

## STATUS OF PRECISION FARMING TECHNOLOGIES IN INDIAN CONTEXT – A REVIEW

## ABSTRACT

Precision farming is a farm management strategy that involves the application of technologies and principles to manage spatial and temporal variability associated with all aspects of crop production for improving crop performance and environmental quality. It is spreading rapidly in developed countries as a tool to fight the challenge of agricultural sustainability. With the progress and application of information technology in agriculture and horticulture sector, Precision farming has been increasingly gaining attention in Indian context. Though it is widely practiced in developed countries, it is still in nascent stage in most of the developing countries like India which needs integrated and sustainable efforts starting from preparatory tillage to post harvest handling in Agri - Horti crops. Knowledge on present developments with regard to precision farming technologies helps to foresee the forthcoming challenges. Hence this article provides an overview of development and current status of precision farming technologies in India.

**Key words:** Precision farming, Information technology, Crop production, Sustainability

## INTRODUCTION

Precision farming is one of the most scientific and modern approaches to sustainable agriculture that has gained momentum towards the end of 20th century. According to International Society on Precision Agriculture (ISPA)- Precision farming is a management strategy that gathers, processes and analyzes temporal, spatial and individual data and combines it with other information to support management decisions according to estimated variability for improved resource use efficiency, productivity, quality, profitability and sustainability of agricultural production (Pavan Kumar *et al.* 2022)

Technological developments in agricultural sector yield better management practices resulting in more precision in agricultural operations from tillage to harvesting to reduce inputs, increase profits, and protect environment (Ess & Morgan, 2003; Rains & Thomas, 2009). Knowledge poverty of the farmers is one of the problems in developing countries. In order to face environmental, technical, infrastructural & social constraints related to adoption of precision farming technologies which can manage and allocate efficiently all resources for sustainable development of agriculture and horticulture is necessary. Precision farming is not just the injection of new technologies but it is rather an information revolution, made possible by new technologies that result in a higher level, a more precise farm management system (Dutta *et al.*, 2011). Precision farming basically means application of the right amount of input at the right time and the right location within a field. It is a scientific approach to improve the crop management by application of information technology (IT) and satellite based technology to identify, analyze and manage the spatial and temporal variability of agronomic parameters (e.g. soil, pest or disease, fertigation etc.) within field by timely application of accurate amount of input to optimize profitability, sustainability, with a minimized impact on environment (Murali krishnan *et al.* 2019).

In this present scenario, the major challenges arising are shrinking land, depleting water and others related to resources in agriculture (Mondal *et al.*, 2011). There is need for promoting farmer-friendly, location-specific production system management technologies in a concerted manner to achieve vertical growth in agricultural and horticultural production duly ensuring quality of produce and better remuneration per unit of area with judicious use of natural resources. In this endeavour, precision farming aims to have efficient utilization of resources per unit of time and area for achieving targeted production of agricultural and horticultural produce. The precision farming technology assures

the productivity enhancement with decreasing the production cost via efficient utilization of resources (Hemraj Meena *et al.* 2021). The accomplishment of the precision agriculture mostly depends on accurate evaluation of variability, management and evaluation in space & time continuum in crop. The key components of precision farming includes capturing the data at an appropriate scale and frequency, interpretation and analysis of the data and implementation of management response at an appropriate scale and time. The key differentiator between the conventional management system and precision farming is the application of modern information technologies towards providing, processing and analyzing the multi-source data of high spatial and temporal resolution for decision-making and operations in the management of crop production.

**Table 1: Classification of Precision Farming (PF) Technologies**

| <b>Data Collection Technologies</b>                                                                                                                                                                                                              | <b>Data Process &amp; Decision Making Technologies</b>                                                                                                                                                                                                        | <b>Application Technologies</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"><li>• Soil sampling and mapping</li><li>• Yield monitoring and mapping</li><li>• Remote sensing</li><li>• Global satellite positioning</li><li>• Geospatial Technology</li><li>• Field/crop scouting</li></ul> | <ul style="list-style-type: none"><li>• GPS-GIS based farm management</li><li>• Agricultural mapping software</li><li>• Geoinformatics</li><li>• Geostatistics</li><li>• Crop modelling</li><li>• Artificial Intelligence based Controlling systems</li></ul> | <ul style="list-style-type: none"><li>• Variable-rate technology</li><li>• Yield monitors</li><li>• Agricultural robots</li><li>• Wireless data logger and Sensor catalogue</li><li>• Global Navigation Satellite system (GNSS) based guidance</li><li>• Hyperspectral sensor based applications</li><li>• Automated control system through Greenhouse and Polyhouse cultivation</li><li>• Precision Lazer Land leveller</li><li>• Mulching</li><li>• Low Tunnel Technology/Walking Tunnels</li><li>• Microirrigation</li><li>• Site-specific Nutrient Management (SSNM)</li><li>• Drone Technology</li></ul> |

The objective of this article was to review the studies on the precision farming technologies in Indian context and to compare the techniques applied in precision farming in terms of application, decision support systems as well as field data collection and analysis techniques.

