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An Overview of Precision Farming and its Viability in India

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ABSTRACT
Precision farming is the most valuable agricultural production breakthrough of this century, focused on the use of information and communication technologies (ICTs). This is the most recent breakthrough technology focused on sustainable agriculture and balanced food production, and it consists of profitability and increased production, as well as increased economic efficiency and reduced environmental side effects. Conventionally, farm production is fraught with difficulties for producers all over the world. Agricultural production must adapt to rapid urbanization, resource depletion, soil erosion, decreased land use, and an increasing lack of clean water. More than 60 percent of land possession in the nation has dimensions less than a square kilometer. Just in the provinces like Punjab, Haryana, Rajasthan, and Gujarat upwards of 20 percent of farming land have an implementation holding density of far more than four hectares. In collaborative farms, commercial and horticultural crops both show a greater potential for Precision Farming. The main goal of this paper is to highlight the role of precision farming in overcoming the problems associated with conventional farming techniques and also illustrate the feasibility of the same within a developing nation-India. When opposed to conventional cultivation practices, precision farming is indeed a method in which inputs are used in specific quantities to increase higher yields. In the near future, Precision Farming may be able to assist local farmers in reaping the benefits of frontier technology without jeopardizing land quality, transforming the green economy into an evergreen revolution.
KEYWORDS: *Agriculture, Precision Agriculture, Global Positioning System (GPS), Precision Farming, Remote Sensing.*

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INTRODUCTION

Indian agriculture supports the rest of the nation and can never be underestimated. Agricultural productivity has improved, regardless of the reality that its sector to Employment has declined too far less than twenty percent, as other industries' inputs have accelerated. This has enabled us to be more self-sufficient and turned us all from the staple food to the overall exporter of farming and similar items after [1], [1].Freedom maximum food crop income of farmers will hit a new peak of 29195E100 million tons in 2019-20, as per the second advance projections. This is exciting news, however, the Indian Institute for Sustainable Agriculture forecasts a three hundred forty-five million ton increase in housing crop production by 2030. The increasing population, increasing average salary, and globalization impact in India would raise the appetite for food production in terms of amount, consistency, nutrition, and diversity [2].

As a consequence, as accessible cultivable land declines, the need for more volume, diversity, and good food will continue to increase. The Indian Council of Agricultural Research (ICAR) has categorized India's agricultural land into fifteen agro-climatic areas that can accommodate a wide variety of seeds and climate conditions. Milk, grains, pulses, tea, almond, and jute, and also rice, wheat, sorghum, vegetables and fruits, sugar beets, and cotton, are all produced in India. Despite this evidence, the average productivity of many Indian crops is very poor. The country's population is projected to grow to become the world's largest in the next decade, and feeding them will be a major concern. Farmers are also unable to make a decent living[3].

As shown in Figure 1, even after more than seven decades of planning since independence, the majority of farmers continue to struggle with low output and/or low returns. The following are the major constraints in Indian agriculture that affects Indian farmers:

