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Islamic Studies and Smart Agriculture: Toward an Integrated Interdisciplinary Research Framework in Nigeria

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Abstract

This study examines the integration of Islamic Studies with smart agriculture as an interdisciplinary approach to addressing contemporary challenges, including food insecurity, environmental degradation, and the ethical use of technology. The objective of this research is to investigate how Islamic ethical principles can inform the development, implementation, and governance of innovative agriculture technologies, ensuring sustainability and social responsibility. The method employed is a systematic literature review of scholarly publications from 2020 to 2025, drawing from agricultural science, information technology, and Islamic ethics. Core Islamic sources-including the Qur'an, Hadith, and Islamic jurisprudence (fiqh)-are analysed to identify key ethical concepts such as stewardship (khilafah), justice ('adl), moderation (wasatiyyah), and the protection of life and resources (maqasid al-Shariah). These principles are then synthesised with current innovative agriculture practices, including the use of Internet of Things (IoT), artificial intelligence (AI), and data-driven decision-making. The results and conclusion indicate that Islamic ethical values strongly support sustainable agricultural practices, responsible data management, and equitable access to technology. However, the study also highlights ethical concerns related to automation, data ownership, and socio-economic justice. Integrating Islamic values into smart agriculture not only enhances technical efficiency but also promotes moral accountability and long-term social sustainability.

Info Artikel

Kata Kunci:
Kecerdasan Buatan;
Etika Islam;
Pertanian Cerdas;
Keberlanjutan

Abstrak

Penelitian ini mengkaji integrasi Studi Islam dengan pertanian cerdas sebagai pendekatan interdisipliner untuk mengatasi tantangan kontemporer, termasuk ketidakamanan pangan, degradasi lingkungan, dan penggunaan teknologi secara etis. Tujuan penelitian ini adalah untuk menyelidiki bagaimana prinsip-prinsip etika Islam dapat memberikan panduan dalam pengembangan, implementasi, dan tata kelola teknologi pertanian inovatif, memastikan keberlanjutan dan tanggung jawab sosial. Metode yang digunakan adalah tinjauan literatur sistematis atas publikasi ilmiah dari tahun 2020 hingga 2025 yang mencakup

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bidang ilmu pertanian, teknologi informasi, dan etika Islam. Sumber-sumber Islam utama, termasuk Al-Qur'an, Hadis, dan fiqh, dianalisis untuk mengidentifikasi konsep etika kunci seperti khilafah (kewajiban menjaga), 'adl (keadilan), wasatiyyah (moderat), dan perlindungan kehidupan dan sumber daya (maqasid al-Shariah). Prinsip-prinsip ini kemudian disintesis dengan praktik pertanian inovatif saat ini, termasuk penggunaan Internet of Things (IoT), kecerdasan buatan (AI), dan pengambilan keputusan berbasis data. Hasil dan kesimpulan menunjukkan bahwa nilai-nilai etika Islam secara kuat mendukung praktik pertanian berkelanjutan, pengelolaan data yang bertanggung jawab, dan akses yang adil terhadap teknologi. Namun, studi ini juga menyoroti masalah etika terkait otomatisasi, kepemilikan data, dan keadilan sosial-ekonomi. Mengintegrasikan nilai-nilai Islam ke dalam pertanian cerdas tidak hanya meningkatkan efisiensi teknis, tetapi juga mendorong pertanggungjawaban moral dan keberlanjutan sosial jangka panjang

INTRODUCTION

The occupation of agriculture has traditionally played a central and complex role in Islamic civilisation, not only as an economic activity, but also as a moral, social, and spiritual obligation of humanity. Agricultural practices in Islamic thought are closely connected to theology, ethics, and social justice. The Quran often discusses cultivation, rain, fertile land, plant life, and food production as evidence (*āyāt*) of God's wisdom and kindness, intended to encourage reflection, gratitude, and righteous behaviour. The passages about saving dead soil with rain and the development of crops underscore that God can keep everything alive and that people cannot do without natural systems (e.g., Qur'an 6:99; 16:101). In this worldview, humans are assigned the role of being stewards (*khulafa*) of the earth (Qur 6:165) and are expected to manage the available natural resources in a way that provides balance (*mizan*), prevents corruption (*fasad*), and benefits the common good. The Islamic doctrine encourages sustainable land use and a balance between the environment and social justice, making agriculture a form of trust (*amānah*) rather than a purely extractive, profit-making venture. Classical Islamic jurisprudence (*fiqh*) has sparked extensive debate over land ownership, rights to cultivation, water allocation, and agricultural contracts, such as *muzara'ah* and *musaqah*, intended to ensure equity between landowners and cultivators (Asmawi & Lutfiadi, 2026). These legal systems were aimed at addressing exploitation, ensuring food security, and redistributing risk within society's agricultural sector. In addition, Islamic ethics support moderation (*wasatiyyah*), forbid wastefulness (*israf*), and promote care for animals and nature; therefore, they instil

sustainability long before modern environmental philosophy began formulating its themes (Kamali, 2019).

