SUPARCO INTERVENTIONS FOR GEOSPATIAL MONITORING OF AGRICULTURAL CROPS

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Agriculture has been a pivotal sector in Pakistan's economy since its independence. It has played a crucial role in providing employment, ensuring food security, contributing to GDP and exports. At independence, Pakistan inherited an agrarian economy with a limited industrial base. The sustainable agriculture sector demands agricultural research, which is crucial for the development and sustainability of the agricultural economy. In Pakistan, where agriculture sector plays a vital role in the livelihoods of millions and contributes significantly to the GDP, investing in agricultural research can lead to substantial economic upliftment. Some of the key elements to be explored through the lens of research and development in the agriculture sector are (i) Enhancing crops' productivity, (ii) Sustainable agricultural practices, (iii) Addressing climate change (iv) Improved Market access and Value addition and (v) Socio-Economic Impacts.

Some of the latest and emerging technologies that can significantly address the challenges of the Pakistani agriculture system are nano-technology, biotechnology, Artificial Intelligence, Precision technology, and Space Technology. Space technology has led to the evolution of Geospatial technologies, which include Geographic Information Systems (GIS), Remote Sensing (RS), and Global Positioning Systems (GPS), which have the potential to revolutionize agriculture in Pakistan. These technologies provide detailed spatial information that can help farmers make informed decisions, optimize resource use, and increase productivity.

If we go into history of satellite technology applications in agriculture sector in Pakistan, two attempts were recorded. In 1970s, crop statistics on cropped area, yield, and production were based on opinions and local market trends. There were no institutional infrastructure working on scientific principles as well as pragmatic system for data collection, analysis and generation of crops statistics to be used by government for policy and decision making to ensure food security, uplift agroeconomics and promote research.

Initially, The Village Master Sampling (VMS) System, implemented by the Central Statistical Organization (CSO) of Pakistan in 1970. It was developed under the guidance of the Federal Bureau of Statistics (FBS) now that is Pakistan Bureau of Statistics (PBS) to enhance agricultural statistics and rural data collection in the country. This system was particularly crucial for creating reliable datasets necessary for formulating agricultural policies and development plans.

The Village Master Sampling System was introduced as part of broader efforts to modernize statistical methodologies in Pakistan. The system involved selecting

a representative sample of villages from revenue records across the country to gather detailed information on various aspects of rural life and agricultural practices. This sampling method was aimed to provide a more accurate picture of rural conditions than previous approaches, which often relied on less systematic data collection techniques. Despite its successes, the VMS system faced challenges such as logistical difficulties in accessing remote villages, ensuring the accuracy of data collection, and maintaining consistency over time. These challenges prompted continuous improvements and adaptations in the system.

Most recent geospatial intervention by National Space Agency of Pakistan i.e., Pakistan Space and Upper Atmosphere Research Commission (SUPARCO) is playing significant role in the development of satellite technology based agricultural crops monitoring system, started in 2005. Initially, the government of Pakistan funded a PSDP pilot project to demonstrate the effectiveness of high-resolution satellite images in major crop-type mapping and monitoring in three districts of Bahawalpur, Rahim Yar Khan, and Ghotki. Technology base was provided by the French satellites of 2.5m to 10m spatial resolution along with collaborative technology incubation with French counterparts. Initially, wheat, cotton and sugarcane crops were assessed in cultivated area and crop yield forecasting along with ground truth surveys was performed. The results were found very promising in term of timeliness in generating spatial statistics, accuracies, for the better decision-making.

Later, this ambitious research project was funded by the Government of Pakistan to expand to the national level major crops monitoring system to generate scientific crop statistics with the collaboration of Food and Agriculture Organization (FAO) of the United Nations and international consultants from various advanced countries. This first phase of the project was a success story in the history of Pakistan by developing scientific method for crop area estimation, yield and production forecasting of wheat, cotton, rice and sugarcane during 2005-2009. Major stakeholders in the pilot project were the Provincial Crop Reporting Services (CRS), the Pakistan Bureau of Statistics, the Ministry of Food and Agriculture, Pakistan Meteorological Department, and others. Two major scientific breakthroughs were achieved: (i) Crop area estimation based on ground surveys data integrated Satellite data processing and development of satellite-based crop area sampling frame for nine different cropping zones across irrigated areas and (ii) development of crop yields and production forecasting/estimation models using FAO-UN philosophy.

