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Reshaping the Agriculture Sector of Pakistan through Innovative Agri-Tech Devices to Achieve Food Security †

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Abstract: Precision agriculture (PA) has the potential to radically transform agronomic systems. It is an effective approach for viable zone management in the agriculture field. In today's era of finite resources and drastic consequences of climate change, an approach to PA which is an integration of below-the-ground sensors, multispectral satellite imagery, and weather monitoring system is reshaping agriculture from static to smart. In this paper, a real-time case study at a lemon orchard in Gadap, Sindh, Pakistan is presented where PA practices are being implemented successfully. At the farm locally developed innovative agri-tech devices are deployed which are embedded with electrical conductivity, soil temperature, soil moisture sensor, and nitrogen, phosphorus, and potassium sensor to monitor real-time conditions of the soil for precision irrigation and fertilizer application. Along with device data, incorporation of weather data, agronomist advisory and use of satellite imagery offer a full-functioning monitoring system for viable decisions. This system also favors tracking variations in crop health & pest attack for precise pesticide spray. The data output is observed through a web application. Using these drivers for PA there was increased flowering in the orchard as compared to other farms in the vicinity. Hence, a promising surplus yield and least toxic better fruit quality are being obtained, along with the preservation of biodiversity and environment sustainability the output yield of lemons was quite better than the conventional agriculture practices. PA is an extraordinary approach to leap closer to food security.

Keywords: precision agriculture (PA); agri-tech devices; remote sensing; food security; Internet of Things (IoT)

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1. Introduction

Global food security drives the recent resurgence of interest in agronomic systems [1]. PA focuses on optimizing farm inputs and contributes to gap fulfillment between crop potential and productivity [2]. Together the IoT-based modules along with sensor probes, multispectral satellite imagery, and weather monitoring systems [3] constitute a management framework to achieve global food security along with the preservation of biodiversity and environment sustainability.

PA was being applied at a lemon farm in Gadap town by Crop2x an agri-tech company that locally develops IoT devices integrated with web applications to access real-time data of the field. The fertilizer for soil nutrients and pesticide treatment was considered through spatial variability with the aim to use resources efficiently and achieve high-quality fruits.

Results indicated that PA implemented in one cycle of lemon enhanced the number of flowers leading to a greater number of fruit formation, Hence farmers can improve the production of the crops by adopting PA practices to minimize soil degradation [4], conserve biodiversity, and maintain a sustainable environment to create the base of food security.

2. Method and Observation

The technological approach of PA implemented at the lemon farm aimed to reshape the agriculture practices in a structured path.

The study provided evidence that usage of resources can be reduced by accessing real-time data of the field conditions through IoT devices on web application coupled with agronomist advisory to take data-driven decisions for variable application of fertilizers, precise irrigation needed by crop for optimal growth, locating spatially low vegetation areas in field and pesticide spray management at ETL level considering weather data to maintain biodiversity and production of least toxic yield.

The highest output with better quality was achieved through PA integrating satellite imagery, fertilizer application, pesticide application, and precision irrigation/ The method is evidence that how the application of PA technology is a promising prospect for global food security and reshaping agriculture.

3. Result

3.1. Satellite Imagery

Satellite imagery by using artificial intelligence has become useful data for decision-making, in precision agriculture. The interaction of radiation with leave or canopy changes shows variability in the field through satellite imagery [5].

The low vegetation areas monitored in the lemon farm were due to the cause of pest incidents treating the localized areas reduced pesticide usage thus protecting the natural environment.

3.2. Fertilizer Application

Unknown nutrient levels in the field and refraining soil analysis leads to soil infertility. The soil sensors enable monitoring of NPK trends and other parameters [6] e.g., soil salinity, Ec, TDS and soil temperature [7].

A known quantity of NPK in soil optimized the usage and avoidance of excess fertilizer as illustrated in Figure 1. Ec functioned as a base in the selection of less alkaline fertilizers and proves to be effective for lemon trees in terms of remarkable production and maintaining soil fertility.

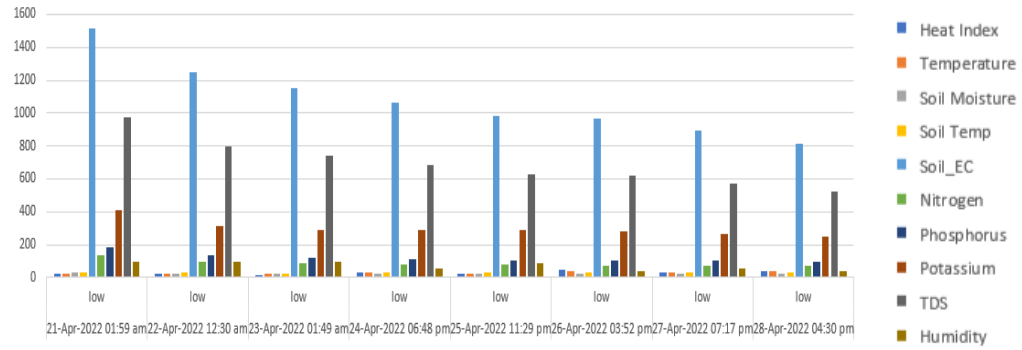

Figure 1. Real-time data of soil condition in the lemon orchard and fertilizer trend that helps in optimum inputs.

3.3. Pesticide Application

Pest surveillance in the field is influenced by favorable temperature and humidity. Integrating spatial variability and weather conditions in PA cost of pesticide application was reduced and profit was maximized.

Site-specific applications [6] of selective and bio pesticides were applied that not only contributed to pest control but also had a significant impact on natural biodiversity proven by the presence of 11 bee hives in the lemon farm. Bees responsible for pollination played a magnificent role in better flowering leading to the highest output in the vicinity.

3.4. Precision Irrigation

IoT devices equipped with soil moisture sensors were placed at certain depths for accurate measurement of the water level in the soil. A precision irrigation time was designed depending on the crop stage, root zone, geographical location, and evapotranspiration [8–10].

The system is capable to forecast irrigation required on the basis of water availability and evapotranspiration illustrated in Figure 1. This helps in eliminating excessive irrigation and root-related diseases in the orchard and irrigation management [11] contributed to good flowering and high-quality fruit production.

3.5. Soil Temperature

Plant roots growing in the soil need a conducive environment to transport nutrients and water to the plant. To keep this mechanism optimal agri-tech devices equipped with soil temperature sensors remarkably influenced soil temperature management.

At high soil temperatures organic matter leaches down the soil and the availability of nutrients through the plant roots is disturbed as the beneficial bacteria die and are unable to decompose the nutrients. At lemon, orchard mulching was done at high soil temperatures illustrated in Figure 1 to prevent the associated problems hence achieving the desired output.

4. Conclusions

Precision agriculture using agri-tech devices was implemented and practiced for a complete cycle of fruiting at a lemon farm.

In reference to the pilot project at lemon farm Gadap if the same PA technology is implemented on the other farms of the country it can provide accurate data to establish agronomic decisions. The output in precision agriculture was promising in terms of profit and the cost of inputs using remote sensing and agri-tech devices was minimized.

This technology is a breakthrough in uplifting the agricultural production of Pakistan in achieving food security.

5. Future Perspective of This Study

If, PA is practically implemented by optimizing the inputs such as water, fertilizer, and pesticide, it will result in the high production with increased quantity and quality of fruit.

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