**MATERIAL & METHODS**

In this study, literature was collected on the status of different precision farming (PF) technologies in Indian context. Scientific articles, reports, books and relevant web pages found after the review process were studied and information on the different Precision farming technologies in Indian context was compiled.

**RESULTS & DISCUSSION**

**a) Status of Precision farming technologies in Indian context – Research Findings**

The literature review shown in Table. 2 was published research focused on different crops, types of precision farming technology and methods of analysis in Indian context. There is a predominance of ex-post approach in these studies and Logit and Probit methods.

**Table 2: Research Findings of Precision farming technologies in India**

| Author                    | Publication year | Location & Crops                             | Studied PF Technology                                                       | Method of Analysis                 | Research Findings                                                                                                                                                                                                                                                                                                                                                                                                         |
|---------------------------|------------------|----------------------------------------------|-----------------------------------------------------------------------------|------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Koch <i>et al.</i>        | 2004             | Bihar state in Paddy                         | Variable Rate Technology                                                    | Logit analysis                     | Results indicated that less N fertilizer was used with the Site-specific Management zones (SSMZ- Variable yield goal) N management strategy when compared with uniform N management. There is a reduction in N fertilizer application and an increase in N use efficiency due to identification of site-specific management zones                                                                                         |
| Persson <i>et al.</i>     | 2005             | Shimla state in Potato crop                  | Differential Global Positioning system (DGPS) Digital Elevation Model (DEM) | Logistic regression analysis       | From the DEM, topographical parameters were extracted and topographical indices were estimated. The relationship of yield and the topographical parameters and indices was investigated and up to 20% of the yield could be explained in the final model for one of the fields                                                                                                                                            |
| Stamatiadis <i>et al.</i> | 2005             | Gujarat state in Cotton crop                 | Soil and crop sensors                                                       | Principal component analysis (PCA) | Ground-based sensors were used to simultaneously monitor soil and canopy reflectance in the visible and near-infrared (VNIR) in a cotton field. PCA technique was used to reveal spatial soil variation from near infrared reflectance (NIR) spectroscopy data of soil. Total carbon expressed a low spatial dependence whereas clay content and pH expressed spatial dependence at a range of 54 and 46 m, respectively. |
| Reyniers <i>et al.</i>    | 2006             | Punjab & Haryana states in Winter Wheat crop | Airborne Data Acquisition and Registration (ADAR) remote sensing            | Correlation & Regression analysis  | To compare aerial image with optical data of an on-ground platform multi-spectral radiometer. The NDVI of the ground system was better related to yield variables at harvest compared to NDVI of the aerial                                                                                                                                                                                                               |

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|                             |      |                                     |                                                  |                                            | system.<br>Best correlation coefficient found for both systems was with nitrogen in grain: 0.84 and 0.91 for the aerial-based and the ground-based system, respectively                                                                                                                                                                                                                                                                                                                                  |
| Mondal and Basu             | 2009 | West Bengal state in Rice crop      | Leaf color chart (LCC) based Nitrogen management | Split plot design                          | Adoption of Leaf Color Chart for Nitrogen Use Efficiency (NUE) in rice saved N by 25 Kg/ha (19.40%), with the highest saving of 314 Kg/ha (21.00%) in Boro season. It resulted in 50, 60, 90 Kg/ha additional yield in pre kharif, kharif and boro seasons. Reduced insecticide applications by 50%                                                                                                                                                                                                      |
| Yang <i>et al.</i>          | 2011 | Punjab state in Wheat crop          | Remote sensing (Multispectral imagery)           | Kappa analysis                             | Accuracy assessment showed that, the inclusion of the short-wave infrared band statistically significantly increased the overall accuracy from 82% to 91%.<br>The increase in pixel size from 10 m to 20 m or 30 m did not significantly affect the classification accuracy for crop identification. These results indicate that SPOT 5 multispectral imagery in conjunction with maximum likelihood and SVM classification techniques can be used for identifying crop types and estimating crop areas. |
| Manjeet Singh <i>et al.</i> | 2013 | Punjab state in rice crop           | Yield monitoring system & Mapping                | Regression analysis                        | Three rice fields were harvested to evaluate the performance of the yield monitor for grain yield and moisture mapping of harvested grains. The actual yield maps were generated by using Arc GIS software. The minimum and maximum yields recorded within all the fields harvested were 577.08 and 7,661.48 kg ha <sup>-1</sup> with an average yield of 4,287.66 kg ha <sup>-1</sup> having 37.26% coefficient of variation (CV) in all the three fields.                                              |
| Pahuja <i>et al.</i>        | 2013 | Punjab state in Horticultural crops | Automated Control System in Green House          | Greenhouse advance microclimate monitoring | WSN monitored and controlled a greenhouse climate with high data and packet reliability (85 to                                                                                                                                                                                                                                                                                                                                                                                                           |

