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# Sanrakshak Agribot: A Precision Farming System for Sustainable and Efficient Crop Monitoring

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**Abstract**

Agriculture has always been one of the most important economic activities in India. Almost 50% of the Indian population depends on it for a living. It not only feeds more than a billion people, but it is also a primary source of raw materials for industries, a source of foreign exchange and a significant source of employment. Yet Indian farming is highly sensitive and fragile. Farmers always have to deal with water shortages, uneven rainfall, increased input prices, and a declining workforce. Crop diseases and pests are typically noticed only after the damage is already done, which leads to heavy losses in yield, wastage of precious water, and a direct hit on the farmer's income. It is not merely a question of more, but smarter--with less, preserving the environment, and ensuring that the soil is healthy even in the future.

Precision farming has new opportunities in recent years due to the Internet of Things (IoT) and agricultural robotics. The sensors installed over the field are now capable of constantly monitoring soil moisture, temperature and humidity and relaying this information to the farmer. This implies that the farmer does not need to walk the whole field daily to monitor the situation; rather, real-time information is available at hand, allowing smarter decisions about when and where to water. The outcome is the saving of water and labor, as well as a healthier crop. IoT is simply taking farming out of guesswork and making it data-driven, and it is this concept that is the basis of our project.

Based on this concept, we present the SANRAKSHAK AGRIBOT — a single, affordable robotic platform designed to monitor and protect the field with minimal human effort. The aim of our system is simple: to give every farmer a reliable assistant that monitors the crop and soil at all times, broadcasts live video so that it can be inspected remotely, and waters the crop automatically when the soil becomes dry. The integration of monitoring and care into a single platform will enable us to minimise water consumption, decrease labour requirements, and enhance crop yields—at a price that can be afforded by a small farmer. The concept and purpose of the system have been presented in this paper, and the in-depth architecture and the components are described in subsequent sections.

## 1. Introduction

### Importance of Agriculture in India

Agriculture is the backbone of the Indian economy and the primary source of livelihood for a large share of the population. The recent estimates show that a significant portion of the Indian labor force is involved in farming and related processes (almost 50 percent). The sector is a major contributor to the national income, a source of raw material to a large number of industries and a major source of foreign exchange due to exports. Agriculture is not only an economic activity, but it is also a social and cultural activity of the country.

Irrespective of its significance, Indian agriculture is experiencing several long-term challenges. One of the most serious is the lack of water. The monsoon is relied on by much of the country, and rain is generally uneven and unpredictable. Where rains are late or fail,
crops suffer, and farmers are left with little recourse. Concurrently, the prices of inputs, including seeds, fertilizers, and labour, have been gradually increasing, and this has put the small and marginal farmers, who constitute the majority of the farming community, at a squeeze.

Another issue that is increasing is labor. Younger generations are increasingly moving away from farm work, leaving an ageing workforce behind. This complicates the process of conducting labor-intensive activities like monitoring of big fields, watering plants and checking plants to eliminate pests and disease. Due to the slow and time-consuming nature of manual monitoring, issues are usually identified only after they have spread and done real harm. When a farmer realises that there is a pest infestation, water shortage or a spot of diseased plants, a large part of the crop might have been wasted.

It is not merely a question, then, of producing more food, but of producing it more intelligently. Indian agriculture needs methods that consume less water and fewer chemicals, require less manpower, conserve the environment and ensure the soil remains productive for the generations to come. Here, modern technology plays a significant role.

### The Role of IoT in Agriculture

The Internet of Things (IoT) is a network of physical devices, sensors, cameras, controllers and machines, which are interconnected to the internet and are capable of collecting, transmitting, and responding to data. IoT in agriculture has introduced the idea of precision farming, in which decisions are made based on field data, not guesswork or averages.

