Sensor Based Organic Farming for Sustainable Development an Indian Perspective

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Abstract— Exponential growth in population and indication of declining productivity is a great challenge against the Indian agricultural sector to achieve food and environmental security. To take on this challenge, modern precision technologies involving systems approach towards efficient crop and input management, and scientific land and water use planning, and slowly moving nonorganic farming towards traditional organic farming is an urgent need of our country. Sensor-based agriculture is the best alternative for improving the production capacity of land on a sustainable basis. Geographical Information System (GIS), Remote Sensing, Variable Rate Technology (VRT), crop growth models and ground-based sensors moving from single to multipurpose and collaborative applications interacting across various verticals industries and peoples. Despite several obstacles, there scope to take a part of precision farming technologies in Indian agriculture. The rate of transformation to precision farming depends on the level of commitment of politicians, scientists and technocrats. In this paper we have discussed the present technological components, current status in relevance to organic, nonorganic farming and modern agricultural technologies with GMO.

Keywords— *WSN;GMO;GM Seeds; Adoption of precision agriculture; Smart Farming; Efficiency; Productivity; yield.*

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I. INTRODUCTION

India is an agriculture country and farming plays an important role in the economy of our country, but due to climatic variations and extreme events and unpredictable atmospheric changes, including at the levels of crop or livestock, farm or cropping systems and the food system will create adverse impacts on agricultural production that results in terms of shortages of agricultural products and rising prices which could endanger the food and livelihood security of our country. So, productive and sustainable growth is important in the agricultural field. In our country, crop production management bit difficult task as more than 90% farmers are managing the crop production by open eye observation. The traditional method for crop production requires implementation of various series of tasks, such as planting, fertilizing, harvesting, with a predetermined schedule. Agricultural and environmental data collected can be used for more intelligent decisions such as weather, soil and air quality, monitoring of crop growth and even equipment and labor costs etc. This is known as precision agriculture, facilitating access to information and promoting capacity building.

Precision farming [1] is new farm management technique introduced to satisfy the uncertainties by discriminating the input application, with an overall objective to increase yield and profit by reducing inputs and environmental degradation caused due to over chemical applications. Precision farming is farm management; typically the varied nature of the terrain of a farm would mean managing these with accuracy, which would result in reduced input and costs subsequently growing more food. A farmer needs to take 40 odd decisions over a crop cycle, from pre-harvesting to post-harvesting phases. Precision farming helps a farmer reach an informed and scientific decision in each of the 40 odd decisions he makes.
There are lot more issues specific to system-specific production technologies, difficult terrain, and inaccessible habitations, crushing of crops by wild animals, management of small, scattered, fragmented, uneven lands etc. can be handled easily and effectively with precision farming. Precision farming doesn't mean to utilize resources but to overall reduce investment, decrease pollution of the environment but also get the most of social and economic efficiency. Precision farming methods help in recognizing areas by farmers that have productivity problems and selecting the best solution, the speed of transformation to precision farming depends much on the level of commitment of politicians, scientists and technocrats at whose mercy the farmers.

II NEED MISCONCEPTIONS, OBSTACLES AND OBSTACLES OF PRECISION FARMING

The need for precision farming:
Throughout the globe peoples are facing food system related challenges today which has increased the demand and supply gap. Much can be achieved immediately with current technologies and knowledge, given sufficient will and investment [2]. In order to cope up future challenges there is need to do radical changes to the food system and investment in research to provide new solutions to novel problems. The rate of decline in productivity, diminishing and degrading

natural resources, stagnating farm incomes, lack of eco-regional approaches, declining and fragmented land holdings, trade liberalization in agriculture, limited employment opportunities in the non-farm sector, and global climatic variations have become major concerns in agricultural growth and development. In order to meet the requirement adoption of newly emerged technology is seen as one key to increase agriculture productivity in the future.

Misconceptions about precision farming: Precision agriculture is a cropping rather than an agricultural concept - This is due to cropping systems, in particular broad-acre cropping, being the face and driving force of PA technology, PA techniques can be used and applicable to all the agricultural sectors from animals to fisheries to forestry

Precision agriculture in cropping equals yield mapping - Yield mapping is a crucial step and the wealth of information farmers are able to obtain from a yield map makes them very valuable. The biggest hurdle lies in collecting the information in the yield map and using it for improving productivity.

