

COLLEGE TRB PAPER 2

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Role of Science and Technology in Transforming Indian Agriculture

Agriculture has always been a central pillar of India's economy, supporting livelihoods, ensuring food security, and sustaining rural development. However, traditional farming practices alone are no longer sufficient to meet the demands of a growing population, climate variability, resource constraints, and global market competition. Science and technology have therefore emerged as powerful drivers in transforming Indian agriculture, shifting it from a subsistence-oriented system to a more productive, climate-resilient, market-linked, and knowledge-driven sector.

1. Enhancing Productivity Through Technological Innovation

The Green Revolution marked the first major technological transformation, introducing high-yielding seed varieties, chemical fertilisers and irrigation expansion. Today, newer scientific advancements are pushing productivity further. Hybrid seeds, improved plant genetics, and biofortified crops increase yields as well as nutritional value. Tissue culture, micro-propagation, and seed treatment technologies ensure healthier and uniform plant growth. Mechanisation—tractors, harvesters, seed drills and drones—reduces time, labour burden and costs while improving precision.

2. Precision Agriculture and Smart Farming

Modern agriculture increasingly relies on data and automation. Precision farming uses satellite imagery, soil sensors, GPS-enabled equipment and drones to monitor crops, analyse soil health, measure moisture, and detect pests. This allows farmers to apply the right amount of fertiliser, water, and pesticides at the right time, reducing wastage and improving efficiency. Smart irrigation systems such as drip and sprinkler technologies help farmers cope with water scarcity by delivering water directly to root zones.

3. Biotechnology for Food and Nutritional Security

Biotechnology has become a crucial tool in strengthening India's food system. Genetically modified and genetically edited crops offer resistance to pests, diseases and climate stress, thereby reducing yield losses. Biofertilisers and biopesticides provide safer alternatives to chemicals, improving soil health and reducing environmental damage. Research in genomics, plant breeding and microbial applications helps create crop varieties suited to diverse agro-climatic zones, enhancing both productivity and resilience.

4. Climate-Smart Agricultural Technologies

Climate change poses a major threat to Indian agriculture, making climate-smart technologies essential. Weather forecasting systems, early warning alerts and mobile advisory services prepare farmers for extreme events. Climate-resilient seed varieties can withstand drought, floods and high temperatures. Conservation agriculture techniques—including minimum

tillage, crop rotation and integrated nutrient management—help retain soil moisture, improve fertility, and reduce greenhouse gas emissions.

5. Digital Technologies and Information Access

Digital tools have expanded the flow of information, connecting farmers to knowledge, markets and services. Mobile apps provide weather updates, scientific advice, crop schedules and price information. Online marketplaces allow farmers to sell produce directly, increasing income and reducing dependence on middlemen. Geospatial mapping, remote sensing, and AI-based crop advisory systems support government planning and extension services, making agriculture data-driven and transparent.

6. Post-Harvest Management and Value Addition

Science and technology also play a vital role beyond the farm. Modern storage technologies, cold chains, food processing and packaging innovations reduce post-harvest losses and extend shelf life. Mechanised sorting, grading and processing create new rural enterprises and jobs. These advancements help farmers gain better prices and integrate more effectively into national and global value chains.

Science and technology have transformed Indian agriculture from traditional practices to a modern, resilient and market-oriented system. They enhance productivity, reduce risks, promote sustainability, and empower farmers with better tools, information and opportunities. As India faces increasing pressure on land, water and climate, the role of technological innovation becomes even more critical. Strengthening research, improving digital literacy, expanding extension services and ensuring equitable access to technology will determine how effectively agriculture can support India's long-term growth and food security.