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The Adoption and Application of Drone Technology in Precision Agriculture in Kenya

Yvonne Odhiambo and Peter Kipkorir

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THE KENYA INSTITUTE FOR PUBLIC POLICY RESEARCH AND ANALYSIS (KIPPRA)

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The Adoption and Application of Drone Technology in Precision Agriculture in Kenya

Yvonne Odhiambo and Peter Kipkorir

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Bishops Garden Towers, Bishops Road
PO Box 56445-00200 Nairobi, Kenya
tel: +254 20 2719933/4; fax: +254 20 2719951
email: admin@kippra.or.ke
website: http://www.kippra.org

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Abstract

Precision Agriculture is one of the innovative concepts of the fourth agricultural industrial revolution (Agriculture 4.0). Precision agriculture entails practices that are aimed at improving yields and maximizing profits while lowering the inputs. The increasing population in Kenya is also leading to increased demand for food production. In addition, the increased cost of inputs and uncertain weather patterns affect food production. This underscores the need to embrace farming practices that enhance yields with reduced input costs. The study employed the futures foresight methodology that encompassed scanning drivers of change using the PESTEL framework, then using the Delphi technique to obtain expert opinions on the relationship between drivers of change with respect to the adoption and application of drone technology in precision agriculture. Finally, a cross-impact analysis was done using the MICMAC software to create the influence dependence map for building the future possible scenarios. The findings revealed that drone technology adoption is influenced by good governance, favourable policies, and subsidies that foster a conducive business environment. In a low adoption scenario, regulatory challenges and high costs of drones create significant barriers to the adoption of drone technologies in precision agriculture. In the high application scenario, drone technologies are widely adopted across the agricultural sector, driven by favourable influential factors including competition in the drone market leading to rapid technological advancements and cost reductions, which in turn accelerate the application of the rate of drone technologies. Both national and county governments need to provide incentives such as subsidies, tax breaks, and grants for farmers to access affordable quality inputs including drone accessories and other mounting devices, reduce the cost of drones to enhance access, and strengthen regulations governing the usage of drones in agriculture to ensure individual privacy and data protection. The county governments and agricultural institutions could establish training programme to equip farmers with the skills needed to operate drones and interpret the data captured using drones. The national government and research institutions can collaborate with the private sector to drive innovation in drone applications. Finally, engaging all relevant stakeholders in regular dialogue and feedback mechanisms is essential to improve uptake and continuously improve the integration of drones in agriculture practices.

Abbreviations and Acronyms

AU	African Union
CA	Conservation Agriculture
CIA	Cross Impact Analysis
CIM	Cross Impact Matrix
CSA	Climate Smart Agriculture
DRONES	Dynamic Remotely Operated Navigation Equipment
FAO	Food and Agriculture Organization
GHG	Greenhouse Gas
GIS	Geographical Information System
GPS	Geographical Positioning System
ICAO	International Civil Aviation Organization
IoT	Internet of Things
KCAA	Kenya Civil Aviation Authority
KNBS	Kenya Bureau of Statistics
NCAA	National Council Aviation Authority
NEPAD	New Partnership for Africa's Development
RPA	Remotely Piloted Aircraft
SARPs	Standards and Recommended Practices
SDGs	Sustainable Development Goal
SSA	Sub-Saharan Africa
STT	Socio Technical Theory
TTM	Transtheoretical Model
UAV	Unmanned Aerial Vehicle

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1. Introduction

As the global population is forecasted to increase by 31 per cent by 2050, the demand for food production is set to escalate. This demographic growth necessitates a 71 per cent increase in resource utilization over the next three decades (Ayaz et al., 2019). This demands a shift from traditional agricultural practices to the adoption of modern agriculture. The Fourth Industrial Revolution in agriculture, also known as Agriculture 4.0, techniques represent the next phase in sustaining the ever-growing world population. Agriculture 4.0 incorporates innovative concepts such as automatic tractors, Precision Agriculture, and the Internet of Things (IoT) for a quantitative reevaluation of farming practices.

Agriculture 4.0 is poised to enhance yields while concurrently reducing input costs, labor requirements, and environmental pollution, addressing the escalating demand for food in the present era (Shirish and Bhalerao, 2013). It is recognized as one of the top ten agricultural revolutions since the 1990s (Crookston, 2006). Agriculture 4.0 signifies a transformative paradigm in meeting the challenges of contemporary agriculture.

In Kenya, Agriculture serves as the foundation for well-being and poverty reduction. It contributes towards the economy through the provision of food for the increasing population; supply of adequate raw materials to a growing industrial sector; a major source of employment; generation of foreign exchange earnings; and provision of a market for the products of the industrial sector. However, the agriculture sector is affected by inadequate levels of agriculture productivity, particularly in food crops; high levels of absolute poverty; and poor infrastructural developments (Mutuma, Bett and Kamau, 2023). Moreover, the escalating costs of inputs and the uncertainties surrounding weather patterns have underscored the necessity for Kenya to embrace farming practices that enhance yields with reduced inputs, optimizing profits. In addition, the country faces an additional challenge with its rapidly growing population, projected to increase from 51.5 million to 70.1 million by 2045 (KNBS 2023). Feeding this increasing population using existing agricultural methods presents a formidable task for Kenya.

In developed countries, drones offer significant benefits, including real-time monitoring of crop health, efficient resource management, and improved yield prediction, however, their adoption and utilization remain limited in developing economies. The contributing factors include high initial investment costs, limited technical expertise among farmers, regulatory issues, and inadequate infrastructure to support widespread drone deployment. In addition, there is limited comprehensive data and research on the specific impacts and effectiveness of drone technology in the Kenyan agricultural context, hindering informed decision-making and policy development.

The main objective of the study was to understand the driving forces in navigating the future of the adoption and application of drone technology in precision agriculture in Kenya to promote sustainable industrialization. The specific objectives of the study were: To evaluate the future of the adoption of drone technology in precision agriculture in Kenya; To assess the future application of drone technology in precision agriculture in Kenya; and to develop possible future scenarios for the adoption and application of precision agriculture.

2. Evolution of Drone Technology and Precision Agriculture

This section presents a detailed discussion of the evolution and transformation of drone technology and precision agriculture.

2.1 History of precision agriculture

In Kenya, the adoption and application of drone technology is very low owing to the high cost of acquiring a well-fitted drone for agricultural purposes. Also, a low awareness of the potential benefits of employing drone technology in agriculture to improve farm management practices. In 2023, the Kenya Drone Business Competition chose about ten youths across the country to come up with innovative ways of how drones can be used in farming to improve crop yield and production in Kenya. The World Bank has done some piloting to farmers in Kitui, Machakos, and Narok to help farmers improve their farm management practices, and the outcomes were very impactful.

Precision agriculture, a promising form of agriculture since the 1990s, has evolved due to satellite positioning and navigation technology. This allows for decision-based precision agriculture, which has led to increased productivity, profitability, quality of farms, clean environment, food safety, and sustainability (Lipper et al., 2014). However, advancements in precision agriculture in less developed countries like Kenya face socioeconomic and technological constraints. Social-economic challenges include a lack of information, site-specific nutritional requirements, and established agronomic service providers. Technological challenges include limited access to machinery, sensors, and remote sensing (Mulla and Khosla, 2015).