Precision farming leads to sustainability- Precision farming is a tool to make agriculture more sustainable however it is not the total answer. Precision farming leads to maximum production efficiency with minimum environmental impact..

Obstacles for precision farming - There are several obstacles for the adoption of precision farming in developing countries in general and India in particular. Some are common to those in other regions but the others are specific to Indian conditions are as follows.

- Culture and perceptions of the users
- Small farm size
- Lack of success stories
- Heterogeneity of cropping systems and market imperfections
- Land ownership, infrastructure and institutional constraints
- Lack of local technical expertise
- Knowledge and technical gaps
- Data availability, quality and costs

For precision farming number sophisticated tools are used which assist in monitoring variation and managing inputs, attribute but still more than 90% of farmers in India are using traditional technique for farming that lacks in real-time data, soil health, water quality, pest control mechanism and demand based precise watering as depicted in Figure 1.

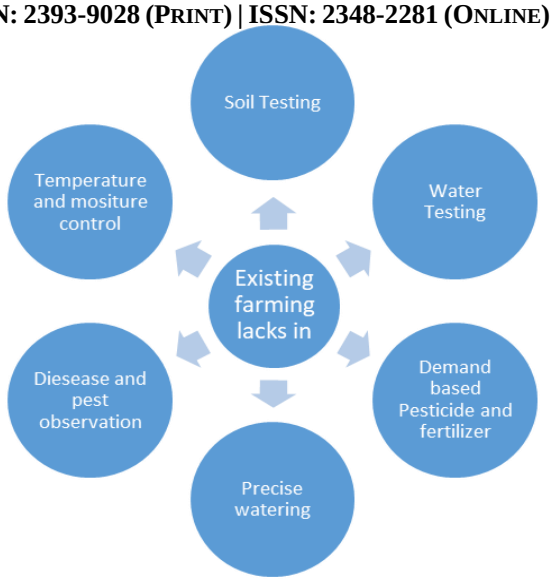

Figure 1. Existing farming status

III ROLE OF SENSOR NETWORK IN FARMING

Sensors are used for collecting live data from the field and provide it for decision making. Agriculture domain is having several requirements:

- Collection of real-time data from the field such as soil moisture, temperature, humidity and rainfall etc.
- Processing on captured data.
- Send an alert message to the user/ farmer.
- Monitoring of distributed land
- Management of water requirement to crop.

In India, water scarcity is a major challenge for farming since there are variation in the rainy season and the rainy season is not constant throughout the year in India so its very important to do, water management in farming and it can be managed effectively with modern Technologies. Wireless sensor networks as a tool provide crop productivity, quality, resource utilization, crop management. The main purpose of WSN to increase crop productivity that will lead to improving the farmer's economic condition. WSN provides a way to capture live data with numerous devices and provide solutions to agricultural issues as shown in Figure 2.

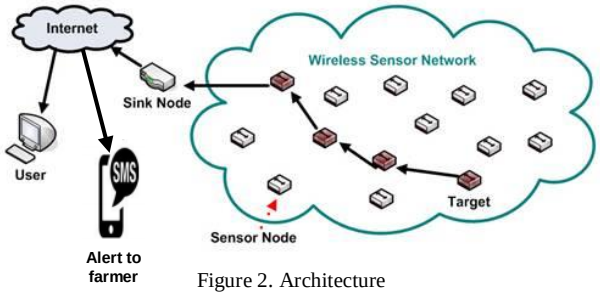

Figure 2. Architecture

Due to the enormous growth in technologies, farming has become more popular and significant. Different tools and techniques are available for the development of farming. According per the UN Food and Agriculture Organization, for feeding the growing population of the Earth, the world will need to produce 70% more food in 2050 than it did in 2006[3]. To meet this demand, farmers and agricultural companies are turning towards sensors based Technologies many agricultural industries have turned for smart farming to enhance efficiency, productivity, global market and other features such as minimum human intervention, time and cost etc.. Equations

Figure 3. Role of WSN in precision farming.

The advancement in technology ensures that the sensors are getting smaller, more sophisticated [4] and more economic. The Sensor network deployed is easily accessible globally in order to achieve smart farming at full pledge, and Farmer can get any required data or information as well as monitor his agricultural sector. All this can be done using smartphones and modern devices, Figure 3. Shows the role of WSN in precision farming.

