Promoting GIS and IoT Powered Climate Smart Technology Among Smallholder Farmers of Pakistan

Syeda Saleha Fatim Ali, Institute of Space Technology, Islamabad, Pakistan

Abstract

Climate change poses a serious threat to agriculture and livestock production. Agriculture is the most vulnerable sector because of its dependence on climate and weather. Climate change is likely to pose a significant threat to the livestock production, which is an important source of livelihood for people in the Asia Pacific region. The increasing population in the region is expected to put severe pressure on food security and the ability to maintain livelihoods. Climate Smart Agriculture (CSA) can play a critical role in achieving food security and sustainable development goals (SDGs) by integrating agriculture development and climate responsiveness.

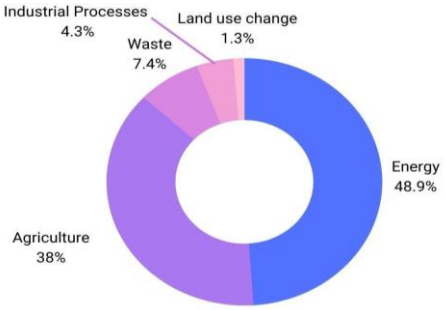
A field-based study was conducted in Sindh and Baluchistan provinces, Pakistan, to assess the state of agriculture, livestock, and horticulture fields and market conditions. The team found that most farmers are aware of the negative impacts of climate change, even if the terminologies used are non-scientific. However, the lack of communication, awareness, acceptance, and adapting technological and practice based reforms among smallholder farmer community is a serious challenge, considering most of the climate-smart technologies costly and impractical by them.

Climate Smart Technology (CST) powered by Geographic Information System (GIS) and Internet of Things (IoT) can help smallholder farmers monitor farm conditions, crop status, water requirements, weather conditions, and yield predictions. With this, capacity building, awareness, and pilot sites-based communication by research institutes, government agencies, and the private sector are necessary for sustainable livelihoods and supply chain management in agriculture-based economies like Pakistan. Policymakers must also ensure that the adoption of climate-smart technologies and scientific reforms increases productivity, reduces workload, and manages resources while maintaining available earning opportunities for smallholder farmers.

The Big Picture

Climate change poses a serious threat to agriculture and livestock production, particularly in the Asia-Pacific region, where the livelihood of people is mainly agrarian) (Vuppalapati, C., 2021). Agriculture is likely to be the most vulnerable sector because of its dependence on climate and weather. Smallholder farmers in Pakistan, who are already struggling with poverty, are facing the brunt of climate change. Most of them are not aware of the scientific terminologies, but they have experienced the negative impacts of climate change. The lack of communication, awareness, acceptance, and adapting technological and practice-based reforms among smallholder farmer community is a serious challenge.

Figure 1: Total GHG emissions in Pakistan (Khanal, (2021)



Despite its critical importance to food security, livelihoods, economic growth, and export revenues, agricultural productivity remains low, with significant yield gaps compared to global averages in key crops like wheat, rice, and sugarcane (Molotoks, A., Smith, P., & Dawson, T. P, (2021)The average farm size in Pakistan is 2.6 hectares (ha), with approximately 43% of the farmers categorized as smallholders with holdings of less than one ha, while only 22% own more than 3 ha of land (Rashamol, V. P., Sejian, V., Bagath, M., Krishnan, G., Archana, P. R., & Bhatta, R. , (2020))In 2016, for the first time in the past 15 years, the sector experienced a negative growth rate of 0.2%, primarily due to the impact of extreme events on key crops, a lack of access to key inputs, and a global downturn in commodity prices ((CIAT), 2017)

Table 1. Global greenhouse gas emission from food production (Poore, J., & Nemecek, T, (2018))

Livestock And Fisheries		Crop Production		Supply Chains				Land Use	
Livestock and fish farms	Wild catch fisheries	Human food	Animal feed	Retail	Packaging	Transport	Food processing	Land use for livestock	Land use for human food
30%	1%	21%	6%	3%	5%	6%	4%	16%	8%

Critical investments in improved seeds, farming technology and techniques, and water infrastructure are needed to tackle the emerging challenges to the sector's development, especially in the context of declining water availability and climate change impacts (Debaditya Gupta, Nihal Gujre, Siddhartha Singha, Sudip Mitra, Role of existing and emerging technologies in advancing climate-smart agriculture through modeling: A review, Ecological Informatics, Volume 71, 2022, 2022).

GIS and IoT Powered Climatic Smart Practices and Technologies

Climate Smart Agriculture (CSA) aims to achieve food security and broader development goals under a changing climate and increase food demand by improving the integration of agriculture development and climate responsiveness. The use of Geographic Information System (GIS), and Internet of Things (IoT) powered Climate Smart Agriculture Technology (CST) like Seed Smart, Water Smart, Soil Smart are really important to be adapted by the agencies and community, particularly the smallholder farmers.

Geographic Information System (GIS) and Internet of Things (IoT) powered Climate Smart Technology (CST) have the potential to revolutionize agriculture in Pakistan. The use of these technologies can help smallholder farmers to better understand their farms' soil fertility, water availability, weather patterns, and crop management. They can also help farmers to monitor their crops remotely, using sensors to detect changes in temperature, moisture, and other variables. Moreover, promoting GIS and IoT powered climate-smart technology can also help smallholder farmers achieve the United Nations Sustainable Development Goals (SDGs), especially SDG 2 (Zero Hunger) and SDG 13 (Climate Action). By adopting climate-smart agriculture practices, farmers can increase their crop yields and improve food security, thus contributing to SDG 2. Moreover, CSA practices can also reduce greenhouse gas emissions and enhance carbon sequestration, contributing to SDG 13. Promoting GIS and IoT powered climate-smart technology can also contribute to environmental sustainability by reducing greenhouse gas emissions, monitor crop water requirements, crop health (nutrients requirement), reduce pesticides and fertilizers, and enhancing carbon sequestration. By optimizing inputs such as fertilizer use and irrigation, farmers can reduce the amount of greenhouse gases emitted by their farming practices. Moreover, by adopting sustainable farming practices such as crop rotation and conservation tillage, smallholder farmers can also enhance carbon sequestration, which can help mitigate the impacts of climate change.

