SMART FARMING TECHNOLOGIES FOR SUSTAINABLE AGRICULTURE

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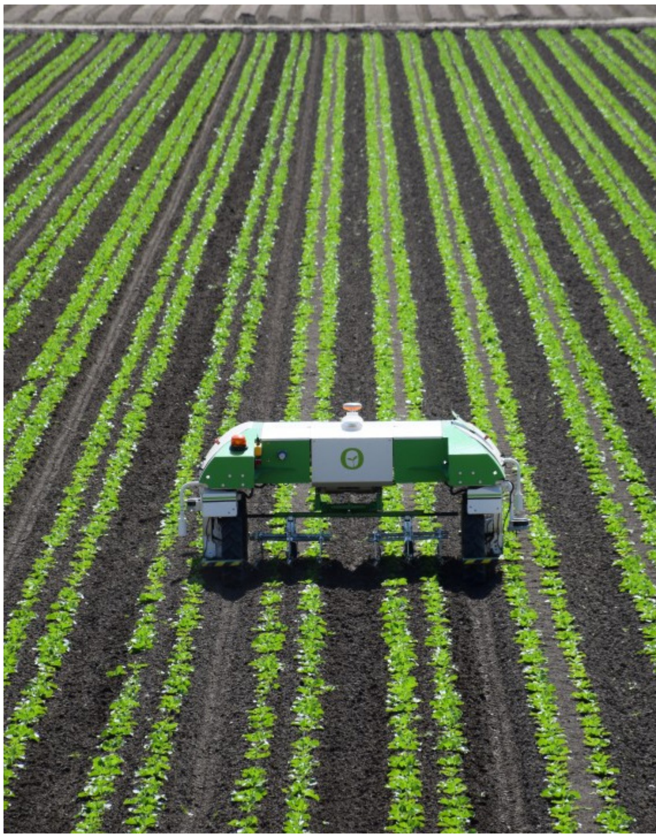
INTRODUCTION



Farming faces challenges that increase the adverse effects on farms' economics, labour, and the environment. Smart farming technologies (SFTs) are expected to assist in reverting this situation. Smart farming, often called smart agriculture, involves utilizing cutting-edge technologies and data-driven farm operations to maximize and enhance sustainability in agricultural output. "Smart Farming Technologies" is a new component that aims to improve agricultural operations' sustainability and production. Tracking animal locations inside and outside of farms, observing patterns in livestock behaviour, early disease detection of crops, less crop waste, and effective crop harvesting are just a few ways farmers can profit from SFT. This strategy aims to improve agricultural productivity, sustainability, and efficiency by leveraging drones, sensors, and data analytics. The farms and agricultural locations that use smart farming techniques are known as smart farms. Smart farming, in a nutshell, is farming with brains! It uses technology like sensors, drones, robots, and even AI to make farming more efficient, sustainable, and profitable.

KEY TECHNOLOGIES:

Precision agriculture (PA) systems, agricultural automation and robotics, and farm management information systems (FMIS) are the three primary categories into which smart farming technologies (SFTs) fall.

1. **Precision Agriculture (PA) Systems:** Precision farming refers to the application of agricultural management techniques based on the specific conditions of the land. It is regarded as a philosophy, an idea, and a managerial technique. In essence, PA projects the picture of certain computer programs that operate the machinery through satellite signals or local sensor arrangements that can forecast crop development. Precision agriculture, often known as high-tech sensor and analytic technologies, is the science of increasing agricultural yields and supporting management decisions. The idea behind precision agriculture was to "farm to the soil," understanding that soil is a geographically variable continuum and that its effects on production are also spatially variable.

Components of PA:

- **Global Positioning System (GPS):** Farmers can precisely gather soil samples from a designated spot in the field each year by using GPS navigators. This allows them to keep an eye on crop conditions and observe the macro- and micro-scale spatial variability of soils. Examining the agricultural property might also produce the entire architecture, including field boundaries, field area acreage, roads, irrigation systems, distances between locations, and areas impacted by weeds and diseases.

- **Geographical Information System (GIS):** The geographic information system (GIS) is regarded as PA's brain. GIS is crucial for the handling and storing of location-specific data since it can quickly assess and process vast amounts of data. Analyzing satellite imagery and maps obtained by satellite information systems for land cover and land management simultaneously could also save time and money.

- **Remote sensing (RS):** Remote sensing (RS) collection of data is done by sensors that are placed on satellites or mounted on aircraft, by detecting the energy that is reflected from Earth. Both passive and active remote sensors are available. While active sensors employ internal stimuli projected by the instrument itself to gather data about Earth, passive sensors respond to external stimuli, most often the reflected sunlight from the Earth's surface, and record this natural energy.

