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# Precision Agriculture Technologies for Sustainable Development

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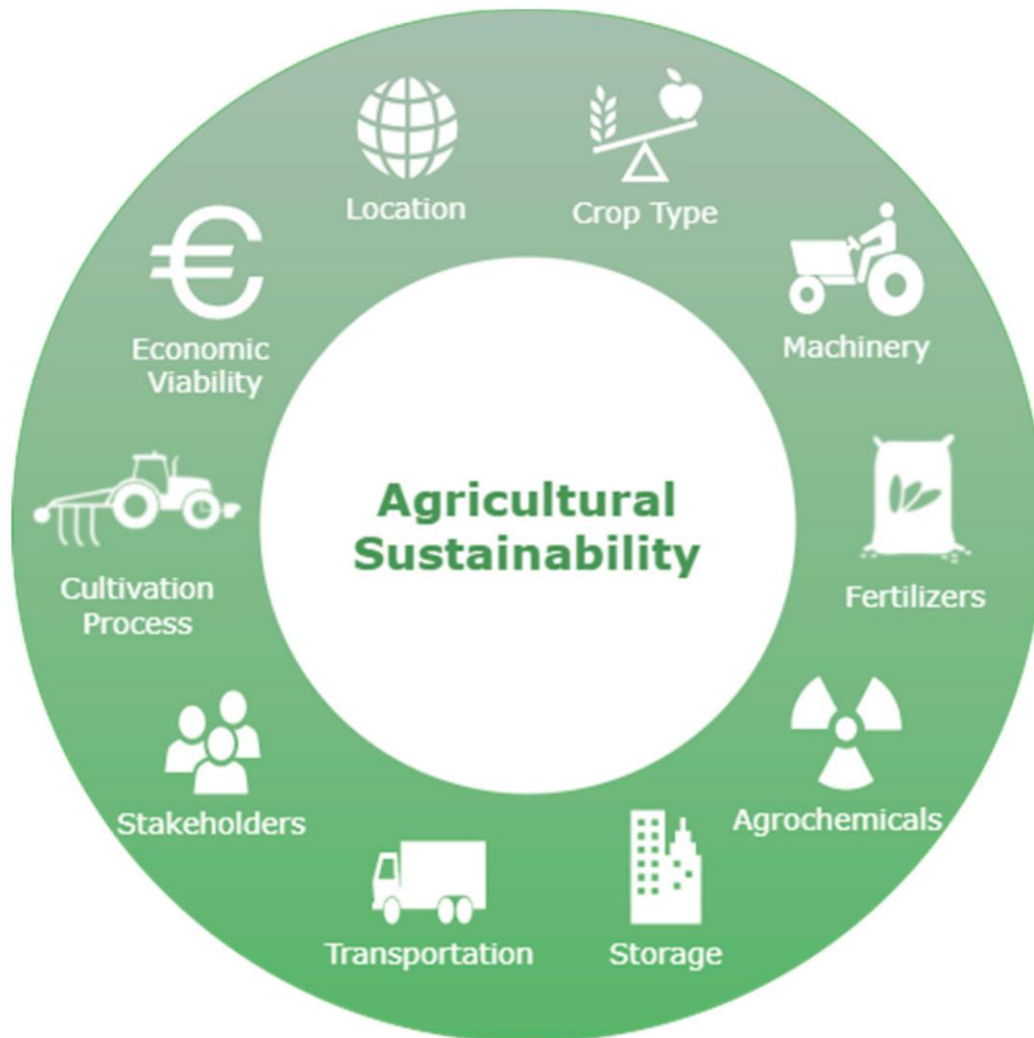
**ABSTRACT:** Socio-economic changes in developing countries, including India, are creating new scopes for appliance of precision agriculture (PA). PA is a hopeful farm management strategy that is changing the way people farm. Now, there is an increasing commitment to reduce reliance on unnecessary chemical inputs in agriculture. Various technologies have been applied to make agricultural products safer and to lower their adverse impacts on the environment, a goal that is consistent with sustainable agriculture. PA has emerged as an important component of the framework to accomplish this goal. This review describes the different components of precision agriculture that can be used for sustainability and environmental protection. The precision farming developments of today provide the skill for the environment friendly agriculture of tomorrow. Especially in the case of small farmers in developing countries, PA holds the promise of substantial yield enhancement with minimal external input. Precision agriculture (PA) involves the application of technologies and agronomic principles to manage spatial and temporal variation associated with all aspects of agricultural production in order to improve crop performance and environmental quality. The focus of this book is to introduce a non-specialist audience to the the role of PA in food security, environmental protection, and sustainable use of natural resources, as well as its economic benefits.

