Precision Agriculture in India- Challenges and Opportunities

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\textbf{ABSTRACT} &  \\

Precision farming is the latest trends in the agriculture sector which makes use of information technology to integrate all the procedures of farming from analyzing the soil-moisture, weather forecasting, and the quality of seed to predicting the real-time of harvesting. Basically, it focuses on the important aspect of inter-field and intra-field variability for growing crops. India is an agrarian country where agriculture is the backbone of the economy and precision farming could be quite useful. In the present article through a systematic literature review the vital role of precision farming was outlined. Also, the article identifies various challenges associated with the adoption of precision farming in India. For the same in-depth interviews with twenty farmers of the villages located near the Hyderabad city were conducted. The article is among the first preliminary study to explore the awareness, usages, and challenges behind the adoption of precision farming in India. The findings of the study will aid the policy makers in designing strategies for promoting precision farming in the emerging markets of India. & \\

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1. Introduction

India is predominantly an agrarian economy facing the challenges of food security, high population, vagaries of monsoon and backward nature of the farmers. In spite of the Green Revolution, there is still a burgeoning demand for the food. India is facing a serious challenge in the productivity of food grains per hectare which is abysmally low. It is almost less than half of the advanced countries and it is three fourth of the world average. Similarly, the per capita food grain availability in the country is almost less than two thirds of the world average. Focus should be on improvements in various aspects like tillage, sowing, growing, harvesting, irrigation, post harvesting and above all, use of GIS data on ground information and adopting a method according to the available space variable data.

2. Literature Review

Precision farming is a systems approach (Dobermann, Blackmore, Cook & Adamchuk, 2004) practiced in the crop management in order to achieve significant improvement in yield of crops. It concentrates on crop specific and soil specific strategies to enhance both quality and quantity of agricultural produce. It also concentrates on input use efficiency and maintaining the quality of soil and environment. In India, there is an indispensable need for Precision Farming because of ‘the fatigue of Green revolution’ (Shanwad, Patil & Gowda, 2004). The country might have attained self-sufficiency in food production due to the ‘green revolution’ but it had put enormous pressure (fatigue of green revolution) on environment because of excessive use of fertilizers, pesticides, irrigation and use of HYVs (High Yielding Varieties). In order to achieve further improvements in agricultural production, the country has to embrace Precision Farming in a big way. India is a position to move from ‘Green Revolution’ to ‘Evergreen Revolution’ (Swaminathan, 2000) to improve yield, income and livelihoods per unit of land and water. The spectacular results of Green Revolution were achieved because of genetic manipulation of certain crops like Rice, Wheat and Maize. The “Ever Green Revolution” would have to focus on a ‘Systems Approach to Farming’ to increase the output per unit of Land, Water and Labor resources and at the same time without affecting the environment. A systems based approach
utilizing the latest technology is the only way to enhance productivity and profitability without putting a stress on ecology and environment. Plant Phenotyping is a new trend in Precision Farming for controlling diseases and thereby achieve qualitative and quantitative improvements in crop production. Plant phenotyping (Anne-Katrin Mahlein) is a scientific method of assessing the performance of a particular 'genotype' under specific environmental conditions. Disease severity and disease incidence could be controlled to a large extent by accurately assessing the pathogens and their impact. The compatibility of Farmers’ expertise and Precision Agriculture is an important aspect in adopting the Precision Farming technology. Acceptance and diffusion of technology is very important for the success of precision farming in the farming community (Aubert, Schroeder & Grimaudo, 2012).

2.1. Objectives

- To explain and highlight the latest trends in Precision Farming which could be integrated into the Indian Precision Farming Architecture.
- To make a detailed study of challenges in the Precision Farming.

3. Methodology

3.1. Phase 1

To explore the latest trends in precision farming which can be integrated into Indian agriculture sector, a systematic literature review of the related literature is done. For the same, academic databases such as EBSCO Host, Proquest, InderScience, JSTOR, Cabells and others are explored with keywords such as precision farming, information technology in agriculture, artificial intelligence in agriculture, internet of things in farming and others. The search included all types of articles ranging from the exploratory, qualitative, and quantitative studies. Findings from the past literature are arranged under the four perspectives—agronomical perspective, technical perspective, environmental perspective, economic perspective, and managerial literature. These perspectives are discussed in the following sections.

