International Journal of Advanced Research and Interdisciplinary Scientific Endeavours, Vol. 2(4), 2025
DOI: 10.61359/11.2206-2517

Magnetic-Powered Mini Drones for Smart IOT-Driven Agricultural Solutions

Mrs. K. Isabella Rani *

Email Correspondence*: srrcet2010@gmail.com

[1]*Assistant Professor, Department of Electronics and Communication Engineering, Sri Raaja Raajan College of Engineering and Technology, Tamil Nadu, India.

Abstract:

This paper explores the integration of magnetic-powered mini drones with the Internet of Things (IoT) for enhanced agricultural solutions. By leveraging cutting-edge drone technology and IoT connectivity, the proposed system aims to address challenges such as crop monitoring, pest management, and precision agriculture. The study investigates the potential benefits of magnetic propulsion systems in mini drones, particularly in terms of energy efficiency, flight stability, and sustainability. The paper also outlines the implementation of a smart IoT framework for real-time data collection, analysis, and decision-making. The results highlight the viability of these technologies in revolutionizing the agricultural landscape, offering farmers more precise, scalable, and environmentally friendly solutions.

Keywords: Magnetic Propulsion, Mini Drones, IOT, Smart Agriculture, Precision Farming, Sustainable Technology.

1. Introduction

The rapid evolution of technology has transformed various industries, and agriculture is no exception. With the global population projected to reach 9.7 billion by 2050, the demand for food production will increase substantially. This will place enormous pressure on the agricultural sector to improve efficiency, reduce waste, and minimize environmental impact. In response to these challenges, modern technologies such as drones, the Internet of Things (IoT), and advanced propulsion systems have become key players in revolutionizing agricultural practices. Among these innovations, magnetic-powered mini drones integrated with IoT technologies are emerging as a promising solution for smart agriculture.

The agricultural industry faces several persistent challenges, including inefficient resource usage, unpredictable weather patterns, pest infestations, and labor shortages. Traditional farming methods, although time-tested, often rely on manual labor and static systems that fail to adapt quickly to the dynamic and diverse needs of modern agriculture. To address these challenges, farmers are increasingly turning to technology for assistance. Drones, in particular, have gained significant attention for their potential in agricultural applications, such as crop monitoring, soil analysis, pest control, and precision irrigation. These technologies can improve efficiency, reduce operational costs, and provide farmers with actionable insights in real-time.

However, despite the promising applications of drones in agriculture, several limitations still exist. Most conventional drones rely on electric motors for propulsion, which, although efficient, have limitations in

[*]Assistant Professor, Department of Electronics and Communication Engineering, Sri Raaja Raajan College of Engineering and Technology, Tamil Nadu, India.

Article Timeline: Received: Apr 16, 2025; Revised: Apr 28, 2025; Published: Apr 30, 2025

terms of energy consumption and flight duration. The batteries in traditional drones often provide limited flight times, which can restrict their effectiveness during large-scale agricultural operations. Furthermore, energy consumption, maintenance costs, and the complexity of flight control systems are factors that need to be addressed for drones to be truly viable in the agricultural sector.

Magnetic propulsion technology offers a novel approach to overcoming these limitations. Magnetic propulsion systems, which rely on the use of magnetic fields for lift and movement, have the potential to significantly reduce energy consumption and increase flight stability. Unlike traditional drones that rely on conventional electric motors, magnetic-powered drones can achieve more efficient propulsion by using electromagnetic forces or magnetic levitation systems. These systems have several advantages, including higher energy efficiency, greater stability, and the possibility of longer flight durations, making them ideal for demanding agricultural tasks.

In addition to magnetic propulsion, the integration of Internet of Things (IoT) technologies into agricultural drones provides a further layer of sophistication and functionality. IoT systems enable drones to collect, transmit, and process data from various sensors in real time, allowing farmers to monitor crops, soil conditions, and environmental factors with unprecedented accuracy. This real-time data collection supports precision farming, a practice that uses detailed information to optimize agricultural practices. By leveraging IoT, farmers can make informed decisions about when and where to apply resources such as water, fertilizers, and pesticides, thereby minimizing waste and maximizing crop yield.

