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Josemar António Ndembi Chissola

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Gödöllő Campus

Department of Agricultural and Food Machinery

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DRIVERS AND BARRIERS TO THE ADOPTION OF AGRO ICT AND PRECISION AGRICULTURE IN AFRICA: A SYSTEMATIC REVIEW

Primary Thesis Adviser: Dr. Zoltán Bártfai

Author: Josemar António Ndembi Chissola

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ABSTRACT OF THESIS

Thesis title: Drivers and Barriers to the Adoption of Agro ICT and Precision Agriculture in Africa: A Systematic Review

Author name: Josemar Antonio Ndembi Chissola

Course, level of education: Agricultural Engineering - Bachelor

Host Department/Institute: Institute of Agricultural and Food Machinery, Department of Agricultural and Food Machinery

Primary thesis advisor: Dr. Zoltan Bártfai,

Agriculture remains the foundation of African livelihoods and economies. Despite the transformative potential of agricultural information and communication technologies (AgroICT) and precision Agriculture (PA), their adoption by smallholder farmers in Africa remains slow and fragmented. This thesis addresses this adoption gap through a Systematic Literature Review (SLR) of 158 studies published between 2010 and 2025. The review reveals that research on this topic is recent, rapidly accelerating, and geographically skewed toward Anglophone countries such as Nigeria, Ghana, and South Africa, leaving large regions under-researched. Findings also show that the digital transformation in Africa is overwhelmingly "mobile-first," with 56% of studies focusing on basic mobile phones and apps. A core tension emerged, which shows that smallholder adoption is motivated by strong, rational drivers, but is severely affected by foundational, structural barriers. The most critical barriers are infrastructural deficits (poor internet, unreliable electricity), socio-economic limitations (low digital literacy, high costs), and the contextual misalignment of technologies not designed for smallholder realities. Finally, this thesis concludes that the adoption gap is not a technical problem but a human and systemic one. Realizing the promise of digital agriculture requires a strategic change from isolated pilot projects to building a supportive ecosystem. This includes public investment in foundational enablers (rural connectivity, digital literacy), promoting locally co-created, mobile-centric solutions, and implementing inclusive, ethical policy frameworks.

Keywords: AgroICT, Precision Agriculture, Africa, Smallholder Farmers, Adoption Barriers, Systematic Literature Review, Digital Agriculture

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1 INTRODUCTION AND OBJECTIVES

1.1 Background

Agriculture is the indispensable foundation of human society, representing the primary means by which civilization acquires food, fiber, and biological fuel. At its core, agriculture is the practice of cultivating soil, growing crops, and raising livestock to sustain human life and support economies. The Food and Agriculture Organization of the United Nations (FAO, 2024) describes agriculture not only as a source of nourishment but also as a pillar of rural livelihoods, economic development, and environmental management.

Across centuries, farming has evolved from subsistence practices to complex, globally integrated systems that feed billions and employ nearly one in four people worldwide (World Bank, 2023). However, today, this sector faces mounting pressures from a combination of environmental, demographic, and economic forces that threaten its ability to meet future needs. For instance, the global population is projected to reach nearly 9.7 billion by 2050, demanding a 60% increase in food production compared to 2005 levels (FAO, 2009; United Nations, 2022), which creates increased pressure and challenges on the entire food supply chain. These challenges are driven not only by rapid population growth but also by changes in dietary preferences and the increasing volatility caused by factors such as climate change, natural disasters, and other human activities (World Bank, 2025). In Africa, these pressures are particularly acute, where agriculture is predominantly rain-fed and smallholder-dependent, making it highly vulnerable to climate shocks (Nauta et al., 2024).

Conventional farming relies heavily on resources, consuming approximately 70% of global freshwater and contributing significantly to greenhouse gas emissions and land degradation (Senker, 2011). One of the major limitations of traditional farming, often referred to as broadacre or uniform management, is its inherent inefficiency, starting from the practice of treating entire fields as homogeneous units, despite well-documented spatial and temporal variability in soil properties, moisture, and crop health (Zhang et al., 2002; Gebbers & Adamchuk, 2010). This one-size-fits-all approach leads to significant economic and environmental costs. For example, uniform fertilizer application frequently results in overuse in nutrient-rich zones and underuse in deficient areas, wasting inputs and reducing return on investment (Sawyer et al., 2006). Economically, farmers in countries such as the U.S. alone spend billions annually on nitrogen fertilizers, with an estimated 30-50% lost to leaching, volatilization, or runoff due to imprecise application (USDA ERS, 2021). Environmentally, this excess contributes to eutrophication of waterways, greenhouse gas emissions (notably nitrous oxide), and soil degradation (FAO, 2017; Sutton et al., 2011). Moreover, without real-time, site-specific data, farmers cannot detect or respond quickly to localized stressors such as pest infestations, disease outbreaks, or micronutrient deficiencies. This reactive management often results in preventable production losses and greater production variability across seasons (Mulla, 2013; Lowenberg-DeBoer, 2019). Therefore, a new management methodology is required that can sense, analyze, and respond dynamically to these localized variations to improve sustainability and profitability.

As natural resources, such as arable land, water, and soil nutrients, become scarcer, the goal of feeding an expected world population of nine billion by 2050 requires a massive increase in food production, creating uncertainty among farmers and consumers. This uncertainty, combined with rising input costs, requires a fundamental and transformative change in how farming is managed. The solution to maximizing production efficiency while minimizing environmental impact lies in the intelligent application of digital tools, collectively known as Agricultural Information and Communication Technologies (Agro-ICT) (Kushwaha et al., 2024).

AgroICT is the integration of digital tools or technologies, such as satellite imagery, global positioning systems (GPS) guided machinery, soil sensors, drones, mobile apps, cloud platforms, and data analytics into farming operations (Kushwaha et al., 2024; Liakos et al., 2018). In Africa, this often manifests as mobile phone-enabled services (m-Agri) for market information and advisory services (Emeana et al., 2020; Erlangga et al., 2023), as well as more advanced applications like drones for monitoring (Kwao et al., 2024) and AI-driven precision agriculture (Nturo et al., 2025). These technologies allow farmers to monitor field conditions in real time, predict crop needs, apply water or fertilizer only where necessary, and track outcomes over time. As Kamilaris et al., (2017) note, AgroICT transforms agriculture from an experience-based practice into a knowledge-driven enterprise. Additionally, as traditional agricultural methods become less sustainable and no longer environmentally viable (FAO, 2024), the industry started to shift from the generalized, field-wide applications to a highly optimized and data-driven approach, marking the emergence and adoption of new methods or technologies, such as AgroICT, even more important.

AgroICT is widely seen as one of the most important means of addressing the current challenges in traditional farming. It offers potential to improve decision making, monitor environmental and crop conditions more precisely, reduce waste, and increase production without proportionally increasing inputs or damaging the environment (Zahedi & Zahedi, 2012; Montecé Mosquera et al., 2020). Studies in Tanzania and Kenya have shown that the use of mobile phones is associated with higher agricultural productivity and improved information access (Quandt et al., 2020; Ndimbo et al., 2025).

Among the various applications of AgroICT, precision agriculture stands out as a crucial approach that translates digital innovations into concrete, data-driven farming practices. Precision agriculture, also known as precision farming, is a modern agricultural management strategy that leverages advanced technologies to increase the efficiency, productivity, and sustainability of farming practices (Raj et al., 2025). This approach optimizes the use of inputs, reducing wastage and minimizing environmental impact (Mahanto et al., 2024; Raj et al., 2025). It involves the precise application of resources such as water, fertilizers, and pesticides, adapted to the specific needs of different parts of a field. By utilizing tools like remote sensing, geographic information systems (GIS), GPS, and robotics, precision agriculture aims to recognize, assess, and manage the spatial and temporal variations in soil conditions within fields (Kushwaha et al., 2024). This method not only increases profitability but also promotes sustainability and environmental conservation.

According to the International Society of Precision Agriculture (ISPA 2019), precision agriculture is a management approach that collects, interprets, and applies data over time and space, as well as information about individual plants and animals. This data is integrated with other relevant sources to guide decisions that account for variability, aiming to increase the efficiency of resource use, increase productivity and quality, improve profitability, and promote the sustainability of agricultural production. The integration of ICT in agriculture is important for modernizing practices and addressing challenges such as food security and environmental sustainability. ICT tools increase the efficiency of agricultural operations, leading to higher production (Ribeiro et al., 2021). It also facilitates the sharing of knowledge and skills among farmers, promoting innovation and adaptation, as seen in the co-creation of digital tools in Rwanda (Adewopo et al., 2025) and the design of user-centred digital advisories in Tanzania (Ortiz-Crespo et al., 2021).

1.2 Problem Statement

Despite the undeniable potential of AgroICT and PA to transform farming into a more efficient, data-driven, and environmentally sustainable enterprise, their promise to simultaneously address food insecurity, economic inefficiency, and environmental degradation remains critically unfulfilled across Africa due to a persistent and significant adoption gap, particularly among small and medium-scale farmers who form the backbone of the food production in the continent (GSMA, 2022). This is not due to a lack of technological solutions, but rather a complex interplay of systemic barriers. These include foundational issues like poor digital infrastructure and a lack of internet access, as highlighted in Northern Ghana (Oklikah et al., 2025; Abdulai, 2024), high initial investment costs, limited technical expertise and digital literacy (Mhlanga & Ndhlovu, 2023; Bontsa et al., 2023), and an absence of context-specific, affordable AgroICT solutions designed for resource-constrained, smallholder.

Critically, the adoption of AgroICT and PA is fragmented. While mobile phone use is widespread and has shown positive impacts (Quandt et al., 2020), the assimilation of more advanced PA technologies, such as sensors, drones, and AI-driven tools, remains in its early stages and often limited to pilot projects or large-scale commercial farms (Onyango et al., 2021; Aroba & Rudolph, 2024). The political economy of technology access further exacerbates these disparities, where structural inequities limit farmer competencies and access (Abdulai, 2024). Existing research, while growing, often focuses on specific technologies or countries, failing to provide a robust, integrated framework that systematically identifies, compares, and prioritizes the most impactful enabling factors and strategies for technology adoption across the diverse African farmland. For this reason, the backbone of Africa's food security risks being left behind in the technological transition. Therefore, a comprehensive and contextually aware systematic examination is urgently needed to synthesize existing evidence, determine how AgroICT can be made universally accessible and adaptable, and establish a clear pathway for its sustainable, large-scale implementation.

1.3 Research Question

The following research questions will guide this study in filling the identified knowledge gap, transitioning from an analysis of barriers to a strategic recommendation for implementation.

RQ1: What are the principal drivers influencing the adoption of AgroICT and precision agriculture in Africa?

RQ2: What are the primary barriers impeding the adoption of AgroICT and precision agriculture across Africa?

RQ3: What is the current status of adoption and literature on AgroICT and Precision agriculture in Africa?

RQ4: Based on the identified drivers and barriers, what main thematic intervention areas are recommended for future policy and practice to accelerate sustainable AgroICT adoption in the region?

Furthermore, to answer these research questions, the following objectives were defined:

1.4 Objectives

1.4.1 General Objective

This thesis aims to systematically identify, synthesize, and critically evaluate the current state of literature on AgroICT and PA in Africa, the main drivers, barriers, and the impact of AgroICT adoption in precision agriculture across Africa.

1.4.2 Specific Objectives

The specific objectives are aligned with the research questions and define the precise steps of the study:

- To determine and systematically categorize the principal technical, economic, and institutional factors that hinder the efficient assimilation and sustained use of AgroICT tools in contemporary agricultural practices across Africa.
- To identify, categorize, and analyze the complex interplay of barriers and drivers influencing adoption decisions.
- To formulate actionable proposals and policy recommendations aimed at improving the accessibility, affordability, and effective implementation of AgroICT to drive sustainable agricultural transformation in Africa.

The remainder of this thesis is structured as follows: Chapter two provides a comprehensive review of the relevant literature on AgroICT, and precision agriculture in Africa. Chapter three details the systematic literature review methodology employed in this thesis. Chapter four presents the descriptive and thematic results of the review, and Chapter five discusses the implications of these findings. Finally, Chapter six concludes the thesis by summarizing the contributions, acknowledging limitations, and suggesting directions for future research

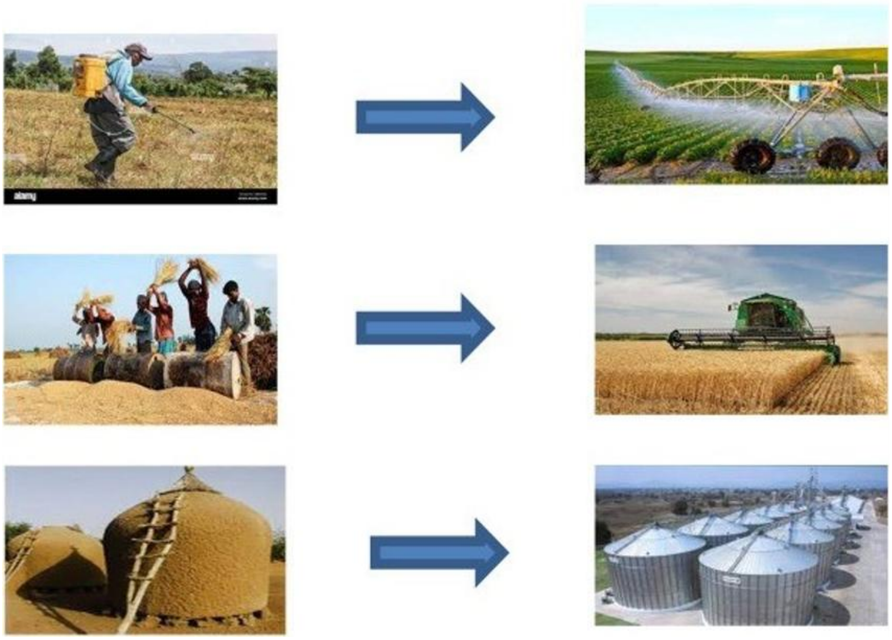
2 LITERATURE REVIEW

2.1 Evolution of Agriculture

The contemporary agricultural scenario is defined by a fundamental divergence between traditional and modern production systems (Álvarez, 2013). Traditional agriculture, which evolved over centuries, prioritizes ecological integration and resilience by relying on internal resource cycling, biodiversity, and local knowledge rather than external inputs (Adefila et al., 2024; Ficiciyan et al., 2018; Sekhar et al., 2024). In contrast, modern agriculture is an industrialized model focused on maximizing productivity and market orientation through high external inputs, such as synthetic fertilizers, large-scale mechanization, and advanced precision technologies (Álvarez, 2013; Carranza-Patiño et al., 2024; Hamadani et al., 2021). This transition from manual, subsistence-based methods to mechanized, large-scale production is illustrated in **Figure 1** (Misra & Ghosh, 2024). While modern methods can lead to environmental degradation (Andrade et al., 2024; Nemade et al., 2023), contemporary development now seeks an integrated model, aiming to combine the productivity gains of modern tools with the inherent sustainability of traditional knowledge to meet future economic and environmental goals (Herath et al., 2018; Kamakaula et al., 2024).

Figure 1: Traditional Vs Modern Agriculture.

(Source: Misra & Ghosh (2024))



2.2 Conceptualization of AgroICT and Precision Agriculture

The rapid evolution of digital technologies in farming has led to a body of overlapping and often confusing terminology. Terms, such as "AgroICT," "Precision Agriculture and "Smart Agriculture" are frequently used interchangeably, though they represent distinct concepts. For the clarity of this thesis, they are conceptualized as follows:

AgroICT (Agricultural Information and Communication Technology) is the broadest term. It functions as an "umbrella concept" referring to the application of any ICT, from basic mobile phones and radios to complex software across the entire agricultural value chain (Mishra, 2018; Teye et al., 2022). It is the foundational digital platform that enables other, more specific strategies.