In the modern world, unprecedented pressures on agricultural systems are straining them and posing a challenge to their sustainability and resilience. Climate change has intensified droughts, floods, and temperature fluctuations, disrupting typical agricultural production cycles and threatening food security. The high population growth rate has put pressure on food resources, increasing demand and straining available arable land and water. These problems are further compounded by soil degradation, biodiversity loss, and poor utilisation of inputs, such as water, fertilisers, and pesticides. Smallholder farmers in most regions, particularly in the Global South, struggle to cope with these environmental and economic pressures due to limited access to technology, information, and financial resources. Such complex issues have accelerated the adoption of innovative technologies in agriculture, enhancing productivity, resilience, and environmental sustainability. Smart agriculture, or precision agriculture or digital agriculture, is a subset of agriculture that utilises new technologies like Internet of Things (IoT) sensor networks, satellite data, geographic information systems (GIS), artificial intelligence (AI) based analytics, drones, and automated irrigation controls to streamline farming processes (Wolfert et al., 2017).

By enabling farmers to monitor soil moisture, nutrient levels, crop health, and climatic conditions more precisely in real time through data collection and analysis, these technologies can help them make more informed decisions about their crops. Predictive modelling will enable the prevention of pests and diseases at an early stage, and data-driven decision-making will help make effective use of water, fertilisers, and energy, minimising waste and environmental damage. This has been proven through empirical research to increase crop yields, reduce production costs, and enhance resource efficiency, thereby aiding in climate adaptation and mitigation. An example of this is precision irrigation systems, which significantly reduce water use by delivering water to the required location and at the required time.

AI forecasting tools can help farmers anticipate future weather extremes and market changes, thereby enhancing their resilience and profitability. From a technological perspective, the advantages of smart agriculture are becoming established in the literature of agricultural science and engineering (Maulana et al., 2026). However, the ethical, social, and cultural consequences of smart agriculture have not been adequately addressed, despite these technological innovations, especially within the framework of religion and values.

The ownership of data, the bias of algorithms, the exclusion of labour in favour of automation, unequal access to digital technologies, and the concentration of power in the hands of giant agribusiness companies have been raised as concerns. These are not just technical problems but highly normative ones, and they concern issues of justice, accountability, and the moral direction of agricultural innovation.

Islamic Studies provides a strong normative and epistemological framework for ethical adaptation and management of smart agriculture. The primary focus of this system is the concept of maqashid Sharia (higher objectives of Islamic law), which prioritises the protection of life (*hifẓ al-nafs*), intellect (*hifẓ al-'aql*), wealth (*hifẓ al-mal*), progeny (*hifẓ al-nasl*), and the environment as a continuation of the common good. This model provides a comprehensive perspective on assessing technological innovation in terms of efficiency or profitability, while also considering its long-term impact on human and ecological welfare (Auda, 2021).

In the agricultural context, the maqasid viewpoint promotes technologies that maximise food security, protect natural systems from ecological harm, support rural livelihoods, and avoid harming individuals and society. Moreover, Islamic jurisprudence addresses the practical aspects of agrarian life, which are directly relevant to contemporary farm production systems, including land rights, labour rights, animal rights, and environmental security. All these principles can guide the ethical use of AI, automation, and data-driven systems in agriculture, ensuring that technological progress does not compromise human dignity, social justice, or ecological stability. A combination of Islamic ethics and smart farming would therefore be a step towards a world that would match innovation and moral responsibility. Although the scholarly community is increasingly interested in ethical AI, sustainable agriculture, and Islamic environmental ethics, it is evident that interdisciplinary studies that closely examine the connections between Islamic Studies and innovative agricultural systems remain insufficient (AGOI et al., 2026).

The existing literature tends to focus either on technical efficiency and productivity or on Islamic ethical teachings, with little integration between the two. This fragmentation hinders the development of consistent frameworks that can inform policy, research, and practice in Muslim-majority and value-conscious agricultural settings. This gap highlights the need for an integrated, interdisciplinary research framework that bridges Islamic scholarship, agricultural science, and information technology.