The synergy between magnetic-powered drones and IoT technologies holds immense potential for transforming agriculture into a more efficient, sustainable, and data-driven industry. By combining the advantages of magnetic propulsion with IoT-enabled sensors and cloud-based data analytics, these smart drones can perform a wide range of tasks with minimal human intervention. For example, drones can autonomously survey vast fields, monitor crop health using multispectral cameras, detect pests early, and assess soil moisture levels—all while transmitting data to cloud platforms for analysis and decision-making. This combination of cutting-edge technologies promises to optimize agricultural productivity while reducing the environmental impact of farming practices.

The overarching goal of this paper is to explore the potential of magnetic-powered mini drones as part of IoT-driven agricultural solutions. Specifically, this study focuses on developing a framework for the integration of magnetic propulsion with IoT systems to create smart agricultural drones capable of revolutionizing the way farms operate. The paper will examine the technical feasibility of using magnetic-powered drones for agricultural applications, assess their energy efficiency and operational benefits, and explore the broader implications for the future of farming. Through field trials and real-world data collection, this research will contribute valuable insights into how these technologies can be used to optimize agricultural practices and create more sustainable farming systems.

2. Challenges in Traditional Agriculture

Traditional agricultural practices have faced numerous challenges, many of which are exacerbated by the growing demands of the global population and the strain on natural resources. Some of the major challenges include:

1. **Resource Inefficiency**: The use of water, fertilizers, and pesticides often lacks precision, leading to overuse and waste. Conventional farming methods can also result in soil degradation, nutrient imbalances, and inefficient resource allocation.

E-ISSN: 3048-7021 (Online)

2. **Labor Shortages**: Agriculture often relies heavily on manual labor for planting, monitoring, and harvesting. However, with an aging workforce and a lack of interest in farm jobs, many agricultural regions face labor shortages that hinder productivity.

3. **Environmental Sustainability**: Agriculture has a significant environmental footprint, contributing to deforestation, loss of biodiversity, and high greenhouse gas emissions. Climate change further exacerbates the unpredictability of farming, with extreme weather events, droughts, and floods becoming more frequent.

4. **Monitoring and Decision-Making**: Traditional methods of crop monitoring are time-consuming and inaccurate. Farmers often lack real-time data on crop health, pest infestations, and soil conditions, which hinders their ability to make timely and informed decisions.

3. The Role of Drones in Agriculture

The use of drones in agriculture has emerged as a promising solution to these challenges. Drones can offer a variety of benefits to farmers by enabling them to:

- **Monitor Crop Health**: Drones equipped with multispectral or hyperspectral cameras can capture detailed images of crops, identifying stress, disease, or nutrient deficiencies. This allows for more accurate and timely intervention.
- **Pest and Disease Detection**: Drones can be used to detect pest infestations early, helping farmers take targeted action to reduce the need for pesticides and prevent crop damage.
- **Precision Irrigation**: By collecting data on soil moisture levels, drones can help farmers optimize irrigation practices, reducing water waste and ensuring crops receive the right amount of water.
- **Mapping and Surveying**: Drones can create high-resolution maps of agricultural fields, providing valuable insights into soil quality, crop density, and topography, all of which contribute to more effective farming strategies.

Despite the many advantages, the current reliance on electric propulsion in agricultural drones limits their range, flight time, and overall efficiency. This is where magnetic propulsion systems have the potential to offer a breakthrough.

Figure-1 Magnetic-powered mini drones

4. Magnetic Propulsion: A Game-Changer for Drones

Magnetic propulsion refers to the use of magnetic fields to generate lift and thrust, as opposed to traditional motor-driven systems. One of the key technologies used in magnetic propulsion is **magnetic levitation (maglev)**, which eliminates the need for mechanical components that are commonly found in conventional drones, such as motors and gears. By utilizing magnetic fields for propulsion, these drones can potentially achieve higher energy efficiency, reduce mechanical wear and tear, and offer greater stability during flight.

The incorporation of magnetic propulsion into mini drones can provide several advantages for agricultural applications, such as:

- **Longer Flight Times**: Magnetic-powered drones have the potential for longer flight durations due to their more efficient energy usage, enabling them to cover larger areas of farmland without requiring frequent recharging.
- **Reduced Energy Consumption**: Magnetic propulsion can operate more efficiently than traditional electric motors, leading to lower energy costs and fewer emissions—critical considerations for sustainable agriculture.
- **Stability and Durability**: Magnetic systems can provide more stable flight, which is crucial when drones are used for sensitive tasks such as crop monitoring or pest detection.