There are differences between precision agriculture practices in Europe and North America and those employed in developing countries like the SSA. In Europe and North America, advanced information systems like satellites and drones are used to determine specific site input requirements. However, in SSA, precision agriculture is mainly guided by farmers' observations and experiences, as advanced technologies are often too costly and not available. The potential of precision agriculture in SSA lies in the availability of information on agricultural production constraints and the development of technologies to address them (FAO, 2017). However, these technologies must be geared toward farmers' needs and existing constraints.

Precision agriculture involves the strategic application of interventions at precise locations and specific times. It is recognized as a modern farming practice supported by various technologies that rely on identifying field variations and tailoring each input accordingly. Central to precision agriculture is the utilization of global positioning systems (GPS) and timely spatial data, serving as crucial facilitators of precision. For instance, applications grounded in GPS technology within precision farming encompass activities like farm planning, field mapping, soil sampling, tractor guidance, crop scouting, driver rate applications, and yield mapping. The use of GPS enables farmers to operate efficiently under conditions of low visibility, including during rain, dust, fog, and darkness (Yao and Wu, 2017).

The GPS was made available for civilian use in 1993 when the Department of Defense and the Department of Transportation signed a joint agreement. Precision agriculture greatly benefited from the availability of GPS for farming, and soon multiple companies were providing GPS for this purpose. Agribusinesses and farmers constructed real-time kinetic correction towers to enable improved location because the earlier systems' placement did not allow for location within a few meters of the targeted spot (Allen et al., 2004). Due to variations in air layers, GPS signals derived straight from satellite signals inherently contain inaccuracies.

2.2 Drone Technology in Precision Agriculture

Dynamic Remotely Operated Navigation Equipment (DRONE), also known as Unmanned Aerial Vehicle (UAV) or Remotely Piloted Aircraft (RPA) is a device that can fly either with the help of autopilot and GPS coordinates on the pre-set course or can be operated manually with radio signals using the remote control or smartphone app (Mogili and Deepak, 2018). With the availability of so many sensors such as chemical, acoustic, Global Positioning Systems (GPS), thermographic, altimeter, hydrometer, and a camera along with communication sensors and recording instruments like hard discs, Personal computers and tablets can detect things beyond the visible range of human sight (Anderson, 2014). Therefore, real-time, more accurate, reliable, and objective information can be derived from drones in greater detail and with fewer errors.

Agricultural drones offer real-time data, empowering farmers to make well-informed decisions regarding farm inputs. Microdrones hold the promise of enhancing and enriching the data collected by operating near crops, facilitating the acquisition of higher spatial-temporal resolution data. Drone imagery proves valuable in providing precise estimates of crop loss (Anthony et al., 2014). Drones offer superior image resolution compared to aerial images captured by satellites or crewed aircraft. They possess the advantage of being able to monitor a field every week throughout the growing season, unlike satellites that experience delays of a week or two before images become available. The utilization of drone technology in agriculture is currently instrumental in assisting agricultural businesses in meeting the evolving and expanding demands of the future. Drones contribute to increased efficiency in various aspects of the farming process, including crop monitoring, planting, livestock management, crop spraying, and irrigation mapping. Drones exhibit distinct features that make them uniquely applicable in agriculture, particularly in assisting farmers in maximizing their harvest. They achieve this by detecting issues early on and managing crops through specific cameras designed to identify pests and water shortages (Reinecke and Prinsloo, 2016; Stehr, 2015).

Drone technology promises to foster innovations that will disrupt existing industries (by providing products and services. Drones are anticipated to play an increasingly prevalent role in both large and small-scale farming operations, contributing to activities ranging from scouting to security. The data collected by drones on farms serves as invaluable input for informed agronomic decisions and is integral to the broader concept known as 'precision agriculture' (Giones and Brem 2017; Beninger and Robson, 2020).

Agriculture holds a crucial position in the worldwide socio-economic landscape, with its significance particularly pronounced in the African continent. Integrating drones into agriculture can create employment opportunities for the youth and enhance agricultural production. In agriculture, drones are commonly employed to capture real-time imagery and sensor data from farm fields, eliminating the necessity for physical field inspections. This facilitates increased yields and reduced farm costs. The integration of new agricultural technologies or practices has been a significant determinant impacting the economic well-being of farmers and the productivity of agricultural production. Similarly, agricultural innovations have played a pivotal role in shaping agricultural production systems (Pathak et al., 2019; Malveaux, Hall, and Price, 2014).

2.3 Institutional Legal and Policy Framework for Adoption and Application of Drone Technology

2.3.1 International institutional legal and policy framework on drone technologies

Formal regulations are customarily implemented as laws, and drones operating in controlled airspace are subject to formal regulations, as are other types of aircraft. Aviation provides an environment that is almost uniquely unforgiving of mistakes, and when it comes to international standards, ICAO acts as a focal point in terms of the need for harmonization of terms, strategies, and principles about the development of a regulatory framework for drones globally (ICAO, 2015).

The International Civil Aviation Organization (ICAO 1947) is a United Nations (UN) specialized agency that works with its member states and industry groups to reach a consensus on international civil aviation Standards and Recommended Practices (SARPs) and policies in support of a safe, efficient, secure, economically sustainable, and environmentally responsible civil aviation sector globally. Individual countries may apply rules about drones different from the SARPs, but they must file those rules with the ICAO (Clarke and Moses 2014).

2.3.2 Regional institutional legal and policy frameworks on drone technology

Support from the African Union (AU) to its member states regarding emerging technologies in the agriculture sector is the issuing of decision 987 published by The New Partnership for Africa's Development (NEPAD) in 2018, which is fundamentally a continent-wide document on drone technology for agriculture and is available in 23 languages. The regulations framework from the National Council Aviation Authority (NCAA) is primarily based on ICAOs SARPs and states are invited to inform the ICAO of non-compliance (ICAO, 2015).

The African Union's Agenda 2063 Goal 5 (modern agriculture for increased productivity and production) and 10 (world-class infrastructure crisscrossing Africa) and the United Nations' Sustainable Development Goals (SDGs) 2 (zero hunger) and 9 (industry, innovation, and infrastructure) are socio-economic developmental frameworks aspiring to address the hunger and malnutrition challenges through sustainable agriculture. This agenda supports the adoption of modern technologies in agriculture to improve the production of food sustainably.

2.3.3 Kenya's institutional legal and policy frameworks on drone technology

In Kenya, the oversight and regulation of civil aviation, including unmanned aerial vehicles (UAVs), fall under the scope of the Kenya Civil Aviation Authority (KCAA) in accordance with the Civil Aviation Act of 2013. KCAA serves as the primary regulatory body for UAV usage within the national airspace, a responsibility that extends beyond its traditional role of regulating large, crewed aircraft, encompassing their airworthiness and operations. In regions where UAV regulations are established, KCAA typically assumes several key responsibilities related to UAV use, including (i) monitoring airborne and ground-based equipment impacting flight safety; (ii) overseeing pilot licensing; (iii) issuing flight permits; and (iv) establishing standards for UAV operations along with minimum requirements for operating various UAV classes based on take-off mass and size. These regulations are captured in the Civil Aviation UAV Regulations, 2020.

The Civil Aviation Act of 2013 ensures that the integration of drones into precision agriculture adheres to safety, security, and regulatory standards. This legal clarity not only safeguards the integrity of the aviation space but also encourages the widespread adoption of drone technology in precision agriculture, thereby enhancing productivity, resource efficiency, and sustainability in Kenya's farming practices.