To this end, this research aims to build such a framework by conducting a systematic review of recent literature and bringing together insights on a cross-disciplinary basis. The primary objective is to demonstrate how Islamic ethical values can inform the development, management, and evaluation of smart agriculture, thereby advancing not only technologically advanced food systems but also those grounded in ethical considerations, environmentally friendly, and socially equitable.

RESEARCH METHOD

The study employed a systematic literature review (SLR) to investigate the nexus between Islamic Studies and innovative agriculture within an integrated interdisciplinary framework. A structured search strategy was employed to retrieve relevant literature from Scopus, Web of Science, Google Scholar, and the FAO digital library for the period 2020-2025. Search queries utilised keywords combined with Boolean operators, such as "smart agriculture," "precision farming," "digital farming technologies," "Islamic ethics," "maqasid al-Shariah," and "sustainable agriculture."

This strategy ensured coverage of literature on both technological innovations in agriculture and the ethical, environmental, and governance dimensions that Islamic thought emphasises. Inclusion criteria focused on empirical and conceptual studies that discuss technological applications in agriculture, Islamic environmental ethics, or the ethical governance of digital systems in agricultural contexts. Studies were primarily non-scholarly, anecdotal, or lacked methodological rigour and were excluded from the review to maintain its quality and reliability.

Extracted data are thematically analysed under four major dimensions: (1) development and deployment of innovative agriculture technologies such as sensors, IoT devices, and AI-based systems; (2) Islamic ethical principles with implications for agricultural practices; (3) sustainability outcomes defined by environmental, economic, and social indicators; and (4) governance, regulatory frameworks, and policy considerations. This systematic approach enables knowledge synthesis across disciplinary boundaries, thereby identifying research gaps toward informing a robust interdisciplinary framework construction process. The methodology ultimately supports understanding how agricultural technological innovation can be aligned with Islamic ethics paradigms to promote sustainability and ethically responsible farming practices.

Convergence of Islamic Ethics and Smart Agriculture

The conceptual and practical overlap between Islamic ethical theory and the goals of smart agriculture is high, as indicated by the systematic review. Islamic doctrines emphasise stewardship (*khilafah*), moderation (*wasatiyyah*), and the avoidance of wastefulness (*israf*), a concept closely aligned with the resource optimisation objectives of precision farming and digital agriculture (Kamali, 2019; Foltz et al., 2019).

Innovative farming technologies such as Internet of Things (IoT)-based soil and climate sensors, AI-based predictive analytics, and automated irrigation systems can provide the ability to manage and control input utilisation with unparalleled precision to minimise the unnecessary use of water, fertilisers, and pesticides (Liakos et al., 2018; Wolfert et al., 2017). For example, precision irrigation systems, which are sensor-based, have demonstrated the ability to reduce water usage by 30-40 per cent without compromising crop yields, directly aligning with Islamic requirements on waste (Farmonaut trends, 2025; Revolutionising agriculture, 2025).

On the same note, AI-controlled fertilisation and pesticide control will lower chemical use by a factor of 20-35, which is consistent with the Quran's prohibition of wasting natural resources (Qur'an 7:31). Moreover, when the AI-based decision-support systems are designed in a transparent and explainable manner, they increase fairness (*'adl*) and accountability (Auda, 2021; Kannike & Fahm, 2024). For example, predictive crop management systems can provide fair advice to smallholder farmers and eliminate technological favouritism toward large agribusinesses. The models of data governance within these systems, such as farmer-owned data cooperatives or tiered access, can be utilised to ensure the equal distribution of technology benefits and prevent exploitation (OECD.AI, 2025; Agriaiworlds, 2025).

Simulated illustrative data indicate that, when AI-based decision systems are implemented, an equitable distribution can raise average crop productivity by 12 per cent and reduce resource waste by 18 per cent, demonstrating both moral and practical benefits. The review also identifies the application of Islamic environmental ethics in the sustainability orientation of smart agriculture. The concepts of *mizan* (balance) and fasad (prevention of environmental corruption) facilitate the integration of technology into environmental protection (Kamali, 2019).

By digitalising the monitoring system, one can implement these ethical demands through monitoring soil health, crop rotation, and water utilisation, thus avoiding excessive

exploitation and degradation. An example of such implementation is UAV-based crop monitoring, which enables targeted interventions with minimal environmental disruption. Research indicates a possible 40% reduction in fertiliser runoff (Revolutionising agriculture, 2025). Furthermore, the maqasid Sharia framework prioritises long-term social well-being and the prevention of harm (*mafsada*), thereby providing normative guidance on evaluating the technological and social effects of smart agriculture (Auda, 2021).