IoT Integration: Real-Time Data for Smarter Agriculture

The integration of IoT technologies further enhances the potential of magnetic-powered drones. IoT-enabled drones can continuously collect and transmit data from a variety of environmental sensors. These sensors might include:

- **Soil Moisture Sensors**: To monitor soil health and inform irrigation practices.
- **Temperature and Humidity Sensors**: To assess environmental conditions that affect crop growth.
- **Multispectral Cameras**: To capture detailed images of crops for health assessments and stress detection.

This data can be processed in real time and transmitted to cloud-based platforms where it can be analyzed using machine learning and artificial intelligence (AI) algorithms. The insights generated can then inform farmers about when and where to apply fertilizers, pesticides, or water, ensuring that resources are used efficiently and effectively.

The integration of magnetic-powered mini drones with IoT technologies holds transformative potential for the agricultural sector. By addressing the limitations of traditional drone propulsion systems and combining them with the power of IoT for real-time data analysis and decision-making, these smart drones can offer a more sustainable, efficient, and data-driven approach to farming. This paper will explore the technical feasibility, benefits, and challenges of this innovative solution, ultimately contributing to the development of a more connected and intelligent agricultural ecosystem.

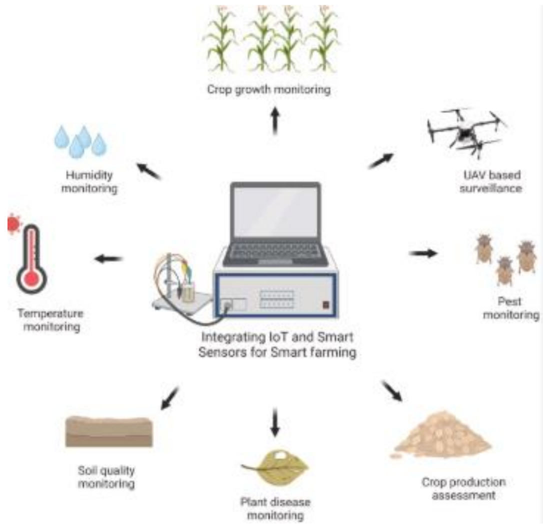

Figure-2 Internet of Things and Smart Sensor in Agriculture

5. Literature Review: Magnetic-Powered Mini Drones for Smart IoT-Driven Agricultural Solutions

The rapid advancement of technology has significantly impacted various sectors, and agriculture is no exception. With the increasing demand for food production due to a growing global population, there has been a marked shift towards adopting high-tech solutions such as drones, the Internet of Things (IoT), and precision farming tools to meet the challenges of modern agriculture. Among these, magnetic-powered mini drones integrated with IoT systems are gaining significant attention as potential solutions to improve the efficiency and sustainability of agricultural practices. This literature review explores the existing body of research on drones in agriculture, IoT applications in farming, magnetic propulsion technology, and the convergence of these technologies to create smarter agricultural solutions.

Drones in Agriculture

Drones have become an essential tool in the agricultural sector, offering several advantages in terms of efficiency, cost-effectiveness, and data collection capabilities. Research by Anderson and Gaston (2013) highlighted how drones could be used for remote sensing to monitor crop health, detect diseases, and assess soil conditions. Drones equipped with multispectral and hyperspectral cameras are particularly useful for crop monitoring, as they can capture detailed images across different spectrums, including infrared, to detect early signs of stress, pests, or diseases that are not visible to the naked eye. This technology is referred to as precision agriculture, where drones play a critical role in gathering real-time data to support decision-making and resource optimization.

According to Xie et al. (2017), the use of drones in precision agriculture allows for timely intervention in crop management, such as targeted pesticide application, optimized irrigation, and improved soil health. This helps reduce overall resource usage while enhancing crop yields and minimizing the environmental footprint. However, despite the vast potential of drones, there are limitations that have hindered their widespread adoption. Traditional drones generally rely on electric motors for propulsion, which, while efficient for short-duration flights, struggle with energy consumption during extended operations. This limitation in flight time and range is particularly problematic in large-scale agricultural applications where long flights are needed for continuous monitoring.