The technologies covered include yield monitors and remote sensing, and the key agronomic principles addressed are the optimal delivery of fertilizers, water and pesticides to crops only when and where these are required. As a result, it is shown that both food production and resource efficiency can be maximized, without waste or damage to the environment, such as can occur from excessive fertilizer or pesticide applications. The authors of necessity describe some technicalities about PA, but the overall aim is to introduce readers who are unfamiliar with PA to this very broad subject and to demonstrate the potential impact of PA on the environment and economy.

**KEYWORDS:** precision, sustainable, development, technology, agriculture, natural, resources

## I. INTRODUCTION

The International Institute for Sustainable Development (IISD) is an independent think tank championing sustainable solutions to 21st– century problems. Our mission is to promote human development and environmental sustainability. We do this through research, analysis and knowledge products that support sound policymaking. Our bigpicture view allows us to address the root causes of some of the greatest challenges facing our planet today: ecological destruction, social exclusion, unfair laws and economic rules, a changing climate. IISD’s staff of over 120 people, plus over 50 associates and 100 consultants, come from across the globe and from many disciplines. Our work affects lives in nearly 100 countries. Part scientist, part strategist—IISD delivers the knowledge to act. IISD is registered as a charitable organization in Canada and has 501(c) (3) status in the United States.[1,2]



IISD receives core operating support from the Province of Manitoba and project funding from numerous governments inside and outside Canada, United Nations agencies, foundations, the private sector and individuals. Worldwide, food and agriculture systems face three complex challenges. First, demand for nutritious food continues to rise globally. Second, food and agriculture systems are having to adapt to changing weather and ecological conditions, while reducing the harm they cause to the environment. And third, farmers and farmworkers face economic precarity and vulnerability, with too many living in poverty and chronic hunger. The challenges are immense, but there are technologies that can make a positive difference. This report looks at innovations in three areas of technology, particularly how the declining costs and increased availability of renewable energy can make a difference. The report looks at how off-grid electrification using solar photovoltaics (PV), dramatic improvements in battery capacity and performance, and the data revolution in information and communication technology (ICT) can each strengthen the resilience and sustainability of food and agriculture systems in low-and middle-income countries. History teaches us that the introduction of new technologies has unpredictable effects. Policy-makers need to anticipate potential risks to ensure technologies do not undermine public policy objectives. New technologies open the possibility of bringing an affordable and reliable supply of energy to rural communities everywhere. For this to work, it is important to understand the challenges. [3,4] For example, a number of the innovative technologies considered here are associated with high upfront costs, even though the running costs are negligible. If this is understood in advance, governments can work with end users and financial services providers to protect inclusive access. Another challenge is the need for effective privacy laws and regulations to manage data gathering and data use by private firms and government agencies. This remains a work in progress in both rich and poor societies, but it is a challenge that countries without strong legal institutions might hesitate to take up. Yet affordable energy from renewable sources is critical to realizing the UN Sustainable Development Goals (SDGs), not least SDG 2, which is the goal to end hunger sustainably, with

improved nutrition, increased small-scale food producer income, and better environmental outcomes. This paper looks at answers to the question, “How can disruptive technologies help?” [5,6]