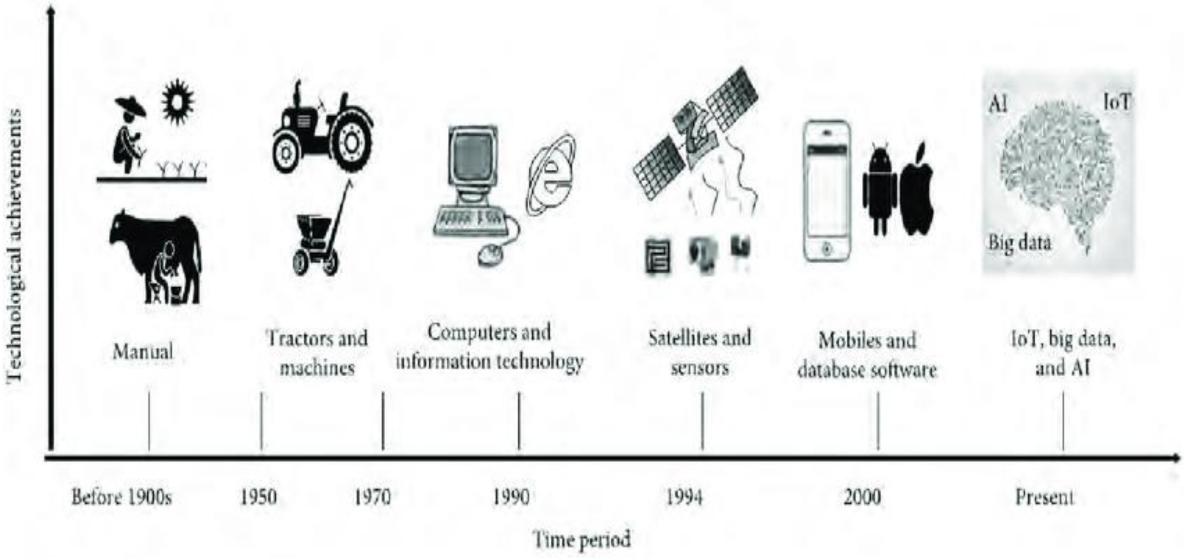
The primary justification for investing in AgroICT lies in its demonstrable ability to improve farm efficiency and economic sustainability across diverse agricultural systems (Lowenberg-DeBoer, 2015). By enabling site-specific resource management, these technologies directly address the largest sources of inefficiency in conventional farming: uniform application and resource waste (Mulla, 2013). More importantly, AgroICT provides the technological backbone for PA, which is best understood as the modern management strategy that applies this technology on the ground. Unlike conventional farming, which treats an entire field as a uniform unit (often leading to wasted resources), PA recognizes and addresses the spatial and temporal variability within the farm (Gebbers & Adamchuk, 2010). By leveraging digital tools such as remote sensing and variable-rate application systems, PA allows inputs, such as fertilizer, water, and pesticides, to be applied only where and when they are needed, matching the resource to the specific needs of each small area of the field (Abobatta, 2021; Raj et al., 2025).

Contemporary agricultural technology systems represent convergence points where traditional agricultural knowledge meets cutting-edge information technologies, creating new possibilities for data-driven decision making and automated farm management. The conceptual frameworks guiding these developments draw from diverse disciplines, including agronomy, computer science, engineering, and systems theory, resulting in highly multidisciplinary approaches.

Precision agriculture is not a single technology but a cyclical process: (i) data collection (using tools such as GPS and sensors) to observe farm variability, (ii) data analysis (using software) to make informed decisions, and (iii) site-specific application (using tools such as variable-rate applicators) to deliver precise inputs of water, fertilizer, or pesticides. The historical development of PA is outlined in **Figure 2.**

Figure 2: Evolution of technology in Agriculture. Progression from mechanization through precision agriculture to smart farming and digital agriculture.

(Source: Kamath et al., (2019)).



AgroICT conceptualization emphasizes the integration of agricultural domain knowledge with information technology capabilities to create solutions that address specific agricultural challenges. This integration requires understanding both agricultural processes and information technology possibilities, leading to interdisciplinary approaches that combine agronomic expertise with computer science, telecommunications, and systems engineering knowledge. The resulting solutions must be appropriate for agricultural contexts, considering factors such as rural connectivity, user capabilities, and economic barriers.

The theoretical framework for AgroICT draws from multiple disciplines, including information systems theory, agricultural systems analysis, and technology adoption models (Fountas et al., 2020). This multidisciplinary foundation demands an integration of agricultural domain knowledge with information technology capabilities to create solutions that are both technically feasible and contextually appropriate. Gebbers and Adamchuk (2010) assert that successful AgroICT implementation requires careful consideration of technical feasibility, economic viability, social acceptability, and, critically, agricultural relevance. The resulting solutions must not only align with existing farming practices but also consistently provide sufficient value to justify the initial capital outlay and continued operational use by farmers.

Figure 3: AgroICT information flows across agricultural value chains and stakeholders.

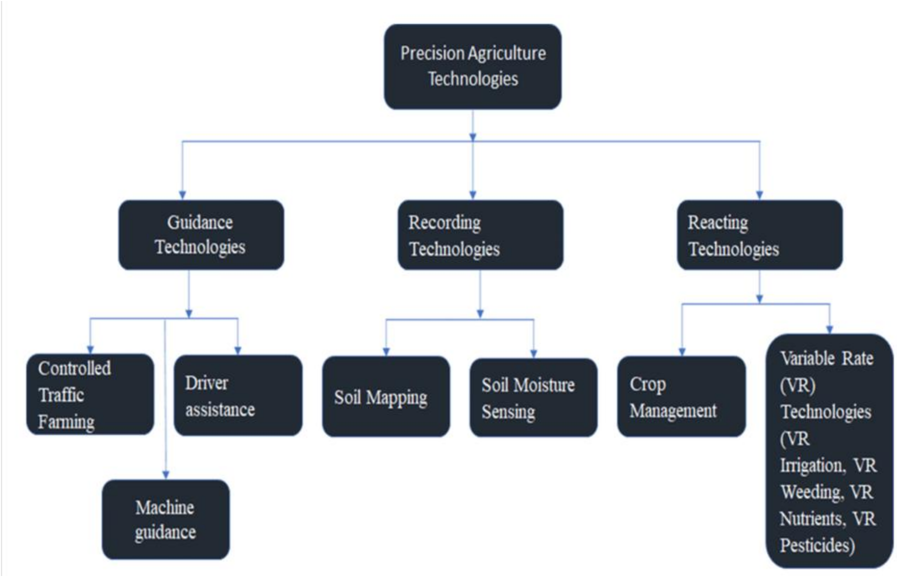
(Source: Appelqvist et al., (2022))

Precision agriculture encompasses both philosophical and technical dimensions that distinguish it from conventional farming approaches. Philosophically, it represents a shift from experience-based to data-driven decision-making, emphasizing measurement, analysis, and systematic optimization of agricultural practices. Technically, it involves the integration of multiple technologies, including GPS, GIS, remote sensing, variable rate technology (VRT), and production monitoring systems (Panotra et al., 2025).

The evolution of PA is a direct response to increasing global food demand, coupled with resource scarcity and environmental pressure. Because it focuses on site-specific management and data-informed practices, PA improves farm productivity while simultaneously minimizing negative environmental impact (Mahanto et al., 2024). Moreover, emerging applications, such as AI-powered analytics and machine learning models are now enabling predictive forecasting of crop health and production, thereby improving risk management and building greater resilience to climate volatility (Sharma & Srushtideep, 2022). In essence, precision agriculture represents the practical realization of AgroICT, successfully translating complex digital innovations into actionable insights that improve efficiency, profitability, and sustainability, positioning the sector as a knowledge-driven enterprise essential for food security in the 21st century (Montecé Mosquera et al., 2020).

The spatial dimension of precision agriculture operates at multiple scales, from whole-field management zones to sub-meter precision applications. Management zones represent areas within fields that exhibit similar characteristics and can be managed uniformly, while variable rate applications enable precise control of input applications based on real-time or historical data. This multi-scale approach allows farmers to optimize management decisions at the most appropriate spatial resolution for specific applications and constraints.

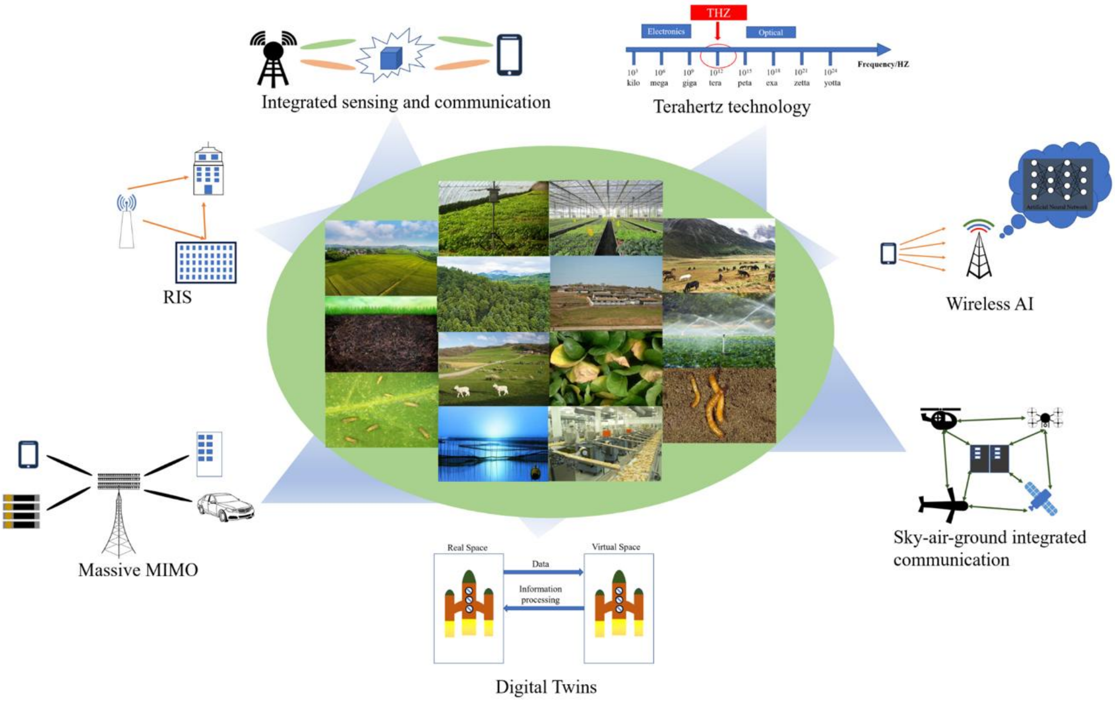
Figure 4: Precision Agriculture Conceptual Framework.
(Source: Shrestha & Khanal, (2020))



Finally, smart agriculture represents the most recent evolution, integrating PA with advanced data management. It leverages sophisticated technologies such as the Internet of Things (IoT), cloud computing, and big data analytics to create a fully networked farm system (Mishra, 2018; Teye et al., 2022). While PA uses data for site-specific management, Smart Agriculture uses real-time, networked data for automated and context-aware decision-making. The core of smart agriculture is the transformation of the farm environment into a sophisticated Cyber-Physical Agricultural System (CPAS). This paradigm moves beyond localized data collection to emphasize real-time monitoring, automated decision-making, and adaptive management systems that respond dynamically to changing field conditions. Smart agriculture achieves this by comprehensively integrating IoT sensors and networks, advanced cloud computing, Artificial Intelligence (AI) algorithms, and robotics to create responsive farming environments that can adapt to changing conditions without constant human intervention, as shown in **Figure 5** (Kour & Arora, 2020; Bikoro, 2022). The goal is to create semi-autonomous or fully autonomous farming operations that minimize human intervention while optimizing inputs such as water and fertilizer down to the individual plant level, thereby maximizing resource efficiency and producing stability (Wanyama et al., 2024). This CPAS framework requires seamless interoperability between physical farm operations and digital information processing systems, integrating networked sensors, automated actuators, and intelligent control systems (et al., 2024). These systems combine networked sensors, automated actuators, communication infrastructure, and intelligent algorithms to create responsive farming environments that can adapt to changing conditions without constant human intervention (Kour & Arora, 2020).

Figure 5: Smart Agriculture System Architecture.

(Source: Zhang et al., (2022))



In contrast, digital farming represents a significantly broader conceptualization that encompasses the application of digital technologies and data-driven approaches across the entire agricultural value chain. This concept extends the focus beyond the field-level automation of smart agriculture to include upstream and downstream processes, such as supply chain transparency, market integration, knowledge sharing platforms, and the provision of tailored financial services (Addison et al., 2024; Pinto et al., 2007). Digital farming is fundamentally driven by the recognition of data as a strategic asset, emphasizing the development of interconnected digital platforms that link farmers not only to technological tools but also to information, financing, and end-markets (Abdulai et al., 2023). It addresses the entire business dimension of agriculture, promoting economic sustainability through enhanced digital access and connectivity across the ecosystem (Zoma & Ngouloubi, 2024).

Smart agriculture and digital farming share common technological foundations, including data collection, analytics, connectivity, and decision support systems, but they differ in their conceptual boundaries and primary objectives (Su et al, 2023). Smart agriculture prioritizes automation and real-time control, while digital farming emphasizes information access and digital service integration (Wanyama et al., 2024). Digital Farming is descriptive and encompassing, focusing on the broader digital ecosystem integration and the flow of data as a resource that informs farmer profitability, market access, and extension services (Abdulai, 2024).

2.2.1 Integration and Interoperability Concepts

The integration and interoperability of agricultural technology systems represent critical concepts for achieving the full potential of precision agriculture and smart farming approaches. Integration refers to the technical and functional coordination of multiple technology components to create unified systems that deliver improved capabilities beyond individual components. Interoperability encompasses the ability of different systems, devices, and platforms to communicate, exchange data, and coordinate operations across diverse technological environments.

Technical integration challenges include data format standardization, communication protocol compatibility, timing synchronization, and system coordination across heterogeneous technology platforms. Agricultural systems typically involve equipment from multiple manufacturers, software from different developers, and data from various sources that must be integrated to create coherent management systems (Kour & Arora, 2020). Successful technical integration requires careful attention to standards, interfaces, and system architecture design.

Functional integration involves combining different agricultural technologies to create comprehensive management systems that address multiple aspects of agricultural production simultaneously. This includes integrating crop monitoring with irrigation control, combining soil analysis with fertilizer application, and coordinating pest management with harvest planning (Kebe et al., 2023). Functional integration requires understanding agricultural system interactions and designing technology systems that support holistic farm management approaches.

Data integration represents a fundamental challenge and opportunity for agricultural technology systems that must combine information from multiple sources, including sensors, remote sensing, weather services, market information, and historical records. Effective data integration enables comprehensive analysis and decision-making based on complete information about agricultural system status and context (Panotra et al., 2025). Data integration requires attention to data quality, temporal alignment, spatial registration, and semantic consistency across diverse data sources.

Interoperability standards and protocols facilitate communication and coordination between different agricultural technology systems and components. Industry standards, including ISO 11783 (ISOBUS) for agricultural equipment communication, Open Geospatial Consortium (OGC) standards for spatial data exchange, and IoT protocols for device connectivity, enable integration across diverse technology platforms. Standardization efforts reduce integration costs and increase system flexibility and scalability.

2.3 Technological and ICT Components in Precision Agriculture

The technological foundation of modern AgroICT systems consists of interconnected components essential for data collection, communication, processing, and automated control, which together enable precision agriculture and smart farming applications. Understanding these building blocks is crucial for grasping how contemporary agricultural technology functions.

Sensing Technologies form the primary interface between digital systems and the physical agricultural environment, providing continuous monitoring of conditions. These include soil moisture sensors, weather stations, plant growth monitors, and livestock tracking devices, all of which generate the real-time data streams fundamental to precision agriculture decision-making (Mishra, 2021).