These nine cropping zones include four form Punjab (North East, Potohar, Central and South zones), Sindh (Left Indus and Right Indus zone), Khyber Pakhtunkhwa (Peshawar Valley and South zone), and Balochistan Irrigated zone. While, the FAO-UN crop yield foresting philosophy was based on the integration of agro-meteorological conditions with crop inputs applied, irrigation water use, fertilizer applications, and satellite-based vegetation indices like Normalized Difference Vegetation Index (NDVI) from SPOT Vegetation sensor data of one km resolution. International consultants carried out the technology audit to ensure the quality of crop statistics generated through use of satellite technology. In general, SUPARCO developed crops monitoring system was found way ahead in comparison to conventional system adopted by the provincial CRS.

Later, SUPARCO took initiative for further improvements in developed geospatial technology for crops monitoring, sharing of technologies with agricultural departments across the country, building dedicated labs and execution of capacity building programs during 2009-2017. Under the project, three dedicated information systems were developed i.e., (i) Crops Information Portal hosting all spatial and non-spatial data related to crops, agro-met, irrigation, fertilizer and NDVI for near real-time data reporting and charting[23] (ii) Pakistan Global Agricultural Area Monitoring (GLAM-Pakistan) based on Terra/AQUA satellite MODIS sensor data for change detection in crop conditions[24] and (iii) Smartphone application for ground survey data collection with real time transmission of data from field to Labs during 2012-2016. Further, dedicated Geospatial Labs were established in Provincial HQs of all four provinces along with at University of Agriculture Faisalabad and University of Agriculture Tandojam. Extensive capacity building program was run to ensure adoption of technologies by stakeholders up to gross root level.

Additionally, two more satellite data-based products were generated during the course of the project execution. Firstly, high resolution land use land cover (LULC) mapping and Atlases for Punjab and Sindh later expanded to Khyber Pakhtunkhwa, Balochistan and Gilgit Pakistan.[25] This LULC is globally accepted valuable geospatial products used in disaster

[23]https://openknowledge.fao.org/server/api/core/bitstreams/592ecbd0-7cda-43f3-bfe7-f9d1f59eb2b7/content
[24]https://glam.nasaharvest.org/explore
[25]https://www.fao.org/geospatial/resources/detail/en/c/1024589/

management, procurement of land for building infrastructures, land use policy optimization and others. Secondly, crops field digital layer extraction (crop mask or crop data layers) products were generated for wheat, rice, cotton, maize and sugarcane crops.[26] Best case use of crops field data was demonstrated for Punjab Kissan Package 2015 when farmers of cotton and rice growers were given subsidies. These crops digital fields were used to verify farmer claim of crop cultivation and ensured transparency in subsidy distribution.

In recent years with evolution of artificial intelligence, Internet of Things (IoT), drone technologies, SUPARCO is researching on integrated used of satellites, aerial and ground-based sensors technologies not only to provide spatial statistical information on crops but to promote adoption of precision farming system to enhance the crops productivity with sustainable agriculture. A PSDP project is under execution in collaboration with PMAS arid agricultural university since 2020 to demonstrate the precision agriculture benefits and integration with satellite technology for better decision support system at field/local scale.

The agriculture sector in Pakistan has made significant advances since independence, transitioning from traditional practices to modern techniques. Despite facing numerous challenges, it continues to be a cornerstone of the economy and a crucial source of livelihood for millions. Addressing current challenges through sustainable practices, technological innovation, and effective policies is key to ensuring the sector's continued economic growth and development. Further, agricultural research holds the key to transforming Pakistan's agricultural economy. By focusing on enhancing productivity, promoting sustainability, addressing climate change, improving market access, and supporting socio-economic development, research will drive significant improvements in the agricultural sector. Investments in research and development, coupled with effective policy implementation, will be crucial in realizing the full potential of Pakistan's agriculture.

SUPARCO's use of satellite technologies in agricultural crop monitoring has provided significant benefits for Pakistan's agriculture sector. By offering timely and accurate information, supporting resource management, and aiding in policy planning, SUPARCO has enhanced the efficiency and sustainability of agricultural practices. Addressing the challenges of data accessibility and capacity building will further strengthen the impact of these technologies, ensuring a more resilient and productive agricultural economy in Pakistan. In conclusion, National space agency of Pakistan has significantly contributed towards better agricultural economy.

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