“Precision farming or precision agriculture is about doing the right thing, in the right place, in the right way, at the right time. Managing crop production inputs such as water, seed, fertilizer etc to increase yield, quality, profit, reduce waste and makes it eco-friendly”. Precision agriculture is also referred to as Satellite Farming or Site Specific Crop Management (SSCM). It is one of the latest concept based approaches to farming which focuses on the important aspect of inter-field and intra-field variability for growing crops. One of the important aspects of Precision Farming is to develop and design a highly responsive DSS (Decision Support System) which will help in the economic utilization of inputs and at the same time maximizing the output.

The first level of agricultural revolution happened from 1900 to 1930. The focus was on ‘farm mechanization’ to enhance agricultural productivity. After the implementation of mechanization in agriculture in that period, a farmer could produce food to feed 6 people. The second phase of agricultural revolution was the green revolution (1960-90). It focused on the usage of genetic modification to increase agricultural output and each farmer could feed about 155 people. With the new technology and the advancements in the new agricultural revolution, the objective is to feed 265 people.

One of the few reasons that blocked the adoption of Precision Farming was land tenure system, smallest size of the farm lands and diversity of the crops. India achieved success through Precision Farming in the production of crops like coffee, tea, sugar-cane and sugar beet. In this context, Precision Farming or Precision Agriculture is indispensable and an economic necessity to increase the productivity in agriculture in a planned manner. “Precision Agriculture is the application of technologies and principles to manage spatial and temporal variability associated with all aspects of agricultural production for improving production and environmental quality”.

The important question is “is it necessary for a country like India to adopt the Precision Farming or Precision Agriculture in a big way?”. What are the challenges in taking up this novel concept? How can it be implemented? What is the right approach?

- Reducing soil degradation
- Reducing the chemicals used crop production
- Utilizing water resources in an economical and effective manner
- Propagating the adoption of modern farm practices across the country in order to increase the output.
- Improving the quality of agricultural produce.
- Reducing the cost of production of agricultural Products.
As per the National Committee of Plasticulture Applications in Horticulture, the topic is analyzed from four perspectives: Agronomical perspective, Technical perspective, Environmental perspective and Economic perspective. Besides, a managerial perspective is also described.

3.1.1.1. Agronomical Perspective

The various requirements of a crop influence or determine the specific agronomical practices to be used for the crop. The agronomic perspective of Precision Farming is mostly based on some kind of intuitions in the use of application of certain traditional recommendations which are being followed from times immemorial and in fact there should be a total change in the mindset of the people who follow those traditional recommendations or practices. Reducing soil degradation and utilizing water resources in an economical and effective manner are the important agronomic concerns to be addressed in the Precision Farming.

3.1.1.2. Technical Perspective

The farmers are to be trained and educated to use the technology in the production of crops and also save the precious time. As per the National Mission on Micro-Irrigation (NMMI), Micro-Irrigation has to be taken up on a large scale across India because of vagaries of monsoon, shortage of water coupled with huge tracts of land available.

Precision farming focuses mostly on the enabling technologies and it is suggested to use the following five types of Technologies--GPS (Global Positioning System), Computers, GIS Geographic Information System), RS (Remote Sensing) and application control. Besides, there is an array of technological innovations available to the modern farmer. They are Arial and autonomous vehicles for agriculture, Digitalization of plot boundaries, Orthomosaic Maps, Phytophysiological Approach, Prescriptive Planting, The Internet of Things, Phytophysiological Approach, Plant phenotyping, Mobile Technological Platforms. A brief description of the technologies is given below.

Utilization of Orthomosaic Maps

The latest technology used for mapping places in the world is that of Orthomosaic maps. An Orthomosaic map is an aerial photograph and his corrected to ensure that the scale is uniform and it doesn't have any distortions. It is also called orthophoto, orthophotograph or orthoimage and it is can be used for the measurement of distances accurately. It could be of tremendous use in agriculture when one wants to use 'technology for viability'. Nowadays, Orthomosaic maps are used in mapping highly frequented search locations like malls, schools, cities or when there is a fire accident or a disaster. They can be used in real estate to measure a house or some thousands of acres of land.