- **Variable Rate Technologyy (VRT):** Variable Rate Technology (VRT) is used in PA to precisely apply inputs in variable types and quantities on various plots of land under the needs and current situation. A multi-year analysis of one or more variables that impact crop output as well as the yield values of the crop of interest is conducted for VRT, and the outcome is the successful creation of management zones with clearly defined features and management recommendations. Variable rate technology, or VRT, and variable rate applications, use programmed machinery coupled to sprayers to apply the right quantity of chemicals based on farm factors, such as crop condition and development stage, as well as data gathered earlier on crop growth.

2. **Agricultural automation and robotics:** Automation and robotics have a big part to play in helping society meet its needs for agricultural productivity. Industrial production and products have become more efficient and less expensive thanks in large part to the contribution of robots. Self-guided tractors and harvesters that rely on GPS and vision have already become commercially accessible, marking the beginning of a similar trend in agriculture during the last two decades. In the last few years, farmers have begun experimenting with autonomous devices that can replace or automate tasks like weed eradication, mowing, spraying, pruning, thinning, and harvesting. Workers utilizing robotic platforms have demonstrated twice the efficiency of those utilizing ladders in the fruit tree sector, for instance. The most efficient use of resources and integrated management of pests and diseases is made possible by developments in sensors and control systems. The way that food is cultivated, cared for, and harvested is about to undergo a revolutionary shift that has just begun.

Components of Agricultural automation and robotics:

- **Automated machinery:** Automated control systems and GPS are available for smart tractors and other farm equipment. As a result, waste may be decreased and overall productivity can be increased through accurate and effective planting, harvesting, and other duties e.g.- Autonomous tractors, Eco robotics robot weeder, laser land leveller, etc.

- **Robotics:** A variety of jobs, including weeding, fruit picking, and crop status monitoring, can be carried out by agricultural robots. These robots can be remotely commanded or operated on their own e.g.- Tractor trailed sprayer, orchard prunner, flower & fruit thinner, mechanical fruit harvester, trunk shaker, etc.

- **Weather Forecasting Tools:** Farmers can more efficiently organize their operations, including planting, harvesting, and irrigation when they have access to timely and accurate weather forecasts e.g.- doppler radar, radiosondes, weather satellites, buoys, etc.

- **Farm Management Software:** Entire farm management is made easier for farmers by comprehensive software solutions. These platforms provide insights into crop yields, costs, and profitability by integrating data from multiple sources e.g.- Agrivi, Granular, Trimble, FarmERP, FarmLogs, Agworld, AgriWebb, etc.

- **Livestock Monitoring Systems:** Wearable animal technology, which offers real-time data on behaviour, location, and health, is one example of a smart tool for livestock husbandry e.g.- cattle watch, automated milking systems, drones, heat sensors, etc.

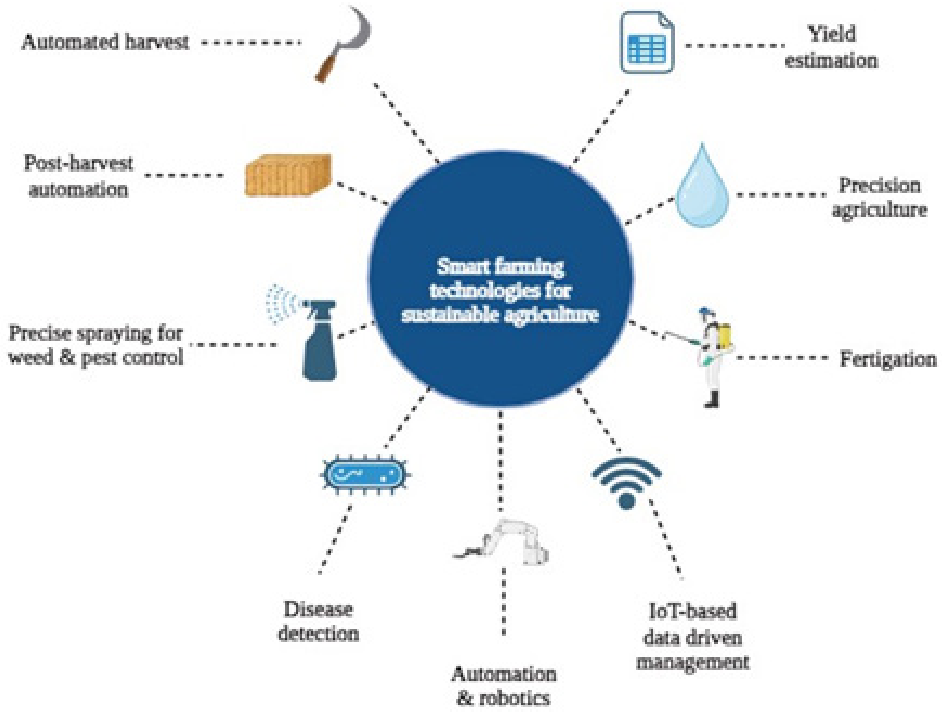
3. **Farm management information systems (FMIS):** Farm management information systems (FMIS) that are accurate and simple to use are essential to a productive farm's operations. Still, a lot of farmers do not use FMISs these days for a variety of reasons, including ignorance and the complexity of the many FMISs that are available. Appropriate FMISs are rare, especially for small to medium-sized farms and multifunctional farms. The goal of this study is to deduce a specific FMIS from a general FMIS. The requirements of medium-sized, multifunctional farms must be the primary emphasis of the concrete FMIS. This implies that the farmer needs to have the authority to distribute the farm's limited resources. It can help farmers by managing farm information, making decisions, reducing production costs, maintaining product quality and safety.