3. Literature Review

This section explains some of the theoretical frameworks used in illustrating the process of adoption and application of technologies and outlines how social institutions interact with technical systems to facilitate the adoption and application of drone technology in agriculture. The section further provides a review of the application of drones in precision agriculture.

3.1 Theoretical Literature Review

Two main theoretical frameworks were considered to explain the process of adoption and application of drone technology in precision agriculture.

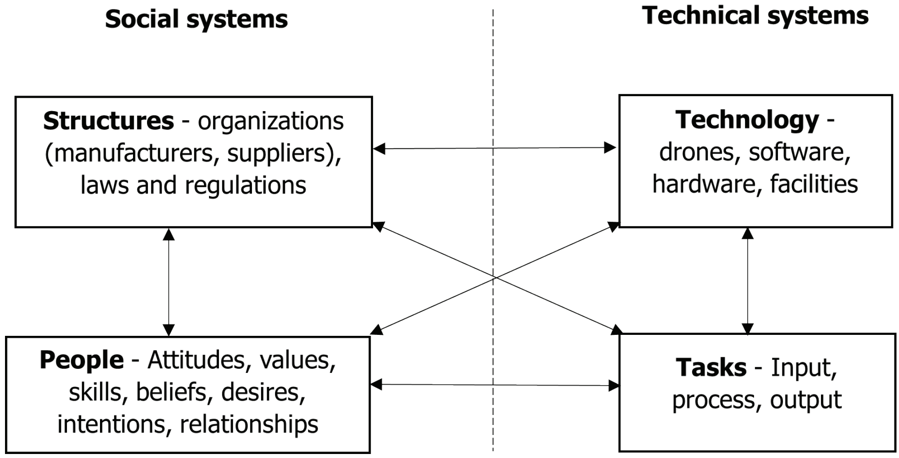
3.1.1 The Socio-technical Systems Theory

The integration of drones in precision agriculture makes it pertinent, that is, they are identified as technical components of the social construct. Considering this, the study was underpinned theoretically by the Socio-technical Theory (STT). According to Geels (2004), STT suggests that new technology is diffused through its interactions with social groups (i.e., users) and rules/regulations, drawn from sociology, institutional theory, and innovation studies. It describes the diffusion of new technological systems and is made up of interconnected dimensions that upon interacting with each other are vital to the diffusion and development of new technology. These dimensions are namely: technological systems, rules and institutions; and social groups, human actors, and organizations.

STT encompasses the interaction among people, society, technical means, and technologies as well as offers various necessary means to attain a common optimization. One of the reasons for the high rate of failure of many information and technical systems is considering technology as a tool rather than a socio-technical system (Kling and Lamb, 1999). Similarly, Drone technologies must be viewed as socio-technical systems for policymakers to formulate formidable structures that will support successful adoption and application in precision agriculture and contribute positively while safeguarding human livelihood (Shmelova et al., 2018).

Socio-technical systems are described as an action or work system where technical and human sub-systems exist and together build one entity. Therefore, drone technology falls under the category of socio-technical systems because they are technological systems that play a role in society by performing certain tasks including security, agricultural medical, and recreational among others (Cartelli, 2007). Figure 1 represents the schema of the STT as proposed by Bostrom and Heinen 1997

Figure 3.1: Representation of social-technical systems



Source: Adapted from Bostrom and Heinen (1997)

Thus, drone technologies, as socio-technical systems can function optimally within the realm of society when they co-exist with the environment, they are placed by being regulated to prevent catastrophes and reckless management and promote sustainable industrialization. Interpreting drone technologies through the lens of socio-technical theory requires an ecosystem to function optimally; humans to develop and manage them; regulations to protect the drone technologies as well as people's freedoms from infringement; and performing the necessary responsibilities they were built for. Using futures foresight capabilities will help understand the emerging threats and opportunities in the drone technology industry with this perspective, changes in any component of the socio-technical systems, will cause and necessitate changes elsewhere in the system due to its complex interactive nature This means that policymakers and regulators can draw up strategies for keeping society safe and promoting socio-economic development through drone technologies (Clegg et al., 2017).

The study adopts the socio-technical theory (STT) in navigating the future of drone technology in precision agriculture for sustainable industrialization because UAVs can be classified as socio-technical systems.

3.1.2 Transtheoretical model of adoption

The second chosen theoretical perspective is the Transtheoretical Model of Adoption (TTM). Originally formulated by Prochaska and DiClemente (1983) to explain stages individuals undergo during behaviour change, TTM proves beneficial for comprehending the process of adopting a technology or practice.

The TTM comprises several key stages that individuals traverse: Precontemplation, Contemplation, Preparation, Action, and Maintenance. In the context of precision farming in Kenya, the pre-contemplation stage denotes a lack of awareness among farmers regarding the transformative potential of drone technology. The contemplation stage signifies a period where farmers are considering adoption but may harbor uncertainties.

As farmers progress to the preparation stage, policies should facilitate readiness by offering resources like training programmes, financial incentives, and supportive infrastructure. The subsequent action stage involves the actual adoption of drone technology, necessitating policies that create an enabling environment, remove barriers and provide essential support for effective integration. Post-adoption, farmers enter the maintenance stage, demanding sustained support and reinforcement. By aligning policy recommendations with the TTM, the discussion paper aims to offer a comprehensive intervention, promoting the sustainable industrialization of Kenya's agriculture sector through the adoption and application of drone technology in precision farming.

3.2 Application of Drone Technology in Agriculture

As per Zarco-Tejada et al. (2014), Precision agriculture plays a role in sustaining agricultural production and mitigating environmental impact, exemplified by the reduction of nitrate leakage, enhanced water-use efficiency, and improved fuel efficiency (Zarco-Tejada et al., 2014). In the status of precision agriculture, there are several issues, such as unsustainable resource utilization, long-term monoculture, intensive animal farming, environmental compromises, uneven distribution of digitization, food safety issues, inefficient agri-food supply chain and lack of awareness of and inertia toward novel changes. These issues prevent achieving efficiency, productivity, and sustainability from agricultural production and escalate unintended impacts on ecosystems (Liu et al., 2021). Consequently, precision agriculture employs diverse methods, including geographical information systems (GIS), and leverages remote sensing, particularly with the timely and spatially efficient data generated by drones. While GIS techniques have evolved in their application for agricultural decision support, the recent integration of flexible, detailed, and timely drone-generated spatial data is further augmenting the capabilities of precision agriculture applications (Talebpour, Türker, and Yegül, 2015).

The incorporation of drone technologies into agriculture aims to address the above challenges, giving rise to Agriculture 4.0, also known as the Fourth Industrial Revolution in agriculture. This evolution places a heightened emphasis on sustainability in agriculture, prompting many farmers to embrace precision agricultural technologies to mitigate environmental impacts and foster long-term sustainability. Consequently, agricultural manufacturing processes and supply chains have experienced increased autonomy and intelligence, featuring the automation of tasks like planting, seeding, harvesting, and soil sampling. This shift towards greater automation enhances farming efficiency and contributes to reducing labour costs.

4. Methodology

This study employed foresight methods in examining the futures adoption and application of drone technologies in precision agriculture in Kenya. Semi-quantitative methods apply mathematical principles to quantify the subjectivity, rational judgments and viewpoints of experts.