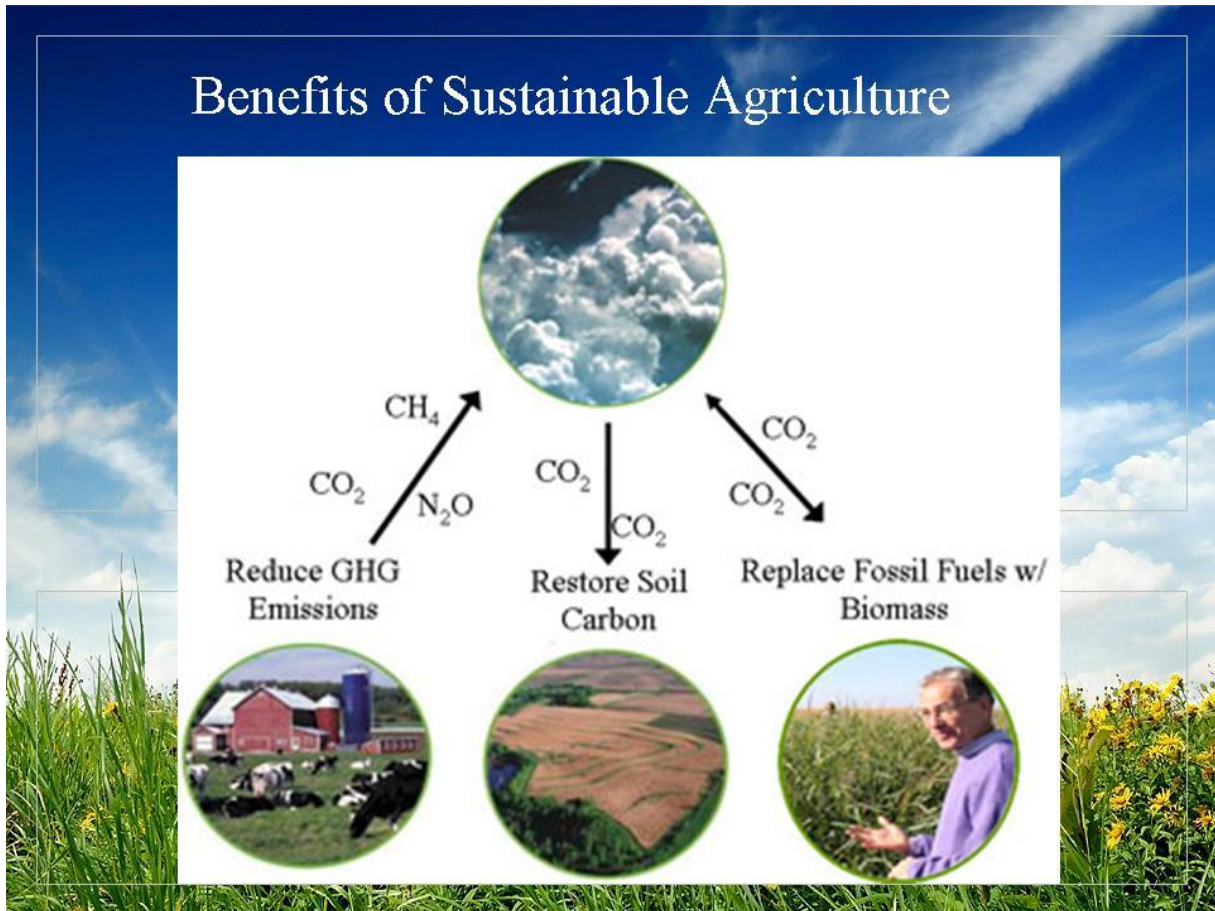
## II. DISCUSSION

Precision agriculture is a data-driven approach to farm management that can improve productivity and yields, thereby increasing the overall profitability of farming.



It also helps reduce the need for inputs such as water and artificial fertilisers and pesticides, thus reducing the environmental footprint of farming. Advances in digital technologies like mobile phones, remote sensing using satellites, unmanned aerial vehicles (UAVs), Internet of Things (IoT), artificial intelligence (AI), and cloud computing, as well as their growing affordability are making precision agriculture applications accessible for smallholder farmers in developing countries. [7,8]

This report is meant as a guide for project managers exploring the use technology and innovation in agricultural initiatives. It provides an overview of the above technologies and the precision agriculture applications they enable, through real-world examples and use cases. It also highlights technical and operational considerations such as the technological feasibility of solutions, suitable business models for scaling up their adoption, and potential barriers such as lack of digital infrastructure and literacy and digital skills among farmers.



We throw away about half of the food we produce - more than 900 million tons of it every year. Yet 2 billion people in the world are unsure where their next meal will come from, according to the UN.

So, the challenge for Real Action: Smart Agriculture to answer is: How can we leverage technology to reduce food waste, and get perishables to the right place at the right time – and in the right amount?[9,10]

Our first Real Action series focuses on a promising remedy to this problem with Smart Agriculture, a suite of advanced farming technologies. This emergent concept applies IoT in farming, along with other cutting-edge technologies such as AI, Big Data and robotics, to the food supply.

