Chapter 13
Smart Soil Monitoring System for Smart Agriculture

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ABSTRACT

Accurate and timely information is crucial to optimize resources. Sensors determine clay, organic matter, moisture, and nutrients of soil. Sensors at various locations are connected using different technologies. Its data will be automatically reported to cloud without any internet connection. Sensors broadcast data to local base stations (LBS) at different ranges of distances using WiFi, LPWAN, LoRa, Bluetooth, etc., and then to central base station (CBS), which is far away. Modulation, coding techniques, and line of sight keeps signal intact. Data from CBS goes to cloud for analysis, visualization, and trend analysis. This helps farmers to get frequent and real-time data without actual need of physical presence. It reduces manpower, water usage, and other costs of agriculture and has positive environmental impact. Integration with other data like weather forecasts gives more precise information. Convergence of technologies, sensors, cloud, automation, etc. without human interaction contributes to IoT.

INTRODUCTION

By the year 2050, population of world is expected to rise tremendously at 9.1 billion people as compared to 7.4 billion in 2016. Rise in income is driving people to expand their diets with more protein. As per report from Food and Agriculture Organization (FAO) of United Nations, farmers must increase their production by 70 percent as compared to current levels. Food growers must ramp up their production to feed the growing world population. Demand for food will be increased by approx 50 percent as com-

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pared to 2013 with the growth in population. It is estimated that urbanization growth will boost another 2.4 billion people in cities and towns(Ayaz et al. 2019). Growing urbanization leads to reduction of rural population and hence declining workforce for agriculture, even as demand for food is increasing. In addition to that, rural people are getting aged rapidly and there will be acute shortage of man power in coming future. Due to population growth and urbanization world's current farmland is becoming unsustainable, such that 25 percent of available agricultural land is already degraded. Water assets are already exceedingly utilized with near to 40 percent of world's rural population is facing water scarcity. Unbalanced fertilizers are used to restore yield which effects proportion of soil nutrients. Nitrogen (N), phosphorus (P), and potassium (K) are the major soil nutrients while iron, manganese, copper, zinc, boron, molybdenum, and chlorine are the minor ones of soil. Correct balance of these nutrients is essential for the plant growth and to have high yields. Macronutrient such as Nitrogen is responsible for the creation of amino acids; Phosphorous and Potassium helps in the formation of plant roots, photosynthesis and improves disease resistance. Soil fertility is decreased due to unbalance feeding of fertilizer without knowing the actual requirement of nutrient to a particular crop and irrigation at the wrong time of day.

The traditional approach of the agriculture is getting changed with evolution in science and technology. Integration of technology with agriculture improves and address the real need of consumers and maintains the demand and supply of food requirement. Modern farms and agriculture functions works differently due to progression in technology such as sensors, devices, machines, information technologies, fast communication networks. They use robots, sensors, aerial images, GPS technologies. Latest technology enables farmers to optimize resources and use fertilizers, water as per requirement. It is expected that with the advancement of technology, efficiency and productivity of agriculture will be increased as bigger and smaller farms are coming closure and getting more connected as compared to previous years. Collection of data is important to understand the patterns and data points are projected to increase by 4 million from an average farm. Internet of Things (IoT) makes it possible to analyze the structured and unstructured data so as to give more insights into food production (Kaur, Tomar, & Singh, 2018). IoT platforms are applying machine learning, artificial intelligence etc to data from field sensors and transforming agricultural systems into real AI systems. By analyzing and associating information about weather, seeds, soil, disease probability, pest attacks, farmers will make more informed decisions.

1. SOIL MONITORING AND ITS PARAMETERS

Food system in large part starts from soil. Taking care of land soil is essential for secured and sustained supply of food. It is often taken for granted and is an important natural resource. Composition and nature of soil varies with change in geographical location and also with climate, animals, and plants feeding on them, the soil's parent material, and soil's age. Basic components of soil are Minerals, Water, dead organic matter, air, and living microorganisms.

Depending upon the use of soil its composition may vary. For example, agricultural soil has about 45% minerals, 5% organic matter, 20-30% air, and similar portion of water. Further the exact composition depends on certain parameters like type of crop, terrain, temperature, humidity etc. Soil quality is the capability to deliver required nutrients, fertility, and components to plants for their desired growth. It changes and depends upon its usage and kind of crop farmers are cultivating. Key soil parameters are as Bulk density, texture, Water retention, Aggregation, temperature, moisture, soil organic carbon, and microbial biomass carbon. These properties are collected and a soil quality index is prepared. This

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