Sensor technology is more efficient due to the following reasons:

- Global Connectivity through any devices.
- Minimum human efforts
- Faster Access
- Time Efficiency
- Efficient Communication

The key advantages [5] of using Sensor Network in enhancing farming are as follows:

- Water management can be efficiently done without wastage of water using sensors
- Helps to continually monitor the land so that precautions can be taken at an early stage.
- It increases productivity, reduces manual work, reduces the time and makes farming more efficient.
- Crop monitoring can be easily done to observe the growth of the crop.
- Soil management such as PH level, Moisture content etc can be identified easily so that farmer can sow seeds according to soil level.
- Sensors and chips used in network would recognize the diseases occurred in plants and crops.
- Sensors send the EPC (information) to the sink and are shared across the internet.
- The farmers, researchers and scientist can access this information from a remote place and take necessary actions, Automatically crops can be protected from coming diseases
- Farmer can easily be connected to the global market without restriction of any geographical area that lead to increase in sale at global market.

Despite several pros and cons obstacles listed earlier, business opportunities for precision farming technologies including GIS, GPS, RS and yield monitor systems are immense in many developing countries [6]. The scope for funding advanced precision farming related hardware, software and other desired precision equipment's is gradually increasing. Precision farming is becoming boon especially for the developing countries. Rice, wheat, sugar beets, onions, potatoes and cotton among field crops and apples, grapes, tea, coffee and oil palms among horticultural crops are perhaps the most relevant. For all these crops, yield mapping is the first step in determining the precise locations of the highest and lowest yielding areas of the field. Precision farming based Sensor network –innovation has the potential to significantly boost the economy especially of rural areas.

IV PROPOSED METHODOLOGY

For realizing the sensor based precision farming a laboratory model is prepared and sensors are deployed in testbed as shown in Figure 4

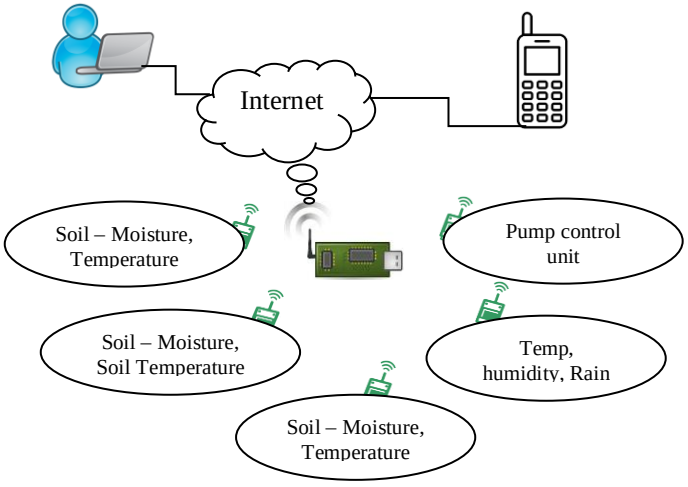

Figure 4. Proposed Laboratory Testbed Setup.

For realizing the network we have done the utilization of Arduino microcontroller . For providing temperature, moisture and other parameters DHT11 is connected to ardunio as an input device on other hand water pump control connected to ardunio as an output device. Coordinating station is of raspberry pi that connects the sensors of Internet cloud server through which farmer is in a position to view the parameters specific to farm and control the operation from mobile or internet connected device.

Sensor networks sense and forward the recorded parameter to sink or station node for carrying aggregation and uploading it on the cloud. Application logic is designed to keep the system up to date with the latest agricultural field parameters so that farmers get updated information about their farm through smartphone from a remote location.

V ORGANIC VS NON-ORGANIC FARMING

Revolution in farming especially Green Revolution has done a great impact on the way of farming, there is a shift from tradition organic farming to nonorganic i.e. farmers started using chemical fertilizers, insecticides and GM seed [7,8] in order to increase the yield or production of farm but it has created some adverse effect on the health of human, animals as well on the environment. For sustainability there is need to get done the risk-benefit analysis of modern agriculture techniques especially GMO [9, 10] and nonorganic techniques.