With IoT-based systems, sensors can be installed in a field to measure a wide variety of parameters. Soil moisture sensors give an indication of the amount of water that the soil actually has, and thus irrigation can only be used when it is really necessary. Cameras and vision systems enable the farmer to view the field in real-time, so they do not have to walk through all the rows to inspect crops. All this data may be transmitted to a computer, providing a farmer with a constantly updated and precise view of the situation in the field. The advantages of this method are significant. Water, the most constrained resource, can be utilized much more efficiently by irrigation where and when it is needed. The need for labour is less since it is possible to monitor remotely. The crops will be healthier since the issues can be identified at an early stage. And since the resources are used more efficiently, the environmental footprint of agriculture

becomes smaller.

IoT is essentially transforming the field of agriculture into a more data-driven field rather than an experience- and intuition-driven field. It is this transformation that motivates our project.

**Problem Statement and Supporting Data**

The above-described challenges are not just qualitative, as they are also reflected in the well-documented statistics. The next tables highlight the most important figures of water use and loss, water stress and crop failure, and the potential of precision irrigation. These data underline the need for a low-cost, always-on monitoring and care platform such as the SANRAKSHAK AGRIBOT.

**Table 1: Water Use and Loss in Indian Agriculture**

| Indicator | Value |
|---|---|
| Share of India's freshwater consumed by agriculture | 80–90% |
| Irrigation water lost to evaporation, runoff, or deep percolation before reaching roots | Varies by irrigation method and local conditions |
| Share of losses attributable to evaporation in flood irrigation | Varies by soil, climate, and irrigation practices |
| Area brought under micro-irrigation in India | > Over 11.5 million hectares |

**Table 2: Water Stress and Crop Failure**

| Indicator | Value |
|---|---|
| Borewells that had dried up in a study across ~100 villages in Karnataka | Over 60% |
| Reduction in farm income for farmers with dried-up wells | ~25% lower |

**Table 3: Potential Benefits of Precision Irrigation**

| Indicator | Value |
|---|---|
| Water saved through drip/micro-irrigation | 30–70% |
| Yield increase from drip/micro-irrigation | Varies by crop and region; substantial increases have been reported in some studies |

These numbers indicate two essential gaps that the SANRAKSHAK AGRIBOT is meant to address. To begin with, the dramatic loss of irrigation water suggests that irrigation decisions should be made on the basis of real-time soil moisture, and not by guesses. Second,
since field monitoring is slow, and sporadic, manual, monitoring methods are slow to detect pests, disease, and water stress until they have caused damage and has already spread. Both of the issues are directly

addressed by an always-on system that keeps an eye on the field and waters the crop automatically.

## The SANRAKSHAK AGRIBOT

### Concept and Aim

The SANRAKSHAK AGRIBOT is a single, multi-function robotic platform designed to monitor and protect agricultural fields with minimal human effort. The name reflects the system's purpose: to act as a guardian of the crop, keeping a constant watch and responding to conditions in the field.

The core idea is to combine two essential functions—monitoring and care—into one affordable platform, rather than requiring a farmer to purchase and maintain separate machines for each task. The system is intended to be accessible to small and marginal farmers, for whom cost is often the deciding factor in adopting new technology.

The aim of the SANRAKSHAK AGRIBOT is to:

- Provide continuous, real-time monitoring of crop and soil conditions.
- Stream live video from the field for remote inspection.
- Automatically irrigate the crop when soil moisture falls below a set threshold.
- Reduce water usage, labor demands, and input costs.
- Improve crop productivity and field safety.

By delivering these capabilities in a single platform, the system seeks to make smart farming practical and affordable for the farmers who need it most.

### System Architecture

The SANRAKSHAK AGRIBOT is designed based on the ESP32-CAM module, which is the processing unit of the system. The ESP32-CAM is a powerful microcontroller with an inbuilt camera, giving the robot the ability to stream live video and capture images, as well as process sensor data and drive its motors and actuators.

The robot is attached to a four-wheel chassis which is heavy-duty and powered by metal gear motors. The motors are controlled by two BTS7960 motor drivers, which control one pair of wheels each. This design provides the control and torque to navigate through rough terrain in the field.

To drive and position tools, MG996R servo motors are used and driven by a PCA9685 servo driver board. This enables the camera and any other mechanisms attached to it to move accurately.

A rechargeable battery pack of a size to accommodate the combined weight of the motors, sensors, and pump drives the system. A key design factor is power management, as the robot will have to work in the field over a long time.