4.1 Analytical Framework on Scenario Building on the Adoption and Application of Drone Technology

The study did a scenario building to bridge the gap in the adoption and application of drone technologies in precision farming for sustainable industrialization. This was done in five phases which are: Exploring the future through scanning of drivers of change using the existing literature, selection of panel experts and use of Delphi questionnaire to extract the key drivers based on the PESTEL framework, analysis of key drivers of change to identify the driving forces of adoption and application of drone technology using the MICMAC tool, creation of possible future scenarios for the adoption and application drone technology and finally, provide strategic policy recommendations to improve adoption and application of drone technology.

4.1.1 Exploring the future of drone technology

This step involved scoping and scanning for the plausible future drivers of change of adoption and application of drone technology. This study was done in Kenya with the main objective of navigating the future of the adoption and application of drone technology in precision agriculture for sustainable industrialization in Kenya. Using the existing literature on drones, 35 drivers were identified. The drivers were then categorized into five groups commonly known as the Political, Economic, Social, Technological, Environmental, and Legal (PESTEL) framework.

4.1.2 Selection of panel experts for the Delphi survey

The study employed the Delphi method which is an interactive multi-stage foresight method that relies on experts to identify possible future trends and patterns of a phenomenon. The objective of this method is to structure diverse group opinions and develop a convergence on future scenarios of drone technology adoption and application among experts. The study followed the PESTEL analysis framework, which is a well-established framework in the reviewing literature, categorization, and structuring of the drivers of change.

The target sample size was 33 respondents from a structured list of stakeholders (table 4.1). The panel experts were identified through networking and referrals, a selection that was based on the technical specialization in agriculture, the application of drones, and regulations of drones. The experts were tasked to rate the level of influence the scanned drivers had on the adoption and application of drone technology.

The Delphi survey questionnaire was prepared using Google Forms and shared with experts and the 33 gave their opinions respectively. For the Delphi Survey, the questionnaire had 5 main questions according to the categorization of PESTEL and several questions in each category with respect to the drivers of change, giving a total of 35 questions The experts were asked to rate the level of influence of the drivers of change on the adoption and application of drone technology using the Likert scale (0=" no influence", 1="weak influence", 2="moderate influence" and 3= "strongest influence").

Table 4.1: Sampled stakeholders

Stakeholder	Sample
UAV training organizations-Trainers	5
Resellers and Distributors of drones-CEOs and Sales Reps	5
Cropnuts-Drone operators	5
Kenya Civil Aviation Authority-Regulators	3
Astral Aerial Solutions-Drone technology applications	5
Farmers-Machakos, Narok, Uasin Gishu, Kiambu, Nyamira, Trans Nzoia, and Kitui counties	10

Source: Authors' compilation

4.1.3 Analysis of drivers of change

The heart of scenario building is to identify the right key factors which construct and influence the future environment of adoption and application of drone technology.

Cross-impact analysis

Cross-impact analysis was originally developed by Gordon and Helmer in 1996, and since it has been used as a future research method. Cross-impact analysis is a method that entails a process of scanning possible futures to reduce uncertainties and investigates pairwise analysis of listed events. It is a scenario design methodological approach in which the mutual connection of a set of drivers has been assessed by expert judgment.

Cross-impact analysis is used to capture the inter-relationship between key influencing factors. The cross-impact analysis generates a quartet map divided into four quadrants (areas) representing four types of drivers. The difference between drivers lies in their influence and dependence. The distribution of the factors within one of the quadrants of the influence map infers distinct aspects of factor impact and the evolution is based on varying levels of factor influence and dependence.

The horizontal axis of the cross-impact matrix indicates the degree of dependency, and the vertical axis shows the extent of influence. A driver is considered an influential driver if the sum of the row values in the cross-impact matrix are highest while the driver can be considered as a dependent driver if it has high total summed values of a column in the cross-impact matrix. Summarily, drivers can be ranked based on the influence or dependence on each other in a matrix.

For this study, cross-impact analysis was conducted to map the drivers of change into four quadrants using the MICMAC tool. Factors within quadrant I (Top Right) are called relay factors. Factors in quadrant II are called driving forces or influential factors. Factors in quadrant III are called autonomous factors while factors in quadrant IV are called result factors.

4.1.4 Creation of scenarios

Using the drivers from the first and second quadrant of the cross-impact analysis, the authors developed two possible future scenarios each for the adoption and application of drone technology. The level of influence of the drivers is very key in determining the highly influential drivers on the adoption and application of drone technology.

5. The Future of Adoption and Application of Drone Technology

This section presents the findings on the Key factors influencing the adoption and application of drone technologies in precision agriculture. It also explains the level of influence of drivers against each other using the interconnectedness map. It also maps the key drivers using the cross-impact analysis tool. Further, it provides the ranking of drivers in terms of their influence and dependency within the cross-impact model. These steps of presentation aided in building future possible scenarios on the adoption and application of drone technology.

5.1 Analysis of Drivers Using the PESTEL Framework on the Adoption and Application of Drone Technology

Using the existing literature, 35 drivers of change were identified as shown in Table 5.1. Several journals were reviewed to extract and categorize the drivers using the PESTEL framework. The number of drivers scanned for each category are as follows; Political=5, Economic=7, Social=6, Technological=6, Environmental=6 and Legal=5.

Table 5.1: PESTEL analysis framework on adoption and application of drone technology

Category	Drivers	Papers reviewed
Political	Government policies	Zhang and Kovacs (2012); Tremblay (2019); Kakaes (2015); McCarthy (2015); Schwab (2016); Bednarz, (2018); Giones, and Brem, (2017); Zwickle, Farber and Hamm (2014)
	Business regulations	
	Political stability	
	Governance	
	Foreign trade policies	
Economic	Economic growth	Phillips (2018); Bolman (2019); Smith and Clark (2020); Brown (2019); Jones and Thomas (2018); Davis and Roberts (2021); Anderson and Fisher (2020)
	Drone market demand	
	Agricultural productivity	
	Agricultural expenditure	
	Investment in technological infrastructure	
	Consumer behaviour	
	Financial shocks	
Social	Population growth	Batty (2018); Manyika et al. (2017); Jha and Kumar (2020); Rahman and Solmaz (2017); Adams and Friedland (2011); Zhang and Kovacs (2012); Smith (2018); Colomina and Molina (2014); Bhattacharyya and Datta (2020)
	Urban development	
	Migration	
	Demand for labour force	
	Job creation	
	Perceived benefits	

Category	Drivers	Papers reviewed
Technological	Technological innovations Technological efficiency Cost of drone technologies Technological development Related technologies (IOT, AI, machine learning) Digitalization	Garry and Rehm (2019); Zhou and Han (2018); Smith and Brown (2020); Patel and Mehta (2017); Lee and Kim (2019); Johnson and Wang (2018); Ahmed and Khosravi (2021); Giones and Brem (2017)
Environmental	Climate change Land access Land use Air pollution Environmental safety Soil Fertility	Anderson and Gaston (2013); Colomina and Molina (2014); Zhang and Kovacs (2012); Turner, Lucieer and Watson (2012); Mulla (2013); Lillesand, Kiefer and Chipman (2015); Tahar and Ahmad (2013)
Legal	Technological safety Market competition Public safety Data protection Individual privacy	Hodgkinson and Johnston (2018); Finn and Wright (2012); Garvey (2015); Clarke (2014); Collier (2016); Miraj (2018); Dempsey (2017)

