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Role of Precision Agriculture in climate change adaptation

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A B S T R A C T

Precision agriculture is the use of information technology to better manage agricultural and live-stock growth, and it is being praised as yet another method to help the world to attain food secu-rity. Precision agriculture has the ability to boost output, better resource management including herbicides, fertilizers, irrigation, feeding, and labor, give better sustainable productivity, and minimize the environmental effect of crop output. However, based on farming features such as plants and livestock growth, farm size, management, the farmland availability to technical help precision agriculture can be a very unique method. As a result, compared to all other agriculture breakthroughs, the implementation of Precision agriculture has been slow and much less con-sistent. Modern Precision agriculture management systems are infrequently used on small low mechanization farms, which account for the majority of the world agricultural production, and are popular in the world least food secure regions. And, like other agricultural techniques, the advantages accrue mostly to those who accept it and the community as a whole, while those who do not or cannot adapt are facing a disadvantage, which undesirably is the case for the majority of farmers throughout the world at the moment. Food availability, access, usage, and stability are the four major elements of food security, according to FAO (Food and Agriculture Organization of the United Nations).

Key words: precision agriculture; climate change; adaptation

1. Introduction

Pakistan is Asia biggest country, with a geographical area of 881,913 km^2, the greatest population, and the most valuable natural resources, with 26 percent committed to agriculture production, which accounts for 21 percent of the overall gross domestic product [1]. With an increasing number of severe weather patterns, temperature anomalies, and climate variability changes in precipitation, the effects of climate change have become more pronounced. As a result, the agricultural production system must account for global climate change while maintaining productivity. Precision agriculture is a combination of technologies that use sensors, information systems, upgraded machinery, and intelligent management to optimize productivity by controlling for variables and uncertainty in agricultural systems as shown in figure 1 [2]. Precision agriculture is one of the ways that may be used to improve agricultural output while lowering costs and reducing environmental impact by maximizing resource use by the use of suitable technology[3,4]

Precision agriculture promotes field-level operations in terms of agricultural science “matching the farming practices with crop needs”, protection and environmental “restrict the use of a chemical product as needed”, and economics “more efficient in resource utilization”. The farmer may use it to create a record of their farm (on-farm data collecting), improve the decision-making process, and improve the production qualities [5]. However, several issues with precision agriculture adoption in Pakistan are connected to agricultural management, such as farmers who continue to use a traditional cropping method, a lack of money, and a lack of technological understanding at the farmer level [6]. In addition, precision agriculture technology is frequently regarded as a costly and inaccessible technology. From either perspective, the defining features of tropical agriculture, as well as current knowledge of efficient agricultural production, may lead to a creative approach to precision agriculture adaptation. Best practices and existing local knowledge have previously been formed in conventional farming, particularly in open field tropical agriculture production. As a result, we suggest an appropriate adaption of precision agriculture to strengthen conventional agricultural management in order to promote improvement.

The main objectives of precision agriculture are (1) to reduce the number of inputs to grow crops and increase harvestable crop yield at lower costs. (2) increase the efficiency of agrochemical applications with lower environmental impact. (3) automate and log farm operations in data analysis, efficiency and convenience (4) minimize labor engagement in farm operations on autopilot, GPS guided, and wifi connected.

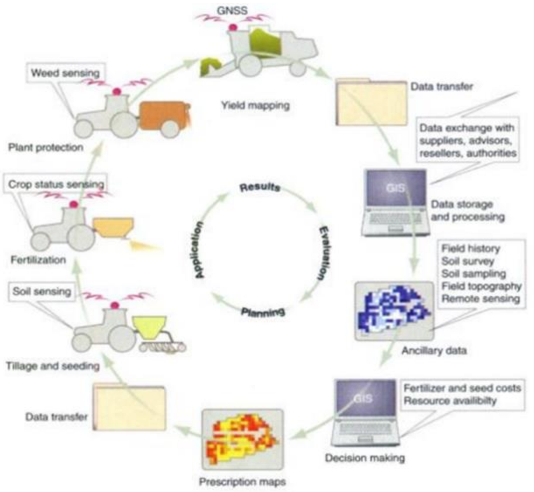

Figure 1. Agricultural growth information flow in precision agriculture (Source: Gebbers and Adamchuk, 2010)

2. Materials and Methods

Precision agriculture is a method for using Technology, such as sensor technology and robots, to enhance farmland production processes. Precision agriculture is "information-intensive," as the information flow diagram in Figure 2 illustrates.

