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Sustainable farming through Precision Agriculture – A patent analysis

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Abstract - *In the era of growing population there is a high need to increase the agricultural potential. Sustainable development is also of at most concern. Growing demand for the food burdens the nature with excessive chemicals. Agriculture and agro-industries are considered to be highly important for the country's economic development as they contribute significantly in Gross Domestic Product (GDP). Although the service and industrial sectors showed higher rates of growth and have been contributing higher percentages to Gross National Product (GNP), Worldwide, expansion in agricultural commodities and food products has been accompanied by significant increase in usage of agricultural inputs such as fertilizers, pesticides, farm machinery and improved seed material. The use of such intensive inputs in agriculture and access to plentiful energy, where they were previously limited or unavailable, has enabled an increase in food production and thus provides better food and livelihood security. The paper discusses about the different patents given in the area of sustainable agriculture. In the course of action, we discuss about some of the modern technologies which have helped the framers not only in increasing crop productivity but also in sustainable development.*

Key Words: **agricutlture, sustainability, machine learning, precision agriculture**

1.INTRODUCTION

Population of the world is growing in an exponential way. But the agricultural land is not growing at the same rate. In fact, it is actually shrinking due to constructional activities. The large population has to be fed in the available land, hence there is a need to increase the crop productivity. Agriculture has shifted its scope and focuses more towards commercialization and export-orientation. Farmers have started using chemical fertilizers as a solution to increase the productivity but it is actually harming the nature and depleting the soil nutrients which again lead to the under performance in the future days. Though these chemicals are temporarily increasing the productivity, they are harming the human health as well as the nature's health so it is crucial to increase farm performance without depleting the nature.

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1. Need of soil testing

Farmers which are growing the same crop will be using the same fertilizers and also using the same quantity of fertilizers many are times the crop might already be containing these nutrients since their farms are situated in different areas obviously the nutrients available in the land will also be different.

The reason why farmers do not take interest on the soil testing is that either they need to travel to the place where the testing takes place or the tester himself has to visit the land. Hence, they choose their own decisions. Since the testing is done only on a particular sample the decisions will be taken based on the result of this particular sample only. But the nutrients and moisture content differs from one part to another part of the land these decisions often lead to the economic losses along with spoiling the nature.

2. Factors affecting crop growth

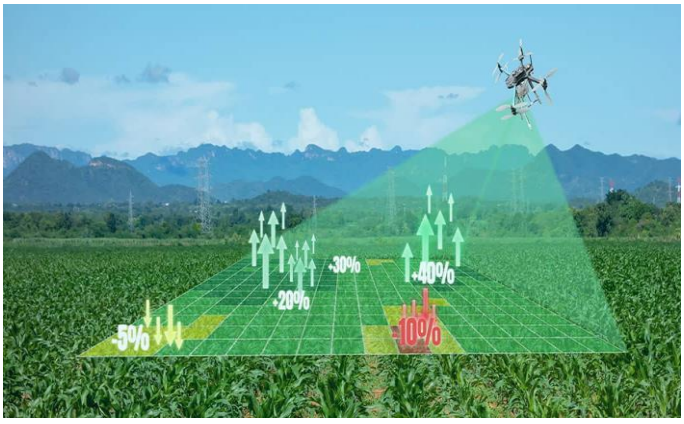

Fig -1: Variation in the yeild

Though we use the same inputs in same quantity, the yield at different parts of the same land is different. Since the same quantity of inputs(fertilizers, water, pesticides) are used, the result expected is also the same. But this thing doesn't happen in many of the cases as illustrated in the following picture.

This leaves us to think on different internal and external factors that affect the health of the plant. Following are the major factors which contribute to the plant health and productivity.

Worldwide, expansion in agricultural commodities and food products has been accompanied by significant increase in usage of agricultural inputs such as fertilizers, pesticides, farm machinery and improved seed material. The use of such intensive inputs in agriculture and access to plentiful energy, where they were previously limited or unavailable, has enabled an increase in food production and thus provides better food and livelihood security. In developing countries increased growth in agricultural production depends on continuous improvement through technological changes. This requires a sustained and rapid growth in the use of agricultural inputs such as seeds, fertilizers, pesticide, farm implements, farm machinery, etc.,

A number of different factors can cause agricultural productivity to increase or decrease. It is important to note that productivity is not an absolute measure, but rather a reflection of the ratio between inputs and outputs. A field that produces twice as much of some crop as it did in a previous year is not necessarily twice as productive; if the farmer spent twice as much on that field, the net change in productivity would be zero.