Source: Authors' compilation

5.2 Adoption of Drone Technology in Precision Agriculture

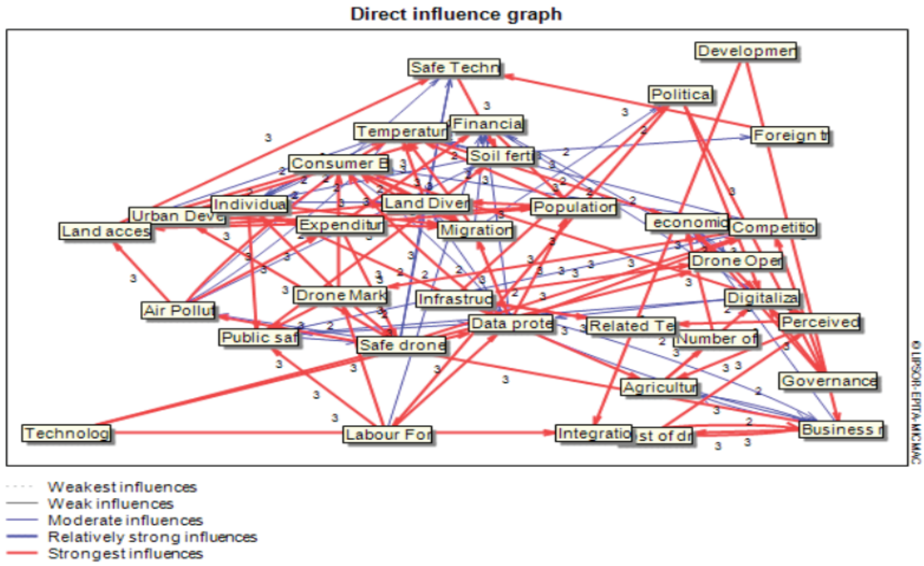
This section presents a detailed discussion of results on drivers of adoption of drone technology. Specifically, it provides a relationship between drivers in terms of influence on each other (Pillkahn, 2008), the cross-impact matrix analysis and finally ranks the drivers in terms of influence and dependence using the MICMAC software.

5.2.1 Direct influence graph for adoption of drone technology in precision agriculture

Figure 5.1 is the direct influence graph representing the strongest and relatively strongest influences of drivers on each other. This graph analyzes the dynamics within a system, showing how changes in one factor can impact others, and to understand the interdependencies within the system. It visualizes and quantifies influences and aids in decision-making.

The arrows between nodes indicate the direction of influence from one factor to another. The lines are color-coded and vary in thickness to represent the strength of the influence, with legends provided at the bottom.

Figure 5.1: Direct influence graph for the adoption of drone technology in precision agriculture



Source: Authors' compilation using MICMAC Software

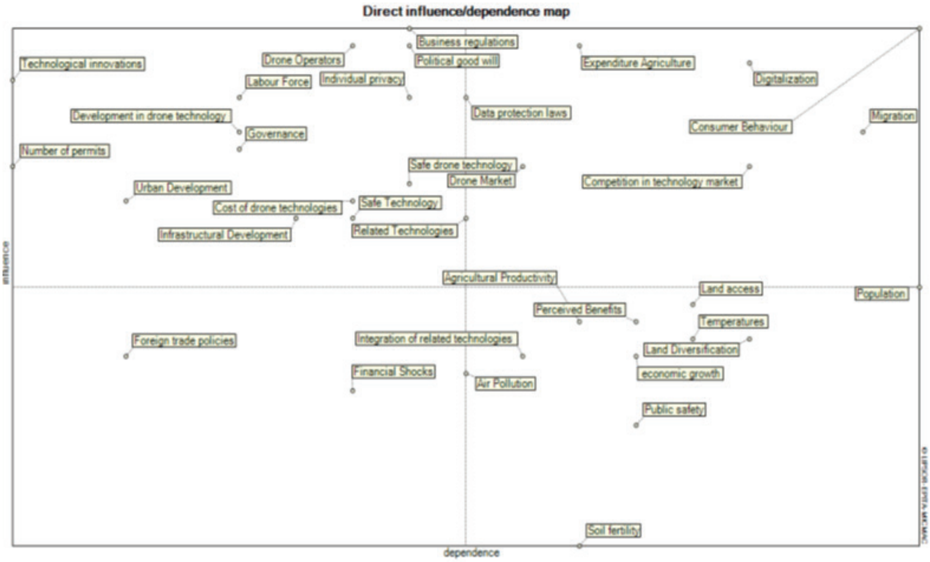
Each line is labeled with a number indicating the strength of the influence on a scale, with 3 representing the strongest influence based on the visible labels. For example, drone operations may influence digitization with a moderate influence, while digitalization may have a strong influence on perception which in turn influences governance with a strong influence. The influence graph aims to reveal the level of influence of drivers affecting drone technology adoption on each other.

5.2.2 Cross-impact analysis of drivers of adoption of drone technologies

The results in Figure 5.2 show that each driver holds a unique position in the diagram in relation to all others. The drivers' location was classified into four types of factors. factors on the top-left quadrant (High Influence, Low Dependence) are known as the drivers of change or influential factors. They can significantly shape the adoption of drone technology in precision agriculture because of their high influence on other drivers, with minimal external influence on them. Any change in any of these drivers influences the other drivers and the system. In the context of drone technology in Kenya, governance and technological innovation factors fall here, they are key in driving the adoption of drone technologies in precision agriculture.

The factors on the top-right quadrant (High Influence, High Dependence) are known as the critical, relay, or linkage drivers. They are highly interconnected with the system; both influencing and being influenced by other drivers. They have unstable behaviour as they could change to be input or output drivers. Consumer behaviour is one such driver, as it is shaped by many factors like economic conditions and technology and plays a crucial role in the adoption of drone technology in precision agriculture in Kenya.

Figure 5.2: Direct influence/dependence map for adoption of drone technology in precision agriculture



Source: Authors' compilation using MICMAC Software

The factors on the bottom-left quadrant (Low Influence, Low Dependence) are known as independent factors, autonomous, or outliers. They operate somewhat detached from the system, with neither strong influences on nor strong dependencies from other drivers. For instance, air pollution would not be a major factor in drone technology adoption nor greatly affected by it within the agricultural sector.

The factors on the bottom-right quadrant (Low Influence, High Dependence) are called the dependent or resultant drivers. These are the outcomes of the system. They do not have much influence on other drivers but are heavily influenced by several factors within the system. Soil fertility for example is considered a dependent driver because it is an outcome of the application of drone technology in precision farming in Kenya.

5.2.3 Direct influence and dependence rating of drivers for adoption of drone technology according to the MICMAC method

Table 5.2 shows the level of influence and dependence of the drivers of change. The ranking is based on the total row sum for the influence factors and the total column sum for the dependence. The higher the row sum the higher the influential the driver is. The key driving forces are factors that have high influence and very low dependence. Therefore, in Table 5.2, the drivers are ranked in ascending order for both their influence and dependence

Table 5.2: Direct influence and dependence rating of drivers according to the MICMAC method

	Drivers	Influence rank	Dependence rank
1	Number of permits	14	34
2	Business regulations	1	20
3	Political goodwill	3	21
4	Governance	13	29
5	Foreign trade policies	29	32
6	Economic growth	30	9
7	Drone market	15	15
8	Agricultural productivity	25	12
9	Infrastructural development	20	28
10	Consumer behaviour	2	1
11	Financial shocks	33	24
12	Expenditure agriculture	4	13
13	Population	23	2
14	Urban development	18	33
15	Migration	11	3
16	Labour force	8	30
17	Drone operators	5	25
18	Perceived benefits	26	10
19	Technological innovations	7	35
20	Related technologies	21	17
21	Cost of drone technologies	19	26
22	Development in drone technology	12	31
23	Integration of related technologies	31	16
24	Digitalization	6	4
25	Temperatures	27	7
26	Land access	24	8
27	Land diversification	28	5
28	Air pollution	32	18
29	Safe technology	22	27
30	Soil fertility	35	14
31	Safe drone technology	17	22

	Drivers	Influence rank	Dependence rank
32	Competition in the technology market	16	6
33	Public safety	34	11
34	Data protection laws	9	19
35	Individual privacy	10	23

Source: Authors' computation from MICMAC Software

Drivers with high influence and low dependence are pivotal drivers in promoting the adoption of drone technology for precision agriculture. For instance, business regulations (influence rank: 1, dependence rank: 20) and consumer behaviour (influence rank: 2, dependence rank: 1) are among the most influential and critical drivers respectively. Business regulations significantly shape the landscape for adopting drone technology, while consumer behaviour, being both highly influential and highly dependent, suggests a reciprocal dynamic where consumer actions and responses can drive and be driven by other factors.