Positioning Technologies, primarily Global Navigation Satellite Systems (GNSS) and GPS, provide the precise geolocation necessary for spatially referencing all collected data and activities. GPS enables farmers to create detailed field maps, implement variable rate applications, guide autonomous equipment, and maintain accurate operational records. The integration of this precise location data is what enables the site-specific management that defines precision agriculture (Kushwaha et al., 2024).

Remote Sensing Technologies complement ground-based sensors by offering broad-scale monitoring capabilities via satellite imagery, aerial photography, and Unmanned Aerial Vehicles (UAVs). These technologies assess crop conditions, estimate yields, and detect pests and diseases across large areas. Remote sensing provides both comprehensive field coverage and valuable historical trend analysis, which is crucial for long-term planning (Panotra et al., 2025).

Finally, Communication and Networking Technologies are required to transmit all this data and coordinate system functions. IoT platforms facilitate device connectivity and data integration, while cellular, Wi-Fi, and satellite systems provide the necessary network access, especially in remote agricultural locations. As Kour and Arora (2020) explain, these communication layers enable real-time monitoring, remote control, and seamless integration with cloud-based analytics platforms.

These communication systems enable real-time monitoring, remote control, and integration with cloud-based services and analytics platforms.

2.3.1 GIS and GPS

The foundational technologies supporting precision agriculture are GPS and GIS. These tools enable the accurate identification, analysis, and management of spatial variability across farmland.

The GPS, a satellite-based navigation system, is essential for determining the precise latitude, longitude, and altitude of any point on Earth's surface (El-Rabbany, 2002). In modern agriculture, GPS technology is indispensable, providing the locational accuracy needed for field mapping, automated machinery guidance, and the meticulous recording of crop performance data across a field (Weidong et al., 2010). To achieve the high degree of spatial accuracy required for critical PA tasks, the Real-Time Kinematic (RTK) correction system is often employed. RTK significantly improves standard GPS positioning to centimetre-level precision, which is vital for operations such as automated steering of tractors, accurate row planting, and highly precise Variable Rate Technology (VRT) applications of inputs (Pierce & Nowak, 1999; Tey and Brindal, 2012).

This level of precision minimizes overlap, maximizes resource efficiency, and ensures that management actions are applied exactly where intended.

Figure 6: Collection of GPS information using a tablet with the chief of a rural community near Lilongwe, Malawi.

Source: (Esri, 2014)

Complementing the locational power of GPS is GIS. GIS are sophisticated software platforms designed to capture, store, manage, analyze, and visualize all forms of geographically referenced data (Longley et al., 2015). In the context of farming, GIS functions as the central hub for synthesizing diverse field information. It allows farmers to overlay multiple layers of spatial data, such as high-resolution soil maps, historical production data, real-time pest infestation boundaries, and topographic profiles, onto a single geospatial interface (McBratney et al., 2003). This synthesis and visualization capability is what enables farmers to transform raw positional data from GPS and sensors into actionable intelligence, revealing patterns of variability that mandate site-specific management strategies. Together, GPS provides the “where” and GIS provides the “why” and how to manage the field variability, forming the indispensable spatial infrastructure of AgroICT.

2.3.2 Remote Sensing and Data Interpretation

Another foundational pillar of AgroICT is Remote Sensing, which supplies the crucial, real-time data on crop health and status. Remote sensing captures information using various sensors across the visible, near-infrared (NIR), and thermal infrared (TIR) wavelengths (Weiss et al., 2020). This spectral information is used to calculate Vegetation Indices and assess crop health, moisture, and vigor (Lillesand et al., 2015). Beyond standard multispectral data, which is used for calculating common indices like NDVI (Mulla, 2013), more specialized techniques increase diagnostic capacity. Hyperspectral sensing, on the one hand, uses hundreds of narrow spectral bands to provide a fine-grained analysis essential for nutrient status assessment and specific disease identification (Thenkabail, 2018). On the other hand, thermal sensing measures surface temperature changes, which directly correlate with plant water stress and water use efficiency (Mulla, 2013). As shown in **Figure 7**, when tractor-mounted sensors monitor the field landscape, they capture this spectral variability in real-time, allowing for immediate, site-specific adjustments to inputs.

Figure 7: Remote sensing used in precision agriculture: tractor-mounted sensors monitor, highlighting the spatial landscape of the crop, so the site-specific input can be applied.

Source: (Azmat, 2025).

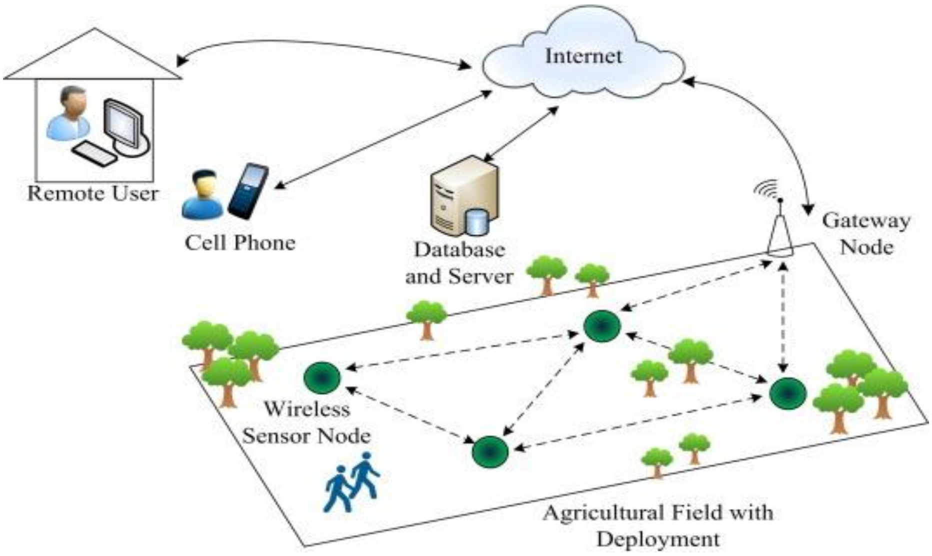
The data gathered from these remote sensing platforms is immediately integrated within the GIS environment to generate detailed Prescription Maps (Rx Maps). These maps delineate specific management zones based on metrics such as nutrient deficiency or potential pest outbreak (Mulla, 2013). This powerful integration of remote sensing data with GPS location and GIS analysis is what enables Variable Rate Technology (VRT). On the other hand, without this data-driven insight, VRT cannot function optimally. The system allows for the precise, differentiated application of inputs, such as applying varying fertilizer rates only where the remote sensing data indicates a deficiency, thus maximizing efficacy, reducing waste, and mitigating environmental impact (Zhang et al., 2002). Thus, remote sensing transforms general field observation into quantifiable, spatial information that dictates the action taken in a precision agriculture system.

Moreover, non-optical methods like Radar sensing (for soil moisture) and LiDAR (for canopy structure and height) overcome limitations of weather and lighting, providing necessary 3D and sub-surface information (Mulla, 2013). Additionally, Unmanned Aerial Vehicles (UAVs) equipped with these sensors offer flexible, high-resolution, and timely monitoring that is vital for localized disease detection and site-specific plant management (Mulla, 2013). This comprehensive suite of data is synthesized by the GIS platform to generate Prescription Maps, which, when combined with GPS location, enable Variable Rate Technology (VRT), the ultimate goal of applying inputs precisely where and when they are needed, thereby maximizing efficiency and minimizing environmental impact (Zhang et al., 2002).

2.3.3 Wireless Sensor Networks (WSN) and IoT

Another indispensable pillar of the AgroICT framework is the deployment of Wireless Sensor Networks (WSN) and the IoT, which facilitate real-time, in-situ monitoring of field conditions, as illustrated in **Figure 8.** WSNs comprise numerous inexpensive, low-power sensor nodes strategically distributed throughout the agricultural field (Rietz et al., 2023). These nodes are dedicated to collecting micro-level environmental data, such as soil moisture content, ambient temperature, humidity, and nutrient levels. The data is transmitted wirelessly to a central Gateway Node, which aggregates information from the localized network.

Figure 8: Wireless Sensor Networks and Internet of Things.
(Source: Giri & Pippal, (2017)).



Furthermore, the integration of these WSNs with the IoT transforms the localized network into a fully connected smart farming system. The Gateway Node funnels the vast amount of heterogeneous data collected from the field into the internet, where it is stored in a centralized Database and Server (Gubbi et al., 2013). As a Result, this established architecture enables authorized remote users to access critical field information instantly via mobile devices or computers, facilitating management from anywhere in the world. This continuous, real-time data stream, coupled with advanced data analytics, transforms traditional farming by moving management from reactive, periodic observation to proactive, predictive intervention (Elijah et al., 2018). In addition, this IoT layer effectively closes the management loop: WSNs capture the necessity for action by monitoring the field, and the IoT ensures that the resulting data-driven decisions are applied seamlessly and precisely, whether automatically or by a human operator (Popović et al., 2017).

2.3.4 Agricultural Drones

Agricultural drones, or Unmanned Aerial Vehicles (UAVs), represent a pivotal technological component that operationalizes the principles of both PA and smart agriculture. These systems offer a highly flexible, cost-effective, and resource-efficient platform for both aerial data acquisition and targeted field intervention. Wanyama et al. (2024) identify UAV as critical enablers for improved, localized farm management and resource optimization, particularly in adapting PA methodologies to the scale and constraints of smallholder systems.

Figure 9: Agricultural Drone Spray for AgroICT.
Source: (DroneAg, 2024).

The operational utility of UAVs spans the entirety of the crop management cycle. According to Daponte et al. (2019), drones facilitate crucial tasks such as comprehensive crop surveillance, precision planting, detailed crop health evaluation, site-specific spraying of inputs, and irrigation monitoring. Abdi et al. (2025) note that this systematic application of drone technology is instrumental in maximizing operational efficiency while simultaneously achieving a substantial reduction in manual labor and the volume of agricultural inputs required.

This efficiency is particularly vital for improving food production and promoting the technical change necessary for development (Abate et al., 2023). A study by Sampaio and Bártfai (2024) found a steady growth in research output, highlighting the pivotal role of UAVs in shaping precision farming and identifying the integration of AI, promoting environmental sustainability, and optimizing drone technology as critical areas for future innovation. The core capability of agricultural drones resides in the sophisticated remote sensing payloads they carry, which typically encompass high-resolution visual (RGB), Near-Infrared (NIR), thermal, and multispectral sensors (Tsouros et al., 2019). The data captured by these sensors enables the rapid construction of highly detailed spectral and geospatial maps. BIKORO (2022) notes that this data acquisition capability allows for the instantaneous and pre-visual identification of subtle indicators of plant stress, nutrient deficiencies, or the earliest manifestation of pests and diseases at the spectral level. According to Weldegebriel et al. (2024), this rapid diagnostic capability is essential for facilitating timely, highly localized interventions, which minimize potential production losses and significantly improve the efficacy of expensive agricultural inputs.

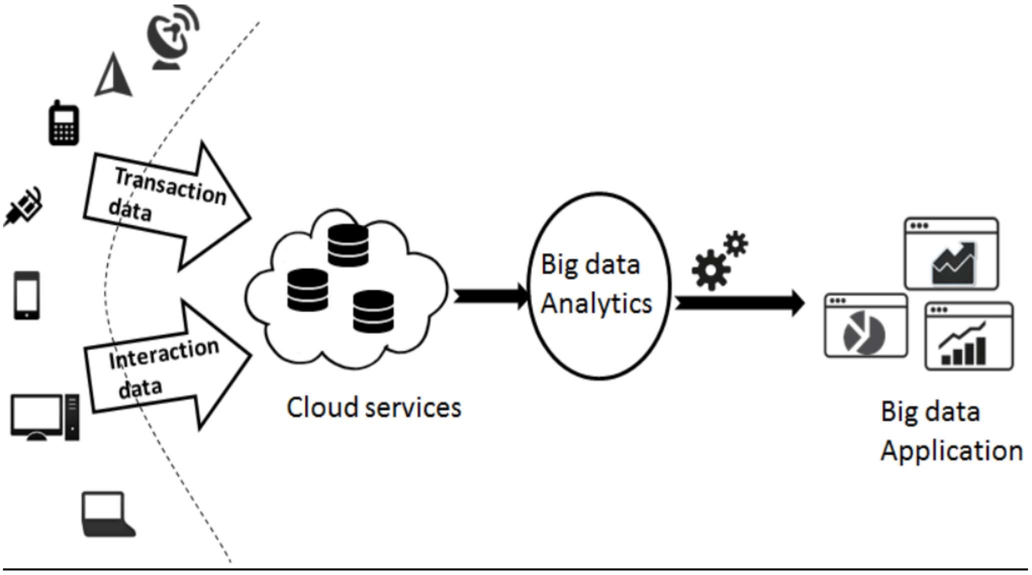
Furthermore, the seamless integration of drone technology with broader IoT systems extends its utility into sophisticated livestock and ranch management. Ruiz et al. (2023) specifically analyze the use of drone-based thermal imaging as a highly effective tool for proactive animal health monitoring, capable of instantly detecting abnormal body heat signatures that reliably indicate illness or injury within a herd. Abate et al. (2023) stress that this capability for early intervention is critical for rapid disease control.

2.3.5 Data Analytics and Decision Support Systems

Data analytics forms the computational core of modern agricultural technology, transforming raw sensor data into actionable information and automated decisions (Su et al., 2023). This core relies heavily on machine learning (ML) and AI, which allow systems to identify complex patterns, make predictions, and continually optimize farm decisions, including production forecasting, disease detection, and precise resource allocation (Misra & Ghosh, 2024). The results of this sophisticated analysis are delivered through Decision Support Systems (DSS).

The infrastructure supporting this intelligence relies on modern computing architectures. Cloud computing and Edge computing manage the large volumes of data generated by sensors. Kour and Arora (2020) highlight that while Cloud platforms provide scalable storage, Edge computing is vital for bringing processing closer to the data source, ensuring the real-time speed and reduced latency required for effective agricultural interventions. This entire data pipeline is ultimately integrated into Farm Management Information Systems (FMIS). FMIS represents the practical operational implementation of digital agriculture, combining all data analytics outputs with essential management tools like field mapping, input tracking, and financial reporting in a unified software environment to support holistic farm control (Pinto et al., 2007).

Figure 10: Cloud Data, Big Data Analytics, and Applications.
(Source Neaga, et al., (2015))



2.4 Classification Systems and Typologies

Classification systems are essential for understanding the diverse structure of agro ICT and PA technologies, as they provide structured approaches for comparative analysis and system design, according to Misra (2022). These frameworks organize technology to effectively match capabilities with user needs across various operational dimensions. For instance, systems can be classified by their core function and application. Functional classification organizes tools based on their primary role, such as sensing, data processing, communication, or automation, as detailed by Su et al., (2023). This approach is often paired with an Application Domain framework, which groups technologies based on specific agricultural challenges like crop production, livestock management, or irrigation, according to Pinto et al. (2007).

Furthermore, typologies distinguish technologies based on their operational context in space and time. The Temporal classification system separates tools into real-time monitoring, periodic assessment, or long-term strategic planning platforms, according to Panotra et al. (2025). Finally, to inform investment and adoption decisions, technologies are often classified by their

Maturity, ranging from experimental concepts to commercially available systems, as described by Kour and Arora (2020).

2.4.1 Automation and Control Systems

Automation technologies represent the actualization component of agricultural technology systems, translating analytical insights and management decisions into physical actions within agricultural environments. Agricultural automation encompasses VRT, automated irrigation systems, robotic equipment, and autonomous vehicles that execute precise management actions based on data-driven instructions (Panotra et al., 2025). These automation capabilities enable the closed-loop control systems that characterize smart agriculture approaches.