The risk-benefit analysis of the GM crops

Benefits

- Using insect resistant varieties approximately halves the consumption of insecticides,
- Reduced insecticide use can increase the proportion of valuable insects in the crop,
- GM plants based on BT genes appear to have no negative impact on honey bees.
- Improved resistance to diseases, pests and herbicides
- Improved tolerance to cold/heat
- Improved tolerance to drought/salinity
- Reduced maturation time
- Increased nutrients, yields, quality and stress tolerance
- Shelf life increased, medicated foods like edible vaccines—for example, bananas with bacterial or rotavirus antigens
- Increased food security for the growing population
- Enhanced taste and quality
- Reduced maturation time
- New products and growing techniques

Issues concerns to Human and animal Health environmental safety concern:

- Better yields of meat, eggs, and milk
- Improved animal health and diagnostic methods
- Increased resistance, productivity, hardiness, and feed efficiency
- Affects human health include allergens, transfer of antibiotic resistance markers and ‘outcrossing’.
- Transgenes affects the pollination, through cross-pollination, unknown effects on other organisms (e.g., soil microbes), and loss of flora and fauna biodiversity.

Environment

- "Friendly" bioherbicides and bioinsecticides
- Conservation of soil, water, and energy
- Bioprocessing for forestry products
- Better natural waste management
- More efficient processing

Safety

- Create harm to human health like allergens, transfer of antibiotic resistance, unknown effects.
- Unknowingly transgenes are transferred through cross-pollination may results in unknown effects on other organisms (e.g., soil microbes), and loss of flora and fauna biodiversity may affect environment.

Ethics

- Violation of natural organisms' intrinsic values
- Unethical to mix genes among species
- Unethical to mix animal genes in plants
- Stress for animals

Concerns

Most of the researchers and scientists had analyzed other aspects apart from human health risks and environmental safety concerns. There have been claims and counter-claims regarding the growing of the GM crops and as of now with limited facts and figures, it is very difficult to analyze the risks and benefits associated with this technological breakthrough in agriculture.

A glance at some of the arguments put forth by the opposing viewpoints would shed some light on this aspect is summarized in Table 1.

TABLE 1. FOR AND AGAINST OF GM CROP

FOR	*AGAINST*
No significant difference was noted between Bt Brinjal and Non-Bt Brinjal as per biosafety .	The current safety assessments are inadequate to catch most of the harmful effects of GM crops.
Human health concerns due to pesticide use can be addressed with this transgenic Brinjal with its in-built tolerance to pests resulting in lesser use of pesticides.	Several studies in Bt crops show that there are many potential health hazards. With Bt crops, allergies have been reported. Itching skin, eruptions on the body, swollen faces, etc., have been reported, correlated with levels of exposure to Bt Cotton.
With this in-built tolerance against pests in Bt Brinjal, there would be a substantial increase in marketable yields resulting in higher incomes for farmers.	Apprehension has been expressed that the target pest would grow resistance to the Bt toxin with time. Not enough studies on soil ecology have been done to understand the impact of Bt toxin. Farmers from various parts of the country have reported a decline in their soil productivity after growing Bt Cotton.
Pricing of the seeds would be based on a cost recovery model, making it affordable for all farmers. Moreover, farmers would be able to save and reuse their seeds for the hybrids.	With the promotion of GM agriculture in general and with Bt Brinjal in this case, the rights of non-GM farmers to stay GM-free get badly affected.

VI GMO STATISTICS AN INDIAN PERSPECTIVE

Farming community has adopted biotech crops, during the initial 20 years of commercialization, reflects the substantial multiple benefits realized by both large and small farmers in industrial and developing countries, which have grown biotech crops commercially [11].

India is occupying the 4th position with 11.6 million hectares of GM crop during 2014 and 2015. The top ten countries with GM Crop cultivation are depicted in Table 2.

TABLE 2. GM CROP CULTIVATION

Country	*Crop*	*Area (million Hectare)*
USA	Maize, soybean, cotton, canola, suga beet, alfalfa, papaya and squash	70.9
Brazil	Soybean, maize, cotton	44.2
Argentina	Soybean, maize, cotton	24.5
India	**Cotton**	**11.6**
Canada	Canola, maize, soybean and sugar beet	3.70
China	Cotton, papaya, poplar, tomato, sweet pepper	11.0

Bt cotton is the only transgenic crop approved for cultivation in India[13] subsequent to extensive evaluation and regulatory process. Bt cotton was introduced primarily for bollworm control. Yields of cotton which was 189 kg lint per ha in 2001 increased to 504 kg lint/ha in 2015.