Other influential drivers include political goodwill (influence rank: 3, dependence rank: 21) and expenditure on agriculture (influence rank: 4, dependence rank: 13). These factors highlight the importance of supportive policies and investments in agriculture for the successful adoption of drone technology. The significance of political goodwill underscores the necessity for governmental support and positive regulatory environments to foster technological advancement.

In contrast, drivers with high dependence and lower influence are highly impacted by changes in the system but do not significantly drive themselves. For example, economic growth (influence rank: 30, dependence rank: 9) and migration (influence rank: 11, dependence rank: 3) are significantly influenced by other factors, indicating their susceptibility to broader economic and social trends. The high dependence on economic growth underscores the need for a stable and growing economy to facilitate the widespread adoption of technology. The drone market (influence rank: 15, dependence rank: 15) is an example of such a balanced driver, suggesting that market dynamics are both a result of and a contributing factor to the overall system. This balanced nature of the drone market indicates that while it is influenced by various factors, it also significantly contributes to shaping the adoption landscape.

Some drivers exhibit low influence but high dependence, indicating they are largely shaped by other factors within the system. Digitalization (influence rank: 6, dependence rank: 4) and land access (influence rank: 24, dependence rank: 8) fall into this category. Their high dependence underscores the need for enabling conditions and infrastructure to support the adoption of drone technology. The role of digitalization in particular highlights the necessity for technological infrastructure and integration to drive adoption integration. Drivers with low influence and low dependence, such as safe drone technology (influence rank: 17, dependence rank: 22) and safe technology (influence rank: 22, dependence rank:

27), have limited impact on the system and are less affected by other factors. These drivers, while part of the overall ecosystem, do not play significant roles in driving or being driven by the adoption process. Their lower rankings suggest that although they are important, they do not significantly alter the system dynamics.

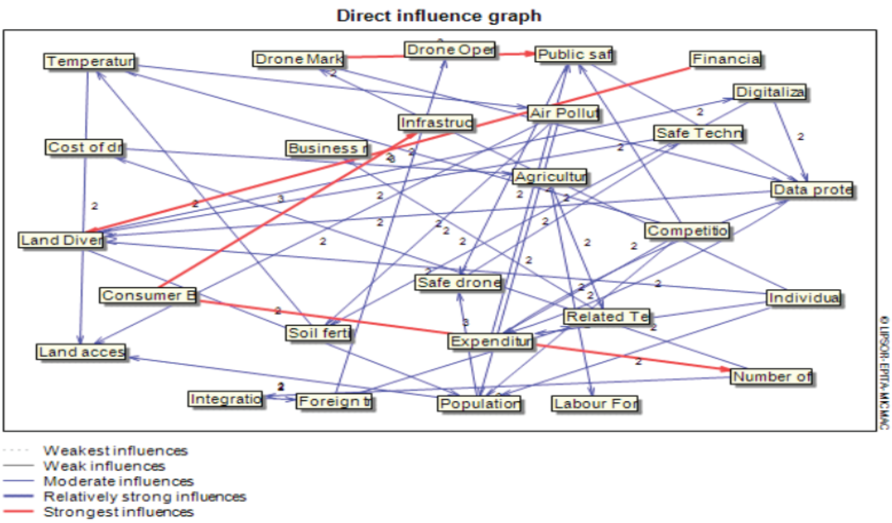
5.3 Application of drone technologies in precision agriculture

This section presents a detailed discussion of results on drivers of the application of drone technology in precision agriculture. Specifically, it provides a relationship between drivers in terms of influence on each other, the cross-impact matrix analysis and finally ranks the drivers in terms of influence and dependence using the MICMAC software.

5.3.1 Direct influence graph for application of drone technologies in precision agriculture

Figure 5.3 shows the relationship between drivers, how they influence each other and the level of influence. Drivers with the strongest level of influence are likely to have a high impact on the application of drone technology. The arrows show the direction of influence while the nodes represent the key drivers and how they influence each in determining the future of application of drone technology. the description of drivers as used in MICMAC software is well defined in Appendix I.

Figure 5.3: Direct influence graph for application of drone technologies in precision agriculture



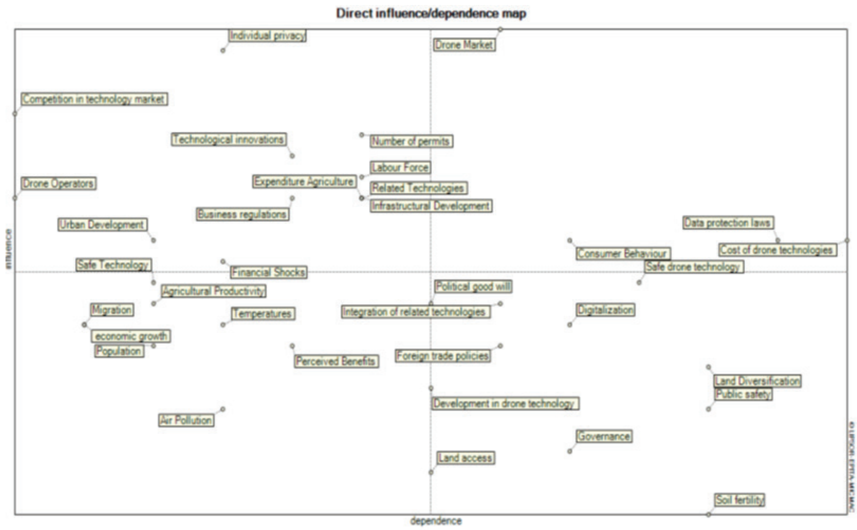
Source: Authors' compilation using MICMAC Software

The drone market has a strong influence on public safety. This means that having an efficient drone market, with clear guidelines on regulations and utilization of drones will shape the aspects of public safety in terms of privacy and confidentiality in any sensitive matter among the public.

5.3.2 Cross-impact analysis of drivers of application of drone technologies

The factors in the top-left quadrant are called the drivers/influential (High Influence, Low Dependence) factors. The factors in this quadrant are influential but not heavily dependent on other factors. They can drive changes in the system with relatively little influence from other drivers. Competition in the technology market is an indication that competitive dynamics in the drone market can significantly influence other factors, such as technological advancements and market growth, without being strongly influenced by other factors. The number of drone operators suggests that the operational aspects of drones, in terms of efficiency and capabilities, are key influencers in their adoption but are generally stable and not highly dependent on fluctuating external drivers.