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|                      |      |                                    |                                                            | and control software (GH-ACMCs) Collaborative data processing and statistical analysis like histogram, cumulative distribution frequency | 100 percent) and low battery drop (0.03 V). The climate controller tracked the initially high inside VPD and lowered the value to meet optimal conditions by operating the devices as needed. Furthermore, the real-time display of greenhouse climate-control statistics helped the grower make better decisions in executing greenhouse operations, eventually leading to healthy crop growth and better yields.                           |
| Karimi <i>et al.</i> | 2014 | Rajasthan state in Corn            | Artificial Intelligence based control system               | Remote hyperspectral image analysis                                                                                                      | Support Vector Machines (SVM) and ANN as instruments for detecting and classifying weeds on a corn field with the aim of intelligently controlling the amount of nitrogen application for weed management. In the research, the SVM technique achieved low misclassification rates and high generalization ability in comparison to the ANN. Conclusion is arrived that SVM is best suited for the effective detection and control of weeds. |
| Halimi and Moussa    | 2015 | Uttar Pradesh state in Potato crop | Robotic Greenhouse system for crop scouting                | Radial Basis Function Networking analysis                                                                                                | The Guelph Intelligent Greenhouse Automation System (GIGAS) is an intuitive robotics system with outstanding functional capacity for greenhouse applications. The research indicated that 92.3% production efficiency is achieved using GIGAS whereby a 63.2% increase in yields was achieved                                                                                                                                                |
| Durga <i>et al.</i>  | 2018 | Telangana state in Rabi maize crop | Precise irrigation system using nano soil moisture sensors | Split plot design                                                                                                                        | The research results indicated that the plant height of maize was significantly influenced by irrigation methods and irrigation scheduling. Higher plant height was recorded at 60, 90 days after sowing and at harvest in drip irrigated plots over surface irrigation method. There is decrease in the dry matter production in tensiometer based irrigation                                                                               |

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|                           |      |                                  |                                          |                                 | scheduling due to less frequent irrigation associated with tensiometer irrigation.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Kanannavar <i>et al.</i>  | 2020 | Karnataka state in Paddy         | Precision Laser Land leveller technology | Uniformity coefficient analysis | The research results indicated that there is a considerable reduction in drudgery of land levelling, higher levelling index, higher uniformity in soil-moisture distribution. It was observed that 25 to 35 % increase in paddy yield and water saving (25-30%), 30- 40 % labour saving and 30 to 40 % saving in energy requirement in paddy cultivation.                                                                                                                                                                                                                                                                                                                                            |
| Arti Verma                | 2021 | Punjab state in Capsicum crop    | Low Tunnel Technology                    | Randomized Block Design (RBD)   | The research findings indicate that the yield of PSM-1 variety cultivated in low tunnels is a profitable method with yield of 82 quintals/acre.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Padmaja <i>et al.</i>     | 2021 | Telangana state in Cucumber crop | Drip & Fertigation                       | Split plot design               | Yield attributes were significantly higher at 150% recommended dose of NK than 75%recommended dose of NK. Fruit yield was significantly higher at 150 % recommended dose of NK (76.70 t ha <sup>-1</sup> ) than 75% recommended dose of NK (60.30 t ha <sup>-1</sup> ) and onpar with both 125% and100% recommended dose of NK. Water use efficiency was higher in drip irrigation scheduled at 0.8 Epan (28.6 kg m <sup>-3</sup> ) followed by 1.2 Epan (27.2 kg m <sup>-3</sup> ) and 1.0 Epan (26.6 kg m <sup>-3</sup> ). 150 % recommended dose of NK registered significantly higher water use efficiency (30.1 kg m <sup>-3</sup> ) than75% recommended dose of NK (23.5 kg m <sup>-3</sup> ). |
| Subramanian <i>et al.</i> | 2021 | Tamil Nadu state in rice crop    | Drone technology                         | Coefficient of variation        | The research study indicated the efficacy of pesticide spray (fungicide copper oxychloride 53.8% @ 35 g 16 L <sup>-1</sup> against bacterial and fungal diseases) in rice fields using drones during the cropping season of September 2020. Preliminary studies have shown the optimal flying height (3 m), speed (5 m                                                                                                                                                                                                                                                                                                                                                                               |