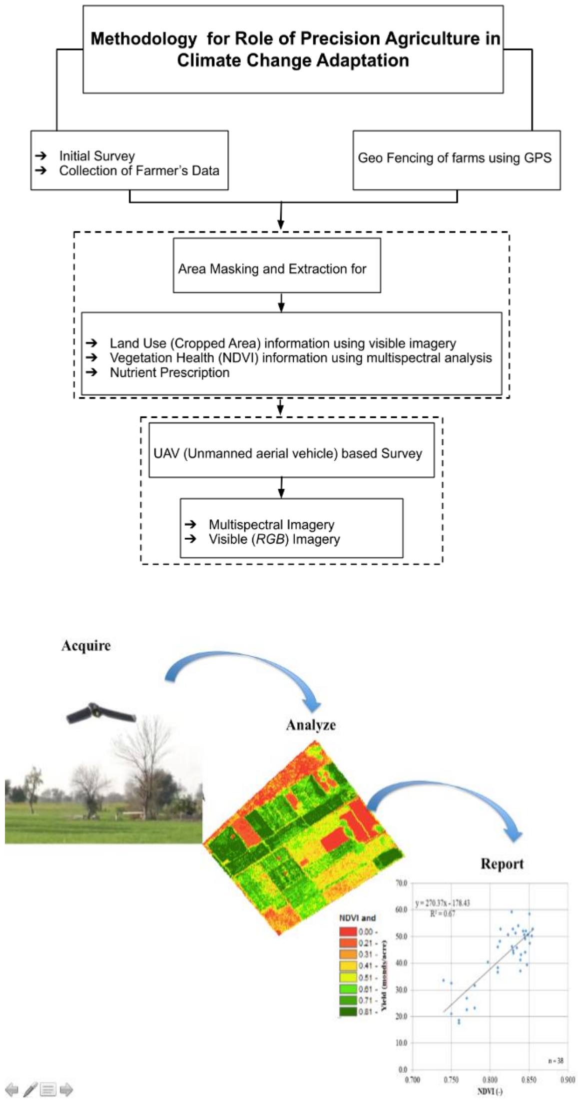

Figure 2. Methodology of precision Agriculture in climate adaptation.

1. Crop Monitoring

Monitoring of crop health at different growth stages to determine plant vigor and identifying hot spots where crop is more prone to nutrient deficiency or under pest attack. Monitoring of Farm's overall performance and crop yield and corresponding income estimation advisory service to the farmers. The monitoring mechanism included the following sensors figure 3. (1) Handheld optical sensors (Green Seeker) this sensor localizes monitoring for a few acres. (2) Multispectral sensors (On-Board Quad Copters) these sensors included small-scale monitoring of 10-20 acres per scan and 10-15 minutes flight. (3) Multi-Spectral Sensors (On-Board UAV) included Medium scale monitoring of 300-350 acres per scan and 30-50 min flight.

Figure 3. (a) Shows the Handheld Optical Sensors, (b) Shows the Spectral Sensors and (c) Shows the Multi Spectral Sensors

a. Monitoring through UAVs

Due to advancements in UAVs technology, the usage of unmanned aerial vehicles in farmland has grown substantially in recent years (see Figure 4). UAVs are a low-cost alternative detecting technology and data analysis approach as a mobile robot[7,8]. UAVs come in a variety of shapes and sizes, and even low-cost UAVs may collect high-resolution data from various locations in space. Although unmanned aerial vehicles (UAVs) are yet to be used in the majority of precision agriculture applications, they are progressively playing a role in the sector in terms of sustainable farming practices and efficiency.

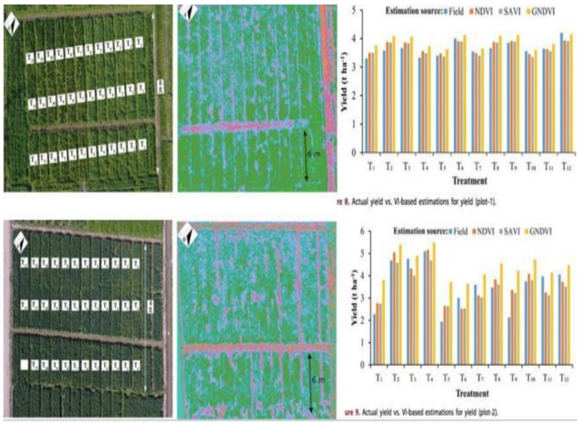

Figure 4. Crop monitoring through UAVs (Quad Copters and Fixed Winged)

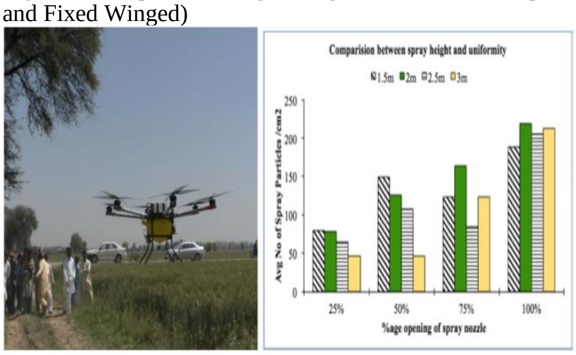

Figure 5. Precision Spraying (UAV based)

The rising emphasis of developing effective climate change adaptation responses indicates so many studies: improving current climate risk management, better depiction of the procedures by which key climate operators affect agricultural production, evaluating the effectiveness of adaptation options, understanding likely adoption rates and how to improve them, and working to develop more resourceful agriculture production.