The Emergence of Farmers' Suicides - National Bureau of Crime Records. The latest figure updated to 2012 is 284,694. Poor farmers are getting outraged at this tragedy and the role of seed monopolies in cotton farming is mainly contributing to farmers suicides[14] has to be studied, one must focus on cotton areas, not on the entire country .

Destruction of choice -Farmers are not having any choice left other than Bt. the systematic wiping out of non Bt. alternatives due to aggressive marketing of Bt. Cotton has created a monopoly. Its deliberate destruction of available alternates that have pushed farmers into the Bt. cotton trap, and that leads farmers to the suicide trap.

Failure to Yield - Yield of cotton have not grown since Bt. cotton was introduced [8]. As per stats before introduction of Bt cotton yields were higher than after. Our field surveys reveal frequent failures.

Increase in Pests and Pesticide Use - Contrary to the claim of the GMO lobby, pests have increased[15], not reduced, and therefore pesticide use has gone up, not come down. Table 3 shows the year-wise increase in the cost of pesticides in Maharashtra.

TABLE 3. INCREASING COST OF PESTICIDE IN MAHARASHTRA

YEAR	Maharashtra	
	The area under BT Cotton Million Hectares	**Cost of Pesticides (Rs Crores)**
2004-05	0.200	92.10
2005-06	0.607	273.45
2006-07	1.840	847.32
2007-08	2.880	1326.24
2008-09	2.984	1335.34
2009-10	3.315	1483.22
2010-11	3.9	1654.00
2011-12	4.095	1858.00

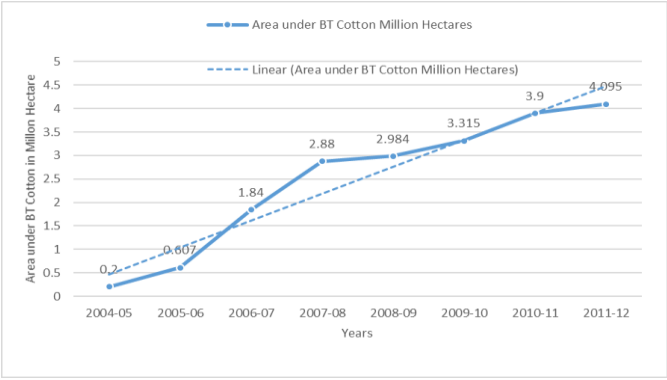

Figure 5. The area under cultivation of BT Cotton in Million Hectare

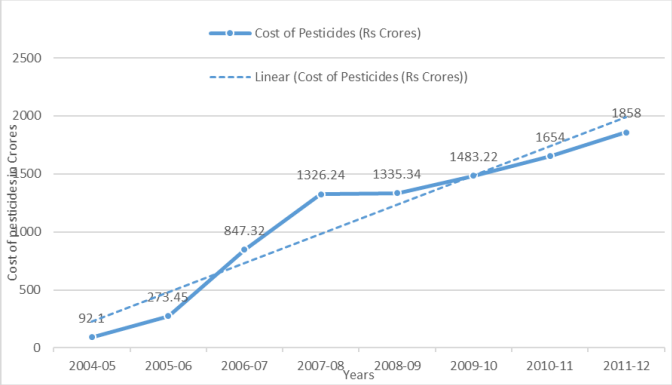

Figure 6. Cost of pesticide consumption in Rs Crore

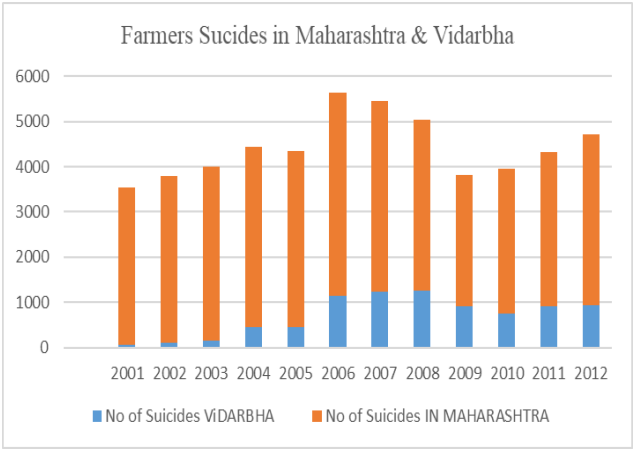

Figure 7. No. of suicides in Vidarbha and Maharashtra

Field studies in Vidarbha show a 13 fold increase in the use of pesticides after Bt cotton was introduced as shown in Figure 5 & 6. Farmers' profits have not increased; in fact, farmers have gotten into debt, and that is the reason they are committing suicide.