The Orthomosaic Maps can be used in agriculture to help the farmers by providing information or insights with regard to the performance of the crops and keeping a very perfect record of the crops on a piece of land over time. It is also called Drone mapping. It is also recommended that the government of India can start the process of creating a separate body--on the lines of National Digital Orthoimagery Program (NDOP) in the United States of America --for orthomapping of extensive tracts of agriculture lands. Google maps or google images are a perfect example of Orthomosaic maps. For example see Fig. 1.

![Orthomosaic Map](https://uavcoach.com/drones-orthomosaic-map/)

Fig 1- An Orthomosaic Map of a School and a Farm in New Zealand
(Source: https://uavcoach.com/drones-orthomosaic-map/)
Phytomorphological Approach

One of the important approaches in precision farming is that of Phytomorphological Approach. This is an approach based on the material crop growth and characteristics of a farm based on its land or topography. It basically involves hydrological study where in the content of water, the quality of water and the distribution of water in a particular earth terrain is analyzed. It is observed that ‘water stress’ in the soil leads to crop failure. Hence, it is important to locate a field and identify the various aspects of a terrain with respect to the crop yield, the pH, magnesium, nitrogen, potassium, organic matter content and the moisture levels. In fact it may also contain some highly technical real time sensors which will also enable the measurement of the chlorophyll levels.

Prescriptive Planting

Prescriptive Planting is another type of Precision farming which will help a farmer by providing the data about a land tract. The objective is to maximize the output of a given tract of land and plants and adjust farming according to the various conditions. Prescriptive planting is based on data driven planting advice. Monsanto and DuPont are using this technology. A farmer may increase or decrease the seed density based on the available nitrogen and other phytosanitary aspects of the land. The ROI (Return on Investment) is very high with limited use of water, pesticides, fertilizers and enhancing the field.

The Internet of Things

The internet of things is another technological tool available in Precision Farming. It is a highly practical network of some physical objects which are fitted with sensitive electronic gadgets for the collection and aggregation of the data through some farm management software. The nitrogen, Phosphorus and potassium in liquid manure can be measured. Cattle can be fitted with some extraordinary sensors which will help in identifying the stomach acidity and digestive problems faced by the cattle and also identify the optimal time for the breeding of cattle. There is also a technology which helps in the efficient management of beekeeping because the beekeeping has got its economic value and it is also a very important aspect of agriculture for the pollination of the crops. The productivity is increased by monitoring the Honey Bee colonies in terms of monitoring humidity, carbon dioxide and temperature.

Phytobiome

Phytobiome is one of the latest technologies emerging in the area of Precision Farming across the world. It was launched by the American Phytopathological Society (APS) in the year 2015 it focuses on two important things-- the plant as an important aspect (Phyto) and the ecological aspects of an area (the biome).

It encompasses the study of the plant and the ecosystem of a place including the micro and macro organisms living in or around the plant. These organisms may be the microbes, the animals and other plants in a particular area. The ecosystem comprises of the soil quality, air quality and the type of climate available in a particular area. In addition to all these, an open access journal called 'Phytobiome' was also launched in the year 2016 to develop a roadmap by the various stakeholders and also to develop a strategic plan to study phytobiomes and apply them in the development of agriculture.

Plant Phenotyping

Plant phenotyping is a scientific method of assessing the performance of a particular ‘genotype’ under specific environmental conditions. Disease severity and disease incidence could be controlled to a large extent by accurately assessing the pathogens and their impact.

Mobile Technological Platforms

Connected farmer’s mobile technological platform which was initiated in East Africa by Vodafone and Technoserv, a social service organization. The same thing could be introduced in India to help the farmers and agriculturists and update them with latest information and technologies available.