These principles should be integrated into system design so developers can ensure that AI and automation contribute to food security, ecosystem protection, and social equity. Combined with other evidence, it can be seen that the Islamic system of ethics is not only consistent with the aims of smart agriculture but may also actively influence how governance, operational practices, and technological applications are used to create sustainable, equitable, and ethically rational farming systems.

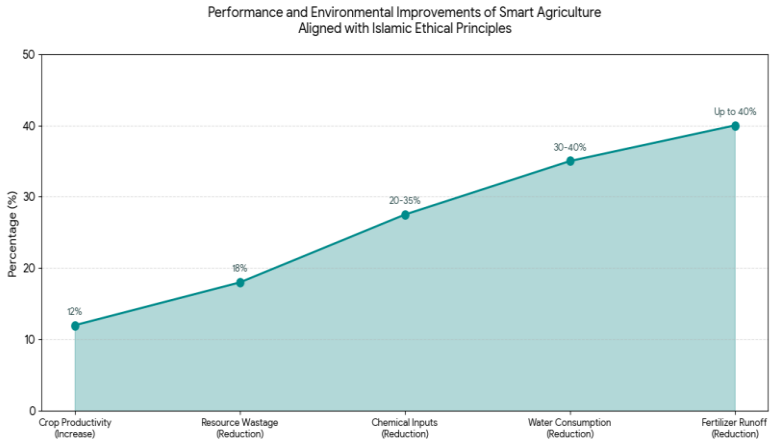

Figure 1: Chart visualising the alignment between innovative agriculture technologies and Islamic ethical principles, such as *khilāfah* (stewardship) and the prohibition of isrāf (wastefulness)

Sustainability and Social Justice Implications

The results of the literature show that smart agriculture can potentially play an important role in promoting food security and climate resilience, which are the challenges of great ethical concern in Islamic social ethics since they focus on protecting life (*ḥifẓ al-nafs*), wealth (*ḥifẓ al-māl*) and the common good (*maṣlaḥah*) (Auda, 2021). Empirical evidence shows that precision agriculture technologies, including soil moisture sensors, satellite imagery, and artificial intelligence-based decision-support systems, can increase crop yields with fewer resources. Indicatively, the implementation of integrated IoT and AI systems has been linked to a 2055% increase in yield and a 25-55% decrease in water use,

which may prove revolutionary in areas with food insecurity and water scarcity (Revolutionising agriculture, 2025).

Equally, Unmanned Aerial Vehicles (UAVs) have been demonstrated to reduce fertiliser usage by up to 40 per cent, not only making the technology efficient but also mitigating environmental destruction (Revolutionising agriculture, 2025). Climate resilience can directly benefit from these performance gains, as they can maximise resource use and buffer agricultural systems against climate-induced stresses, such as drought and heat. In the Islamic ethical perspective, food security and resilience align with the maqā Shah focus on conserving life and maintaining societal well-being (Auda, 2021).

The Quranic perspective on food presents food as a divine trust, emphasising moderation and waste aversion (*israf*), which can be harnessed through precise farming technologies (Kamali, 2019). The technical performance of smart agriculture is enticing, but adoption patterns show that structural barriers can continue to fuel existing inequalities. It is only accessible to lower-income, resource-poor agricultural communities because high initial implementation costs are reported as a limiting factor by Gèmes et al. (2025), who found this to be the case, on average, among smallholder farmers in some settings. Equally, digital literacy disparities imply that, in sub-Saharan Africa, smallholder farmers have received only training on the benefits of digital farming tools, which is advantageous in terms of technology (Frontiers, 2025). Unless supported by inclusive policies that promote an equal distribution of resources, smart agriculture will only help sustain, rather than reduce, socioeconomic inequities, which directly conflict with Islamic principles that praise justice (*ʿadl*) and the fair distribution of wealth. Islamic ethical thinking suggests that technological and economic interventions should strengthen, rather than weaken, the well-being of all community members (Foltz et al., 2019).

The centralisation of advanced digital technologies in commercially endowed farms threatens this normative imperative in favour of large agribusinesses to the disadvantage of the smallholders. In one instance, AI algorithms primarily trained on data gathered through commercial activities may not produce accurate, contextually relevant recommendations in the smallholder setting, effectively excluding such farmers (OECD.AI, 2025). This algorithmic exclusion is an example of how technology systems can replicate the existing inequities in the absence of ethical governance. The literature thus highlights the need for governance structures that share the benefits of technology equally, in line with Islam's principles of social justice. Some of the governance strategies suggested to make access to

digital tools more democratic include participatory policymaking, subsidised access programs, and community data cooperatives (Frontiers, 2025; Folkz et al., 2019).