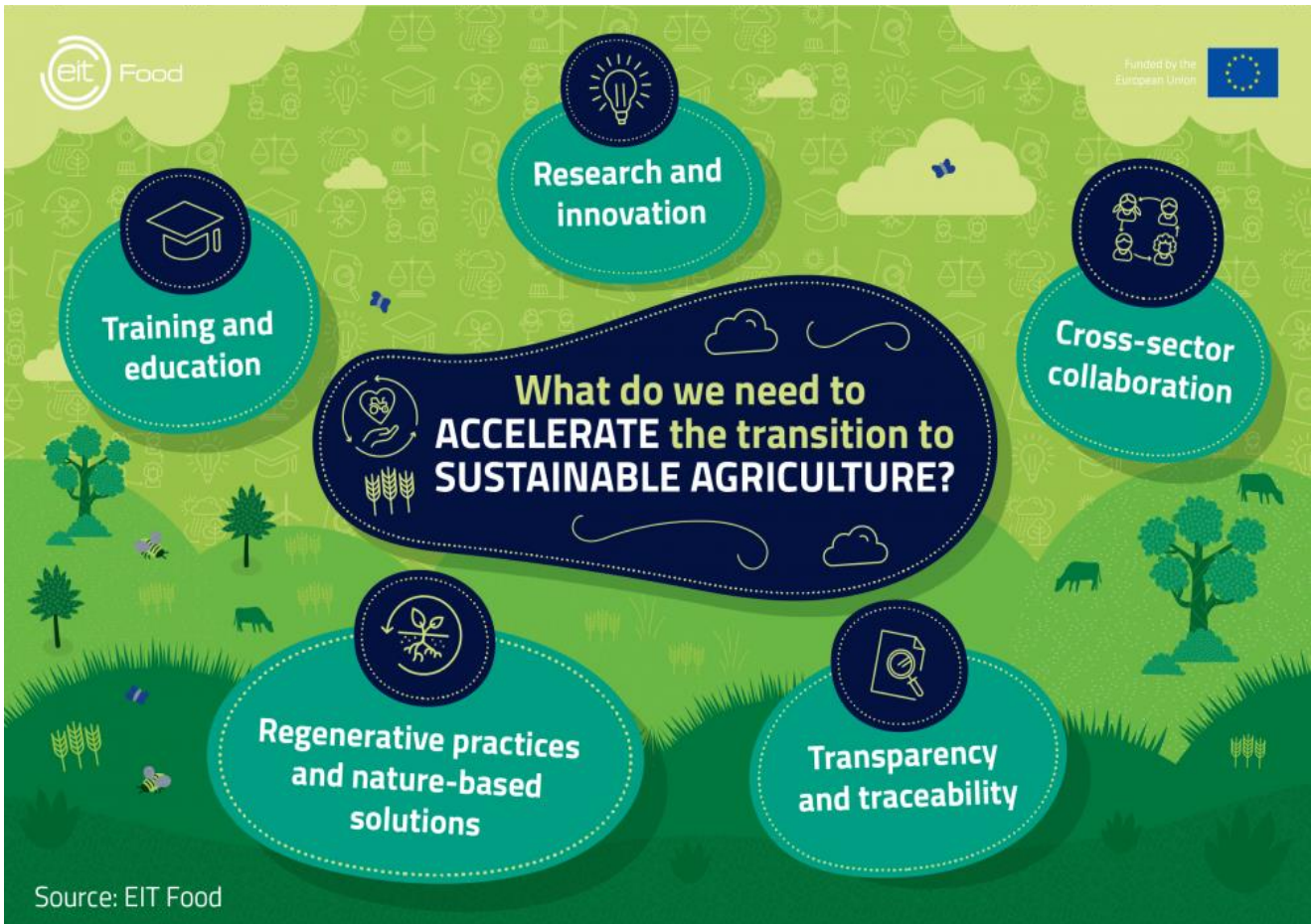
The applications of these technologies run the gamut from autonomous greenhouses that deliver irrigation automatically to drones that scout for pests and count fruit – and everything in between.

The aim of Smart Agriculture, also called smart farming and 5G farming, is to solve the challenges in farming, shipping and storing food – and to unlock new efficiencies.

### III. RESULTS

Precision agriculture (PA) identifies variability in fields. This allows greater accuracy in targeting the correct amount of inputs, at the correct time, and in the correct location compared to conventional agricultural methods. As such, precision agriculture has significant potential to reduce agricultural inputs, enhance agricultural sustainability, and increase production in order to meet the growing world-wide demand for food. This study focuses on southern Alberta, the largest, most fertile and productive agricultural region in Canada. Given the high concentration of agriculture in this region, the potential benefits of precision agriculture could be significant. A greater understanding of the adoption of precision agriculture is therefore warranted. Based on a survey of farmers, the study finds the region is actively

advancing PA technologies and the findings indicate PA technologies tend to be spread across all land and crop types; the technologies are applied to both dryland and irrigated farms and across cereals, oilseeds and speciality crops. Farmers are highly satisfied with precision agriculture and intend to continue adoption of precision agriculture technologies. Further, some non-adopters intend to become adopters. If there are limits to adoption it is because some farms are too small to warrant the adoption of precision agriculture and the attendant high investment costs. [11,12]



Practitioners of sustainable agriculture seek to integrate three main objectives into their work: a healthy environment, economic profitability, and social and economic equity. Every person involved in the food system—growers, food processors, distributors, retailers, consumers, and waste managers—can play a role in ensuring a sustainable agricultural system.