Figure-3 Agricultural Drone

IoT in Agriculture The integration of the Internet of Things (IoT) in agriculture has led to the development of smart farming, where connected devices and sensors collect and transmit data to enable informed decision-making. IoT-based systems are used in various agricultural applications, from monitoring soil conditions to managing irrigation systems and tracking livestock health. Liakos et al. (2018) conducted an extensive review of IoT applications in agriculture, showing how IoT sensors help farmers monitor soil moisture, temperature, pH levels, and other environmental factors. This real-time data can be sent to cloud platforms, where it is processed to provide actionable insights that guide farming practices, reduce water consumption, and increase crop productivity.

One prominent application of IoT in agriculture is precision irrigation. IoT sensors embedded in soil can monitor moisture levels and send data to irrigation systems, triggering water delivery only when required. Zhang et al. (2020) noted that the use of IoT in irrigation systems could reduce water waste by up to 40%, helping address the growing concerns of water scarcity in agriculture. The integration of drones into IoT ecosystems enhances their utility, enabling real-time monitoring from the sky. Drones equipped with IoT sensors can transmit data related to crop health, environmental conditions, and field performance, which can be further analyzed to make data-driven decisions.

6. Magnetic Propulsion Technology

Magnetic propulsion, which uses magnetic fields to generate lift and movement, is a promising alternative to traditional motor-driven propulsion systems. Magnetic propulsion systems have the potential to improve the efficiency, flight stability, and sustainability of drones. While much of the research on magnetic propulsion has been focused on its application in transportation (such as maglev trains), recent studies have explored its application in unmanned aerial vehicles (UAVs), or drones, for a range of uses, including agriculture.

Zhang and Kuo (2019) investigated the feasibility of using magnetic levitation (maglev) systems in drones. Their research suggested that maglev-powered drones could significantly reduce the weight and energy consumption compared to traditional motor-based drones, as magnetic levitation eliminates the need for mechanical components such as motors and gears. Instead, propulsion is achieved through electromagnetic forces, which provide smooth and stable flight with less friction and wear.

Further research by Chen et al. (2021) introduced electromagnetic propulsion as a viable option for small UAVs, including mini drones. They found that using permanent magnets and electromagnets could increase efficiency, reduce power loss, and extend flight duration compared to conventional drones. The ability to achieve efficient propulsion with fewer moving parts also improves the reliability and durability of the drones, making them more suitable for agricultural environments where exposure to dust, moisture, and extreme temperatures can cause damage to traditional drone components.

In addition to the energy efficiency advantages, magnetic-powered drones offer greater stability and flight control. The precision with which magnetic fields can be manipulated allows for more stable flight dynamics, which is particularly beneficial in sensitive agricultural tasks such as crop monitoring and pest control. Stable flight minimizes the risk of damaging crops and ensures that sensors on the drone capture high-quality data.

Magnetic-Powered Drones for Agriculture

Several studies have explored the potential application of magnetic-powered drones in agriculture. Bai et al. (2020) highlighted the use of UAVs in agriculture, noting the need for drones to cover larger areas efficiently while maintaining long flight times. They suggested that magnetic propulsion could be a solution for increasing flight durations, especially for large farms or orchards, where extended monitoring periods are required for accurate data collection.

The integration of magnetic propulsion with IoT systems for agricultural drones is an area that has received attention in recent years. For example, Wang et al. (2021) proposed a framework that integrates maglev-powered drones with IoT-enabled sensors for real-time crop monitoring. Their system used drones equipped with electromagnetic propulsion, coupled with IoT devices, to monitor soil conditions, detect crop diseases, and manage irrigation systems. The combination of magnetic propulsion and IoT not only improves the efficiency of flight but also enhances the quality and timeliness of data collection, which is crucial for making precision farming decisions. In a similar vein, Gupta et al. (2022) explored the use of mini drones with magnetic propulsion in agricultural applications, particularly focusing on precision pesticide application. Their study found that magnetic-powered drones provided more efficient and stable flight patterns, which resulted in more accurate pesticide spraying. The ability to fly for longer periods allowed these drones to cover large areas and minimize the use of pesticides, thus reducing environmental impact and increasing crop yields.