Policy recommendations / conclusions

GIS technology can be used to create maps and analyze spatial data, such as soil characteristics, crop health, and land use patterns. By analyzing this data, farmers can determine the best locations to plant crops, where the soil is most fertile, and where water is most abundant. GIS can also help farmers to identify areas that are at risk of flooding, drought, or other climate-related hazards. This information can be used to make decisions about crop selection, planting times, and water management. IoT technology can be used to monitor crops remotely, using sensors to detect changes in temperature, moisture, and other variables. This data can be transmitted to farmers' smartphones or other devices, allowing them to make real-time decisions about crop management. For example, if a farmer detects a drop in soil moisture levels, they can adjust their irrigation system to prevent crop damage.

The adoption of GIS and IoT powered CST is not only beneficial to smallholder farmers but also to agencies and the community. By using these technologies, agencies can better understand the needs of smallholder farmers and provide them with the necessary information and resources. The community can also benefit from the increased productivity of smallholder farmers, which can help to reduce poverty and food insecurity.

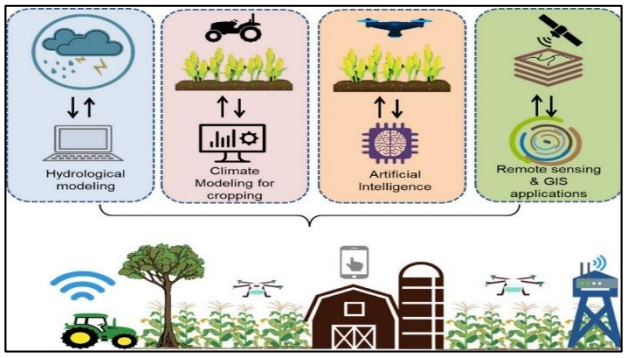
However, the adoption of these technologies is not without challenges. Smallholder farmers may not have access to the necessary hardware or software, and they may lack the necessary skills to use these technologies effectively. Additionally, the cost of these technologies may be prohibitive for smallholder farmers, who are already struggling with poverty.

To address these challenges, it is essential to provide training and support to smallholder farmers. Agencies can provide training on how to use GIS and IoT technologies effectively, as well as access to the necessary hardware and software. Incentives, such as subsidies or low-interest loans, can also be provided to help smallholder farmers afford these technologies. Additionally, partnerships can be formed with private sector organizations to provide these technologies at a lower cost.

Real-life examples of the successful adoption of GIS and IoT powered CST can be found in other countries. In India, for example, the use of IoT technology has helped farmers to reduce water usage by up to 50%. In Kenya, the use of GIS technology has helped farmers to identify the best locations to plant crops, leading to increased yields and profitability. These success stories demonstrate the potential of GIS and IoT powered CST to transform agriculture in Pakistan.

The adoption of GIS and IoT powered Climate Smart Technology is essential for promoting climate resilience among smallholder farmers in Pakistan. However, to ensure the successful adoption of these technologies, it is essential to provide training and support to smallholder farmers, as well as access to the necessary hardware and software. Incentives and partnerships can also play a crucial role in making these technologies affordable and accessible to smallholder farmers. The potential benefits of adopting these technologies are significant, including increased productivity, reduced crop damage, and improved water management, all of which can contribute to reducing poverty and food insecurity. Therefore, it is imperative that government agencies, private sector organizations, and community stakeholders work together to promote the adoption of GIS and IoT powered CST among smallholder farmers in Pakistan. By doing so, we can help build a more sustainable and climate-resilient agriculture sector that can better withstand the challenges posed by climate change.

Figure 2. Climate Smart Agriculture



Acknowledgments

The author acknowledges the smallholder farmers, technology providers, and all those who facilitated during extensive field surveys.

References

(CIAT), W. B. (2017). *Climate-Smart Agriculture in Pakistan. CSA Country Profiles for Asia Series. International Center for Tropical Agriculture.* The World Bank Washington, D.C.

Debaditya Gupta, Nihal Gujre, Siddhartha Singha, Sudip Mitra, Role of existing and emerging technologies in advancing climate-smart agriculture through modeling: A review, Ecological Informatics, Volume 71, 2022. (2022). Role of existing and emerging technologies in advancing climate-smart agriculture through modeling: A review, Ecological Informatics,. *Volume 71*.

Khanal, P. R. ((2021). *Water, Food Security and Asian Transition: A New Perspective Within the Face of Climate Change. In Water Security in Asia.* Springer, Cham.

Molotoks, A., Smith, P., & Dawson, T. P. ((2021). Impacts of land use, population, and climate change on global food security. Food and Energy Security,. 10(1), e261.

Poore, J., & Nemecek, T. ((2018)). Reducing food's environmental impacts through producers and consumers. Science,. 360(6392), 987-992.

Rashamol, V. P., Sejian, V., Bagath, M., Krishnan, G., Archana, P. R., & Bhatta, R. . ((2020)). Physiological adaptability of livestock to heat stress: an updated review. Journal of Animal Behaviour and Biometeorology. 6(3), 62-71.

Vuppalapati, C. (2021). Agricultural Economy and ML Models. In Machine Learning and Artificial Intelligence for Agricultural Economics. *Springer, Cham*, (pp. 161-218).