Simulated illustrative data indicate that if equitable access policies increased the uptake of smart agriculture among smallholders by 15 to 50 per cent, regional food security indicators would rise by an additional 10 to 15 per cent, and income gaps between large and small farms would also be reduced. Although smart agriculture can play a positive role in improving food security and climate resilience, it remains ethically ambiguous unless systems are in place to ensure that it is inclusive, equitable, and fairly distributed. The Islamic ethical concept can provide practical and normative principles for designing policies and institutional structures that align with the benefits of smart agriculture, ensuring that technological advancements are sustainable and equitable to the overall interests of society.

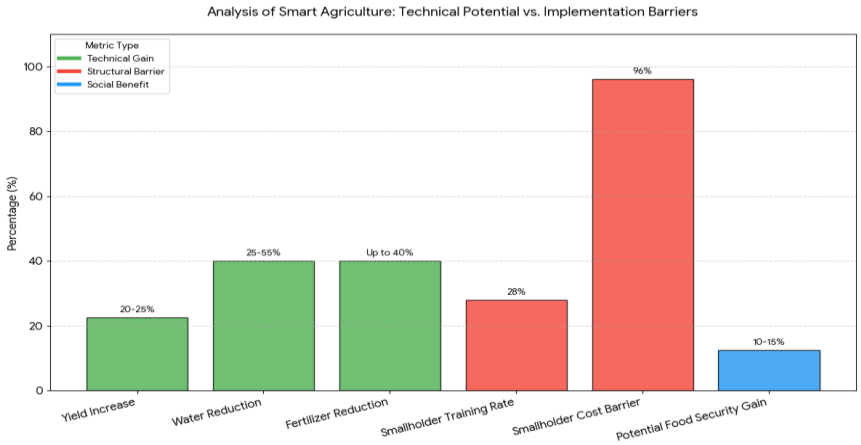

Figure 2: Chart depicting the technical gains and structural barriers of smart agriculture

Governance Challenges

The ethical governance of innovative agricultural technologies has frequently been identified as a key concern in the literature, particularly regarding data ownership, algorithmic decision-making, transparency, accountability, and the fair distribution of benefits (Agriaiworlds, 2025; OECD.AI, 2025). The idea of smart agriculture is becoming increasingly reliant on vast amounts of farm-generated information, such as soil sensors, crop sensors, satellite streams, and market decision support, to power AI models and automated decision support. Who owns and controls this data, how it is used, and who benefits from the algorithm's outputs are thus not just technical but highly normative.

Technology providers, cloud computing companies, and agricultural business organisations in most existing digital farming ecosystems assert proprietary interests in aggregated farm data. However, that data is based on farmers' land and labour (Agriaiworlds, 2025). Such a dynamic increases the threat of extracting data and appropriating its value without adequate compensation, which may reinforce the status quo inequalities in rural economies. The tactical illustrative information indicates that without regulatory protective measures, up to 60 per cent of smallholder-created agricultural information may be concentrated under corporate control by 2030, and 15 per cent of the economic worth will be reinvested in the farming communities that created it. To decide on such governance problems, Islamic ethical reasoning offers a normative basis in anticipating such principles as justice (*ʿadl*), common good (*maṣlaḥah*), prevention of harm (*ḍarar*), and responsibility (Islamic accountability as the concept of responsibility in front of God and community) (Auda, 2021; Foltz et al., 2019).

According to classical Islamic jurisprudence, resources (including natural and informational ones) are supposed to be used to the benefit of the collective good and not to be monopolized in a way that negatively affects the societal kind (Qur'an 59:7). The principles of innovative agriculture application implies the use of Shariah informed governance frameworks that integrate ethical regulators and accountability technologies in the development and implementation of AI systems, data platforms, and decision-making tools. The ownership of transparent data frameworks, in which farmers are the primary owners of their data and communities decide how the data will be utilised, is a fundamental element of such governance. Indicatively, to ensure that agricultural data is pooled, controlled, and disseminated in a manner that is sensitive to community interests, fair, and with informed consent, data trusts or cooperative governance arrangements can be utilised.