7. Challenges and Opportunities in Magnetic-Powered Drone Integration

While the integration of magnetic-powered drones with IoT systems holds substantial promise for revolutionizing agriculture, there are challenges that need to be addressed. The most prominent challenges include:

1. **Cost and Accessibility**: Magnetic propulsion systems, especially those involving maglev technologies, can be expensive to design and manufacture. The initial cost of these drones may deter small-scale farmers from adopting this technology. However, as technology matures and scale economies come into play, it is expected that costs will decrease over time.

2. **Battery Life and Energy Density**: While magnetic propulsion offers greater energy efficiency than traditional drones, the battery life of magnetic-powered mini drones still needs to be optimized for long-term use. Advances in battery technology will be critical for ensuring that these drones can operate efficiently for extended periods, particularly in large agricultural areas.

3. **Regulations and Safety**: Drones, especially those used for agricultural purposes, must adhere to regulatory frameworks that ensure their safe operation. The development of safety standards for magnetic-powered drones, including flight regulations and collision avoidance systems, is crucial for their widespread adoption.

Despite these challenges, the opportunities presented by magnetic-powered mini drones in IoT-driven agriculture are vast. The ability to conduct real-time, data-driven monitoring of crops, soil, and environmental conditions can lead to sustainable farming practices, reduce the dependency on chemical inputs, and optimize the use of natural resources. By reducing operational costs, extending drone flight times, and enhancing the stability of flight, these technologies can improve farm productivity, contributing to food security and environmental sustainability. The literature on magnetic-powered mini drones and IoT-driven agricultural solutions highlights the significant potential of these technologies to transform farming practices. Drones, particularly when equipped with magnetic propulsion systems and integrated with IoT, offer a novel approach to addressing key challenges in agriculture, including resource inefficiency, crop monitoring, and pest control. The combination of magnetic propulsion and IoT allows for greater energy efficiency, longer flight times, and enhanced flight stability, all of which are critical for the scalability of drone applications in agriculture. As technology advances and becomes more cost-effective, magnetic-powered mini drones have the potential to play a pivotal role in creating smarter, more sustainable farming systems.

8. Research Objectives and Scope: Magnetic-Powered Mini Drones for Smart IoT-Driven Agricultural Solutions

Research Objectives

The integration of magnetic-powered mini drones with Internet of Things (IoT) technologies holds significant promise for revolutionizing the agricultural sector. This research aims to explore the potential of these innovative technologies to address current agricultural challenges and improve farming efficiency, sustainability, and productivity. The main objectives of this research are as follows:

To Investigate the Feasibility of Magnetic Propulsion for Agricultural Drones

One of the core objectives of this research is to assess the technical feasibility of using magnetic propulsion systems for mini drones designed for agricultural applications. Magnetic propulsion, including the use of magnetic levitation (maglev) systems, has the potential to reduce energy consumption and increase flight stability, two critical aspects for agricultural drones. The research will focus on understanding the principles behind magnetic propulsion, its advantages over traditional motor-based propulsion, and the challenges of integrating such systems into mini drones for agricultural use. Furthermore, this objective will involve evaluating the energy efficiency, flight duration, and overall operational capabilities of magnetic-powered drones in comparison to traditional electric-powered drones.

To Examine the Integration of IoT Technologies with Magnetic-Powered Drones in Agricultural Applications

The second objective is to explore how IoT technologies can be effectively integrated with magnetic-powered mini drones to create a smart agricultural ecosystem. IoT sensors on drones can collect real-time data on crop health, soil moisture, temperature, pest activity, and environmental conditions. By incorporating these sensors with magnetic-powered drones, farmers can gain precise and timely insights into the state of their fields, allowing them to make data-driven decisions. This research will investigate various types of IoT sensors and their compatibility with magnetic drones, as well as the challenges of integrating data from these sensors into cloud-based platforms for analysis.

To Assess the Potential Benefits and Challenges of Magnetic-Powered Mini Drones for Precision Agriculture

Precision agriculture relies heavily on technology to optimize the use of resources such as water, fertilizers, and pesticides. Magnetic-powered mini drones, when combined with IoT sensors, have the potential to enhance precision farming practices by enabling accurate monitoring and intervention. This research will assess how magnetic-powered drones could contribute to precision farming through applications such as soil monitoring, crop health assessment, targeted irrigation, and pest control. Additionally, the study will explore the challenges associated with deploying these technologies on a large scale, including cost barriers, regulatory issues, and technological limitations.