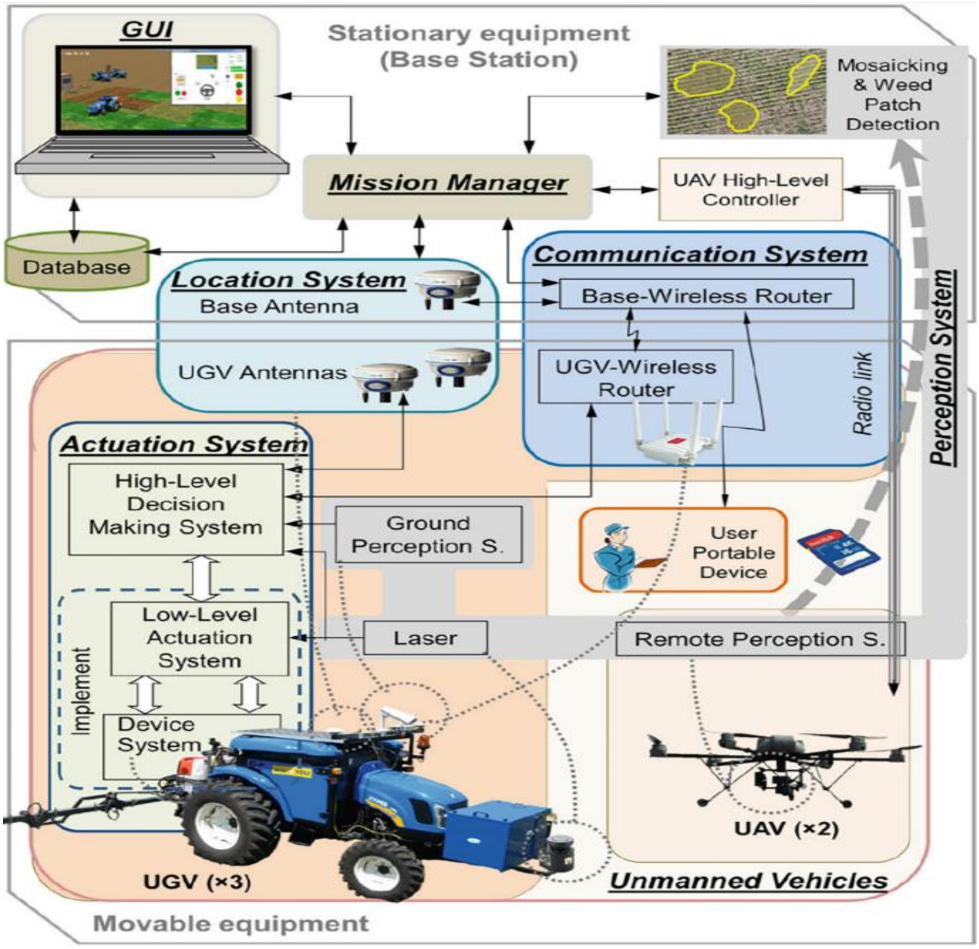
VRT enables precise control of input applications, including fertilizers, pesticides, seeds, and water, based on spatial variability maps and real-time sensor data. VRT systems combine GPS guidance, application control systems, and prescription maps to deliver inputs at optimal rates across heterogeneous field conditions (Deekshithulu et al., 2024). This technology represents the practical implementation of precision agriculture concepts through spatially variable management actions.

Automated irrigation systems integrate soil moisture monitoring, weather data, crop water requirements, and control algorithms to optimize water application timing and quantities. These systems range from simple timer-based controllers to sophisticated systems that integrate multiple data sources and predictive models to minimize water use while maintaining optimal crop conditions (Kushwaha et al., 2024). Automated irrigation represents a critical application area where precision agriculture concepts directly translate into resource conservation and productivity benefits.

Control system integration enables coordination between multiple automated components to achieve system-level optimization and avoid conflicts between different automation subsystems. Integrated control systems manage interactions between irrigation, fertilization, pest management, and harvesting operations to ensure coordinated and efficient farm management (Su et al., (2023), 2023). This system-level integration represents the ultimate goal of smart agriculture approaches, where individual technologies work together seamlessly.

Figure 11: Agricultural Automation System Components.

(Source: Montes & Ribeiro, (2023))



2.5 AgroICT and Precision Agriculture in Africa

The integration of AgroICT and PA represents an important and transformative movement taking shape across Africa. This digital transformation holds significant promise for addressing the persistent, multifaceted challenges of climate vulnerability, endemic resource inefficiency, and chronic food insecurity, particularly within the dominant smallholder farming systems in the region. AgroICT functions as the foundational digital ecosystem, encompassing a range of tools, including mobile services, the IIoT, remote sensing, and Artificial Intelligence (AI) (Abdi et al., 2025). In contrast, PA is the data-driven strategic management approach that leverages the information derived from these technologies to enable site-specific farm interventions, thereby optimizing input use (Wanyama et al., 2024). This digital shift is fundamentally supported by robust empirical evidence indicating that the targeted use of technology can significantly improve productivity, enhance livelihoods, and promote technical change across various scales (Abate et al., 2023; Weldegebriel et al., 2024).

The most successful applications and primary drivers of AgroICT adoption in Africa have typically revolved around mobile telephony, which effectively bypasses the logistical and financial challenges associated with extensive fixed infrastructure (Anteneh & Melak, 2024). Mobile-centric solutions are central to digital agricultural extension and advisory services, which have been shown to accelerate technical change and positively affect technology adoption and production outcomes among smallholders, as evidenced by video-mediated experiments in Ethiopia and income studies in Ghana (Abate et al., 2023; Abubakari et al., 2023; Weldegebriel et al., 2024). Further, beyond basic communication, advanced PA technologies are being contextually adapted. Remote sensing and GIS are critical for large-area monitoring and for developing climate-resilient tools, such as high-resolution drought indices optimized for precision farming in regions, such as North Africa (Abdelrahim & Jin, 2025). Furthermore, the application of Fourth Industrial Revolution (4IR) technologies, including AI, IoT, and Blockchain, is actively being explored and implemented in Sub-Saharan Africa (SSA) to build smarter, more responsive irrigation systems, improve resource efficiency, and advance agricultural production through digitalization, exemplified by efforts in Somali agriculture and smart irrigation systems (Abdi et al., 2025; Bikoro, 2022; Wanyama et al., 2024; Zoma & Ngouloubi, 2024).

However, despite the immense potential and localized successes, the path to sustainable adoption of technology in agriculture in Africa is profoundly constrained by significant contradictory realities that constitute core barriers to a universal roll-out. The fundamental challenge lies in the political economy of access and the question of whether rural smallholders possess the requisite competencies and are truly "ready" for agricultural digitalization (Abdulai, 2024). Research highlights a substantial and often overlooked gap between the optimistic rhetoric of digital transformation and the daily, lived realities of farmers, where engagement is frequently complicated by factors such as illiteracy, a lack of trust in data, and insufficient post-adoption support infrastructure (Abdulai et al., 2023). Consequently, merely making technology available is insufficient, as successful implementation demands a deep contextual understanding that requires co-creating and implementing digital innovations in a manner relevant to specific smallholder systems, avoiding the pitfalls of imposing generic global models (Abdulai, 2022; Adewopo et al., 2025). Moreover, pervasive technical and economic barriers remain formidable obstacles across vast stretches of SSA, including inadequate power supply, poor telecommunications infrastructure, a lack of green finance, and fragmented markets, all of which restrict the large-scale deployment of sophisticated AgroICT systems (Addai et al., 2024; Bi & Zhang, 2024; Choruma et al., 2024).

2.6 Research Gap

Although the potential of AgroICT in Africa is widely acknowledged, its practical adoption remains fragmented and slow. This disconnect is most evident among the smallholders who are the foundation of the food production on the continent. The existing literature addresses this issue through numerous case studies, pilot programs, and regional reports. However, these findings are often highly localized, focusing on a specific country or a single technology. As a result, this valuable research has not been synthesized in a comprehensive or systematic way. It therefore remains unclear which drivers are most critical, which barriers are the most pervasive across the continent, and where the main thematic trends truly lie.

This fragmentation in the literature creates an urgent need for a systematic examination to collect and make sense of this scattered evidence. To address this specific gap, this thesis employs a Systematic Literature Review (SLR). This methodology was chosen to rigorously identify, synthesize, and critically evaluate the full body of research. The ultimate aim is to provide a comprehensive and evidence-based answer regarding the principal drivers and barriers to AgroICT and PA adoption in Africa, bringing much-needed clarity to the field.

3 MATERIALS AND METHODS

To thoroughly investigate and systematically understand the factors that affect the adoption of AgroICT and PA in Africa, this thesis used a systematic literature review (SLR) methodology. This rigorous approach was selected because it employs a structured, replicable, and transparent process for finding, selecting, and critically synthesizing all relevant empirical and conceptual studies that address a defined research question (Petticrew & Roberts, 2006; Tranfield et al., 2003). By implementing an explicit search strategy and clear criteria for study inclusion and exclusion, the SLR minimizes potential research bias and significantly enhances the reliability and generalizability of the synthesized findings (Cook et al., 1997; Liberati et al., 2009). The procedural framework for the review employed was strictly guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement (Page et al., 2021). The adoption of PRISMA ensures comprehensive reporting, maximizes transparency, and facilitates the future reproducibility of the results presented.

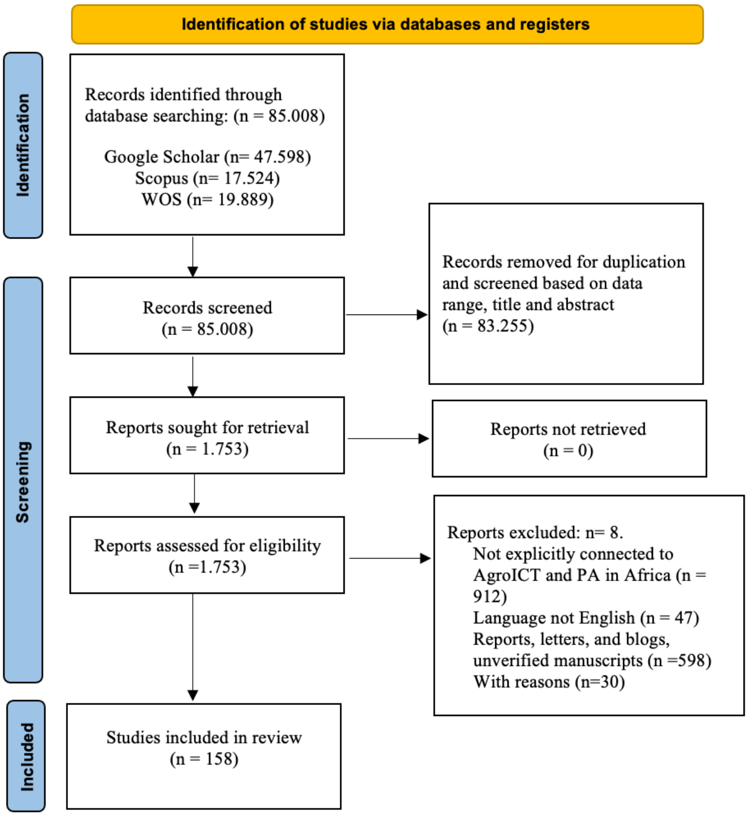
Data Identification

The entire review process for this thesis was conducted through three principal, sequential stages: (i) data identification and search strategy, (ii) data screening and eligibility, and (iii) final inclusion of studies and synthesis. At first, the data identification process involved a comprehensive and multi-platform search across three prominent academic databases: Web of Science (WoS), Scopus, and Google Scholar. This strategic selection was based on their collective ability to provide broad and complementary coverage of the scientific literature (Kitchenham, 2004). WoS and Scopus were included for their robust indexing, transparent citation data, and focus on high-quality, peer-reviewed content, which are essential for mapping the field's intellectual structure and assessing article quality (Falagas et al., 2008; Mongeon & Paul-Hus, 2016). Google Scholar was integrated to mitigate the known coverage bias of commercial indexes, thereby capturing a wider array of scholarly literature, including grey literature, pre-prints, conference proceedings, and reports from governmental or non-governmental research organizations. This is particularly valuable for identifying emerging trends in a rapidly evolving field like AgroICT in Africa (Gusenbauer & Haddaway, 2020).

The literature search included documents published only in English from 2010 to 2025. The year 2010 was selected as the starting point because this period marks the significant global proliferation of mobile technology and the widespread adoption of smartphone-enabled services across Africa, fundamentally changing the aspect of potential AgroICT applications

(Aker & Mbiti, 2010; GSMA, 2022). The search was concluded in 2025 to ensure the capture of the most recent and relevant studies available at the time of the review. Therefore, to comprehensively identify relevant literature for this systematic review, the search queries were structured by combining the most important concepts, using the Boolean operators AND and OR. The queries focused on three primary, intersecting groups to ensure maximum coverage of the study's scope: (i) Core technology terms ("AgroICT" OR "Precision Agriculture" OR "Digital Agriculture" OR "Smart Farming" OR "ICT for Agriculture"), (ii) Geographical focus, which specified the region of study, using broad and regional terms, ("Africa" OR "African" OR "Sub-Saharan Africa" OR "SSA" OR "North Africa" OR "East Africa" OR "West Africa" OR "Southern Africa"), and (iii) Adoption and contextual terms, which captured the evaluative and systemic aspects of the study, combining terms related to the most important outcomes and challenges, ("Adoption" OR "Driver" OR "Barrier" OR "Constraint" OR "Challenge" OR "Opportunity" OR "Willingness to Pay" OR "Acceptance" OR "Smallholder"). Further, the use of quotation marks ensured exact phrase matching for important terms, while the broad inclusion of regional terms in the geographical group prevented the omission of relevant country-specific studies within the continent.

Figure 12: Flowchart of the data selection process for review in this study
(Source: Author)



Screening and inclusion:

After identifying the initial data, the screening phase began. As shown in the PRISMA flow diagram (Fig. 12), the initial search found 85.088 records across three databases. These records went through a multi-step screening process. First, duplicates were removed, and an initial check of titles and abstracts was done to exclude unrelated studies. Further filtering included selecting only peer-reviewed articles from trusted organizations and published within the specified years (2010-2025). This systematic filtering narrowed the pool to 1753 articles for a more detailed review. The next step involved a full-text review of the 1753 articles. During this stage, studies were checked against specific criteria: the research had to mainly focus on the AgroICT and precision agriculture in Africa, be conducted in one or more African countries, be peer-reviewed or from a well-known reputable organization and provide enough relevant information for this thesis. Articles were excluded if they did not primarily focus on AgroICT and precision agriculture across Africa, were not written in English, conducted outside of the timeframe, were inaccessible despite reasonable efforts, or had incomplete information that made it impossible to extract relevant data, were theses, blogs, unverified manuscripts, or non-relevant reports. This detailed evaluation led to the exclusion of 1595 articles.

Inclusion:

The final inclusion phase resulted in 158 articles and reports suitable for in-depth analysis, as detailed in the PRISMA flow diagram (Figure 12). For each included study, key information was systematically extracted and organized. This information included: author(s), year of publication, country or region of study within Africa, abstract, publisher, type of technologies, questions, main findings, and conclusions or recommendations. Microsoft Excel was used to store, organize, and facilitate the preliminary analysis of the extracted data. This synthesized information directly informed the answers to the research questions in this study.