Seeds of Suicide: GMO Bt. cotton is has played major role for increasing farmers' suicides the combination of high costs of seed due to royalty collection, failure to increase yields or control pests, Bt. cotton has intensified the agrarian distress faced by farmers in the cotton areas of India [13]. Maharashtra is a state which today has a maximum area under Bt. cotton. The scenario of Vidarbha, where farmers are mainly doing cultivation of Bt. cotton, is the center place of farmers' suicides, clearly shows that suicides increased after the introduction of Bt. Cotton[8]. There were only 52 farmer suicides in 2001 but since 2002 suicides have increased alarmingly as the area under Bt. cotton increased as shown below in Table 4.

TABLE 4: NUMBER OF FARMERS' SUICIDES OVER THE YEARS IN VIDARBHA & MAHARASHTRA

Years	No of Suicides in Vidarbha	No of Suicides in Maharashtra
2001	52	3500
2002	104	3700
2003	148	3850
2004	447	4000
2005	445	3900
2006	1148	4500
2007	1246	4200
2008	1248	3800
2009	916	2900
2010	748	3200
2011	916	3400
2012	927	3800

Prospects of organic farming - Considering potential advantages of organic farming over the modern agricultural practices once again the modern farmers of India as well across the globe are getting attracted towards organic farming. Organic farming encompasses biological processes without the intervention of inorganic remedies such as chemicals or biotechnological intervention like genetically modified organisms (GMO). The concept of organic farming has been given a special relevance in Rig Veda but commercialization of agriculture especially the use of pesticides, fertilizers and GMO has done the negative impact on the environment. An interesting fact is that fertilizers have a short-term effect on productivity but on the contrary have a long-term negative effect on the environment. In the name of meeting the ever-increasing needs of population growth, we have taken a wrong turn of unsustainability.

Apart from several benefits, it has been demonstrated extensively that plant products from organic farming are substantially better in quality like bigger in size, look, flavor and aroma. Animal products are of better quality when they are fed with feed and fodder produced organically[18]. The underground water of the area where the organic farming system is in practice has been found to be free of toxic [19] chemicals.

Organic agriculture is productive and sustainable, organic food production costs are higher in the developed countries as organic farming is labor-intensive[20] and labor is costly in these countries. But the use of technology in conjunction with the organic farming will provide us desired yield with sustainability.

VII CONCLUSION

Precision farming in almost all the developing countries, including India, is in its initial stage, but there are numerous opportunities for adoption. I believe that progressive Indian farmers, with guidance from the public and private sectors and agricultural associations, will adopt it on a limited scale as the technology shows the potential for increasing production and

economic returns on fields with significant variability, and for minimizing environmental degradation there is need of sensor based smart farming to improve productivity, yield, efficiency, water management, crop monitoring, and management. Sensor based farming leads to minimize human efforts, simplifies farming techniques. Along with these features smart farming can help to grow the market for farmers with a single touch and minimum efforts.

GM technology enables plant breeders to bring together in one plant useful genes from a wide range of living sources, not just from within the crop species or from closely related plants. This powerful tool allows plant breeders to do fast what they have been doing for years and generate superior plant varieties. GM crop propagation proves to be a good alternative for revenue generation in the form of high yield, but controversies surrounding GM foods and crops commonly focus on human and environmental safety.

We have a strong feeling that farmers suicides are directly related to seed monopolies, increased in uses of fertilizers, insecticides decrease in yield of crop produced specially by using GM seed, so unless and until comparative study is not done to examine the reasons for not accepting GM technology by the developed country, our farmers must have to adopt traditional seeds, organic fertilizers and insecticides with support of Sensor-based precision farming to improve the yield and overcome issues specific to GMO's on human health and environment for sustainable development.

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