There are many practices commonly used by people working in sustainable agriculture and sustainable food systems. Growers may use methods to promote soil health, minimize water use, and lower pollution levels on the farm. Consumers and retailers concerned with sustainability can look for “values-based” foods that are grown using methods promoting farmworker wellbeing, that are environmentally friendly, or that strengthen the local economy. And researchers in sustainable agriculture often cross disciplinary lines with their work: combining biology, economics, engineering, chemistry, community development, and many others. However, sustainable agriculture is more than a collection of practices. It is also process of negotiation: a push and pull between the sometimes competing interests of an individual farmer or of people in a community as they work to solve complex problems about how we grow our food and fiber. [13,14]

#### IV. CONCLUSIONS

□ In addition to strategies for preserving natural resources and changing production practices, sustainable agriculture requires a commitment to changing public policies, economic institutions, and social values. Strategies for change must



take into account the complex, reciprocal and ever-changing relationship between agricultural production and the broader society.

The "food system" extends far beyond the farm and involves the interaction of individuals and institutions with contrasting and often competing goals including farmers, researchers, input suppliers, farmworkers, unions, farm advisors, processors, retailers, consumers, and policymakers. Relationships among these actors shift over time as new technologies spawn economic, social and political changes.

A wide diversity of strategies and approaches are necessary to create a more sustainable food system. These will range from specific and concentrated efforts to alter specific policies or practices, to the longer-term tasks of reforming key institutions, rethinking economic priorities, and challenging widely-held social values. Areas of concern where change is most needed include the following:

### **Food and agricultural policy**

Existing federal, state and local government policies often impede the goals of sustainable agriculture. New policies are needed to simultaneously promote environmental health, economic profitability, and social and economic equity. For example, commodity and price support programs could be restructured to allow farmers to realize the full benefits of the productivity gains made possible through alternative practices. Tax and credit policies could be modified to encourage a diverse and decentralized system of family farms rather than corporate concentration and absentee ownership. Government and land grant university research policies could be modified to emphasize the development of sustainable alternatives. Marketing orders and cosmetic standards could be amended to encourage reduced pesticide use. Coalitions must be created to address these policy concerns at the local, regional, and national level.[15]

### **Land use**

Conversion of agricultural land to urban uses is a particular concern in California, as rapid growth and escalating land values threaten farming on prime soils. Existing farmland conversion patterns often discourage farmers from adopting sustainable practices and a long-term perspective on the value of land. At the same time, the close proximity of newly developed residential areas to farms is increasing the public demand for environmentally safe farming practices. Comprehensive new policies to protect prime soils and regulate development are needed, particularly in California's Central Valley. By helping farmers to adopt practices that reduce chemical use and conserve scarce resources, sustainable agriculture research and education can play a key role in building public support for agricultural land preservation. Educating land use planners and decision-makers about sustainable agriculture is an important priority.

### **Labor**

In California, the conditions of agricultural labor are generally far below accepted social standards and legal protections in other forms of employment. Policies and programs are needed to address this problem, working toward socially just and safe employment that provides adequate wages, working conditions, health benefits, and chances for economic stability. The needs of migrant labor for year-around employment and adequate housing are a particularly crucial problem needing immediate attention. To be more sustainable over the long-term, labor must be acknowledged and supported by government policies, recognized as important constituents of land grant universities, and carefully considered when assessing the impacts of new technologies and practices.

### **Rural Community Development**

Rural communities in California are currently characterized by economic and environmental deterioration. Many are among the poorest locations in the nation. The reasons for the decline are complex, but changes in farm structure have played a significant role. Sustainable agriculture presents an opportunity to rethink the importance of family farms and rural communities. Economic development policies are needed that encourage more diversified agricultural production on family farms as a foundation for healthy economies in rural communities. In combination with other strategies, sustainable agriculture practices and policies can help foster community institutions that meet employment, educational, health, cultural and spiritual needs.

### **Consumers and the Food System**

Consumers can play a critical role in creating a sustainable food system. Through their purchases, they send strong messages to producers, retailers and others in the system about what they think is important. Food cost and nutritional



quality have always influenced consumer choices. The challenge now is to find strategies that broaden consumer perspectives, so that environmental quality, resource use, and social equity issues are also considered in shopping decisions. At the same time, new policies and institutions must be created to enable producers using sustainable practices to market their goods to a wider public. Coalitions organized around improving the food system are one specific method of creating a dialogue among consumers, retailers, producers and others. These coalitions or other public forums can be important vehicles for clarifying issues, suggesting new policies, increasing mutual trust, and encouraging a long-term view of food production, distribution and consumption.[16]

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