Advancing Rice Yield Forecasting and Crop Assessment in Kazakhstan's Kyzylorda Region: A Multisource Satellite Data Approach

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Abstract. The monitoring and prediction of rice yields are essential across various domains, including agriculture, environmental conservation, ecology, agricultural insurance, and land resource management. The central districts of Kazakhstan's Kyzylorda region, encompassing 70% of the total rice cultivation area, are of particular importance for ensuring national food security. This study focuses on the central Kyzylorda region, specifically the Syrdarya, Zhalagash, and Karmakshi districts, which serve as the primary hub for rice cultivation in Kazakhstan. The primary objective is to advance remote sensing techniques tailored to evaluate crop conditions and forecast rice yields, accounting for the region's unique soil and climatic attributes. The research methodology involves comprehensive analysis of Sentinel-2 and Landsat-8 satellite data, harmonized with ground-truth information. This analysis encompasses the latest rice crop data for 2020 and precise sowing dates. Extensive field surveys were conducted to gather crucial data on growth, development, crop health, and productivity under specific agrometeorological conditions. The study provides a detailed flowchart outlining the sequential processing of remote sensing data and ground-based information, with a primary focus on forecasting rice yields in the central Kyzylorda districts for 2020. Rigorous satellite data analysis established robust correlations between the Normalized Difference Vegetation Index (NDVI) and various crop conditions, directly linked to rice yield, with high precision (R2 values ranging from 0.82 to 0.91). Validation exercises, cross-referencing satellite data with real-time field data, further enhanced accuracy. The research outcomes have extensive applications, benefiting agriculture, environmental preservation, ecology, insurance, statistics, and land management. This study underscores the significance of addressing critical challenges across various sectors through multifaceted findings.

1 Introduction

The utilization of satellite data, particularly high-resolution sources such as Sentinel-2 (with a spatial resolution of 10 meters) and Landsat-8 (with a resolution of 30 meters), offers a valuable opportunity to access accurate and timely insights into agricultural land productivity and the prediction of rice yields [1]. Crop yields, as a fundamental metric for assessing agricultural production effectiveness, carry global significance. Specialized governmental agencies and private analytical organizations worldwide are deeply involved in the complex task of forecasting crop yields and harvests[2]. The precision of these yield predictions is eagerly awaited by analysts globally, given their direct influence on the valuation of world stock quotes for agricultural commodities [3]. Furthermore, the results obtained through meticulous rice monitoring using satellite-based methods play a pivotal role in ensuring equitable subsidy allocation and serve as vigilant oversight of adherence to agrotechnical farming practices. The integration of satellite and ground-based data analysis equips stakeholders with the capability to identify spatial disparities and disruptions within rice paddies [4]. It enables prompt decision-making in the realm of agrotechnical interventions, all aimed at improving crop conditions and ensuring stable grain harvests. Ultimately, these collective efforts substantially contribute to increasing crop yields, bolstering agricultural efficiency and profitability, with a notable impact observed within the crop industry in Kazakhstan [5].

In regions around the world, including Kazakhstan, methodologies for monitoring and forecasting grain yields, with a particular focus on rice, rely heavily on satellite imagery with varying spatial resolutions. These methodologies encompass the analysis of vegetation indices and satellite observations[6]. Numerous scientific studies consistently demonstrate the effectiveness of the Normalized Difference Vegetation Index (NDVI) as a reliable indicator for assessing crop conditions and predicting yields. NDVI, derived from satellite data, relies on the examination of spectral

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