Figure 5.4: Direct influence and dependence map on the application of drone technologies



Source: Authors' compilation using MICMAC Software

The factors on the top-right quadrant are called critical drivers (High Influence, High Dependence). These factors are both highly influential and highly dependent, making them sensitive to changes attributed to the driving forces identified. The drone market as a factor in this quadrant indicates that it both shapes and is shaped by many factors such as consumer behaviour, technology, and financial aspects. Consumer behaviour shows that while consumer acceptance and demand significantly impact the drone technology market, they are also influenced by a range of other factors including technological development and marketing efforts.

The factors in the left quadrant are referred to as independent drivers (low influence, low dependence). These are the least connected drivers, having minimal impact on and from other factors in the system. They might represent more isolated issues within the broader context. Migration reflects on the demographic changes affecting labor availability or market size, but it does not strongly influence or get influenced by the core dynamics of drone technology adoption. While generally crucial, in this specific context, these factors might not be central to the immediate dynamics of drone technology adoption in precision agriculture indicating they operate with relative independence from other core drivers.

The factors on the bottom-right quadrant are called the dependent or resultant drivers (low influence, high dependence). The factors in this quadrant are influenced by many parts of the system but have little influence over others. They are outcomes of the system's dynamics. Soil fertility is an outcome of agricultural practices influenced by drone usage but does not itself significantly influence the application of drone technology. Public safety concerns might be impacted by how drones are used and regulated but are unlikely to drive drone technology policies or development directly.

5.3.3 Direct influence and dependence rating of drivers for application of drone technology according to the MICMAC method

Table 5.3 shows the level of influence and dependence of the drivers of change. The ranking is based on the total row sum for the influence factors and the total column sum for the dependence. The higher the row sum the higher the influential the driver is. The key driving forces are factors that have high influence and very low dependence. Therefore, in Table 5.3, the drivers are ranked in ascending order for both their influence and dependence.

Table 5.3: Direct influence and dependence rating of drivers according to the MICMAC method

	Driver	Influence rank	Dependence rank
1	Number of permits	4	16
2	Business regulations	7	21
3	Political goodwill	19	13
4	Governance	33	7
5	Foreign trade policies	26	10
6	Economic growth	22	32
7	Drone market	1	11
8	Agricultural productivity	20	28
9	Infrastructural development	8	17

10	Consumer behaviour	12	8
	Driver	**Influence rank**	**Dependence rank**
11	Financial shocks	16	24
12	Expenditure agriculture	9	18
13	Population	27	29
14	Urban development	13	30
15	Migration	23	33
16	Labour force	6	19
17	Drone operators	10	34
18	Perceived benefits	28	22
19	Technological innovations	5	23
20	Related technologies	11	20
21	Cost of drone technologies	14	1
22	Development in drone technology	30	14
23	Integration of related technologies	21	12
24	Digitalization	24	9
25	Temperatures	25	25
26	Land access	34	15
27	Land diversification	29	3
28	Air pollution	31	26
29	Safe technology	17	31
30	Soil fertility	35	4
31	Safe drone technology	18	6
32	Competition in the technology market	3	35
33	Public safety	32	5
34	Data protection laws	15	2
35	Individual privacy	2	27

Source: Authors' compilation from MICMAC Software

Drivers with high influence and low dependence are particularly crucial in the system. For example, the drone market has the highest influence rank (1) and a relatively low dependence rank (11), making it the most influential driver with significant control over others but less influenced by them. Similarly, the number of permits (influence rank: 4, dependence rank: 16) and technological innovations (influence rank: 5, dependence rank: 23) also exhibit high influence and moderate dependence, indicating their pivotal role in driving the system's dynamics.

On the other hand, drivers with high dependence and low influence are heavily influenced by other factors within the system. The cost of drone technologies stands out with the highest dependence rank (1) but a lower influence rank (14), suggesting it is highly reliant on other drivers' actions and conditions. Data protection laws (influence rank: 15, dependence rank: 2) and land diversification (influence rank: 29, dependence rank: 3) also fall into this category, highlighting their vulnerability to changes in other drivers.

Some drivers maintain a balanced position with both influence and dependence. Digitalization (influence rank: 24, dependence rank: 9) and public safety (influence rank: 32, dependence rank: 5) exhibit this balance, indicating their stabilizing role within the system. These drivers are both influential and influenced, playing a mediating role that connects various elements of the system.

Lastly, there are drivers with low influence and low dependence, such as governance (influence rank: 33, dependence rank: 7) and soil fertility (influence rank: 35, dependence rank: 4). These drivers have limited impact on the future application of drones but are still integral to the broader understanding of drone technology use. Their lower rankings suggest they do not drive significant changes, nor are they significantly driven by others.

5.4 The Possible Future Scenarios for the Adoption and Application of Drone Technology in Precision Agriculture in Kenya

5.4.1 High adoption of drone technology in precision agriculture

In this high-adoption scenario, good governance actively supports drone technology adoption in precision agriculture through favorable policies and subsidies, leading to improved agricultural productivity and good returns to the farmers. Technological advancements are localized, with drones designed to meet the specific challenges of Kenyan agriculture, making them more accessible and cost-effective. As a result, consumer behaviour is positive, with farmers showing a high willingness to adopt drones, driven by visible benefits such as increased yields and efficiency. There is a thriving drone market due to competitive pricing and a well-trained labor force which promotes innovation and healthy competition among drone technology service providers.

The adoption of drone technology in agriculture has several positive consequences across various domains. Economically, it enhances efficiency and productivity, which fosters growth within the agricultural sector. Socially, it leads to farmers acquiring new skills, thereby cultivating a workforce that is technologically proficient and enthusiastic about precision agriculture. Environmentally, the efficient use of resources and improved monitoring facilitated by drone technology contribute to better environmental outcomes. This comprehensive impact underscores the transformative potential of integrating advanced technologies into traditional farming practices.

5.4.2 Low adoption of drone technology in precision agriculture

In a low adoption scenario, regulatory challenges and high costs of drones create significant barriers to the adoption of drone technologies in precision agriculture. The Kenyan government has not fully updated its governance structure to accommodate the new technology, resulting in a complex approval process for drone usage in precision agriculture. Moreover, due to insufficient technological advancements at the local level, the drones available are expensive and not tailored to the specific needs of Kenyan agriculture. Consumer behaviour reflects skepticism and low interest due to the perceived high cost and complexity of operations. These factors slow down investment in drone operations and related technologies, stifling innovation, and integration with existing agricultural practices.

The high cost of drones results in a low return on investment, which significantly discourages investment among both small and large-scale farmers. This economic barrier is compounded by slow technological advancement, which restricts the functionality and effectiveness of drones for local agricultural needs. Consequently, farmers continue to rely on traditional farming techniques due to a lack of developed skills in drone technology, further hindering the integration of modern methods into their agricultural practices.

5.4.3 High application of drone technology in precision agriculture

In this more optimistic scenario, drone technologies are widely adopted across the agricultural sector, driven by favorable influences across the quadrants, particularly from the influential and critical drivers. Drivers such as competition in the drone market thrive, leading to rapid technological advancements and cost reductions. Drone operations are streamlined and efficient, directly influencing broader applications due to their demonstrated efficiency and capability improvements in agricultural practices.

