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The Growing Scope of Science and Technology in the Modern World and Its Impact on the Agricultural Sector: A Brief Analysis

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Abstract

The rapid expansion of science and technology in the modern world has significantly transformed various sectors, particularly agriculture. With growing population pressure, climate variability, and the demand for sustainable food production, technological innovations such as artificial intelligence, biotechnology, remote sensing, precision farming, and digital platforms have become increasingly important. These advancements aim to enhance productivity, resource efficiency, and environmental sustainability while improving farmers' livelihoods. This study briefly analyzes the impact of modern scientific and technological developments on the agricultural sector, focusing on productivity enhancement, risk management, and sustainable practices. The significance of this research lies in understanding how technological adoption can address food security challenges, optimise resource utilization, and support climate-resilient agriculture. The research methodology is based primarily on qualitative analysis using secondary data sources, including academic journals, government reports, and credible online databases. Comparative analysis is employed to examine traditional versus technology-driven agricultural practices. The findings suggest that while science and technology have improved agricultural efficiency and decision-making, challenges such as digital divide, cost barriers, and knowledge gaps still exist. Addressing these issues is essential for inclusive and sustainable agricultural development.

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1. INTRODUCTION

Agriculture has always been central to human survival. The agriculture sector forms almost about 18 percent of India's GDP despite employing almost 65 percent of the total workforce. Recent survey indicates that more than 60 % of the population is in to agriculture and the majority among the rest is connected to the other aspects of agricultural practices (Saraswat rakesh, 2024). The other facets of agricultural practices include agricultural machinery companies, fertilizer companies, crop yield marketing and sales companies etc. Traditionally dependent on manual labour and natural cycles, agriculture is now strongly influenced by scientific and technological innovation. Rapid population growth, climate change, water scarcity, and environmental degradation have increased the need for efficient food production systems. Technology such as AI, biotechnology, mechanization, satellite monitoring, and ICT platforms like as e-ganna kisan app, now plays a major role in agricultural development (Khan et al.,2022). These tools help improve crop productivity, optimize resource use, and reduce environmental impacts.

2. LITERATURE REVIEW

Research shows that precision agriculture, biotechnology, AI-driven analytics, and smart irrigation systems significantly enhance productivity and sustainability. Studies indicate improvements in yield, reduced fertilizer use, better water management, and improved farm profitability (Yao, S. & Wu, G. 2024). In 1960, during the Green Revolution, India managed to achieve self-sufficiency in foodgrain production by leveraging modern methods of agriculture like chemical fertilizers, pesticides, higher quality seeds, and proper irrigation (Kumar prakash, 2025). However, barriers such as high cost, lack of technical skills, digital divide, and data privacy concerns limit adoption, especially in developing countries. The overall farm mechanization level in India is around 47%, while developed nations have over 90% (ICAR Report, 2023-24). Modern agriculture is undergoing a technological revolution, often called Agriculture 4.0, which utilizes AI, IoT, drones, and automation to increase efficiency, sustainability, and crop yields while reducing resource usage. Key technologies include precision GPS for tractor guidance, soil sensors for monitoring, automated robots for harvesting, and AI-driven weather analysis.

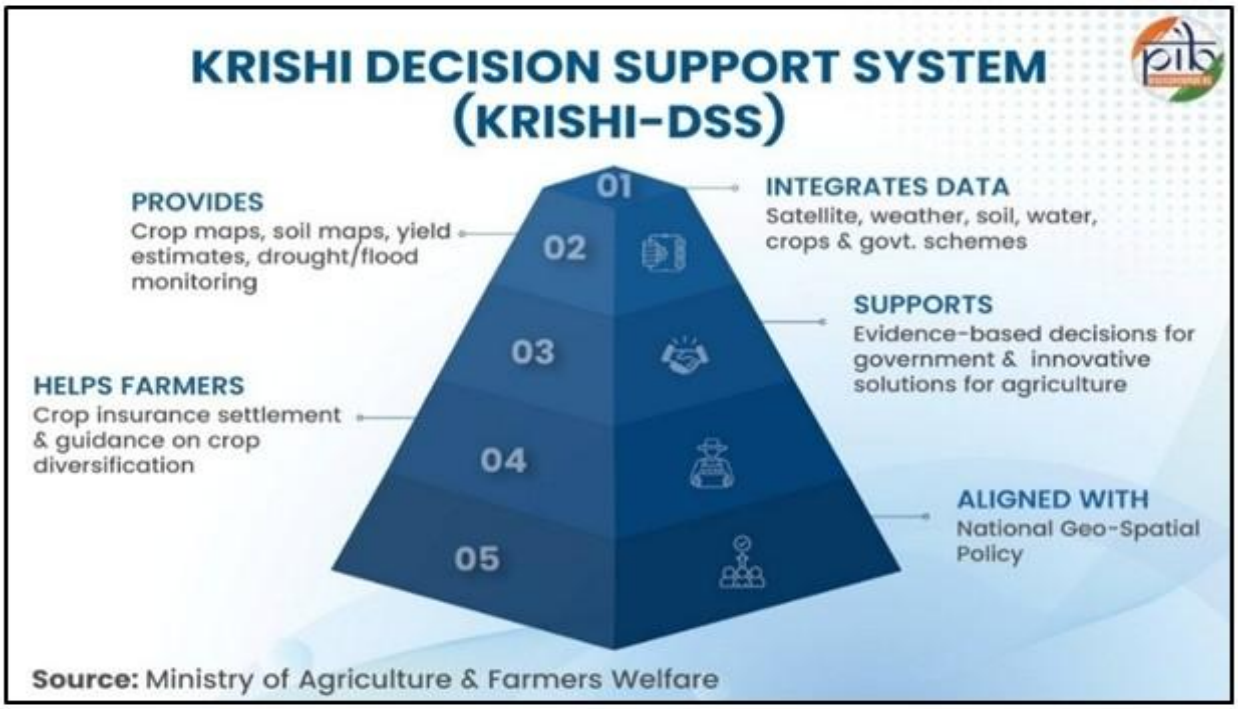
3. RESEARCH METHODOLOGY

This research adopts a qualitative methodology based on secondary data sources. Academic journals, research reports, and policy documents were analyzed to understand technological trends and their agricultural impacts. Comparative and descriptive analysis methods were used to interpret findings. By adhering to this methodology, this review aims to provide a transparent, reproducible, and comprehensive assessment of the role of modern technologies in enhancing agricultural productivity and land use efficiency.