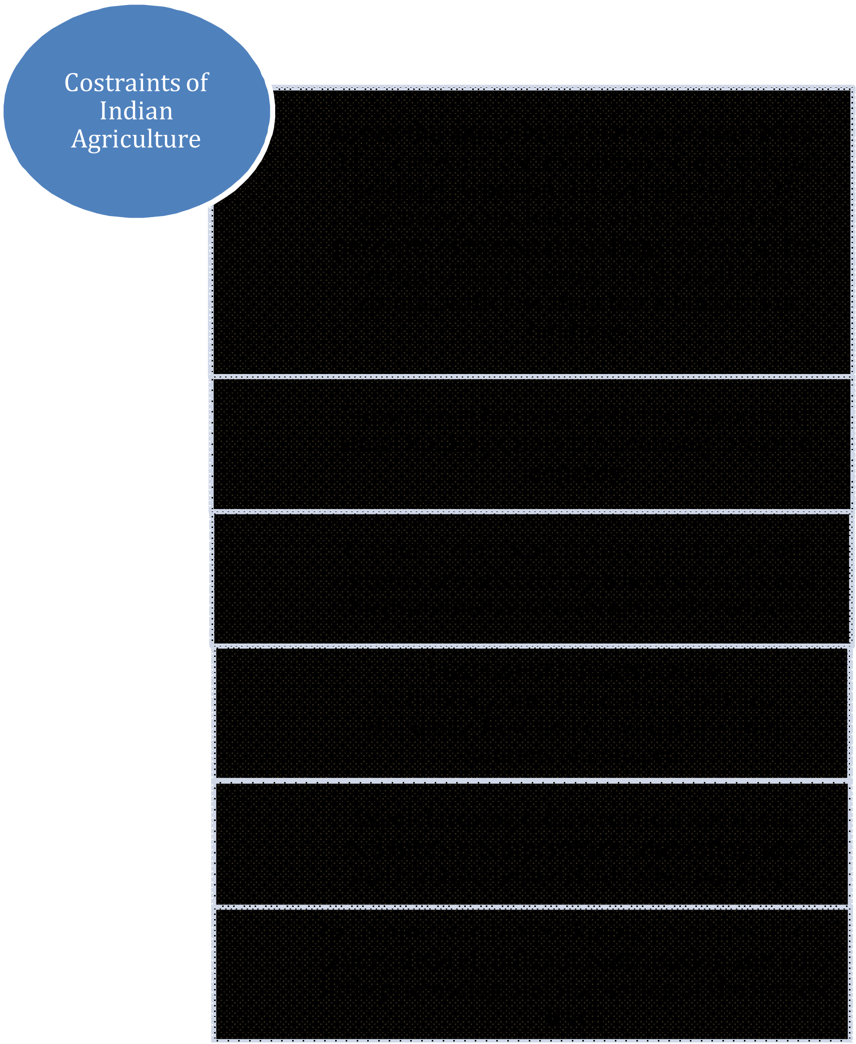

Figure 1: Constraints that are affecting the Indian agriculture system and Indian farmers.

For all the stakeholders and planners the future of agriculture is an important aspect to be considered. A few major challenges of farming in India that include farmers' small holdings, preliminary and secondary processing, the infrastructure supporting, efficient use of resources and marketing, supply chain, and reduction of intermediaries were highlighted and addressed by the government as well as a few other organizations. They also highlight the need of working with cost-effective technologies along with the consideration of environmental protection as well as conservation of the natural resources[4].

Precision farming or precision agriculture is the term that refers to processing or executing the right thing, in an accurate manner and at an accurate place and time. The capital requirement in crop production management includes seed, soil, water, fertilizers, etc to enhance the quantity of yield and profit, reduce water wastage and thereby become environment friendly. Precision farming also includes the process of matching agricultural practices as per the climatic condition of farming and enhancement of accuracy of the applications accordingly[5]. If you look at Indian farming techniques, you'll see there are many more than one hundred fifty million hectares of farmland accessible and many more than one hundred eighteen million peasants in the country. According to statistics from the past forty years, farmland has diminished while the majority of the peasants have increased. According to the Agricultural Census of India, 2010-11, the overall number of active operational holdings was considerably larger than the amount regulated arena, with an estimated 138.35 million operational holdings and a totally controlled area of 15959E100 thousand acres as shown in Table 1 [3].

Table 1: A table illustrating the *Indian agricultural census* of *2010-11*, of all social groups.

Sr. No.	Size Class (In Ha.)	Total Holdings	
		Number	Area
1	Below 0.5	64778954	15541313.53
	(0.5 - 1.0)	28247225	20567151.16
2	Marginal	92925079	35008364.59
	(1.0 - 2.0)	24878250	35244161.51
3	Small	24879250	35244161.51
	(2.0 - 3.0)	9658734	23264412.08
	(3.0 - 4.0)	4256838	14640575.73
4	Semi Medium	13995652	37804888.71
	(4.0 - 5.0)	2441021	10861978.30
	(5.0 - 7.5)	2510792	15229264.02
	(7.5 - 10.0)	934225	7946875.29
5	Medium	5885027	33927008.41
	(10.0 - 20.0)	790031	10588883.36
6	20 & Above	174734	6428058.90
7	Large	973764	16006932.16
8	All Classes	139349462	150592855.98