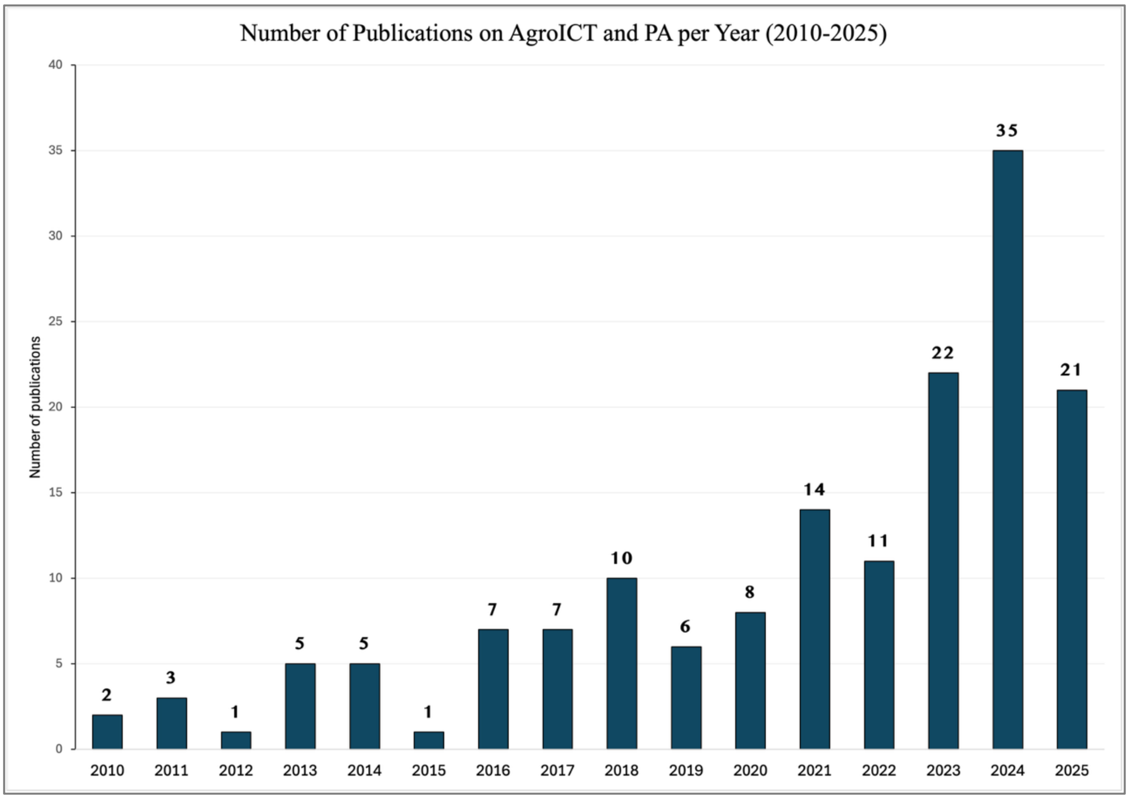
4 RESULTS

For this thesis, the systematic search and screening process, detailed in Chapter 3, culminated in a final review of 158 studies considered relevant for analysis. This chapter presents the descriptive and thematic findings extracted from this body of literature. The analysis mapped the research field by examining publication trends, geographical focus, and publication journals, and addressed the core research questions by synthesizing the main technologies, drivers, and barriers related to AgroICT and precision agriculture adoption in Africa.

4.1 Publication Trends Over Time

Academic interest in African AgroICT and PA adoption is a distinctly recent phenomenon. As Figure 13 illustrates, the body of 158 included studies was sparse prior to 2016, with most years producing five or fewer publications. After 2016, the field experienced a significant surge in research activity. This trend accelerated significantly, culminating in 35 publications in 2024 alone. This sharp upward trajectory highlights a rapidly escalating scholarly and policy recognition of the topic's importance across the continent.

Figure 13: Yearly distribution of included publications on AgroICT and PA (2010-2025)
(Source: Own editing based on systematic literature review)



4.2 Geographical Focus of Research

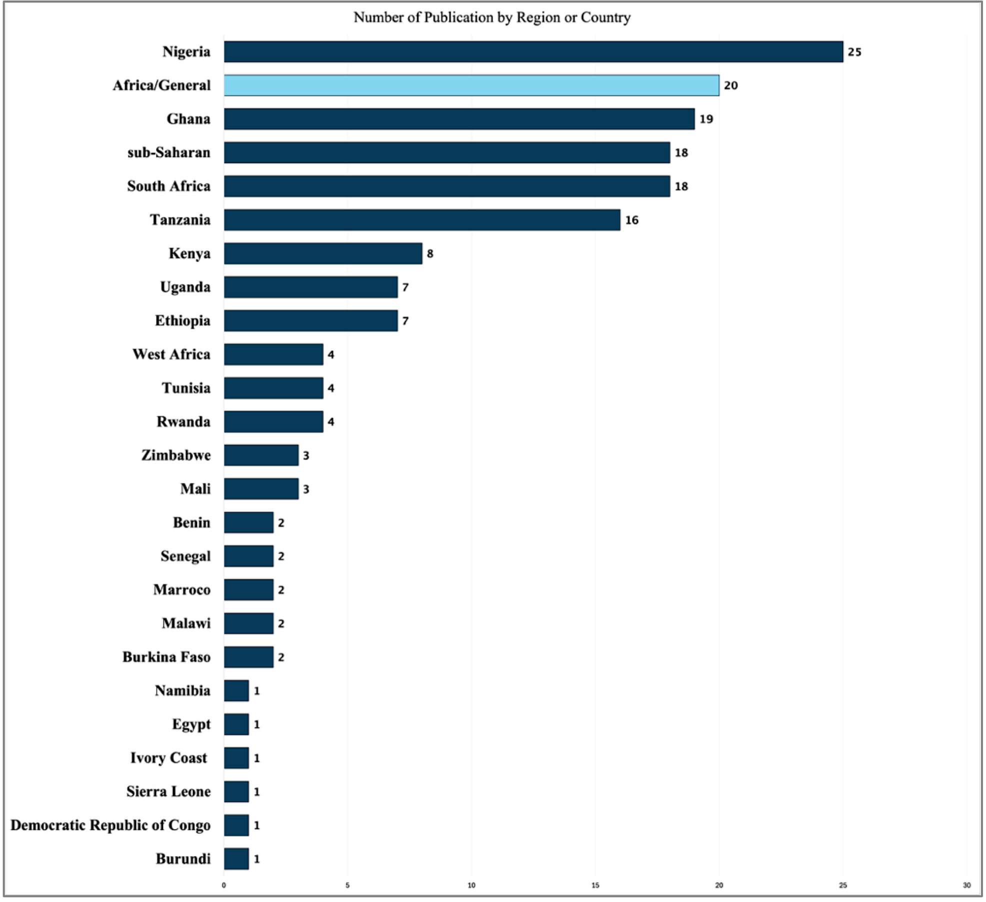
My analysis of the 158 included studies reveals a research map of Africa that is not evenly distributed, but rather distinct, with vast, under-researched territories **(Figure 14**). Because some studies covered multiple locations, the 158 articles generated 172 total geographical mentions, which makes it possible to map where scholarly attention has been focused.

Looking country by country, Nigeria clearly emerges as the primary center of gravity for AgroICT and PA research, attracting the most significant focus with 25 dedicated studies. Ghana follows as another major hub of activity, with 19 publications and South Africa with 18 studies, while Tanzania (n=16) and Kenya (n=8) round out the top-studied nations.

Beyond these individual countries, a significant portion of the literature takes a wider-angle coverage. Many studies are framed regionally, with 20 publications discussing the entire continent, and another 18 focusing on the sub-Saharan region as a whole.

Figure 14: Geographical distribution of publications by country or region (n=172 mentions from 158 studies). Source: Own editing based on systematic literature review.

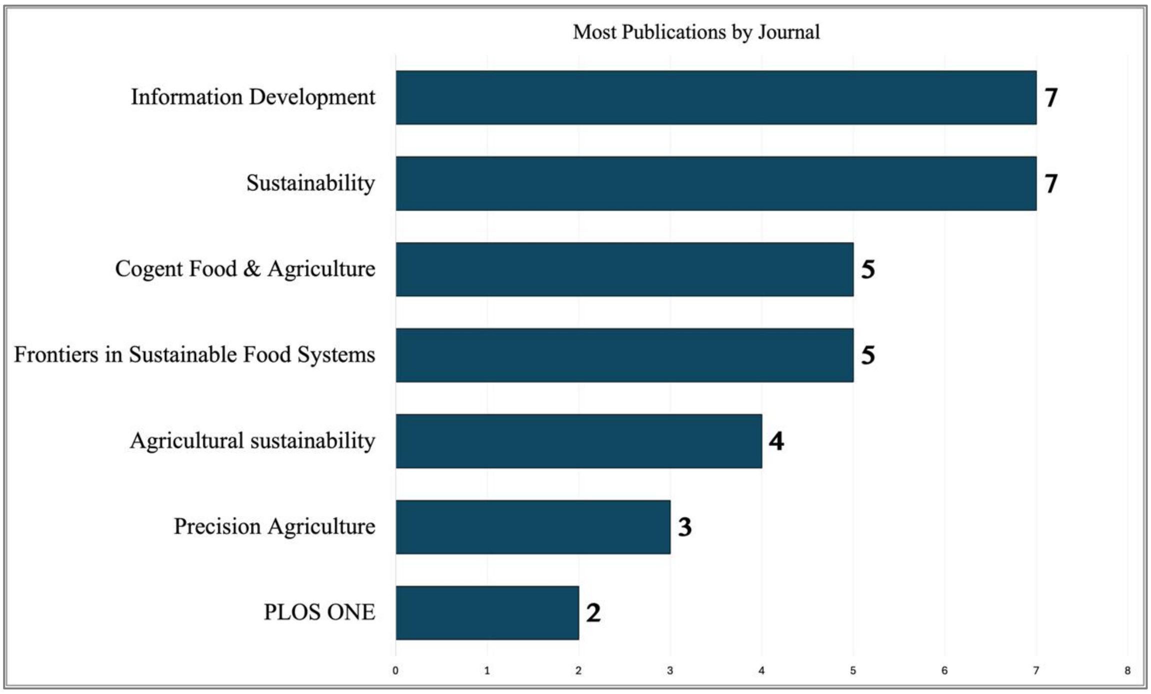
(Source: Own editing based on systematic literature review)



4.3 Leading Publication Journals

The scholarship on this topic is spread across various interdisciplinary venues rather than being siloed in one field (**Figure 15).** No single journal dominates the field, but journals such as Information Development and Sustainability emerged as the most frequent publishers, each contributing 7 of the 158 included articles. Journals with an explicit agricultural focus, such as Cogent Food & Agriculture (n=5) and Precision Agriculture (n=3), also feature prominently, highlighting the relevance of this topic to both international development studies and specific agricultural science.

Figure 15: Journals with the highest number of included publications in the review. Source: Own editing based on systematic literature review.
(Source: Own editing based on systematic literature review)

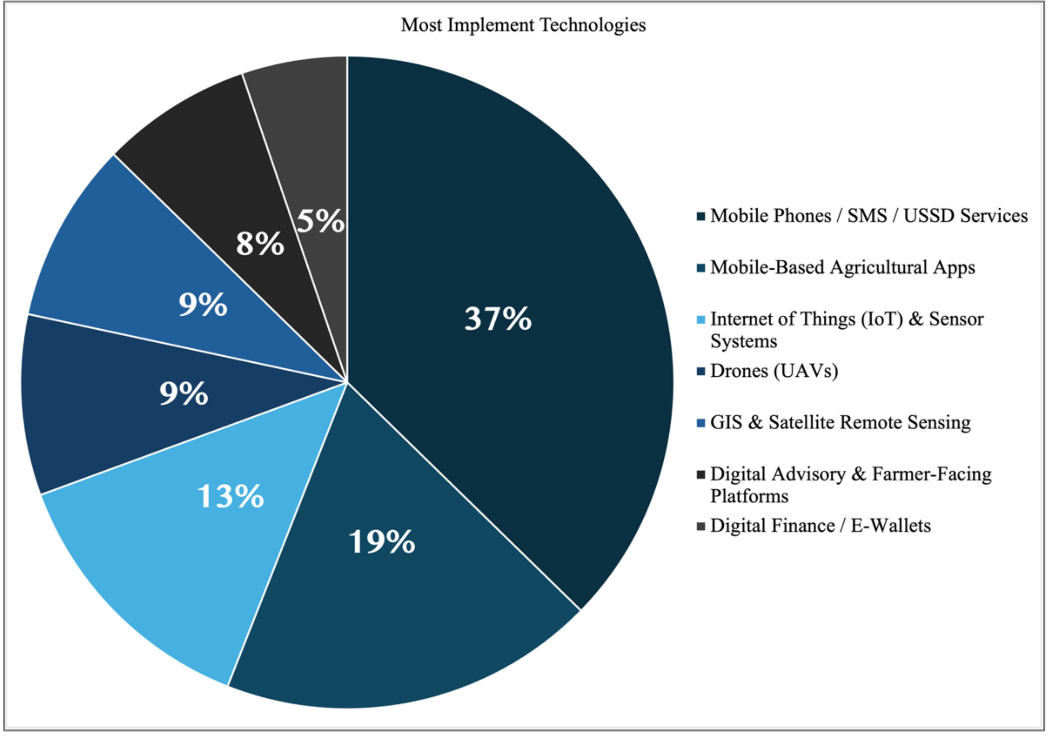


4.4 Thematic Analysis of Adoption

Dominant Technologies in the Literature The literature's technological focus, detailed in **Figure 16**, overwhelmingly centers on accessible, low-cost, mobile-based solutions. Basic Mobile Phones (SMS/USSD) (37%) and Mobile-Based Apps (19%) collectively represent 56% of all technologies studied. This focus strongly reflects the high mobile penetration on the continent as the primary vector for digital inclusion.

Based on the reviewed studies, I found that more complex, capital-intensive technologies remain secondary areas of research. IoT and Sensor Systems (13%) are the next most common category, followed by data-heavy tools like Drones (UAVs) (9%) and GIS/Satellite Remote Sensing (9%). Digital finance and dedicated advisory platforms make up the remainder, indicating the research field is still primarily concerned with foundational access rather than high-end precision tools.