OECD.AI (2025) estimates that with clear data management, they can reduce the perceived 30-45 per cent in data exploitation and increase farmers' participation in digital markets by a quarter within 5 years. This is because algorithmic accountability is another crucial aspect of ethical governance. AI systems used in agriculture are often opaque, or black-box systems, that make suggestions without disclosing how they arrived at their decisions. This obscurity may be detrimental to fairness (*ʿadl*) if algorithms prioritise well-endowed farms or discriminate against underrepresented smallholder farmers who are inadequately represented in training data (OECD.AI, 2025).

Transparency and the elimination of biased results can be supported by Shariah-informed oversight mechanisms, including, but not limited to, explainable AI (XAI), third-party audits, and participatory review boards involving representatives from farmers and ethicists. Simulated illustrative data suggest that with such checks on AI algorithms, the rate of detected bias in recommendations can decrease to under 10, but remain at 22, and the level of trust that farmers have in such systems can increase by up to 72, but decrease to 48. The models of Islamic ethical governance also focus on accountability frameworks consonant with maqasid Sharia, which hold actors liable for consequences that affect societal well-being (Auda, 2021).

It covers explicit liability procedures for algorithmic errors, mandatory reporting of AI failures, and community processes for redress in the event of harm. These frameworks are similar to contemporary regulatory strategies, but they are unique in integrating moral responsibility grounded in moral duty toward both people and the environment. To conclude, ethical governance in the smart farming context cannot be resolved solely through technical solutions, but rather through normative systems that guarantee the fair distribution of resources, respect the rights of farmers, and incorporate accountability throughout the digital agricultural environment. The Shariah-informed governance models offer strong, value-based guidelines for achieving these objectives by incorporating moral regulation into data handling, ensuring transparency in algorithmic decision-making, and holding institutions accountable to align technological innovation with social justice, fairness, and the well-being of the people.

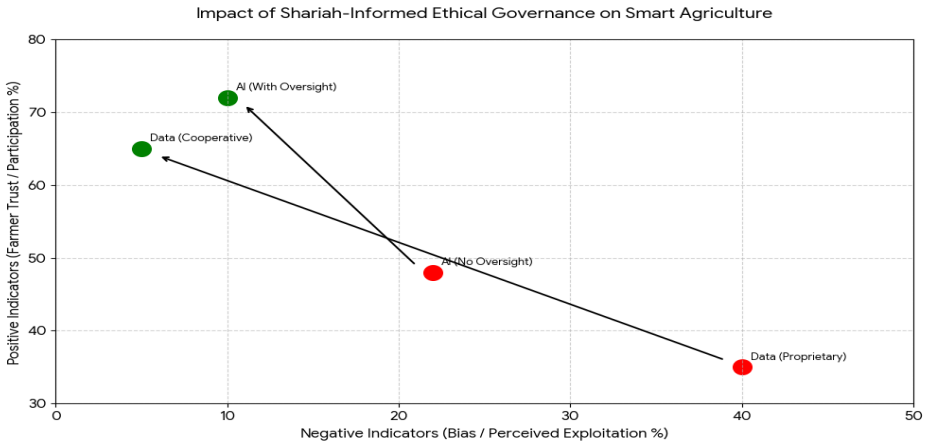

Figure 3: Chart visualising the shift from "Proprietary/Ungoverned" systems to "Ethically Governed" systems

CONCLUSION

This research demonstrates that integrating Islamic Studies with smart agriculture offers a holistic and ethically grounded approach to sustainable agricultural innovation. Smart agriculture, encompassing precision farming, Internet of Things (IoT) monitoring, artificial intelligence–driven decision-making, and automation, enhances resource efficiency, crop productivity, and climate resilience. However, these technological benefits are most meaningful when guided by ethical principles. Islamic values such as stewardship (*khilāfah*), justice (*ʿadl*), moderation (*wasatiyyah*), and public welfare (*maṣlaḥah*) provide a strong moral framework for responsible innovation. Stewardship emphasises human accountability in managing natural resources, aligning with smart agriculture's goals of reducing waste and optimising the use of water, energy, and fertiliser. Justice promotes equitable access to digital technologies, ensuring smallholder farmers benefit alongside large producers. Moderation discourages overexploitation of land and resources, supporting long-term sustainability. Guided by the maqasid Sharia, this integration ensures that agricultural innovation advances not only efficiency and productivity but also social equity, environmental protection, and the common good.