According to the survey, the total size of the holdings was calculated to be 1.15 hectares, which suggests that each producer had an 115E100-hectare arena of space to build plants on. Rajasthan was believed to have 6888 thousand acres of operating holding and 21136 thousand tons of fully functional arenas as just a consequence of these figures. Furthermore, the total size of the properties was calculated to be 307E100 hectares, implying there is plenty of room to strike the right balance between available farmland and property under production[6].Consider this state: 'A farmer leaves towards his arena with his (Global Positioning System) – GPS directed tractor. The Global Positioning System witnesses the precise position of the tractor inside the arena. It throws the warning sign to a mainframe present at the tractor that has a (Geographic Information System) - GIS, for mapping the nutrient requirement of the soil into it. The (Geographic Information System) – GIS, in collaboration with the Decision Support System, determines the specific fertilizer demand for that area and then directs a variable-grade manure applicator, that is mounted to the tractor, to administer the same dose at that precise position. Much of this happens in a couple of seconds, formerly the tractor goes anymore.' Sounds like something out of a science fiction novel. However, this Precision farming (PF) illustrates to major farmers in the United States and Europe[7], [8]. As a result, the first point that falls into the brain is- this scheme is not suitable for developing nations, especially India, in which agrarians are poor, agriculture is mainly subsistence, and farmland holdings are limited[9].This is far from reality because this strategy has a lot of promise for enhancing agricultural productivity in developed countries. This article aims to understand the feasibility of precision farming adoption in India, as well as the importance of satellite-based satellite data in making it possible.

The Purpose of Precision Farming:

Precision cultivation aims to improve crop yield and environmental quality. It is defined as the application of technology and principles to reduce spatial and temporal variability in all types of agricultural profitability. Precision farming, in other terms, is the matching of resource utilization and agricultural activities to regional differences in soil types and crop requirements. Thus, the theories of precision agriculture involve:

- Variations take place in soil or crop characteristics within an arena.
- These variants are acknowledged, and often analyzed.
- As a result of a field's spatial uncertainty, decisions are taken by the management.

The definition of precision farming has been attributed to a variety of names. In general, both of these words are composed of two expressions. The first expression could be something like "site-specific," "spatially variable," "prescription," "GPS-based," or "precision," while the second expression could be something like "farming," "agriculture," or "crop processing." Though agriculture in the twentieth century was marked by enhanced labor and land growth, the use of exogenous variables and an improvement in the quality and effectiveness of exogenous factors it was also correlated with the promotion of consistency in organic farming areas, as well as harmful agricultural adverse effects[10].The Precision Farming strategies serve the dual goal of making productivity and mitigating environmental loss by cherishing the heterogeneity within the sector and implementing management methods to accommodate the variability. Precision farming's true worth comes from the farmer's ability to do more effective tillage, change implantation speeds, apply fertilizer as per soil requirements, schedule more crop management systems with greater precision, and understand yield variation within a region. These advantages will improve crop production's total cost efficiency, but the grower must be able to change his style of management to make things work[9].

Remote Sensing:

Precision farming necessitates knowledge of the average features of remote, homogeneous management zones. Soil checks for nutrient abundance, yield sensors for crop production, soil examples for organic material quality, details in soil charts, or field conductivity indicators for soil humidity content will all have these average characteristics. In certain cases, the arenas are systematically tested along a normal network, and the measured sample values are parsed using geo-statistical strategies[11], [12]. Soil, temperature, and crop variability geostatistical simulation necessitates a collection of a significant number of tasters at near intervals across the agrarian landscape. These types of samplings are both expensive and time-consuming. The benefits of utilizing remote sensing technologies to acquire spatially variable as well as temporally variable details for precision agriculture have been demonstrated by some researchers. Satellite-based detectors or CIR movie camcorders on deck light aircraft can be used to collect remote-sensing depictions for PF[10]. There are three specific approaches to using remote sensing for precision agriculture. As per the first method, multispectral objects could be utilized for outlier detection. Disease/pest, marijuana production water logging, and other anomalies are examples of such anomalies. It has been possible to diagnose diseases and distinguishes weed from crops using disfigurements in the noticeable portion of the range. An instrument for detecting water stress tolerance in plants has been developed using the discrepancy between remotely sensed average temperature and surface atmospheric temperature readings. However, this method of anomaly detection necessitates routine crop monitoring via a remote sensing sensor[13].