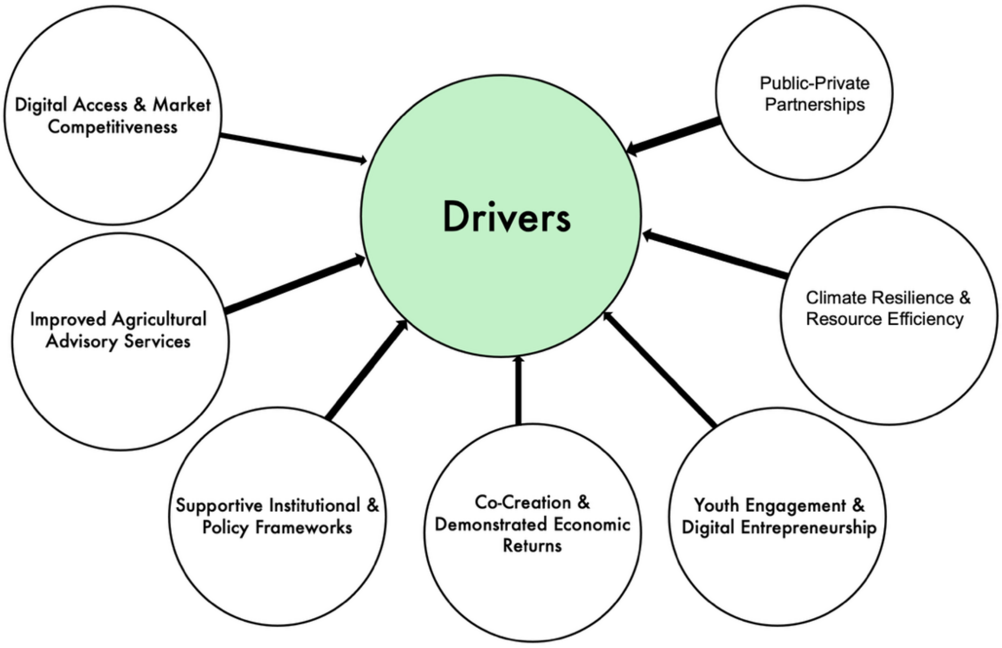
Figure 16: Distribution of reviewed studies by the primary AgroICT technology implemented *(Source: Own editing based on systematic literature review)*



4.5 Drivers and Barriers to AgroICT and Precision Agriculture Adoption in Africa

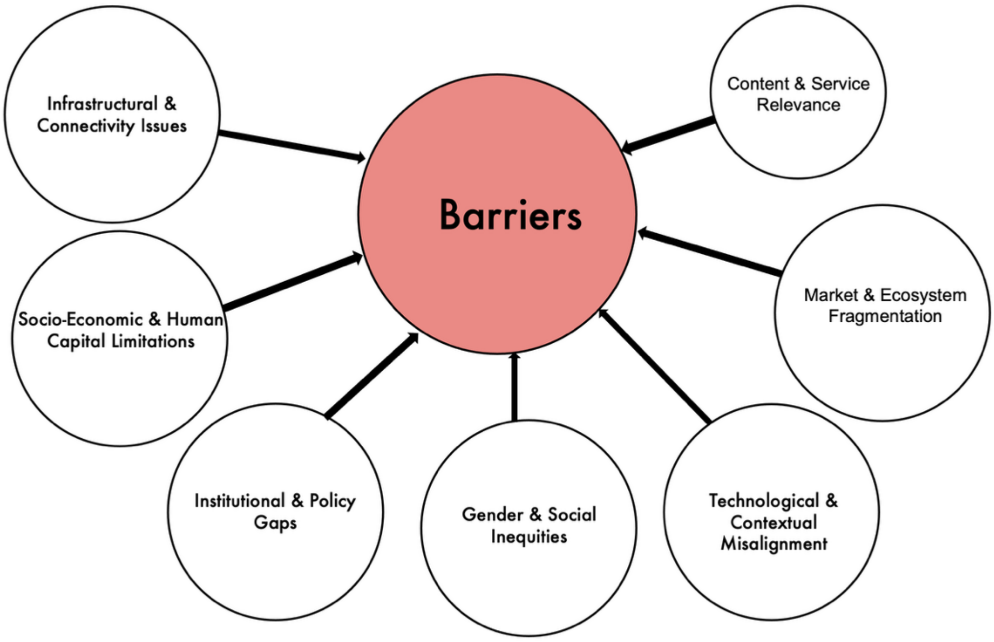
As shown in **Figure 17**, through thematic analysis of the included literature, nine principal categories of drivers influencing the implementation of AgroICT and precision agriculture in Africa include environmental pressures, economic opportunities, policy and regulatory frameworks, technological and digital innovation, resource scarcity, social inclusion, market competitiveness, financial support, and sustainability commitments.

Figure 17: The most important drivers for AgroICT and PA adoption identified in the literature. *(Source: Own editing based on systematic literature review)*



On the other hand, the review also shows that infrastructural and connectivity issues, socio-economic and human capital limitations, institutional and policy gaps, gender and social inequities, technological and contextual misalignment, market and ecosystem fragmentation, and content and service relevance are the main barriers affecting the implementation of AgroICT and PA in Africa, as shown in **Figure 18.**

Figure 18: Main barriers for AgroICT and PA adoption based on the literature.
(Source: Own editing based on systematic literature review)



5 DISCUSSION

This systematic review was initiated to synthesize the fragmented body of research on the adoption of AgroICT and Precision Agriculture in Africa. The objective was to map the current state of the literature, identify the principal drivers and barriers, and understand the interventions proposed to bridge the adoption gap.

The results from Chapter 4 reveal a field of study that is recent, rapidly accelerating, and highly concentrated. The findings show that research is geographically skewed towards Anglophone countries like Nigeria, Ghana, and South Africa, and technologically focused on low-cost, accessible mobile phone solutions. Thematically, the review shows a core tension: the "pull" of adoption, driven by clear economic opportunities and improved access to information, is being severely counteracted by the "push-back" of foundational, structural barriers.

5.1 AgroICT and Precision Agriculture literature in Africa

The descriptive analysis from Chapter 4 tells a story about the priorities and current problems in the research on AgroICT and PA in Africa. The first main finding is the recency of the field (**Figure 13**). The sharp acceleration in publications post-2016 indicates that AgroICT in Africa is moving from a recent concept to a mainstream research and policy agenda.

The second main finding is the imbalance of the research. The heavy concentration in Nigeria, Ghana, and South Africa (**Figure 14**) means our collective understanding is largely based on these relatively advanced, Anglophone-led digital ecosystems. This creates a significant knowledge gap, as the drivers and barriers in these nations are likely very different from those in the vast, under-researched regions of Francophone, Lusophone, and Central Africa.

The third and most critical descriptive finding relates to the technology itself (**Figure 16**). The data is unequivocal: the digital agricultural revolution in Africa, as documented by researchers, is overwhelmingly mobile-first. Mobile Phones (SMS/USSD) and Mobile Apps combined account for 56% of the technologies studied. This finding directly challenges the global North's high-tech "Smart Farming" narrative of autonomous drones and IoT sensors. For the African practitioners in this field, the most impactful innovations are low-cost, accessible, and often text-based. This implies that the most effective solutions are not necessarily the most technologically advanced, but the most contextually appropriate.

5.2 Drivers of AgroICT and Precision Agriculture Adoption

The thematic analysis of drivers and barriers reveals the central challenge of digital adoption. Farmers in Africa are not resistant to technology, but they are, however, constrained by their reality. The drivers identified in this review confirm that smallholders are rational economic actors who will adopt innovations that provide a clear and tangible value proposition. The most prominent drivers were not abstract concepts but concrete benefits, such as economic returns and improved information. This analysis revealed seven main categories of drivers.

The following sections detail each of these thematic drivers, supported by evidence from the reviewed literature.

5.2.1 Digital Access and Market Competitiveness

Access to timely market information is a powerful motivator for digital tool adoption. Ogutu et al. (2014) demonstrate that ICT-based market information services in Kenya significantly improve smallholders' input use and productivity by reducing information asymmetries. Okello et al. (2020) corroborate this, showing that participation in such platforms increases commercialisation and farm income. According to Quandt et al. (2020), mobile phone ownership is strongly associated with higher agricultural productivity among smallholder farmers in Tanzania, serving as a primary gateway to digital services. Similarly, Abubakari et al. (2023) find that both access to and active usage of mobile phones significantly increase household crop income in Ghana. Furuholt and Matotay (2011) further emphasize that mobile phones enhance connectivity across the entire agricultural value chain, from input sourcing to market linkages, thereby improving efficiency and reducing transaction costs.

5.2.2 Improved Agricultural Advisory Services

Digital platforms are increasingly complementing or transforming traditional extension systems. According to Abate et al. (2023), video-mediated extension in Ethiopia significantly accelerates technical change and improves adoption of improved agronomic practices. Van Campenhout et al. (2021) report that ICT-delivered agricultural advice in Uganda leads to measurable gains in yields and input use efficiency. Ortiz-Crespo et al. (2021) add that user-centred design of digital advisory tools in Tanzania enhances relevance and usability, thereby strengthening public extension delivery.

5.2.3 Supportive Institutional and Policy Frameworks

National strategies and institutional support play a catalytic role. According to Izuogu et al. (2023), Nigeria's evolving digital agriculture policy landscape, though fragmented, has created entry points for public-private collaboration. Mazwane et al. (2022) argue that inclusive digital agriculture policies aligned with land reform in South Africa can promote equitable access. Anteneh and Melak (2024) highlight Ethiopia's efforts to institutionalize ICT-based extension as a key enabler of scalability.

5.2.4 Co-Creation and Demonstrated Economic Returns

Technologies developed with farmer input are more likely to succeed. According to Adewopo et al. (2025), co-creation processes in Rwanda's banana farming system led to digital innovations that were trusted, relevant, and sustainable. Masinde and Thothela (2019) report that the ITIKI Plus mobile app, which integrates indigenous knowledge with scientific climate forecasts, was widely adopted in Kenya because it resonated with local decision-making practices. Similarly, Raghunath et al. (2024) show that dual-platform designs in Tanzania improve inclusivity and reach. Additionally, tangible benefits also drive sustained adoption. According to Traore and Moussa (2025), digital finance in Burkina Faso significantly boosts maize productivity and household welfare. Gizachew et al. (2024) find that digital tool adoption among ginger producers in Ethiopia correlates with higher income and risk mitigation. Onumah et al. (2023) report that agricultural innovations, including digital ones, contribute meaningfully to poverty reduction among Ghanaian farm households.

5.2.5 Youth Engagement and Digital Entrepreneurship

Youth are emerging as key agents of digital agricultural transformation. Osabohien (2024) finds that ICT adoption in Nigeria's agricultural sector creates employment opportunities for young people, both as users and service providers. Mabaya and Porciello (2022) note that youth-led agri-tech start-ups are driving innovation in areas like drone services, e-extension, and digital finance. Degila et al. (2023) observe that in West Africa, young farmers are more likely to experiment with and advocate for digital tools, acting as change agents within their communities.

5.2.6 Climate Resilience and Resource Efficiency

Precision agriculture is increasingly valued for its role in climate adaptation. According to Abdelrahim and Jin (2025), their novel GA-MSVDI drought index enables high-resolution monitoring of soil-vegetation conditions in North Africa, supporting timely interventions. Onyango et al. (2021) argue that precision agriculture enhances resource use efficiency, particularly water and fertilizer, in smallholder systems, making farming more sustainable under climate stress. Quarshie et al. (2023) caution that while digital climate-smart agriculture (DCSA) is still emerging in Ghana, early evidence shows promise in improving adaptive capacity.

5.2.7 Public-Private Partnerships

Collaborative models are critical for scaling. According to Mutema and Chiromo (2014), inclusive agribusiness models, such as those piloted by TechnoServe in Zimbabwe, leverage private sector efficiency while ensuring smallholder inclusion. Sanusi et al. (2025) document how commercial digital platforms are revolutionizing Nigeria's rice value chain by connecting farmers to inputs, credit, and markets. Mushi et al. (2025) emphasize that participatory design of national digital information systems in Tanzania, engaging government, NGOs, and farmers, builds ownership and sustainability.

In summary, the review of the drivers impacting the implementation confirms the findings of scholars such as Ogutu et al. (2014) and Abubakari et al. (2023), who demonstrated that access to market information and digital finance directly translates to higher incomes. Similarly, the importance of "improved agricultural advisory services" (Abate et al., 2023; Van Campenhout et al., 2021) shows a clear demand for actionable knowledge that digital tools can deliver more efficiently than traditional extension systems. Furthermore, the review also highlights that how a technology is introduced matters. The drivers of "co-creation" (Adewopo et al., 2025) and "youth engagement" (Osabohien, 2024) suggest that adoption is not just a technical process, but a social one. Technologies designed with farmers (Masinde & Thothela, 2019) and championed by a new generation of digital natives are far more likely to be trusted and integrated.

5.3 Barriers to the Adoption of AgroICT and Precision Agriculture

While the driving factors are strong and interesting, the findings show they are often nullified by a wall of foundational barriers. The most frequently cited barriers across the 158 studies were not related to farmer mindset, but to fundamental deficits, such as infrastructural and connectivity issues (Oklikah et al., 2025) and socio-economic and human capital limitations (Abdulai, 2024). Apart from these two, the review also produced six other barriers.

5.3.1 Infrastructural and Connectivity Issues

The literature consistently identifies infrastructural deficits as a fundamental barrier. According to Oklikah et al. (2025), limited access to telecommunication and internet infrastructure in rural Ghana, and by extension much of Sub-Saharan Africa, constitutes a fundamental barrier to digital farming. Similarly, Uyeh et al. (2023) emphasize that unreliable electricity and poor mobile network coverage undermine the feasibility of deploying digital tools in remote farming communities. McCarthy et al. (2023) further note that even emerging technologies like agricultural drones face operational constraints due to inadequate supporting infrastructure, such as roads and charging facilities in Malawi.

5.3.2 Socio-Economic and Human Capital Limitations

Abdulai (2024) finds that many smallholder farmers in Northern Ghana lack the digital competencies required to effectively engage with digital advisory services, highlighting a critical gap in human capital. According to Abdulai et al. (2023), despite the proliferation of digital tools, the lived realities of farmers, such as low literacy levels and limited smartphone proficiency, often render these tools inaccessible or irrelevant. Mehrab et al. (2021) caution that the global "data divide" exacerbates inequalities, as smallholders in Africa are frequently excluded from data-driven farming due to cost and skill barriers. Muromba (2025) adds that even ostensibly free mobile agricultural services may entail hidden data costs that deter sustained use among resource-poor farmers.

5.3.3 Institutional and Policy Gaps

Izuogu et al. (2023) observe that Nigeria's digital agriculture landscape suffers from fragmented policies and weak coordination among stakeholders, limiting scalability. Mazwane et al. (2022) argue that without inclusive policy frameworks aligned with land reform and rural development agendas, digital agriculture risks deepening marginalization in South Africa. Anteneh and Melak (2024) report that Ethiopia's extension services remain under-equipped to integrate ICT-based advisory models, reflecting broader institutional capacity gaps. Furthermore, Sarku and Ayamga (2025) warn that the absence of robust data governance frameworks enables "data extractivism," where private platforms harvest farmers' data without equitable benefit-sharing.

Gender and Social Inequities

According to Zougmoré and Partey (2022), women farmers in West Africa face systemic barriers to ICT access, including lower phone ownership and restricted participation in digital training. Isaya et al. (2018) document how cultural norms in Tanzania limit women's access to agricultural information, even when it is disseminated via widely available channels. Julius and Atewamba (2018) similarly find that gender dynamics in Nigeria significantly influence ICT use, with women less likely to adopt digital tools even within the same households as their male counterparts. However, digital interventions that are not explicitly designed to be inclusive of women and other marginalized groups will not only fail to reach them but may worsen existing inequalities (Isaya et al., 2018).

5.3.4 Technological and Contextual Misalignment

Adewopo et al. (2025) stress that digital innovations often fail because they are not co-created with end-users, leading to poor fit with local farming practices in Rwanda. Onyango et al. (2021) argue that precision agriculture technologies developed for large-scale, monocrop systems in high-income countries are ill-suited to the heterogeneous, small-scale, and mixed-cropping realities of Sub-Saharan Africa. Ayim et al. (2022) corroborate this, noting that perceived irrelevance and lack of trust in imported digital solutions contribute to low adoption or abandonment.

5.3.5 Market and Ecosystem Fragmentation

Mabaya and Porciello (2022) caution that Africa's digital agriculture ecosystem is characterized by isolated pilot projects with limited pathways to scale. Degila et al. (2023) report from a multi-country West African survey that the lack of interoperability and inconsistent data standards hinder platform integration. Aroba and Rudolph (2024) add that the societal impact of AI-driven precision agriculture remains uncertain due to insufficient evidence on long-term economic returns for smallholders. Addai et al. (2024) and Traore and Moussa (2025) further highlight that without demonstrable benefits, such as improved yields or income, farmers and investors remain hesitant to commit to digital transformation.

5.3.6 Content and Service Relevance

Finally, the relevance and localization of digital content are crucial. Generic advisories that do not account for local agro-ecological conditions, specific crop needs, or the socio-economic reality of smallholders have limited utility (Anteneh & Melak, 2024; Ortiz-Crespo et al., 2021). The sustainability of digital services is also a concern, with many pilot projects failing to scale due to unsustainable business models (Adewopo et al., 2025; Emeana et al., 2020).

5.4 Overcoming the Barriers

Moving beyond a purely diagnostic understanding of drivers and barriers, this discussion also addresses the prescriptive mandate of the proposed question number four, synthesizing the interventions proposed in the literature to overcome these challenges. Our thematic analysis reveals that the proposed solutions are not disparate but converge logically around three interconnected action points.