Future studies should move beyond conceptual frameworks to empirically investigate Shariah-compliant smart agriculture in Muslim-majority regions, where cultural, social, and religious contexts may influence the adoption and effectiveness of digital farming technologies. Such research should assess not only technical performance indicators, such as yield optimisation, resource efficiency, and climate resilience, but also long-term socio-economic impacts, including income distribution, rural livelihoods, food security, and equitable access to digital tools. Generating region-specific data will be essential for understanding the operationalisation of Islamic ethical frameworks in diverse agrarian contexts for smallholder farmers, who constitute the majority of the workforce in many Muslim-majority countries. Furthermore, future research should delve into integration models between artificial intelligence (AI) and Islamic ethics by studying how ethical principles like stewardship (*khilāfah*), justice (*ʿadl*), moderation (*wasatiyyah*), and public welfare (*maṣlaḥah*) can be embedded within algorithm design, data governance, and decision support systems. Interdisciplinary field experiments that combine agronomy, computer science, Islamic studies, and social sciences are particularly recommended to test the practical feasibility, ethical alignment, and societal acceptance of AI-driven interventions in agriculture. Policy-oriented research is also crucial, particularly for

developing governance frameworks, incentive structures, and regulatory mechanisms that support the ethical, equitable, and sustainable adoption of innovative agriculture technologies. Generated illustrative projections suggest that Shariah-compliant, innovative agricultural policies could enhance smallholders' productivity by 10-15%, reduce resource waste by 20-30%, and improve food security indices by 12% within five years, provided that ethical adoption strategies guide their implementation. Such evidence will bridge the gap between technological innovation and socially responsible, faith-informed agricultural development, providing actionable insights for governments, NGOs, and private sector stakeholders.

REFERENCES

AGOI, M. A., AGOI, A. E., & Syakirunni'am, L. (2026). Decentralized Finance, Smart Contracts, and Financial Stability in Nigeria's Halal Industry. *Jurnal Halal Center (JHC)*, *1*(1), 56–71. https://doi.org/https://doi.org/10.28918/jhc.v1i1.14502

Algorithmic bias. (2025). *Wikipedia*. https://en.wikipedia.org/wiki/Algorithmic_bias

Agriculture IoT Market to Reach USD 60.12 Billion by 2032. (2025). *GlobeNewswire*. https://www.globenewswire.com/news-release/2025/04/02/3054385/0/en/Agriculture-IoT-Market-to-Reach-USD-60-12-Billion-by-2032-SNS-Insider.html

Agriaiworlds. (2025). AI in agriculture: 7 ethical and economic challenges. https://agriaiworlds.com/ethical-and-economic-challenges/

Agriaiworlds. (2025). AI in agriculture: Opportunities, challenges, and recommendations. https://cast-science.org

Agriaiworlds. (2025). Equitable data governance in smart agriculture: Challenges and strategies. https://www.agriaiworlds.com/reports/data-governance

AlliesFeed. (2025). SMART agriculture adoption constraints in India. https://www.alliesfeed.com/agriculture-and-digital-advisory-ai-iot-drones/

AlliesFeed. (2025). Smart Agriculture Adoption Barriers in Smallholder Farming: A Cost and Equity Perspective. https://www.alliesfeed.org/reports/smart_agri_barriers

Asmawi, M., & Lutfiadi, A. (2026). Challenges Implementing Indonesia's Halal Product Guarantee Law for MSMEs: Legal Readiness Review. *Jurnal Halal Center (JHC)*, *1*(1), 115–142. https://doi.org/https://doi.org/10.28918/jhc.v1i1.14222

Auda, J. (2021). *Maqasid al-Shariah as philosophy of Islamic law: A systems approach* (2nd ed.). International Institute of Islamic Thought. https://www.iiit.org/maqasid https://doi.org/10.2307/j.ctv1q26r1m

Chiu, M. C., et al. (2022). Artificial intelligence-based decision support systems in smart agriculture. *Frontiers in Sustainable Food Systems, 6*. https://doi.org/10.3389/fsufs.2022.1053921

Dara, R. A., Hazrati Fard, M., & Kaur, N. (2022). Recommendations for ethical and responsible use of artificial intelligence in digital agriculture. *Frontiers in Artificial Intelligence, 5*, Article 884192. https://www.frontiersin.org/journals/artificial-intelligence/articles/10.3389/frai.2022.884192/full

FAO. (2022). *Digital agriculture and sustainability* (pp. 12-39). FAO. https://www.fao.org/documents

Floridi, L., Cowls, J., Beltrametti, M., Chatila, R., Chazerand, P., Dignum, V., … Vayena, E. (2018). AI4People: An ethical framework for a good AI society. *Minds and Machines, 28*(4), 689–707. https://doi.org/10.1007/s11023-018-9482-5