The next strategy is to link spectral response variation to particular variables like soil properties or crop yield. Spectral reflectance can be linked to soil characteristics like soil moisture, organic compounds, and texture. Other soil conditions have been inferred using vegetation spectral reaction. Many grains, such as rice and wheat, have been shown to have a strong relationship with the spectral green vegetation at the full vegetative cover. As a result, administration units can be formed using the yield maps produced through spectral images[14], [15]. The distant sensing statistics should have a high longitudinal resolution to determine within-field inconsistency. Typically, approximately 750 to 1,500 data sets per hectare are used to assess variability. Present satellites could see areas of thirty meters by thirty meters (111E10 hectares), twenty-three meters by twenty-three meters (eighteen hectares), ten meters by ten meters (hundred hectares), and five meters by five meters (four-hundred hectares). We will be collecting data from the upcoming satellite in a range of spatial resolutions, like 1 by 1 meter or over ten thousand data sockets per hectare in some situations[16].

The third method combines biophysical parameters resulting from high-resolution satellite-based remotely sensed statistics (like Leaf Area Index and temperature) through physical crop growth simulation to create a functional decision maintenance framework for precision agriculture. Scientists gave instance, used remotely sensed LAI or evapotranspiration projections as contributions to a basic alfalfa development model. The remote sensing device must have a high spectral determination, covering the entire optical as well as thermal area, to extract biophysical parameters[17].

However, there are some inherent drawbacks to using RS (Remote Sensing) imagery for mapping, including the need for atmospheric correction, instrument calibration, normalization of offender special effects on visual facts, cloud broadcast for statistics, especially mostly throughout the monsoon season, and analyzing imagery from ambient video and digital camcorders[18], [19]. Given the agricultural situation in developed countries, the supply of knowledge with the following features is a prerequisite for a profitable RS technology for precision agriculture:

- Fast turnaround (corrected, acquired, and processed) twenty-four to forty-eight hours
- Low data costs (around Rupees hundred per acre per season)
- Excellent spatial precision (at minimum 2m multispectral for 1-hectare field extent)
- Excellent spectral quality (10 to 20 nanometers for recovering biophysical limitations)
- Excellent temporal determination (at minimum 5 to 6 days per season)
- Prospects of Precision Farming in the Indian Agricultural Scenario

Precision cultivation, despite being an established technique in many ways, is still largely limited to industrialized (American and European) nations. Figure 2 mentioned below view some primary reason for PF's restricted adoption in Asian nations:

Figure 2: Reason for Limited Application of *Precision Farming* in Asian Nations.

Small land ownership and the expense of the PF scheme are the two biggest issues in introducing PF in Indian agriculture. We'll talk about all of them and see if remote sensing mayaid. More than fifty-seven percent (approximately) of operating holdings in India are less than 1 hectare. With this land size as well as the majority of the farming being subsistence, implementing PF strategies on a field-by-field basis is a daunting challenge. Instead of separate fields, adjacent fields with the same crop and related management activities may be considered for PF adoption[20].Since management activities such as seed rate, fertilizer rate, and so on are often dependent on agroecological units, they tend to stay the same over a wide region. In these situations, the PF should be used as an information-based farming method, meaning that the farmer has at least some knowledge of his field's soil type before implementing fertilizer methods. Testing a large quantity of soil testers is currently time-consuming and expensive and it does not capture heterogeneity if the selection is not done properly. A remote sensing founded soil cataloging system would be able to guide samplings toward the heterogeneity trend, overcoming the problems described above[21], [22].

