Soil-Suitability Integrated Model for Improved Rice Production Estimation in Punjab, Pakistan

Division: RS/GIS, Agriculture division
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Location: SATEYE Company Headquarters, Lahore, Pakistan.

Executive Summary:

SATEYE Company conducted a comprehensive study to enhance rice production estimation in key agricultural districts of Punjab, Pakistan, by integrating soil suitability into the traditional CASA model. Recognizing that soil characteristics significantly influence crop growth, the study combined satellite imagery, meteorological data, and field measurements to develop a more accurate predictive model. By introducing a soil suitability constant reflecting factors such as pH, drainage, and soil type, the revised model adjusted productivity estimates to real field conditions. Results indicated that highly suitable soils yielded the highest rice production, while less suitable areas showed reduced output, with total estimated production for the region reaching approximately 1.63 million tons. The findings provide actionable insights for farmers, policymakers, and agricultural organizations, supporting improved crop planning, sustainable soil management, and long-term food security in Punjab.

Introduction:

SATEYE Company conducted a comprehensive study to enhance the accuracy of estimating rice production across key agricultural districts of Punjab, Pakistan. Rice is a vital crop for the region, and having precise information about potential production is essential for planning, resource allocation, and long-term food security. The existing CASA model, although widely used, does not consider variations in soil characteristics, which play a major role in crop growth. Recognizing this limitation, SATEYE aimed to develop a revised approach by integrating soil suitability into the production estimation process. The research took place in districts such as Nankana Sahib, Lahore, Sheikhupura, Hafizabad, and Gujranwala, areas known for extensive rice cultivation. The region's flat terrain, irrigation system, and moderate annual rainfall made it well-suited for detailed remote sensing–based agricultural analysis. SATEYE collected and used satellite data, meteorological observations, and field measurements to build a model that more accurately reflects real conditions on the ground.

Methodology:

The core objective of SATEYE's methodology was to improve rice production estimates by combining remote sensing, environmental data, and soil analysis. The team began by acquiring satellite imagery, including Landsat 8 data, which helped identify crop patterns, measure vegetation health, and determine the fraction of sunlight absorbed by rice plants. Meteorological data such as temperature, sunshine hours, and vapor pressure were collected from local weather stations. Field surveys provided measurements of leaf area index and actual rice yield, which were necessary for validating the model's results.

SATEYE used the CASA model as the foundation for estimating net primary productivity, but introduced a new soil suitability constant to increase accuracy. This constant represented the quality of the soil according to factors such as pH, drainage, electrical conductivity, and soil type. Areas with better soil conditions were assigned higher values, while soils with limitations received lower values. By adding this constant to the model, the team was able to adjust productivity estimates according to real soil conditions rather than relying solely on vegetation indices or climate parameters.

The calculation process included determining how much energy the rice crop canopy received, estimating water stress levels, and analyzing absorbed sunlight. Using NDVI time-series analysis, SATEYE identified actual rice-growing zones across the study region. The model was then run with the new soil suitability factor incorporated, producing detailed estimates of rice yield for each soil category. The results were compared with field observations to confirm their reliability.

Outcomes:

The improved model developed by SATEYE Company produced clear, scientifically sound results that reflect actual rice production potential in Punjab's major agricultural districts. The study revealed that soil suitability has a direct and measurable impact on rice yields. Highly suitable soils produced the highest estimated yields, while areas with poor soil conditions showed significantly lower productivity. By integrating the soil suitability constant, SATEYE successfully created a model that more accurately predicts rice production compared to the traditional CASA approach.

The total estimated rice production for the entire study area was approximately 1.63 million tons, demonstrating the scale and importance of the region's agricultural output. The model also identified where rice is being cultivated on land that is less suitable, indicating opportunities for improved crop planning and resource management. The findings of this study offer major societal benefits. Farmers can make better decisions about where to grow rice, governments can plan more effectively for food security, and agricultural organizations can implement sustainable practices that protect soil health and maximize production. The improved model supports efficient land use, reduces unnecessary strain on unsuitable soils, and provides

a reliable tool for long-term agricultural development. Through this work, SATEYE Company has demonstrated its capability to combine technology, science, and field knowledge to contribute meaningfully to sustainable agriculture and improved food production systems.