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|  |  |  |  |  | s <sup>-1</sup> ), swath (4 m), and the area coverage (4 min acre <sup>-1</sup> ). It clearly demonstrate that drone-enabled pesticide spray is an emerging potential technology to overcome labor shortages and to carry out plant protection measures without loss of time. |
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The research papers analyzed so far in this comparative literature review demonstrate the constructive and effectual utilization of Wireless Sensor Networks in precision farming. Therefore, it is necessary to undertake the design, analysis and implementation of a system that takes into account the specific requirements of a particular crop. The accuracy in precision farming technology can be monitored through sensors and its related interface system. The review related to the existing control & monitoring systems and its modules for sensing micro climate parameters was given in table 3.

**Table 3. Classification of existing control and monitoring systems and its modules for sensing Microclimate**

| References                  | Sensors interfaced                                                                         | Technology                     | Monitoring system | Module interfaced  |
|-----------------------------|--------------------------------------------------------------------------------------------|--------------------------------|-------------------|--------------------|
| Irmak <i>et al.</i> (2006)  | Light, moisture and temperature, soil moisture, Humidity, CO <sub>2</sub> , illumination   | ZigBee, Internet               | PC, Laptop        | ZigBee module 3160 |
| Tan and Panda (2010)        | Humidity, illumination, Temperature                                                        | ZigBee, internet               | Laptop            | CC2420, MSP430     |
| Sabri <i>et al.</i> (2012)  | Temperature, humidity                                                                      | ZigBee, SunplusSPCE061A        | TFT-LCD           | Chip (SoC)         |
| Kim <i>et al.</i> (2014)    | Temperature and soil moisture                                                              | ZigBee, GPRS                   | Mobile phone      | JN5121, ARM9       |
| Rani and Kamalesh (2014)    | Temperature, soil temperature and moisture, Humidity, Anemometer, illumination, rain gauge | ZigBee, Internet               | Laptop, PDA       | MSSENS SoC         |
| Navaro <i>et al.</i> (2015) | Temperature, humidity, PH                                                                  | Sensor node(mono-chip sensors) | -                 | RF CC3271 PSOC kit |
| Sai <i>et al.</i> (2016)    | Temperature, humidity                                                                      | ZigBee                         | PC, Matlab 7.0    | PECRP              |

## CONCLUSION

In precision farming, to obtain high-quality products in agricultural and horticultural crops, the soil, crop, environmental parameters should be effectively monitored and controlled to provide optimal values related to productivity, profitability, input use efficiency, environmental sustainability etc. Hence A review on status of precision farming technologies in Indian context based on remote monitoring and control approaches have been presented. A detailed comparison of various decision-making platforms employed for precision farming such as ANN, DGPS, LCC, ADAR, Bayes, SVM, Remote sensing, mapping technologies and modules used for monitoring sensor data such as ZigBee, internet, GSM and RFID have also been looked at in terms of water and soil requirements. Areas of application of soft computing includes efficient irrigation, nutrient and fertilizer planning and management for optimization of yields, early identification and eradication of crop weeds, diseases and

pests and analysis of crop yield prediction. The research review conducted illustrated that some of the challenges incurred in precision farming can be tamed with the implementation of Wireless Sensor Network with the aid of a discrete, intelligent, intuitive decision making and control protocol for effective yield production & irrigation management. Therefore future strategy for adoption of precision farming in India should consider the problem of land fragmentation, lack of highly sophisticated technical centres for precision farming, specific software for precision farming, poor economic condition of general Indian farmer etc. Integrating farmer knowledge, precision farming tools, and crop simulation modelling to evaluate management options for poor-performing patches in cropping fields can be an excellent option for country like India.

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