Factors that affect farm productivity and often can't be in the control of the farmer are:

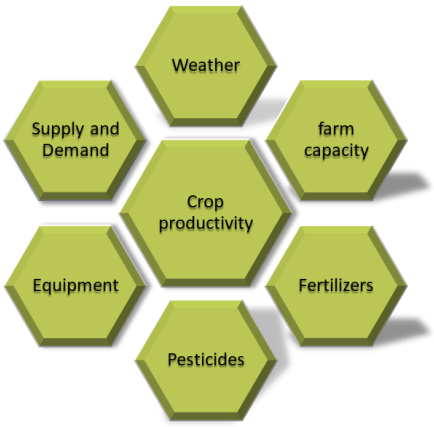

Fig -2: Factors affecting crop productivity

- **Weather** - unusual weather patterns, such as drought, a prolonged rainy season, early or late frosts and other factors can ruin crops and bring productivity down. Ray and Gerber have used detailed crop statistics time series for ~13,500 political units to examine how recent climate variability led to variations in maize, rice, wheat and soybean crop yields worldwide. While some areas show no significant influence of climate variability, in substantial areas of the global breadbaskets, >60% of the yield variability can be explained by climate variability. Globally, climate variability accounts for roughly a third (~32–39%) of the observed yield variability[16]

- **The Capacity of a Given Farm** - soil can't be forced to produce beyond its capacity, although there are methods that can be used to improve production capacity, such as proper fertilizing to add nutrients to the soil so that it can support more crops. Mixed farming is one such technique which can be used to improve the soil nutrients. Here the nutritious output of one crop will be absorbed by another crop to support its own growth.

- **Fertilizers** - Fertilizer is generally defined as "any material, organic or inorganic, natural or synthetic, which supplies one or more of the chemical elements required for the plant growth".. Just like humans and animals, plants need adequate water, sufficient food, and protection from diseases and pests to be healthy. Commercially produced fertilizers give growing plants the nutrients they crave in the form they can most readily absorb and use: nitrogen (N), available phosphate (P) and soluble potash (K). Elements needed in smaller amounts, or micronutrients, include iron (Fe), zinc (Zn), copper (Cu) and boron(B). The main aim of the industry is to provide the primary and secondary nutrients which are required in macro quantities[15]. As per the Fertilizer Control Order (FCO) 'fertilizer' means any substance used or intended to be used as fertilizers of the soil and or crop and specified in part A of Schedule I and includes a mixture of fertilizers and special mixture of fertilizers. Primary nutrients are normally supplied through chemical fertilizers.

- **Pests occurred or not by certain weather conditions** - in addition to spoiling crops, pests can add significantly to the costs of producing a crop. Controlling them may require measures such as fencing, chemical or biological treatments, companion planting or crop rotation, all of which change the ratio of inputs to outputs

- **Available Equipment** - in regions where access to mechanized farm equipment is low, agricultural productivity can also be low as people handle their crops primarily by hand. This involves a big investment of time, energy and money and also limits the total capacity of the land

- **The Supply and Demand in the Market** - farmers will adjust their activities to meet the needs of consumers and this can have an impact on agricultural productivity. In some cases, governments even pay subsidies to farmers to compensate them for not growing crops, which can skew productivity measures.

For agricultural productivity innovation is a key factor. If farmers want to increase their productivity, they need to farm smarter, by using farm management system Agrivi. It helps them manage whole farm production, from tracking of activities on all fields, consumption of fertilizers, pesticides, work hours of workers and mechanization, to tracking of finances and complete farm analysis and reports. Investment in developing new farming techniques and in researching new approaches to farming need to be on a daily basis.

3 Precision Agriculture

Precision agriculture(PA) is a cutting edge technology which makes use of machine learning concept. It is used to help in making decisions such as crop type, adequate quantity of fertilizers, pesticides and water. PA leads to effective utilization of the resources which are not so abundant in the nature. Since, it advises to use the organic manure in place of the chemical-based fertilizers. In the cases where the organic fertilizers are not adequate enough the chemical-based fertilizers will be used, which have to be of minimal quantity.

It uses various tools to achieve the task. agricultural crop type prediction is done using special interpolation and machine learning forward and agricultural specialist make informed crop decisions plant efficiently and all of it resources with this technique it's since it can accurately evaluate the soil nutrient levels and weather patterns it presents itself as a boon in the modern agriculture geo-statistical methods such as kriging interpolation[1] are used to access soil nutrient levels specially across the field this paper analyses the patents given in the agricultural field which prove themselves as beneficiary in the sustainable farming.