Components of Farm Management Information Systems:

- **Data acquisition:** Record information in real time about a range of topics, such as plant health, animal activity, temperature, moisture content of the soil, and so on. Utilizing GPS or drones makes digital maps of features, boundaries, and fields. Sensors that gather data while an apparatus is being operated are frequently seen on modern tractors and machinery. Financial transactions, labour hours, and other data can be manually entered by farmers.

- **Data storage and management:** For quick access and analysis, securely store gathered data in a centralized system. provides remote data access as well as scalability.

- **Communication and decision support:** Be advised in a timely manner of possible issues such as equipment malfunctions, bug infestations, etc. To plan planting and harvesting schedules, manage risks, and allocate resources optimally, use data-driven insights.



BENEFITS OF SMART FARMING TECHNOLOGIES:

Technologies for smart farming are transforming the agricultural sector thanks to developments in data collecting, analysis, and automation. A more economic, sustainable, and productive farming future is possible because of the many advantages these technologies bring. Here are a few salient points:

- **Reduced environmental impact:** Precision farming preserves soil health and lowers pollution by using less water, fertilizer, an d pesticides. Making data-based decisions encourages more effective watering, reducing waste, and guaranteeing optimal use. Automation and precision techniques can reduce emissions and fuel use, which helps mitigate the effects of climate change.
- **Increased efficiency and productivity:** To minimize waste and maximize input consumption, sensors, and targeted applications make sure resources get to the correct location at the right time. Farmers may increase accuracy and free up time by using drones, robots, and self-driving gear to complete monotonous jobs. Better planning results in increased yields and better resource management since it is informed by real-time information and predictive analytics.
- **Improved food security and quality:** The increasing demand for food around the world is met in part by increased productivity and efficiency. Improved food safety and quality are ensured by continuous monitoring and traceability throughout the production process. More

food is available because post-harvest losses are reduced by precise procedures and better storage options.

- **Enhanced profitability and financial resilience:** Increased yields and maybe higher market prices are the result of greater resource utilization and optimized procedures. Profitability is increased by savings from effective resource usage, automation, and focused applications. Farmers may anticipate and reduce risks by using real-time monitoring and predictive analytics, which can lower losses and increase financial stability.

- **Improve labour conditions:** Farmers can focus on more important duties thanks to automation, which also enhances work-life balance and draws in new talent to the sector.

- **Better traceability and transparency:** Customers become more assured about the provenance and handling methods of food.

LIMITATION:

Smart farming technologies have some drawbacks and difficulties despite their many advantages for sustainable agriculture. The upfront costs associated with putting smart farming technology into practice can be high and include infrastructure, software, equipment, and sensor purchases. The adoption and efficacy of smart farming solutions can be impeded in rural and isolated areas due to restricted access to technology and dependable internet connectivity. Security and privacy issues are brought up by the gathering and administration of massive amounts of agricultural data. Specific expertise and abilities are frequently needed for smart farming technology to function and be maintained efficiently. Interoperability standards are lacking, and compatibility problems might make it difficult to integrate disparate technology from multiple sources.

CONCLUSION:

Smart farming is a revolution in sustainable agriculture, driven by technology and data, not just a fad. Its advantages are numerous, ranging from increasing yields to reducing environmental effects. Imagine more food, less waste, and a healthier planet as a result of data-driven decision-making, empowered farmers, and efficient resource use. Even with obstacles like cost and accessibility, things look promising. Smart farming holds the key to enabling a safe and sustainable food system that will benefit future generations by embracing innovation and inclusivity.