**Sensing and Monitoring Capabilities**

The SANRAKSHAK AGRIBOT is equipped with a range of sensors that allow it to monitor the field environment continuously:

- **Soil moisture sensor:** Measures the water content of the soil, providing the data needed to decide when irrigation is required.
- **ESP32-CAM camera:** Captures and streams live video of the field for remote inspection by the operator.

Together, these sensors give the system a clear and continuous picture of the conditions in which the crop is growing.

**Modes of Operation**

The SANRAKSHAK AGRIBOT operates in two complementary modes:

**Monitoring Mode:** This mode makes the robot scan the field and collect data through its sensors. It measures soil moisture and streams live video back to the operator. This enables the farmer to check the crop remotely, detect possible issues at an early stage, and make decisions without having to walk the entire field.

**Care Mode:** In this mode, the robot takes action to care for the crop. The system is connected to the soil moisture sensor, which detects that the soil has become excessively dry, and thus automatically switches on the irrigation, which delivers water to the crop without the farmer being required to be present. This ensures that the crop gets water at the right time, and the crop is also not over-irrigated, leading to wastage.

The integration of these two modes enables the system to monitor the field as well as address the needs of the field on a single platform.

**Sanrakshak Agribot Mobile Application: Features And Functionality**

**1. Overview**

SANRAKSHAK AGRIBOT mobile application aims to provide a centralised application for farmers to monitor the state of their crops, manage the farm, get information about agriculture, and remotely control the robot. The application combines environmental monitoring, crop analysis, irrigation control, farm planning, and robotic controls into one interface.

It mainly aims at streamlining the management of a farm by ensuring that the necessary information is available in a single location. The application offers farmers an opportunity to manage the state of the field, arrange farm documents, check the market prices, research government programs, calculate the potential profitability of the farm, and control the robot with the help of supported controls. The system will help inform agricultural decision-making and limit the reliance on manual field inspection every day.

**2. Environmental Monitoring and Sensor Dashboard**

The application has a sensor dashboard to view environmental parameters and monitor field conditions.

- **Soil Moisture:** Shows soil moisture levels that can be used to estimate when irrigation is necessary.
- **Temperature:** Displays the temperature to inform the farmer about the environmental conditions affecting their crops.
- **Humidity:** Shows the humidity levels to aid in the evaluation of the field conditions.
- **Weather:** It offers weather data to assist farmers in scheduling irrigation and other farming practices.
- **Sensor Dashboard:** Displays any sensor values in a central display to easily monitor them.
- The features are meant to assist farmers in learning about changing field conditions and making timely decisions concerning crop care and irrigation.

**3. Crop Monitoring and Analysis**

The application has features that are meant to assist farmers in evaluating the condition of crops and planning cultivation.

- **Crop Status:** Gives a summary of the crop status based on the available observations and data.
- **Crop Analysis:** Assists in evaluating crop conditions, which would facilitate the determination of possible problems and agricultural decision-making.
- **Field Map:** This is a map view of the field to assist in field organisation and navigation.
- **Crop Rotation Planner:** Assists farmers in planning crop sequences over growing seasons to facilitate improved crop-management practices.

Collectively, these characteristics are supposed to enhance crop monitoring, assist in cultivation planning, and assist farmers in managing their fields effectively.

**4. Irrigation Management**

Irrigation module assists in the control of water supply to crops.

- **Irrigation Control:** Provides farmers with the opportunity to use supported irrigation functions with the help of the application.
- **Soil-Moisture-Based Irrigation:** This method uses soil moisture measurements to assist in determining when irrigation is necessary.
- **Robot-Based Watering:** Gives the operator the ability to turn on the watering mechanism of the robot using the robot-control interface.

The final hardware design incorporates a relay-controlled motor or a pump that is used in the watering mechanism. The system will use sensor information and irrigation controls to minimize unnecessary watering and enhance water management. Real water savings would be required to be tested.

**5. Farm Management and Agricultural Information**

The application offers tools to assist farm management and access to agricultural data.