First, the overwhelming prevalence of barriers such as poor connectivity (Oklikah et al., 2025) and low digital literacy (Abdulai, 2024) requires a foundational, state-level response. Consequently, the literature suggests the most critical interventions are those that build the foundational enablers for a digital ecosystem. These interventions, including national investment in rural electrification, broadband internet, and the integration of digital competency training into public extension services (Anteneh & Melak, 2024), are largely beyond the scope of individual technology developers and fall squarely within the domain of public policy.

Second, to address the pervasive barrier of 'technological and contextual misalignment' (Adewopo et al., 2025; Onyango et al., 2021), interventions must pivot from importing generic solutions to incentivizing context-aware innovation. The findings in this thesis suggest this is best achieved by promoting a local innovation ecosystem, a strategy that directly aligns with the 'co-creation' driver (Adewopo et al., 2025). This implies that policy and investment should be strategically channelled through public-private partnerships (Mutema & Chiromo, 2014) to support local agri-tech startups and youth entrepreneurs (Mabaya & Porciello, 2022), who are inherently better positioned to design and scale solutions that are relevant, trusted, and appropriate for smallholder realities.

Finally, to address the deep-seated barriers of 'institutional and policy gaps' (Izuogu et al., 2023) and 'gender and social inequities' (Zougmoré & Partey, 2022), the literature calls for the implementation of inclusive and ethical frameworks. This moves beyond simple technology deployment to address the "rules" of the new digital economy. On one hand, this requires robust data governance frameworks to protect farmers from 'data extractivism' and ensure equitable benefit-sharing (Sarku & Ayamga, 2025). On the other hand, it demands that all digital agriculture policies are designed with an explicit gender-transformative lens. This ensures interventions actively work to close, rather than widen, the digital gender divide by moving beyond mere 'access' to guaranteeing women's agency and control over digital resources (Zougmoré & Partey, 2022).

5.5 Implications for Policy and Practice

The synthesis of 158 studies provides clear, actionable implications for the primary actors within Africa's digital agricultural ecosystem. The findings suggest a need for a strategic change from isolated interventions to a more cohesive, foundational approach.

For policymakers, this thesis finding of severe 'market and ecosystem fragmentation' (Mabaya & Porciello, 2022) is a critical insight. It suggests that the dominant paradigm of uncoordinated, small-scale pilot projects is insufficient for achieving scalable, national-level impact. Therefore, future state-led strategies must transition towards an inclusive, ecosystem-level approach. This requires a primary focus on investing in the foundational pillars identified consistently throughout this thesis, such as closing the infrastructural divide (Oklikah et al., 2025), integrating digital literacy into national extension services (Abdulai, 2024), and establishing inclusive, coherent digital agriculture policies (Izuogu et al., 2023).

For developers and the private sector, the findings challenge a technology-first mindset. The data clearly shows that the dominant and most accessible technologies in the studied literature are mobile-based, while 'technological and contextual misalignment' was identified as a strong barrier (Adewopo et al., 2025). This implies that the greatest market opportunity lies not in deploying high-cost, capital-intensive tools like advanced AI or drones, but in designing and scaling solutions that prioritize relevance and accessibility. Specifically, this points toward a need for low-cost, text-based (SMS/USSD), offline-functional, and multi-lingual services that are co-created with farmers and provide demonstrable economic returns (Okello et al., 2020).

Finally, for the research community, this review signals a need to evolve the research agenda. The utility of basic mobile phones is now well-established (Quandt et al., 2020); consequently, the field must mature beyond descriptive adoption studies. The geographical and thematic gaps identified highlight clear priorities for future inquiry. These include: (i) expanding the evidence base to the critically under-represented regions, particularly francophone and lusophone Africa; (ii) conducting longitudinal research to measure long-term economic sustainability and impact, rather than just short-term adoption rates; and (iii) performing rigorous, gender-disaggregated analysis of which specific interventions successfully and equitably close the adoption gap (Zougmoré & Partey, 2022).

6 CONCLUSION

This thesis aimed to address a significant challenge in African agricultural development. While digital tools like AgroICT and Precision Agriculture (PA) offer powerful solutions, their use by smallholder farmers remains surprisingly low and uneven. To understand this adoption gap, a Systematic Literature Review (SLR) of 158 studies was performed. The goal of this review was to map the current research, identify the main drivers and barriers, and find practical strategies to connect technological promise with real-world practice.

The analysis showed that research on this topic is new and growing quickly, with most studies published after 2016. This research, however, is not evenly spread. It is heavily focused on a few Anglophone countries, mainly Nigeria, Ghana, and South Africa. This means that large areas, especially in Central, North, and Francophone Africa, are not being studied enough, and our understanding of the continent as a whole is incomplete. Technologically, the findings show that the digital transformation in African farming is "mobile-first." More than half of all studies focused on basic mobile phones (SMS/USSD) and apps, more than on expensive drones or sensors. This strongly reflects the reality of smallholder farming, where affordability, accessibility, and practical use are more important than technological complexity.

The thematic analysis uncovered the main finding of this thesis, which is the central tension between strong reasons to adopt technology and the major structural barriers that prevent it. On one hand, smallholder farmers are clearly motivated by practical benefits. The review shows that digital tools offer better access to markets, more reliable information on weather and prices, and real opportunities to improve farm income. On the other hand, farmers face deep, systemic obstacles that are often beyond their control. The most critical challenges are not a lack of interest, but a lack of basic infrastructure, such as poor internet and unreliable electricity. This is combined with the high cost of technology, low levels of digital literacy, and a shortage of tools designed specifically for local farming conditions.

This review makes it clear that digital adoption is not just a technical problem, but also a human and systemic one. Real progress, therefore, depends on building a supportive environment around the farmer. The evidence from the 158 studies points to three main priorities. First, there must be greater public investment in the basic "enablers" of technology, especially rural internet, reliable electricity, and widespread digital skills training. Without this foundation, even the best tools will fail to scale. Second, future technologies must be developed with farmers, not just for them. When tools are co-created with local input, they are more relevant, trusted, and sustainable. This means supporting local innovators and young entrepreneurs who understand smallholder realities. Third, this transformation must be inclusive and ethical. Special attention is required to ensure that women farmers, who are a major part of Africa's agricultural workforce, have equal access and can benefit from these new tools.

This thesis, while thorough, has its limitations. The review focused only on English-language studies, which likely explains the geographical gaps and means important research from Francophone and Lusophone Africa was missed. The search also centered on academic articles, so important findings from government reports or NGO projects may not be included. Finally, the process of grouping themes, while systematic, involves interpretation. These limitations all point to the need for an even broader research effort in the future.

The findings of this study point to clear directions for future research. First, there is an urgent need for more studies in the under-researched regions, especially in Central, North, and Francophone Africa, to build a true continental-level understanding. Second, researchers should move beyond short-term adoption studies and focus on the long-term impacts of these technologies on farmer incomes, food security, and the environment. This change is important because only long-term evidence can reveal whether these technologies lead to lasting improvements or whether benefits fade once projects end. Finally, more participatory, gender-focused research is needed to not only identify inequalities but to design and test solutions that empower women, youth, and other marginalized groups. Ultimately, this review concludes that the great promise of digital agriculture in Africa will only be realized when the structural barriers of access are finally removed, allowing the proven motivation of smallholder farmers to flourish.

6.1 Contribution

My personal interpretation of these findings is that the current approach to AgroICT in Africa is often top-heavy, prioritizing high-end technological possibilities over on-the-ground agronomic realities. The evidence that "contextual misalignment" is a major barrier is a direct critique of deploying tools that are not field-ready for our situation in Africa. To move forward, a pragmatic, foundations-first engineering approach is required. First, we must treat the digital ecosystem like a physical one. We cannot build a data-driven irrigation system without a reliable power source and water. Similarly, we cannot build a digital agricultural ecosystem without reliable, affordable rural internet and electrification. These are the non-negotiable foundations.

Public policy and investment must prioritize this foundational infrastructure over funding isolated, high-tech pilot projects.

Second, this requires proactive government support that goes beyond just infrastructure. This thesis highlights 'institutional and policy gaps' as a major barrier. From my interpretation, progress is impossible without a clear, stable, and supportive regulatory environment. Governments, particularly in the most needed areas, must actively create national digital agriculture strategies, offer financial incentives or subsidies for adoption, and streamline regulations to encourage, not discourage, innovation.

Third, we must launch targeted awareness campaigns. As mentioned before, the 'human capital' barrier is not just about skills but about awareness and trust. We need national and regional programs, delivered via radio, television, and demonstration farms, to showcase the proven economic benefits of these tools. Farmers need to see the value before they will invest their limited time or money.

Finally, we must engineer a human-centric support system. With this, I mean that technology is only as good as its operator. The most significant barrier after infrastructure is human capital. A sustainable solution is to revolutionize the agricultural extension model. Africans must invest heavily in a "train the trainer" approach, certifying local extension agents and lead farmers as digital tool experts. These local experts become a permanent, trusted human interface for the technology, providing training, support, and basic troubleshooting. This "human infrastructure" is just as critical as the physical infrastructure. In addition to that, co-creation must be a mandatory step in the engineering design process. This thesis also shows that technologies fail when they are imported without adaptation. Engineers and developers must be in the field with farmers, co-designing solutions to solve their stated problems, not the problems we assume they have. This is the only way to ensure the final product is relevant, trusted, and, ultimately, adopted.

7 SUMMARY

This thesis investigated the persistent adoption gap of AgroICT and precision agriculture in Africa. Despite the clear potential for these tools to address food insecurity and environmental issues, their on-the-ground use remains low and fragmented. The primary objective of this study was to systematically identify, synthesize, and evaluate the principal drivers motivating adoption and the primary barriers impeding it. To achieve this, a Systematic Literature Review (SLR) was conducted, adopting to the PRISMA 2020 framework. A comprehensive search of the Google Scholar, Web of Science, and Scopus databases for literature published between 2010 and 2025 produced a total of 158 relevant studies for final analysis.

The descriptive analysis of these studies revealed important findings about the state of research. The field is new and rapidly accelerating, with a significant surge in publications after 2016. The literature is heavily concentrated in Anglophone countries, particularly Nigeria, Ghana, and South Africa, leaving large parts of the continent under-researched. Furthermore, the digital transformation is overwhelmingly mobile-first, with 56% of studies focusing on basic mobile phones (SMS/USSD) and mobile applications, rather than high-cost, high-tech tools.

Furthermore, the thematic analysis identified a core tension between the motivations for and barriers to adoption. Adoption is primarily motivated by strong, rational economic and practical benefits, including improved access to markets, improved agricultural advisory services, demonstrated economic returns, and climate resilience. However, these drivers are often nullified by deep, structural barriers, the most critical of which are fundamental infrastructural deficits, in this case, such as poor internet and unreliable electricity; socio-economic limitations such as low digital literacy, high costs, and illiteracy; and the contextual misalignment of technologies designed for large, Western farms, not smallholder realities.

This thesis concludes that the adoption gap is not a technical problem but a human and systemic one. Merely making technology available is insufficient. To bridge this gap, the findings support a strategic change from isolated pilot projects and toward building a comprehensive, supportive ecosystem.

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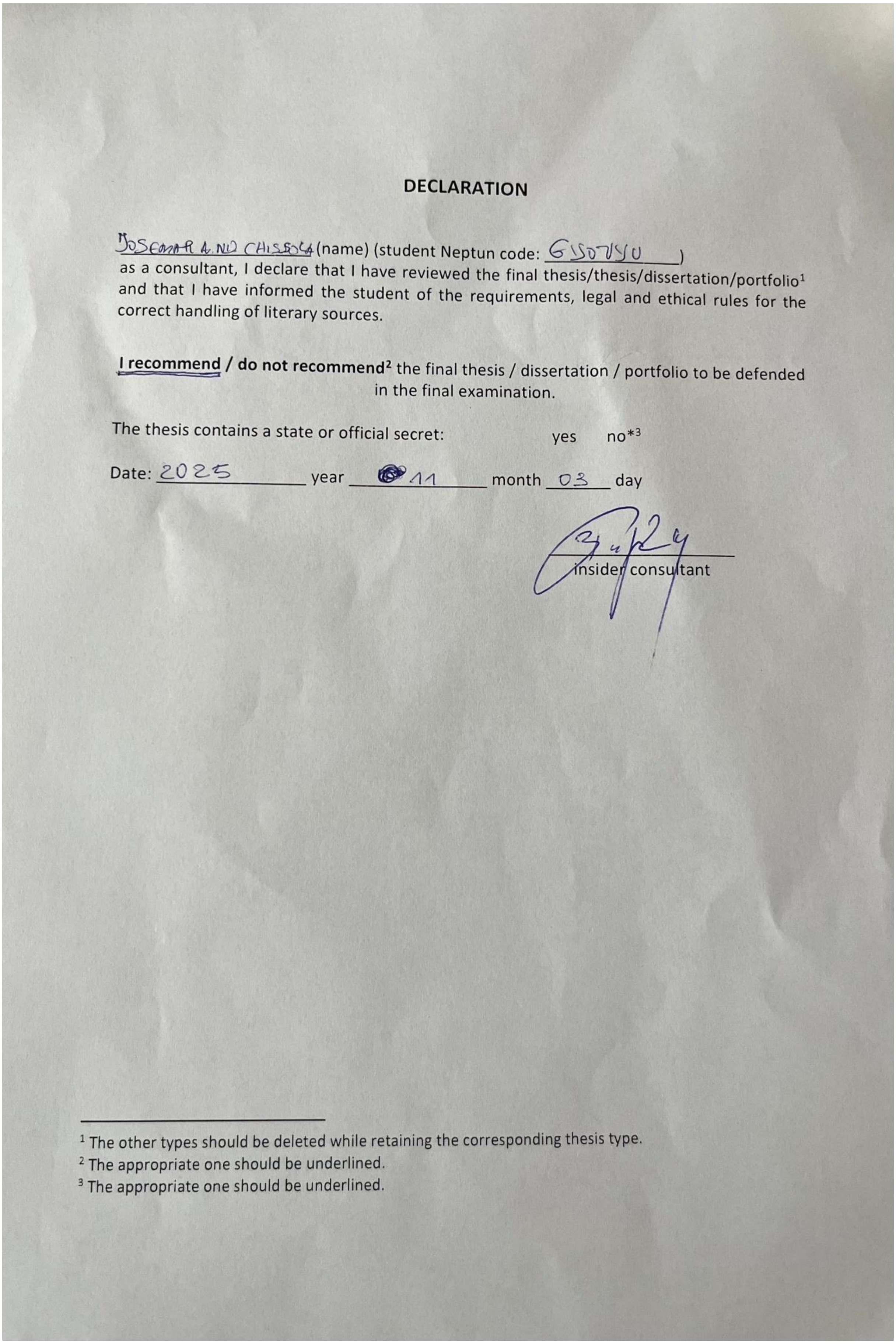
Table of Figures

List of Abbreviations

Abbreviation	Meaning
4IR	Fourth Industrial Revolution
AgroICT	Agricultural Information and Communication Technologies
AI	Artificial Intelligence
CPAS	Cyber-Physical Agricultural System
DCSA	Digital Climate-Smart Agriculture
DSS	Decision Support Systems
FAO	Food and Agriculture Organization of the United Nations
FMIS	Farm Management Information Systems
GIS	Geographic Information Systems
GNSS	Global Navigation Satellite Systems
GPS	Global Positioning Systems
IoT	Internet of Things
ISOBUS	ISO 11783 (Agricultural equipment communication standard)
ISPA	International Society of Precision Agriculture
m-Agri	Mobile phone-enabled services
ML	Machine Learning
NIR	Near-Infrared
OGC	Open Geospatial Consortium
PA	Precision Agriculture
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RTK	Real-Time Kinematic
Rx Maps	Prescription Maps
SLR	Systematic Literature Review
SMS	Short Message Service
SSA	Sub-Saharan Africa
TIR	Thermal Infrared
UAVs	Unmanned Aerial Vehicles
USSD	Unstructured Supplementary Service Data
VRT	Variable Rate Technology
WoS	Web of Science
WSN	Wireless Sensor Networks



DECLARATION

JOSEMAR A. ND CHISSOCA (name) (student Neptun code: GISOVYU)
as a consultant, I declare that I have reviewed the final thesis/thesis/dissertation/portfolio[1] and that I have informed the student of the requirements, legal and ethical rules for the correct handling of literary sources.