Following are some of the patents received in this field:

1) Barsamian and Garrison(2018) state that the farming device will be fed with a set of instructions and the input information. The device will be using this information and make decisions based on the instructions given to it.The farming device acts according to the decisions made, which causes that device to perform an action. The action includes at least one of replanting of a particular area, spraying of a chemical in the particular area or activating an irrigation system.
2) Cohen(2018) worked on the computer-implemented methods to exercise PA. The data is fed to a particular device. The device predicts output conditions, such as diseases, salt damage, soil problems, water leaks and generic anomalies. The computer platform stores site and crop datasets and processed satellite images for the orchards. An orchard data learned model predicts a propensity for existence of output conditions associated with the crops based on the data values for the variables of the site and crop datasets. A precision agriculture management model integrates the orchard data learned model with the satellite model to accurately predict the output conditions.
3) Mewes and Salentiny (2015) have proposed a modeling framework for evaluating the impact of weather conditions on farming and harvest operations which applies real-time, field-level weather data and forecasts of meteorological and climatological conditions together with user-provided and/or observed feedback of a present state of a harvest-related condition to agronomic models and to generate a plurality of harvest advisory outputs for precision agriculture. A harvest advisory model is simulated that predicts the impacts of this weather information and user-provided or observed feedback in one or more physical, empirical, or artificial intelligence models of precision agriculture to analyze soil, crops, plants and resulting agricultural commodities, and provides harvest advisory outputs to a diagnostic support tool for users to enhance farming and harvest decision-making, whether by providing pre-, post-, or in situ-harvest operations and crop analyzes.
4) Reimann proposed a system for predicting soil or plant conditions in precision agriculture with a classification of measurement data for providing an assignment of a measurement parcel to classes of interest. The assignment is used for providing action recommendations, to a farmer and/or to an agricultural device based on acquired measurement data, particularly remote sensing data, and wherein a classification model is trained by a machine learning algorithm, e.g. relying on deep learning for supervised and/or unsupervised learning, and is potentially continuously refined and adapted to a feedback procedure, through better and accurate decisions are made.
5) Guan and Peng(2021) have developed an integrated multi-scale modeling platform. It is utilized to assess agricultural productivity and sustainability. The model is used to assess the environmental impacts of agricultural management from individual fields to watershed basin to continental scales. In addition, an integrated irrigation system is developed using data and a machine-learning model that includes weather forecast and soil moisture simulation to determine adequate requirement of water for farmers. Crop cover classification prediction can be established for an ongoing growing system using a machine learning or statistical model to predict the planted crop type in an area.

6) Sibley and Ibarria (2023) have proposed a method to implement machine learning (ML) algorithm to determine the quality of crops. One or more images of a region of an agricultural environment near the treatment system are captured, and fed to the ML algorithm. By analyzing multiple such images, the ML algorithm gives recommends different suggestions. Multiple processing systems will determine the parameters which are underperforming. Better crop decisions and input requirements are determined based on these results.

7) Bao Tran(2023) has adapted an agricultural method which focused on the contaminants that affected the growth of plants. They used a positive air pressure chamber to prevent outside contaminants from entering the chamber; growing crops in a plurality of cells in the chamber, each cell having multi-grow benches or levels, each cell further having connectors to vertical hoists for vertical movements in the chamber; maintaining pre-set temperature, humidity, carbon dioxide, watering and lighting levels to achieve predetermined plant growth; using motorized transport rails to deliver benches for operations including seeding, harvesting, grow media recovery, and bench wash; dispensing seeds in the cell with a mechanical seeder coupled to the transport rails; growing the crops with computer controlled nutrients, light and air level; and harvesting the crops and delivering the harvested crop at a selected outlet of the chamber.

Conclusion

Using machines and equipment has become an integral part of the agriculture. The routine works are usually handled by the machines in an hassle freeway. Crop type decisions and assessing the plant health require huge data; so machines are used in this process too. Different machine learning algorithms have been employed in this way. The study has extensively analyzed the different patents in the area of precision agriculture. These are the applications of machine learning technologies. These techniques are the need of the day as the growth is important but at the cost of spoiling our own environment. Research and development are going on to reduce the overall cost of implementation so that even the small farmers can also afford.

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