- **Farm Records:** Allows farmers to keep organised records of farm operations, costs, crop information and other pertinent information.
- **Government Schemes:** This provides information on agricultural government schemes that can

provide financial assistance, subsidies, or other benefits to eligible farmers.

- **Market Prices:** Shows the available agricultural market-price information to assist farmers in determining the current prices as they prepare to sell.
- **Alerts and Notifications:** Provides notifications about relevant events, such as sensor readings crossing configured thresholds, irrigation requirements, and other system alerts.

These capabilities are designed to unite farm management and agricultural information with the monitoring and control capabilities of the robot.

**6. Farm Profit Calculator**

The Farm Profit Calculator is intended to assist farmers in estimating the financial performance of their farm operations. Users can estimate their profit or loss of a crop or a farming season by entering the appropriate income and expense data.

The calculator can use the following information:

- **Expected Revenue:** The amount of money that is expected to be raised by selling the crops that are harvested.
- **Cultivation Costs:** Costs of seeds, fertilisers, pesticides, labour and irrigation.
- **Equipment and Maintenance Costs:** Equipment and maintenance costs of relevant machinery.
- **Other Farm Expenses:** Other expenses related to harvesting and cultivation.
- **Estimated Profit or Loss:** It is the difference between the total estimated revenue and the total estimated expenses.

**Advantages of the System**

The SANRAKSHAK AGRIBOT has a number of significant benefits compared to conventional methods of farming and to single-purpose agricultural machinery:

- **Affordability:** The system will make adopting smart farming technology affordable by integrating monitoring and care into a single platform.
- **Water conservation:** Automated irrigation using real-time soil moisture measurements will ensure that water is applied only when required, thus saving on water wastage.
- **Reduced labour:** Remote monitoring and automatic irrigation minimise the use of manual field work.
- **Improved productivity:** Timely identification of issues and regular attention contribute to maintaining crops and enhancing yields.
- **Ease of use:** The system is intended to be used by farmers with little technical training, with a simple mobile interface.
- **Scalability:** The design can be expanded to bigger fields and other functions in the future.

**Challenges and Limitations**

Although the SANRAKSHAK AGRIBOT has a lot of advantages, it has several issues that need to be overcome to be used in practice:

- **Battery life:** Motors, sensors, and a camera use a lot of power when used simultaneously. Long field operation requires an extension of battery life.
- **Field durability:** The robot should resist dust, moisture, heat, and rough field. Robust construction and weatherproofing are important considerations.
- **Cost of maintenance:** The initial cost will be kept low but the maintenance cost and repairs will also have to be affordable to the small farmers.
- **Technical knowledge:** Farmers might require training and assistance to use and maintain the system.

These are the issues that are being overcome by continuous design enhancements, and they are significant areas of future work.

**Future Scope**

**The SANRAKSHAK AGRIBOT is designed to grow and evolve. Several enhancements are planned for the future:**

- **AI-based disease and pest detection:** The system would be able to detect pests and diseases automatically using the camera and machine learning and alert the farmer.
- **Solar power:** The inclusion of solar panels would decrease the reliance on the battery and enable more time in the field.
- **GPS navigation:** GPS would help in autonomous navigation and more effective coverage of big fields.
- **Mobile application:** A special smartphone application would simplify the process of data viewing and control of the robot by farmers.
- **IoT cloud integration:** Data stored in the cloud would enable long-term analysis and improved decision-making in the long run.
- **Weather-based decisions:** The system would be smarter to incorporate weather predictions, which would guide the system to plan the irrigation and other activities.

Such advancements would complement the existing system to turn smart farming into an even more competent and accessible system.

## 2. Conclusion

Water scarcity, increasing prices, and a declining labour force are the major problems that Indian agriculture is facing. Agricultural robotics and the Internet of Things provide a viable way to achieve more efficient, data-driven agriculture. The SANRAKSHAK AGRIBOT brings all these concepts into one low-cost system that tracks the field and takes care of the crop without human intervention. The system will be a viable move towards sustainable and technology-driven farming by cutting down the use of water and labour and enhancing productivity. As it continues to develop, it can transform smart farming to be accessible to the farmers who require it the most.

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