[✓ I recommend] / do not recommend[2] the final thesis / dissertation / portfolio to be defended in the final examination.

The thesis contains a state or official secret: yes no*[3]

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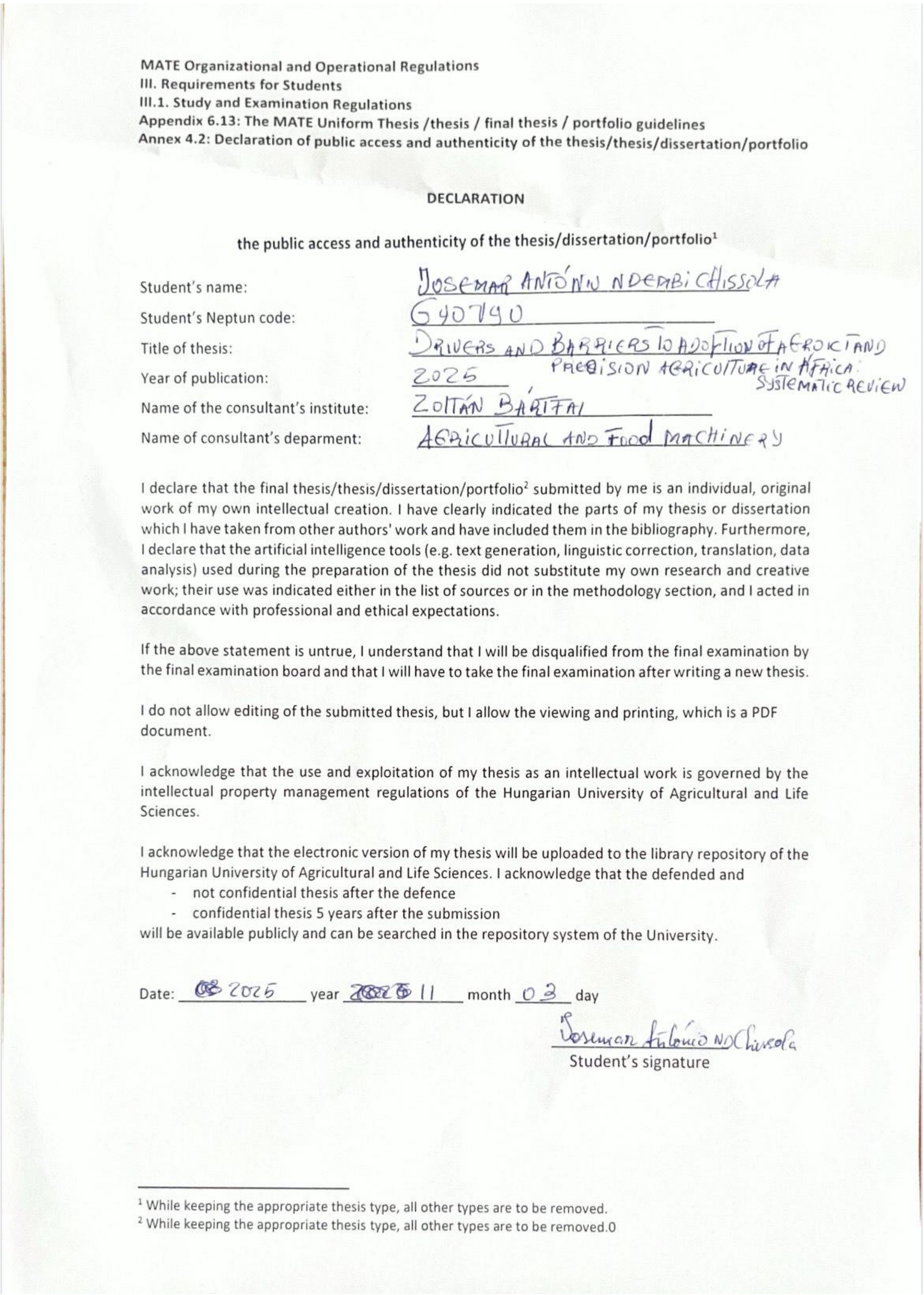

MATE Organizational and Operational Regulations
III. Requirements for Students
III.1. Study and Examination Regulations
Appendix 6.13: The MATE Uniform Thesis /thesis / final thesis / portfolio guidelines
Annex 4.2: Declaration of public access and authenticity of the thesis/thesis/dissertation/portfolio

DECLARATION

the public access and authenticity of the thesis/dissertation/portfolio[1]

Student's name: JOSEMAR ANTÓNIO NDEMBI CHISSOLA
Student's Neptun code: G40V9U
Title of thesis: DRIVERS AND BARRIERS TO ADOPTION OF AGROKIT AND PRECISION AGRICULTURE IN AFRICA: SYSTEMATIC REVIEW
Year of publication: 2025
Name of the consultant's institute: ZOLTÁN BÁRTFAI
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I declare that the final thesis/thesis/dissertation/portfolio[2] submitted by me is an individual, original work of my own intellectual creation. I have clearly indicated the parts of my thesis or dissertation which I have taken from other authors' work and have included them in the bibliography. Furthermore, I declare that the artificial intelligence tools (e.g. text generation, linguistic correction, translation, data analysis) used during the preparation of the thesis did not substitute my own research and creative work; their use was indicated either in the list of sources or in the methodology section, and I acted in accordance with professional and ethical expectations.

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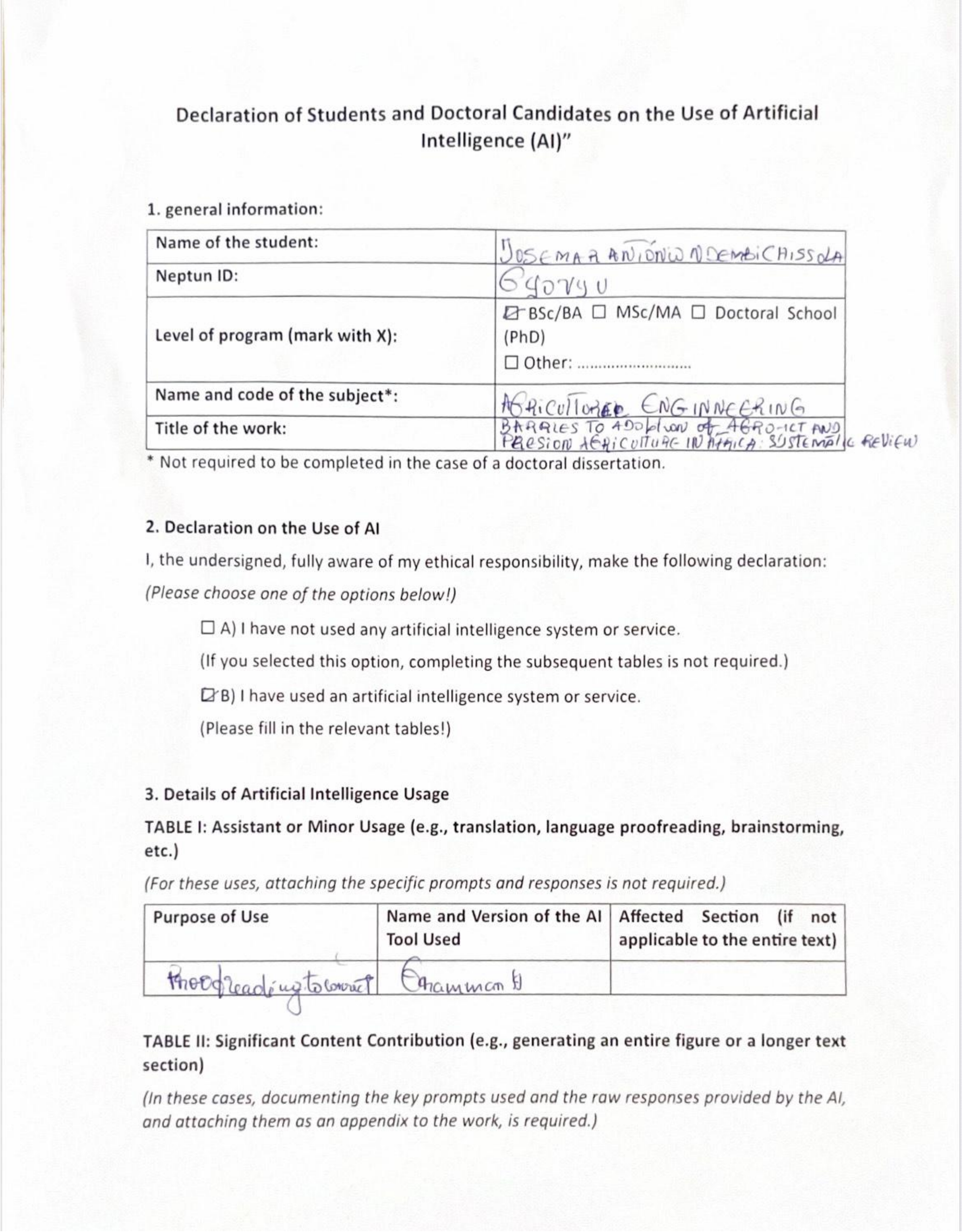

Declaration of Students and Doctoral Candidates on the Use of Artificial Intelligence (AI)"

1. general information:

Name of the student:	JOSEMAR ANTÓNIO NDEMBI CHISSOLA
Neptun ID:	GYOVYU
Level of program (mark with X):	☒ BSc/BA ☐ MSc/MA ☐ Doctoral School (PhD) ☐ Other: ....
Name and code of the subject*:	AGRICULTURAL ENGINNEERING
Title of the work:	BARRIES TO ADOPTION OF AGRO-ICT AND PRESION AGRICULTURE IN AFRICA: SYSTEMATIC REVIEW

* Not required to be completed in the case of a doctoral dissertation.

2. Declaration on the Use of AI

I, the undersigned, fully aware of my ethical responsibility, make the following declaration:

(Please choose one of the options below!)

☐ A) I have not used any artificial intelligence system or service.

(If you selected this option, completing the subsequent tables is not required.)

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(Please fill in the relevant tables!)

3. Details of Artificial Intelligence Usage

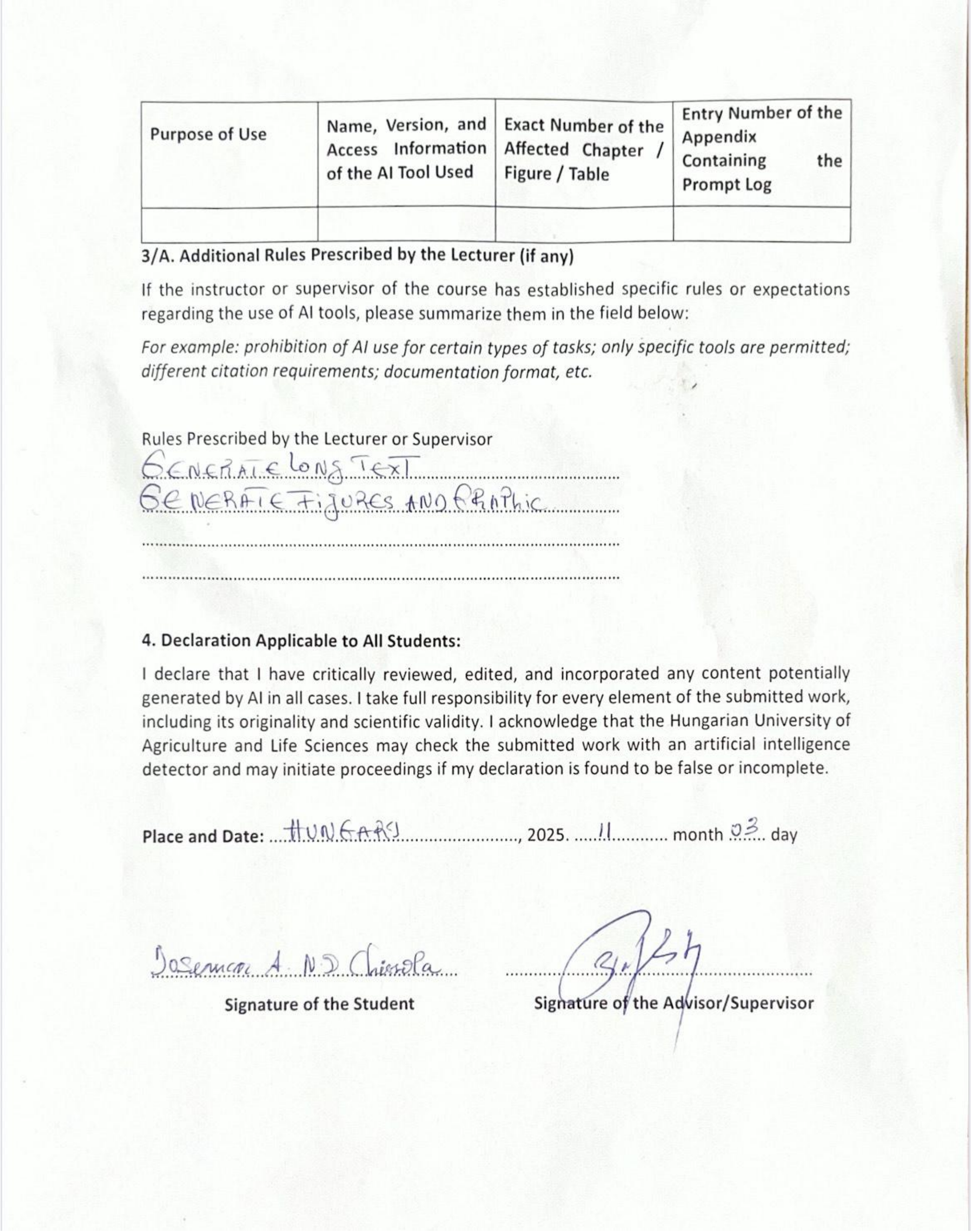
TABLE I: Assistant or Minor Usage (e.g., translation, language proofreading, brainstorming, etc.)

(For these uses, attaching the specific prompts and responses is not required.)

Purpose of Use	Name and Version of the AI Tool Used	Affected Section (if not applicable to the entire text)
Proofreading to correct	Grammarly	

TABLE II: Significant Content Contribution (e.g., generating an entire figure or a longer text section)

(In these cases, documenting the key prompts used and the raw responses provided by the AI, and attaching them as an appendix to the work, is required.)



Purpose of Use	Name, Version, and Access Information of the AI Tool Used	Exact Number of the Affected Chapter / Figure / Table	Entry Number of the Appendix Containing the Prompt Log

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If the instructor or supervisor of the course has established specific rules or expectations regarding the use of AI tools, please summarize them in the field below:

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Rules Prescribed by the Lecturer or Supervisor

GENERATE LONG TEXT

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4. Declaration Applicable to All Students:

I declare that I have critically reviewed, edited, and incorporated any content potentially generated by AI in all cases. I take full responsibility for every element of the submitted work, including its originality and scientific validity. I acknowledge that the Hungarian University of Agriculture and Life Sciences may check the submitted work with an artificial intelligence detector and may initiate proceedings if my declaration is found to be false or incomplete.

Place and Date: HUNGARY, 2025. 11 month 03 day

Josemar A. N.D. Chissola

Signature of the Student

Signature of the Advisor/Supervisor