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Managing the Food Security Nexus under Climate Change: Recent Advances in Precision Agriculture Practices in Pakistan †

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Abstract: Climate change poses a significant challenge to food security. Several traditional approaches are available to prevent food insecurity in climate change scenarios, such as modifications in crop practices, altering field management systems, and climate-smart farming measures. Recently, precision agriculture practices are becoming a more popular way of farming that might help to overcome climate risk and reduce food insecurity. Precision agriculture is a tool for monitoring the food supply chain and managing both the amount and quality of agricultural products. Thus, this work seeks to synthesize and discuss the research related to the importance of a precision agriculture system in preventing food insecurity in the context of a developing countries such as Pakistan. The study is based on the narrative literature review.

Keywords: food security; precision agriculture; adaptive strategies; climate change

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1. Introduction

Food insecurity through climate change can occur directly through the changes in ecological parameters and indirectly through disturbances in the economic growth and reduction in agricultural products [1]. The global climate change influences on food production and distribution are more severe in developing countries than in developed countries. Many adaptations and mitigation techniques, such as improving seed quality, modifying cropping practices, introducing new varieties, and improving irrigation techniques, are available to improve food production during the climatic shift [2]. However, these techniques could not improve much yield. There is a need for an integrated approach that improves the yield without compromising the environment. Thus, precision agriculture is the sole solution to this problem [3]. Precision agriculture is a collection of technologies that integrate sensors, information systems, advanced equipment, and well established management to maximize productivity through reducing variation and uncertainty in agricultural systems [4]. Adapting agricultural inputs within a field to site-specific conditions allows for a more efficient allocation of energy, which helps to preserve ecological integrity while improving the food production system [5]. The precision agriculture strategies not only improve the economic condition of the farmers but also reduce the negative impacts of extensive agriculture practices on the environment. Moreover, this study fulfills the literature

gap of relationship of the tradition agriculture practices with precision agriculture. This study examines the potential of available mitigation and adaptation approaches to prevent food security in climate change situations. Furthermore, it also explores the importance of precision agriculture technologies in elimination of food insecurity in Pakistan.

2. Methodology

This study reviewed the secondary published data from different reliable sources to identify the influence of climate change on food security. To critically analyses the situation in developing countries such as Pakistan, the authors carried out a desk review of the relevant reports, projects, papers, and web-based publications related to food availability, accessibility, and usage in developing countries and Pakistan.

3. Global Food Security and Climate Change

Climate change has an impact on both food security and the lives of farmers involved in agricultural systems. It also influenced the value chains of the agricultural systems. According to the report, about 70% of the total global population lives in some countries/territories experiencing a food crisis, including Afghanistan, the Democratic Republic of the Congo, Sudan, Ethiopia, northern Nigeria, Yemen, Pakistan, the Syrian Arab Republic, South Sudan, and Haiti [6]. The global prevalence of hunger is alarmingly high. According to the report, food insecurity levels in 2021 were higher than any previously recorded, with about 193 million people in need of immediate assistance across 53 countries/territories. An increase of approximately 40 million people was reported in 2020 [6].

The main drivers of food insecurity in developing countries are societal conflicts, economic shocks, and weather extremes. According to Figure 1, 139.1 million people in 53 countries are facing food crises caused by conflicts, 23.5 million by weather extremes, and 30.2 million by economic shock in developing countries [7]. Pakistan already has a high rate of food insecurity, and the recent floods have just exacerbated the situation in the country. According to global food hunger index, Pakistan lies at 92 of a total of 116 countries [6].

Figure 1. Global food crisis [6].

4. Mitigation and Adaptation Measures for Sustainable Agriculture

To deal with food insecurity caused by climate change, various mitigation and adaptation measures are available, such as usage of precision agriculture technologies [8], crop varieties that can withstand climate change, improved agronomic techniques, water and irrigation conservation measures, a diverse agricultural economy, and agroforestry, which is stated by the studies. However, the implications of these techniques are limited to specific areas and conditions.

5. Recent Advances in Precision Agriculture Technologies

Scientists from all over the globe have been trying to find different ways to solve the problem of food insecurity. The ideal alternative to reduce the risk of food insecurities is "precise agriculture". Precision agriculture integrates sensors, information systems, and improved equipment (see for details in Figure 2) and guides the management to maximize agricultural system productivity without damaging the environment.

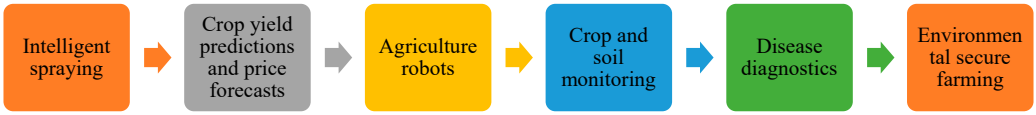

Figure 2. Role of precision agriculture in sustainable agriculture production.

The large-scale application of precision agriculture not only revolutionizes the agriculture systems of developing countries, but it also prevents the further degradation of the environment. Adoption of precision agriculture can provide the following benefits:

- Precision agriculture provides more efficient use of resources, which improves the long-term viability of food production without compromising environmental standards.
- Precision agriculture allows for the management of both the quantity and quality of agricultural products by paying close attention to the whole food production chain.
- Precision agricultural technologies, according to current research, can reduce production costs by up to 20% while increasing productivity and protecting the environment.
- To meet the challenges of fluctuating weather and rising food demand, precision agriculture seeks to invigorate the combination of farm improvement and climate susceptibility [9].

Climate change poses an ever-increasing danger to the billions of people around the globe whose livelihoods depend on agriculture production. These changes could slow a country's economic growth, halting the progress it has made over many years. Precision agriculture technologies are already used in developed countries. Developing countries are also attempting to apply these technologies in the true sense by capitalizing on their technologies, seeking new sources of funding, promoting climate-smart methods, and allowing the institution to operate [1].

The precision agriculture management system adoption is suggested for developments in both conventional agricultural technology (such as tractors, crop genetics, equipment, herbicides, and fertilizers) and information technology (such as GNSS, sensors, computer processing capabilities, telematics, and variable rate technology). The use of precision agriculture technology in crop management systems is a great addition to any conventional farm [4]. With precision agriculture, farmers may apply inputs in a more targeted manner, leading to increased yield, lower cost, more consistent output, and fewer negative environmental impacts [10].

6. Recommendations

Food security is a challenge for developing countries. There is a need for policy guidance regarding the modern agriculture system in developing countries such as Pakistan. Moreover, the government should promote the interdisciplinary efforts of academic research with industrial linkages to promote the adoption of precision agriculture at the farm level.

7. Conclusions

Food security is a challenge for developing countries, as food insecurity is rising with climate shifts. The catastrophic events now frequently occur due to the climate shift, further exacerbating the condition. Several mitigation and adoption approaches are available to overcome the food security issues, especially those caused by climatic changes, i.e., the introduction of modified crop varieties, implementation of soil conservation meth-

ods, efficient irrigation management techniques, renewable energy, etc. Thus, precision agriculture technologies could provide a better solution for sustainable crop yield while improving the quality to meet the rising demand of the population without compromising the environment.

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