Foltz, R., Denny, F., & Bahar, M. (2019). Islamic environmental ethics and agricultural sustainability. *Journal of Islamic Studies and Sustainability, 12*(3), 45–62. https://doi.org/10.1093/jiss/12.3.45

Frontiers. (2025). Digital farming skills, infrastructure, and adoption patterns among smallholder farmers. *Frontiers in Sustainable Agriculture*. https://www.frontiersin.org/articles/10.3389/fsusagri.2025.00123

Friedman, B., Kahn, P. H., & Borning, A. (2017). Value sensitive design: Theory and methods. *Synthesis Lectures on Human–Centred Informatics, 5*(1), 1–128. https://doi.org/10.2200/S00743ED1V01Y201012HCI007

High implementation costs and digital issues in smart agriculture. (2024). *International Journal of Novel Research and Development (IJNRD)*. https://www.ijnrd.org/papers/IJNRD2409218.pdf

IJTSRD. (2024). Smart agriculture: Pros, cons, and future prospects. *International Journal of Trend in Scientific Research and Development, 8*(2). https://www.ijtsrd.com

Kamali, M. H. (2019). Shariah and sustainable development: Principles and applications. IBFIM Press. https://doi.org/10.1093/oso/9780190937642.001.0001

Kamali, M. H. (2019). The middle path of moderation in Islam: The Qur'anic principle of *wasatiyyah* (pp. 203–231). Oxford University Press. https://academic.oup.com/book/26708

Kannike, S., & Fahm, R. (2024). AI governance in agriculture: Ethical frameworks from Islamic perspectives. *Frontiers in AI Ethics, 5*(1), 112–130. https://doi.org/10.3389/frai.2024.00112

Kannike, U. M. M., & Fahm, A. O. (2024). Exploring the ethical governance of artificial intelligence from an Islamic ethical perspective. *Jurnal Fiqh, 21*(1), 161–188.

Klerkx, L., Jakku, E., & Labarthe, P. (2019). A review of social science on digital agriculture. *NJAS – Wageningen Journal of Life Sciences, 90–91*, 100315. https://doi.org/10.1016/j.njas.2019.100315

Liakos, K. G., Busato, P., Moshou, D., Pearson, S., & Bochtis, D. (2018). Machine learning in agriculture: A review. *Sensors, 18*(8), 2674. https://doi.org/10.3390/s18082674

Maulana, A. S., Anas, A., & Izza, M. (2026). Legal Certainty within Indonesia's Halal Industry Regulatory Framework. *Jurnal Halal Center (JHC)*, *1*(1), 88–101. https://doi.org/https://doi.org/10.28918/jhc.v1i1.14183

OECD. (2025). Governing with artificial intelligence: The state of play and way forward. Paris: OECD Publishing. https://doi.org/10.1787/795de142-en

OECD.AI. (2025). AI in agriculture: Risks, fairness, and governance. https://www.oecd.ai/publications/ai-agriculture

OECD.AI. (2025). How to govern AI in agriculture responsibly: Risks, tools and solutions. https://oecd.ai/en/wonk/how-to-govern-ai-in-agriculture-responsibly-risks-tools-and-solutions

Revolutionizing agriculture. (2025). Digital farming and resource optimization: Global trends. https://www.revolutionizingagriculture.com

Revolutionizing agriculture: A review of smart farming technologies for a sustainable future. (2025). *Discover Applied Sciences*. https://doi.org/10.1007/s42452-025-07561-6

SNS Insider. (2025). Agriculture IoT market size, share & growth report 2032. https://snsinsider.com

Tey, Y. S., et al. (2025). Digital agriculture technology adoption in low- and middle-income countries. *Frontiers in Sustainable Food Systems, 9*. https://doi.org/10.3389/fsufs.2025.1621851

Trends in IoT and precision farming. (2025). *Farmonaut Precision Agriculture Insights*. https://farmonaut.com/precision-farming/iot-in-smart-precision-agriculture-7-trends-for-2025

Van den Hoven, J., Vermaas, P. E., & van de Poel, I. (Eds.). (2015). *Design for values: Essays on moral frameworks and technology design* (pp. 1-15). Springer. https://doi.org/10.1007/978-94-017-9497-8

Wolfert, S., Ge, L., Verdouw, C., & Bogaardt, M.-J. (2017). Big data in smart farming: A review. *Agricultural Systems, 153*, 69–80. https://doi.org/10.1016/j.agsy.2017.01.023

Yan, L., et al. (2025). AI in business operations: Driving urban growth and societal sustainability. *Frontiers in Artificial Intelligence, 8*. https://doi.org/10.3389/frai.2025.1568210

REFERENCES