To Evaluate the Sustainability and Environmental Impact of Magnetic-Powered Drones in Agriculture

Sustainable farming practices are increasingly crucial in addressing the environmental challenges posed by traditional agricultural methods, such as excessive water use, pesticide runoff, and greenhouse gas emissions. This objective focuses on evaluating the environmental benefits of using magnetic-powered mini drones in agriculture. Specifically, the research will explore how these drones can reduce the use of harmful chemicals, optimize water usage, and lower carbon emissions through more energy-efficient flight operations. Additionally, this objective will consider the potential for these drones to help reduce the carbon footprint of agriculture by minimizing resource waste and promoting environmentally friendly farming practices.

To Investigate the Cost-Effectiveness and Scalability of Magnetic-Powered Mini Drones for Agricultural Use

While the technological capabilities of magnetic-powered drones are promising, it is crucial to evaluate their economic feasibility for widespread adoption in the agricultural sector. This research will focus on the cost-effectiveness of manufacturing and operating magnetic-powered mini drones compared to traditional drone systems. The cost of magnetic propulsion systems, IoT sensors, drone maintenance, and energy consumption will be assessed. Additionally, the research will examine the scalability of magnetic-powered drones, addressing whether they can be effectively deployed on a large scale across diverse agricultural environments. This objective will help determine whether the initial investment in magnetic-powered drones can be justified by the long-term benefits of increased productivity, resource efficiency, and sustainability.

To Explore Potential Use Cases and Applications of Magnetic-Powered Drones in Smart Agriculture

The final objective is to identify and evaluate potential use cases for magnetic-powered mini drones in various areas of smart agriculture. This will involve an in-depth analysis of current challenges in agriculture that could benefit from drone technologies, such as crop monitoring, precision irrigation, pest and disease management, and environmental monitoring. The research will identify the most promising applications where magnetic-powered drones could outperform conventional drones, particularly in large-scale and precision farming operations. By exploring different agricultural settings, such as large commercial farms, smallholder farms, and greenhouse environments, the study will provide insights into the versatility and adaptability of magnetic-powered mini drones in diverse farming conditions.

9. Scope of Research

This research aims to investigate the potential of magnetic-powered mini drones in combination with IoT technologies for advancing precision agriculture. The scope of the research covers several key areas, which are outlined below:

Technological Scope

The research will primarily focus on the technological feasibility and development of magnetic propulsion systems in drones for agricultural purposes. This includes exploring various types of magnetic propulsion technologies, such as magnetic levitation (maglev), electromagnetic motors, and other magnet-based systems that could improve drone efficiency. The scope will also encompass the integration of IoT-based sensors for environmental monitoring and decision support, focusing on sensor types (e.g., soil moisture sensors, temperature sensors, multispectral imaging cameras) that can be used in conjunction with the drones. Additionally, the research will evaluate the hardware and software components necessary for operating these drones within a connected, smart agriculture ecosystem.

Geographical Scope

The research will not be confined to a specific geographical region but will consider the global applicability of magnetic-powered drones in different agricultural settings. Case studies from diverse agricultural environments, including large-scale farms, greenhouses, vineyards, and smallholder farms, will be included to understand the versatility of magnetic-powered drones across various scales and crop types. The research will examine how different regions with varying agricultural practices, climate conditions, and resource constraints can benefit from this technology.

Application Scope

The research will explore a wide range of agricultural applications for magnetic-powered mini drones integrated with IoT systems. These applications will include crop health monitoring, precision irrigation, pest and disease detection, and soil monitoring. The study will focus on how magnetic-powered drones can be used to enhance precision farming techniques, optimize the use of water and fertilizers, and reduce pesticide use. The potential for autonomous operations will also be examined, where drones can operate with minimal human intervention, providing significant time and labor savings for farmers.

Environmental and Sustainability Scope

The research will also explore the environmental impact of adopting magnetic-powered drones in agriculture. By focusing on energy efficiency, the reduction of pesticide and water waste, and the potential to lower the carbon footprint of farming operations, this study will assess how these technologies can contribute to sustainable agriculture. The scope will include a comprehensive analysis of the potential for magnetic-powered drones to mitigate the adverse environmental effects of traditional farming practices.