Critical drivers like the drone market are robust, with a high rate of application influenced by positive consumer behaviour. Enthusiastic consumer reception, driven by visible benefits such as increased yields and reduced labor costs, reinforces market growth. Even though migration and economic factors are less connected, they indirectly support the adoption by ensuring a stable economic environment and a sufficient labor force for technology deployment and maintenance.

Dependent Drivers such as improved soil fertility from precise agricultural practices using drones and enhanced public safety through regulated and safe drone operations are evident, showcasing the benefits of high technology applications.

5.4.4 Low application of drone technology in precision agriculture

In this scenario, the application of drone technologies in precision agriculture faces significant challenges due to a combination of unfavorable conditions across various factors, particularly those located in the critical and driver quadrants of the Direct influence and dependence map. Despite the potential for competition and the number of drones to drive technological adoption, these factors falter due to a lack of market competition and operational inefficiencies. For example, if the drone market lacks competitive dynamics, innovations and cost reductions that are crucial for widespread adoption may not occur. Similarly, if drone operations are hindered by regulatory barriers or technological limitations, their potential to influence wider adoption is minimized.

Drone market and consumer behaviour experience instability. High dependence on volatile market conditions and consumer skepticism fueled by privacy concerns or perceived risks could drastically affect the market. Without positive consumer engagement and a stable market, the application of drone technology in precision agriculture remains low. Migration and economic factors might not directly impede drone technology application but fail to provide any supportive boost due to stagnant economic conditions or labor market challenges. Outcomes like soil fertility and public safety have minimal improvements from drone technologies due to the low functional application of the technology in actual farming practices.

6. Conclusion and Recommendations

6.1 Conclusion

To achieve a future of high adoption and application of drone technology, favourable governance through policies and subsidies is paramount as they provide a conducive environment for drone technology in precision agriculture. Financial incentives make drones accessible and cost-effective for farmers in Kenya. Experiencing positive consumer behaviour, that is pummeled by benefits such as increased yields and efficiency, coupled with a competitive drone market and a well-trained labour force shall promote technological innovation and healthy competition among service providers. Economically, stakeholders shall experience enhanced productivity and growth in the agricultural sector, while socially, farmers will acquire new technological skills, learn how to operate drones and particularly production and management activities in the farms. Environmentally, drones contribute to efficient resource use and improved monitoring, leading to better outcomes. Lastly, improved soil fertility and enhanced public safety through regulated drone operations further demonstrate the high technology application benefits.

6.2 Recommendations

To maximize the benefits of the adoption and application of drone technology in precision agriculture in Kenya, several strategic policy recommendations that can be considered are provided as follows:

i. To promote the adoption of drone technology, both the national and county governments could provide financial incentives for farmers, such as subsidies, tax breaks, and grants. The Ministry of Agriculture may design and manage these incentive programmes to meet local needs effectively.
ii. Additionally, investments in infrastructure are essential. Both National and County Governments can work together to provide reliable internet connectivity and drone accessories in rural areas, with the private sector partnering to build and maintain the necessary infrastructure.
iii. It is crucial for the Kenya Civil Aviation Authority (KCAA) to develop and implement more comprehensive regulations for drone usage in agriculture that address safety, privacy, and data protection concerns and ensure compliance with the regulations and guidelines for safe drone operations.
iv. Training and capacity building are also important. County Governments and agricultural institutions could establish training programmes to equip farmers with the skills needed to operate drones and interpret the data they provide. Universities and vocational training centers may integrate drone technology into their agricultural education curricula to prepare the next generation of farmers.
v. Supporting ongoing research and development is essential to improve drone technology, making it more affordable, efficient, and user-friendly

for small-scale farmers. The national government and research institutions can lead these efforts, with the private sector collaborating to drive innovation in drone applications. Awareness and education campaigns are also important. County Governments and agricultural organizations to launch initiatives to inform farmers about the benefits of drone technology and how it can enhance their farming practices, partnering with media and NGOs to disseminate information and success stories.

vi. Financial support mechanisms are necessary to help farmers invest in drone technology. National and county governments can provide low-interest loans and microfinance options, with financial institutions developing tailored financial products for farmers adopting new technologies. Private sector engagement is crucial for the development and distribution of affordable drone solutions tailored to the needs of Kenyan farmers. Both the national and county governments should encourage private sector investment, with industry associations facilitating partnerships between technology providers and agricultural stakeholders.

vii. Finally, engaging all relevant stakeholders in regular dialogue and feedback mechanisms is essential to address challenges and continuously improve the integration of drones in agriculture. The Ministry of Agriculture should coordinate these efforts, ensuring that collaborative initiatives align with national and county development goals. By implementing these recommendations, Kenya can harness the full potential of drone technology to transform its agricultural sector, promoting sustainable practices, enhancing productivity, and contributing to the country's economic growth and food security.

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Appendix I: Description of Drivers as used in MICMAC Method

Longlabel	Shortlabel	Description	Theme
Number of permits	Number of	The number of permits issued for drone operation	Political
Business regulations	Business r	Favorable business regulations	Political
Political good will	Political	Political goodwill/stability	Political
Governance	Governance	Good governance	Political
Foreign trade policies	Foreign tr	Favourable foreign trade policies	Political
Economic growth	Economic	Progressive economic growth	Economic
Drone market	Drone Mark	Increase in the size of drone market	Economic
Agricultural productivity	Agricultur	Increased agricultural productivity	Economic
Infrastructural development	Infrastruc	Investment in technological infrastructure	Economic
Consumer behaviour	Consumer B	Changes in consumer behaviour	Economic
Financial shocks	Financial	Occurrence of financial shocks	Economic
Expenditure agriculture	Expenditur	Reduced agricultural expenditure	Economic
Population	Population	Population increases	Social
Urban development	Urban deve	Development in urban areas	Social
Migration	Migration	Rapid rural urban migration	Social
Labour force	Labour for	Reduced demand for labour force	Social
Drone operators	Drone oper	Number of drone operators	Social
Perceived benefits	Perceived	High-perceived benefits	Social
Technological innovations	Technologi	Advanced technological innovations	Technological
Related technologies	Related Te	Efficient related technologies	Technological
Cost of drone technologies	Cost of dr	High cost of drone technologies	Technological

Longlabel	Shortlabel	Description	Theme
Development in drone technology	Developmen	Improved development in drone technology	Technological
Integration of related technologies	Integratio	Integration of related technologies (OT, AI and Machine learning)	Technological
Digitalization	Digitaliza	Increased digitalization	Technological
Temperatures	Temperatur	Extreme temperatures	Environmental
Land access	Land acces	limited access to land for agricultural purposes	Environmental
Land diversification	Land diver	Diversification in land use	Environmental
Air pollution	Air pollut	Reduced air pollution	Environmental
Safe technology	Safe techn	Environmentally safe technology	Environmental
Soil fertility	Soil ferti	Reduced soil fertility	Environmental
Safe drone technology	Safe drone	Drone technologies are safe for human use	Legal
Competition in technology market	Competitio	Regulated market competition for drone technologies	Legal
Public safety	Public saf	Enhanced public safety	Legal
Data protection laws	Data prote	Implemented data protection laws	Legal
Individual privacy	Individual	Protection of individual privacy	Legal

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Kenya Institute for Public Policy Research and Analysis
Bishops Garden Towers, Bishops Road
PO Box 56445, Nairobi, Kenya
tel: +254 20 2719933/4, 2714714/5, 2721654, 2721110
fax: +254 20 2719951
email: admin@kippra.or.ke
website: http://www.kippra.org