. This study considers the term "Agricultural-big-data" as more about the combinations of technologies for advancing analytics in creating new ways of processing data in a more helpful and timely manner within agric-food chains. Hence, solutions for issues relating to access to farming information, understanding consumer needs, and obtaining market information lie in the big-data potentials in modern societies that characterize the digital era. Agriculture big data

*Use footnote for providing further information about author (webpage, alternative address)—*not* for acknowledging funding agencies.

5th Deep Learning Indaba Conference (DLI 2023).

analysis can be grouped into collaborator activities, Farm management, recommendation systems, and expert discovery systems Sonka (2016).

AI technologies, such as machine learning, natural language processing, and predictive analytics, offer valuable tools for managing CASA within agricultural food chains. AI can process vast amounts of data, identify patterns, and provide insights that support informed decision-making and adaptive strategies. Enterprise architectures provide a structured framework for integrating AI into complex adaptive systems within agricultural food chains. By aligning people, processes, and technology, enterprise architectures facilitate the seamless integration of AI tools and techniques. They help organizations define AI use cases, data requirements, governance models, and technological infrastructure.

AgriVerse is a sophisticated cyber-physical-social system (CPSS) that efficiently processes information from both the natural and socio-economic environmentkang (2023). Within AgriVerse, the entire agriculture-related processes along the agri-food chains are conducted, encompassing planning, planting, processing, packaging, storage, distribution, resale, preparation, and consumption wang (2022).

2 Enterprise Architectures in Agriculture

The advancements in big data and Internet of Things (IoT) technologies have facilitated the collection of vast amounts of data kamilaris (2017). This data can be effectively analyzed using AI technology, which incorporates data mining techniques and combines expert knowledge with domain-specific insights to offer decision-making support in agriculture friha (2021). The heterogeneity of agricultural circumstances makes it challenging to obtain comprehensive, accurate, and timely information or knowledge. Moreover, existing predictive models often need more versatility and account for diverse climatic conditions and field-specific characteristics, such as regional, seasonal, and cyclical variations during agricultural production. The emergence of smart cities and city brains zhao (2022) has given rise to the concept of smart villages and agricultural brains, necessitating a solution to address this demand. The envisioned complex adaptable enterprise architecture that machine/deep learning algorithms can apply to manipulate various data sources is depicted in Figure 1. This can in-turn be utilized for the development of adaptable AI applications in the agriculture production ecosystem, such as for disease prediction, pest and fertilization management.

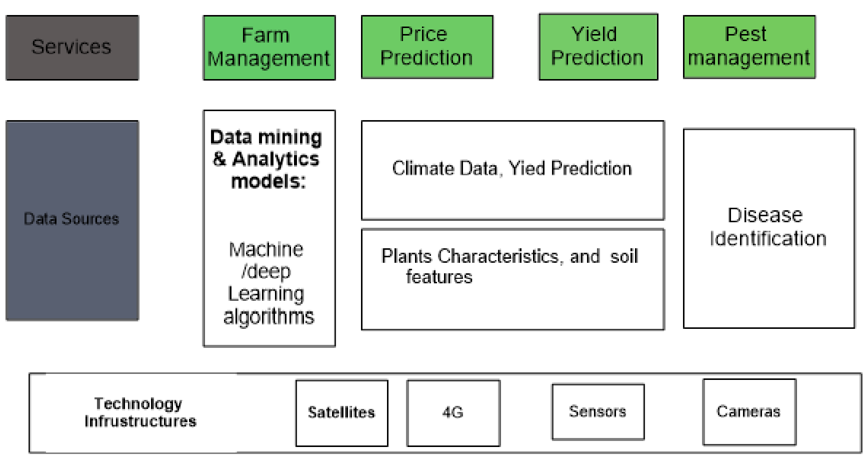

Figure 1: Enterprise architecture enabling adaptable AI applications in complex Agricultural systems

3 Perspectives and Challenges:

Demand Forecasting and Supply Chain Optimization: AI can enable accurate demand forecasting, inventory management, and supply chain optimization, improving operational efficiency and reducing waste. *Quality Control and Traceability:* AI-powered systems can analyze sensor data, images, and other inputs to detect quality issues, ensure product traceability, and enhance food safety measures. *Risk Management and Resilience:* AI models can analyze data from multiple sources, including weather patterns, market trends, and historical data, to assess risks, mitigate disruptions, and enhance the resilience of agricultural food chains. *Data Integration and Governance:* Enterprise architectures are crucial in data integration and governance within AI-driven complex adaptive systems. Can ensure that data from various sources is collected, stored, and processed while addressing data privacy, security, and compliance concerns. Additionally, enterprise architectures define data governance frameworks, including data quality standards, access controls, and ethical considerations. *Scalability and Interoperability:* Enterprise architectures provide a foundation for scalable and interoperable AI solutions within agricultural food chains. They can enable organizations to integrate AI technologies seamlessly across different systems, platforms, and stakeholders. Interoperability ensures efficient data sharing and collaboration among different participants within the food chain ecosystem.

4 Conclusion:

As AI evolves, enterprise architectures must adapt to new technologies, changing regulations, and emerging challenges. Ensuring transparency, explainability, and ethical use of AI remains critical. Organizations must also address challenges related to data integration, talent acquisition, and infrastructure requirements to leverage AI's potential within agricultural food chains fully. Enterprise architectures play a pivotal role in harnessing the potential of artificial intelligence within complex adaptive systems in agricultural food chains. By integrating AI technologies effectively, organizations can optimize decision-making processes, enhance supply chain operations, mitigate risks, and promote sustainability. Through careful planning, data integration, and governance, enterprise architectures enable the seamless integration of AI tools, ensuring scalability, interoperability, and transparency. Embracing AI within enterprise architectures is critical to achieving operational excellence, resilience, and sustainable practices within agricultural food chains.

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