3.1.1.3. Environmental Perspective

Agricultural produce should be made by following an array of eco-friendly practices by causing lowest or least damage to the ecosystem of a region. In the Indian perspective, with the green revolution of 1960s the country achieved self-sufficiency in food production. However, the Green Revolution could
not concentrate on this unique aspect of Precision Farming or Precision Agriculture. The Green Revolution farming focused more on utilization of high yielding varieties (HYVs), cropping intensity and agricultural farm mechanization. There was increased use of pesticides, chemicals, fertilizers and water resources. There was lot of pressure on environment. Hence. In the present scenario, to overcome the fatigue of green revolution, it is very much needed to focus on the Precision Farming.

Green Revolution added to the self-sufficiency and to some extent the food security but there was enormous pressure on the natural resources especially the land. In India, 182 million hectares of land has been degraded out of the total 328.7 million hectares—141.33 million hectares due to water erosion, 11.5 million hectares due to wind erosion, 12.63 million acres due to water logging and 13.23 million acres due to Chemicals and other aspects. Another aspect of environmental perspective is that there should be reduction in the pollution of environment at the same time preserve the precious natural resources—land, soil and water.

3.1.1.4. Economic perspective

The objective of economic thinking is to make agriculture viable, sustainable, scalable and attain economies of scale through multiple means. The farm inputs are to be utilized in an efficient way to reduce the cost of production and increase the output and quality of output. Aggregation of agricultural land for sustainable and precision farming and reduce the operational costs. The cost of using precision farming equipment on the two platforms—Land and Arial—is very huge and hence aggregation of land parcels is important. Purchasing power enhancement, strengthening the ‘Supply Chain Infrastructure and streamlining the ‘Supply Chain Governance’ policies at the national and international level are some of the bigger issues to be addressed as part of the Precision Farming.

3.1.1.5. Management Perspective

Adoption of management practices in agriculture is essential to to achieve optimum levels of agricultural production. Appointment of Farm Financial Managers to a region or District could be considered as a new concept in overseeing the financial aspects of farming and also helping the farmers with financial planning and goal setting. Introduction of Agricultural management topics as electives in the MBA program of B-Schools or IIMs.

Phase 2

To compile data regarding the awareness of farmers in Telangana state about the concept of Precision Farming, a sample of twenty farmers were randomly selected from the list provided by co-operative society of Shankerpally Mondal. These farmers were invited for in-depth interviews. Invitation was sent to the farmers to attend meeting at a nearest village—Dontanapally closer to the campus of the researchers involved.

An unstructured questionnaire prepared to elicit relevant information from the farmers. The demographic detail of the farmers was also captured. The farmers were having their farm land in the surrounding villages of Shankerpally Mondal viz: Poddatur, Mokhila, Kondangal, and Kanur. The age group of these farmers ranges from 25 to 55 years. All the farmers were male, as female are not restricted to domesticated works in these villages. Around seven farmers have completed their primary schoolings. Around 30% of the farmers were using smart phones and has installed a mobile application which supported information of weather forecasting, seed banks, and government policies. All the farmers were having their own farm lands and were the bread earners of their family. The lived experiences of the farmers were analysed through an inductive qualitative technique and thematic analysis and the challenges faced by these farmers which have hindered the adoption of precision farming are arranged under three heads—economic factors, social factors, and environmental factors.

The analysis of the interview data also suggested that most of the farmers are still following the traditional methods of farming and most of them are not aware of any latest trends in the Precision farming. They evinced a lot of interest in the concept of Precision Farming. Finances, climate, unpredictable monsoon, small tract or area of land area are the biggest challenges faced by the farmers.

They are not being updated about the latest trends in farming and there are no awareness programs from the government about Precision farming. They said somebody should be there to motivate them to follow the Precision Farming. They showed lot of enthusiasm and said that if done properly the return on investment by adopting to farming is also good.

Conclusion

Based on the finding it is concluded developing a plan for responsive ‘Precision Farming’ architecture for India by infusing a lot of capital investment into the technology related to farming and agriculture. Agriculture sector contributes 17% of GDP of India with an investment of 1, 87, 223 crores during the
financial year 2017-18. The investment should be made on Precision Farming to enhance the agricultural output and at same time increase the overall percentage of contribution from agriculture to GDP of India.

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