Developments That Prompted Precision Farming:

Much technical advancement in the twentieth century aided in the growth of the precision farming concept. Below are the scientific advancements in Figure 3:

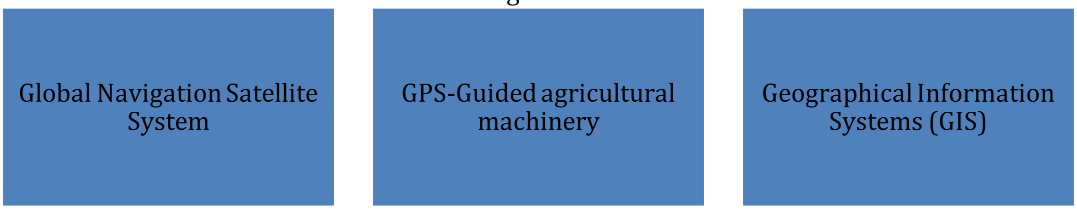

Figure 3: Technologies That Aided In the Development of the Concept ofPrecision Farming.

Global Navigation Satellite System:

Global Navigation Satellite Systems (GNSS), like the USA's NAVSTAR GPS and other former Communist Union's GLONASS, have aided in pinpointing the exact position. The spatial (horizontal) accuracy of the GPS in post-S/A mode can be on the order of 20 meters, while it is about 1 meter in differential mode.

Global Positioning System -Guided Agricultural Machinery:

This is a big breakthrough that gave birth to the idea of precision farming. Agrarian targeting systems are divided into two groups. The chief is for tracking or sensing important soil or crop constraints including soil moisture quality, nutrient supply, weed position, and yield mapping. And the second submission where infield location is needed is for accuracy application apparatus (variable amount applicators), wherein the field automobile's actual positioning should be compared to a demographic trends map of the applicable parameter. Only a real-time position is needed for surveillance operations, while precision applications need both a real-time position and a forward estimation of positioning.

Geographical Information Systems (GIS):

In improved agricultural or precision farming vehicles, GIS serves two purposes. For starters, precision farming requires a mix of GIS and simulation models. There are numerous pieces of evidence for various purposes, including water flow, crop formation, soil degradation, fertilizer and pesticide leaching, and so on. GIS facilitates the integration of geographical data on a variety of topics, including soil, crop, temperature, and pitch history, as well as simulation mockups. Another part of GIS assistance for accuracy agriculture has been the engineering portion, which involves translating research results into operating structures that can be used on farms. GIS can help with such engineering practice by offering a decent forum for storing database schema, basic modelling, presenting findings, developing an interface, and monitoring field navigation when used in conjunction with a GPS. A decision assistance system for precision farming processing at the farm level can be built using GIS.

Precision agriculture aims to adopt agricultural inputs and processes:

There are currently no precision agrarian systems; instead, different elements of conventional crop development schemes have been examined separately for their ability for site-specific organization, most importantly soil fruitfulness. From a systems approach, precision agriculture is similar to the earlier days of no-tillage crop processing. While the technology to grow seeds into tilled soil became possible in the 1960s, effective no-tillage schemes also weren't introduced and applied until many facets of agricultural production, including fertility and pest control, were properly tackled within the failure of tillage and plant residue management. The widespread acceptance of no-tillage did not begin until the decade of the 1980s when the incorporation of suitable technology and public strategy aided its spread among agrarians. Similarly, though some innovations allowed for variable application of nutrients as well as insecticides in the initial days of accuracy agriculture, there was no comprehensive sympathetic of how soil fruitfulness and pests differed in space and time[23], [24].

Most importantly, there were no reasons for what triggered the instability, making it impossible to match suitable inputs to site-specific conditions. Individual elements of precision agriculture are being implemented on farms today, but a comprehensive precision farming method is yet to emerge. Technological advancements continue, and continuing study is resulting in a greater understanding of fundamental mechanisms, but a true system is yet to appear. As an outcome, the thought of precision farming could only be labeled functional at best. Agriculture by the base, agriculture by land, variable rate technology, spatially variable, precise, prescription, or site-specific crop processing, and site-specific administration have all been used to define the definition of precision agriculture since the mid-1980s. All of these concepts, on the other hand, have the general idea of balancing uncertainty at field scales. Precision cultivation, as per scientists, entails "directing of contributions to arable yield manufacture as per crop specifications on a regional basis."Precision agriculture's purpose is to adjust agricultural inputs and practices to regional conditions within a domain that can identify the appropriate operation at the right time and in the right location. Precision agriculture, according to a recent study by the National Research Council's Board (NRCB) on Agriculture Committee, is "an organized approach that utilizes information expertise to put data from various bases to tolerate on agricultural production decisions."While the NRC concept highlights essential informative aspects of precision agriculture, it neglects to stress precision agriculture's fundamental premise: the control of spatial and temporal variability[25], [26].