Scope of Science and Technology

Modern science and technology include digital agriculture, biotechnology, AI-based analytics, robotics, satellite monitoring, and automated machinery. There is very high scope in agriculture sector with various technologies such as-

1. Information technology helps farmers access weather forecasts, markets, and advisory services.



Source- PIB, https://www.pib.gov.in/PressNoteDetails.aspx?id=157351&NoteId=157351&ModuleId=3&reg=3&lang=2

2. Biotechnology and genetic engineering improve crop resilience. Recent advances in biotechnology and genetic engineering have revolutionized agriculture by developing drought-resistant crops, CRISPR-edited varieties, and genetically modified organisms (GMOs), each playing a critical role in enhancing food security under climate change (Varshney et al., 2021).
3. Remote sensing assists in crop monitoring, and mechanization improves operational efficiency. Observing the strength of harvests over a huge region becomes significantly simpler with the utilization of remote sensing in agriculture. (Rekha, B.U. et al. 2018).
4. Smart irrigation systems, integrating IoT-based sensors and drip irrigation technologies, are transforming water management by optimizing usage, reducing waste, and enhancing crop yields (NITI Aayog report, 2025).
5. Automation & robotics technologies eg. Self-driving tractors, Autonomous and Case IH's Autonomous Concept Vehicle, utilize GPS, and computer vision to navigate fields with centimeter-level accuracy, enabling 24/7 operation without human intervention (Lowenberg-DeBoer et al., 2020).
6. The integration of Big Data and Artificial Intelligence (AI) into agriculture has ushered in a new era of precision farming, enabling farmers to make data-driven decisions that optimize productivity, reduce waste, and enhance sustainability.
7. Precision agriculture is a management strategy that gathers, processes and analyzes temporal, spatial and individual plant and animal data and combines it with other information to support management decisions according to estimated variability for improved resource use efficiency, productivity, quality, profitability and sustainability of agricultural production.

Impact on Agriculture

Technology increases productivity, improves water and fertilizer efficiency, enhances climate resilience, and increases farmer's income (Singh Radhamohan, agriculture minister, 2018). Digital Technologies such as ICT, Artificial Intelligence, Big Data, IoT etc. can play a transformative role in modernising agriculture, make it more Industrialised and usher in constructive disruption. Precision agriculture reduces waste and environmental damage. A central component of implementing this strategy is the satellite monitoring of agricultural machinery, which forms the basis for modern farm fleet management (Sahay Jagdishwar, 2022). AI improves pest detection, yield prediction, and farm decision-making. Biotechnology supports disease-resistant crop varieties and higher nutritional value. Having a range of technologies enables the transition of modern agriculture in the field. There are many promising trends and pilot projects in modern technology in agriculture. For example: Village level entrepreneurs use of analysis of soils and drainage, crop health monitoring, yield prediction, and pesticide and fertiliser spot spraying. Thus, Technologies can enable the transition of modern agriculture in the field.

Challenges

Despite benefits, technological adoption faces challenges including high costs, lack of digital infrastructure, technical skill gaps, environmental risks, and data privacy concerns (Katke Kadambini, 2019). Small farmers often struggle to access advanced tools, leading to inequality in technological benefits such as most small farmers lack awareness about satellite advisories. E.g., ISRO's FASAL not widely adopted. Only 25% of farmers are comfortable using digital tools like smartphones and the internet (Cultivating the future: Bridging the digital divide in indian agriculture, Censa Reap, 2024). Agricultural extension workers lack training in remote sensing tools. E.g., Krishi Vigyan Kendras underutilize Bhuvan. According to a 2022 report by TRAI, rural broadband penetration remains significantly lower than urban areas.

Future Prospects

The future of technology in agriculture is rapidly shifting from experimental, isolated tools to fully integrated, AI-driven, and automated systems (Agriculture 4.0). However, recent advancements in digital technology, data analytics, automation, and biotechnology have exponentially accelerated the pace of innovation (Abayneh, et al., 2004 & Behnke K & Janssen, 2020). By 2025–2030, this transformation is expected to redefine global food production, aiming to support a projected population of nearly 10 billion by 2050. Future agriculture will focus on climate-smart technologies, sustainable farming, AI-driven analytics, biotechnology innovation, and digital farm management systems (Havelaar, 2015 & Li A, 2015). Technology will be crucial for global food security and environmental sustainability.Keep in mind with these things policy must move from data scarcity to creating secure, interoperable, and centralized data platforms where data is treated as "the new soil".

4. CONCLUSION

Science and technology have revolutionized agriculture by improving productivity, efficiency, and sustainability. However, equitable access, environmental protection, and farmer training are essential for maximizing benefits. Balanced technological integration will play a critical role in ensuring food security and sustainable agricultural development worldwide.Therefore, policy makers, farmers and industrialists should work together to make this 'golden opportunity' of modern agriculture socially useful.The integration of science and technology into farming is no longer just a possibility—it is the future of agriculture.

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