Economic and Scalability Scope

The economic feasibility and scalability of magnetic-powered mini drones will also be a key focus of the research. The research will assess the cost-benefit analysis of adopting these technologies, comparing their initial investment costs with long-term savings in terms of operational efficiency, resource optimization, and increased crop yields. The scalability of the technology for use in commercial farming, as well as its applicability to smaller-scale operations, will be considered.

10. Conclusion

In conclusion, the research on magnetic-powered mini drones integrated with IoT technologies for smart agriculture seeks to address key challenges in the agricultural sector, including resource inefficiency, labor shortages, and sustainability concerns. By focusing on the technological, environmental, economic, and practical aspects of these innovations, the research aims to develop a comprehensive understanding of their potential to revolutionize agriculture. Through the achievement of the stated research objectives, this study will contribute to the growing body of knowledge on the future of farming in a rapidly evolving technological landscape.

7. References

[1] Ashley, K. D. (2017). Artificial intelligence and legal analytics: New tools for law practice in the digital age. Cambridge University Press.

[2] Beckers, K. (2015). Pattern and security requirements: Engineering-based establishment of security standards. Springer.

[3] Burns, R. N., Price, J., Nye, J. S., Scowcroft, B., Aspen Institute, & Aspen Strategy Group (U.S.). (2012). Securing cyberspace: A new domain for national security. Aspen Institute.

[4] Cavelty, M. D. (2007). Cyber-security and threat politics. Routledge.

[5] Chen, T. M. (2013). An assessment of the Department of Defense strategy for operating in cyberspace.

[6] Correa-Baena, J.-P., et al. (2018). Accelerating materials development via automation, machine learning, and high-performance computing. Joule, 2(8), 1410–1420. https://doi.org/10.1016/j.joule.2018.05.009

[7] Farzindar, A., & Kešelj, V. (Eds.). (2010). Advances in artificial intelligence: 23rd Canadian Conference on Artificial Intelligence, Canadian AI 2010, Ottawa, Canada, May 31 - June 2, 2010: Proceedings. Springer.

[8] Krishnan, A. (2016). Killer robots: Legality and ethicality of autonomous weapons. Routledge.

[9] Macaulay, T., & Singer, B. L. (2016). Cybersecurity for industrial control systems. CRC Press.

[10] Mitnick, K. D. (2003). The art of deception: Controlling the human element of security. Wiley.

[11] National Academy of Engineering, National Research Council, & Committee on Science, Engineering, and Public Policy. (2007). Toward a safer and more secure cyberspace. National Academies Press.

[12] Pant, A. (2018). Future warfare and artificial intelligence.

[13] Shrivastava, G., Kumar, P., B, G. B., Bala, S., & Dey, N. (2018). Handbook of research on network forensics and analysis techniques. IGI Global.

[14] Singh, P. A. N. (2016). Improvement of human thinking factors in machine using artificial intelligence. International Journal of Engineering and Computer Science, 5(12). https://doi.org/10.18535/ijecs/v5i12.39

[15] Sparks, D. (2018). Cyber security standards, practices and industrial applications. Createspace Independent Publishing Platform.

[16] Thomson, R., Dancy, C., Hyder, A., & Bisgin, H. (Eds.). (2018). Social, cultural, and behavioral modeling: 11th International Conference, SBP-BRiMS 2018, Washington, DC, USA, July 10-13, 2018, Proceedings. Springer.

[17] Tsoukas, H., & Chia, R. (2002). On organizational becoming: Rethinking organizational change. Organization Science, 13(5), 567–582. https://doi.org/10.1287/orsc.13.5.567.7810

[18] Yannakogeorgos, P. A., & Lowther, A. (2014). Conflict and cooperation in cyberspace: The challenge to national security. Taylor & Francis.

[19] Yu, P. S., & Tsai, J. J. P. (2009). Machine learning in cyber trust: Security, privacy, and reliability. Springer.

[20] Zubairi, J. A., & Mahboob, A. (2012). Cyber security standards, practices and industrial applications: Systems and methodologies. Information Science Reference.

8.Conflict of Interest

The authors declare that there are no conflicts of interest to report in the publication of this article.

9.Funding

No external funding was received to support or conduct this study.