Many regions agriculture is still vulnerable to climate change, and the ability to manage this risk varies [9]. Given that climate change will manifest itself as increases in variability over a wide variety of time scales, improving the ability to manage climate risk is a key adaptation approach. Developing this ability entails boosting decision-makers "climate knowledge," so that they are better aware of climate impacts on their systems and how to use management alternatives to intervene, limiting negative impacts and maximizing possibilities. It also entails shifting the rhetorical focus from climate change adaptation to climate risk management, as well as incorporating climate change within a larger study area [10].

The analyzing how numerous elements, such as CO2, temperature and rainfall, pests and diseases, and air pollution, influence agricultural systems has a lot of opportunity for improvement. Before accurate assessments of the costs and benefits of adjustments can be produced, comprehensive estimations of background impacts are required. Improved understanding is needed to better estimate the extent and, in some cases, the direction of future climate change impacts on agriculture, as well as to better identify risk thresholds and the possibility of surprises.

Finally, assessing climate risk and developing response plans must be done in the context of numerous uncertainties in the underlying socioeconomic, political, and technical causes, as well as basic challenges in defining the climate system [11]. Uncertainty, on the other hand, is frequently used as an excuse for inaction and might be misinterpreted as a case of "no information." Scientists must improve their ability to measure and communicate uncertainty, while decision-makers must recognize that imprecise information is preferable to no knowledge at all [12]. Given these circumstances, response efforts should concentrate on building more resilient agricultural systems (including socioeconomic and cultural/institutional structures) that can withstand a wide variety of potential changes. Improved resilience is likely to come with a variety of expenses or operating costs that are sometimes underestimated but must be considered. Furthermore, considering the aforementioned risks, there is a need for focused change in management, research, and policy, which is then monitored, studied, and learned from in order to continuously and successfully react to real climatic changes in the future decades. As a result, agriculture's adaptation to climate change will be much more fundamental than an agricultural action.

5. Limitations

There is a growing need to put a greater emphasis on agriculture adaptation to future climate change. At the management level, there are several potential adaption solutions, many of which are versions of existing climate risk management. However, there are few studies that evaluate both the expected efficacy and adoption rates of potential response options. The potential benefits of adaptation in temperate and tropical wheat-growing systems are similar and substantial, even though the likely adoption rates may differ; and second, the majority of the benefits of marginal adaptations within existing systems accrue with moderate climate change, and their effectiveness is limited under more severe climate change, according to a synthesis of studies for cropping systems. As a result, additional systemic modifications in resource distribution, such as economic variation, must be properly considered. Increased adaptation activity, we suggest, will need the integration of climate change risk into a broader risk management framework that considers climatic variability, market dynamics, and specific policy domains. There are several challenges to adaptation; overcoming them will need a comprehensive and dynamic policy strategy that addresses a wide variety of scales and concerns, from individual farmer knowledge to the construction of more efficient markets.

An adaptation analysis technique that can fairly include farmers, agribusiness, and politicians, harnessing vast collective knowledge of agricultural systems while concentrating on values important to stakeholders, is a critical aspect of this strategy. Science must also change in order to be effective, by continuing to assess research requirements and strengthening the central core integrated science in the communication and management tools established with decision makers.

6. Conclusions

In conclusion, Precision agriculture, also within the umbrella Agronomy of smart agriculture and CSA, has significantly contributed to smart agricultural farming. A major theme of CSA technology that has witnessed rapid growth is precision farming. The integration of Earth observation satellites, the Global Positioning System (GPS), and geographical information system (GIS) technologies has provided the expanded scope of precision agriculture practices vital for fine-scale (at the field) monitoring and mapping of crop phenology parameters and yield. In this regard, the review results show evidence that these precision agriculture practices have continued to provide more data to farmers supporting robust decision making under changing economic and environmental factors. The reality of climate change and its negative impact on the environment, socioeconomic activities, and food security cannot be emphasized. Various approaches to CSA have been proposed and implemented on the continent. However, there is a missing link: the fusion of information technology into CSA suited for smallholder farmers. In this regard, the use of unmanned aerial vehicles (UAVs) or drones is proposed. Regarding the adoption of drones for sustainable agricultural management, the uptake of drone technology has steadily grown from a global perspective, e.g., . Notwithstanding this noticeable drone technology adoption growth globally, the present review results illustrate that drone use in the agriculture industry in the Pakistan continent remains minuscule, especially among the smallholder farmers, who have been identified as critical in ensuring food security on the Pakistan continent. It is opined that the continent’s agriculture industry stands a chance to be revolutionized and thereby lift the Pakistani populace out of poverty if the various barriers impeding the adoption of drone technology (such as cost, infrastructure, legislation, and human capital) are addressed.

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Profile

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Dr. M Jehanzeb Masud Cheema is an associate professor at PMAS-Arid Agriculture University Rawalpindi, he also served as program chair for precision agriculture at the Center for Advance Studies in Agriculture and Food Security. He is a remote sensing expert and has experience using multi-sensor satellite data to manage water resources in data-scarce river basins. He has a special focus on developing methodologies to efficiently utilize satellite measurements for hydrology and to model conjunctive water-use in the transboundary Indus River Basin. He is using his expertise in the field of Precision Agriculture by developing satellite and sensor based irrigation, VRT and UAV Systems.

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