The following concept of precision agriculture serves as the foundation for our discussions in this chapter: Precision farming is the utilization of machinery and perceptions to observe the spatial and temporal inconsistency of all surfaces of agrarian construction to improve crop yield and environmental excellence. We give a final comment on the term precision since there is bound to be a misunderstanding between its use in precision agriculture and its use in statistics. Precision denotes the condition or situation of being accurate, where accuracy refers to being minutely accurate, which is a synonym for true[27]. Precision agriculture is a term that describes exactness and means correctness or consistency in all aspects of development. However, in mathematics, precision refers to the similarity of repetitive quantities of the same quantity, while accuracy refers to the similarity of a determined or calculated value to its true value. Precision is synonymous with the repeatability of observations, while accuracy is synonymous with correctness.

As a result, anything may be precise but not exact. Another point to consider is the measurement accuracy indicated by the number of digits recorded for a particular measurement. Because of the architecture of machines, it is simple to imply greater accuracy than was previously possible in different fields of precision agriculture data gathering, analysis, and computation[28], [29]. The number of digits recorded for a calculation implies the precision of the measuring instrument between which the actual measurement is presumed to lie. The higher the accuracy inferred by a calculation, the more and more digits are recorded. A pH of 5.44 indicates greater accuracy than a pH of 5.4. One additional digit across the last relevant one determined by the examiner is the required precision with which to register a figure. In the implementation of precision agriculture, statistics play a significant role, and caution must be taken when grappling with accuracy, precision, and inferred precision in reporting results[30].

CONCLUSION

Precision farming should be implemented in India using two different strategies: one for limited farming and the supplementary for high-contribution profit-creation farming. In the circumstance of the previous, the primary issue is increased production. The scheme must be changed to knowledge-based agriculture in this case, with the farmer having latitudinal information about the crop and soil. This data can be used to create a more effective input system. Since the field sizes are so limited in this case, a single bonded pitch or a cluster of pitches may be called a unit for mutable rate applications. However, in the latter case, like Indo-Gangetic wheat and rice, as well as gardening crops similar as grape potato (Punjab), tea (Assam), and (Maharashtra), field sizes are enormous and agriculturalists are wealthy. Already, agricultural inputs are strong, resulting in ecological imbalances in many areas. Apart from increasing productivity, the quality of input usage is the primary consideration here. Remote sensing statisticsmay be utilized to perceive spatial or temporal fluctuations, and advanced instruments including variable rate applicators can be used to take the appropriate steps. Precision farming is critical for increasing sustainability while still reducing environmental depletion. While it is commonly used in developed countries for commercial crops, it is still in its infancy in most developing nations. Remote sensing will deliver critical feedback (inconsistency map) for precision farming applications at a lower price. Precision farming research has previously begun in India, at places like the Indian Space and Research Centre (ISRO), the MS Swaminathan Research Establishment in Chennai, the Indian Agricultural and Research Institute in New Delhi, and the Project Executive of Cropping Schemes Research in Modipuram, among others. In the upcoming years, Precision Farming could be able to assist Indian farmers in reaping the benefits of frontier developments without endangering land quality, transforming the green revolution into an evergreen revolution.

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CONFLICT OF INTEREST

The authors have no conflict of interest

AUTHOR CONTRIBUTIONS

Dr. Rohit Kumar, Dr. A.K. Yadav, - Contributed to conducting an experiment, collecting and analyzing data, and paper preparation; Dr. Heena - Research supervisor; Mr. Aishwary Awasthi, Dr. Dinesh Singh - Data analysis and interpretation.

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