ASSESSING CROP WATER REQUIREMENTS USING SATELLITE INDICES IN GOOGLE EARTH ENGINE

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Abstract

Water scarcity is a critical challenge in modern agriculture. Traditional methods of monitoring crop water stress are time-consuming, expensive, and difficult to apply over large areas. This study demonstrates the use of the Google Earth Engine (GEE) cloud platform and high-resolution Sentinel-2 satellite imagery to evaluate crop moisture levels automatically. By calculating the Normalized Difference Vegetation Index (NDVI) and the Normalized Difference Water Index (NDWI) over a summer growing season (May to September), we tracked the dynamic relationship between plant health and water needs. The results show that sudden drops in NDWI accurately indicate periods of water stress, which can be directly correlated with the crop's vegetative growth stages shown by NDVI. This remote sensing approach provides a fast, automated, and cost-effective method for farmers and water managers to optimize irrigation schedules and save water resources.

Keywords: Google Earth Engine, NDVI, NDWI, Crop Water Stress, Sentinel-2, Precision Agriculture, Remote Sensing.

1. Introduction

Water is the most important resource in agriculture. Today, because of global climate change and water scarcity, managing water efficiently is more critical than ever. Traditionally, farmers walk through their fields to check if the soil is dry or if the plant leaves look yellow and thirsty. However, manually checking hundreds of hectares is slow, expensive, and often leads to late decisions and lost crop yields.

This is why remote sensing and space technologies are completely changing how we monitor farms. Instead of checking the soil from the ground, we can use satellites as giant "health scanners" for crops. This paper introduces a modern approach to assessing crop water stress using the Google Earth Engine (GEE) cloud platform and high-resolution Sentinel-2 satellite imagery.

The practical and theoretical significance of this research is that it shifts water monitoring from a manual, guesswork-based task to a highly accurate, automated process. By calculating specific satellite indices—like the Normalized Difference Vegetation Index (NDVI) to check plant growth, and the Normalized Difference Water Index (NDWI) to measure exact leaf moisture [1]—we can see exactly which part of a field is thirsty without ever touching the plant. The novelty of this work lies in using GEE to process heavy satellite data instantly. This creates a strong foundation for future automated systems and mobile applications that can deliver real-time irrigation alerts directly to farmers, saving both water and time.

2. Literature Review

To accurately monitor crop water needs from space, scientists rely on specific spectral indices. The Normalized Difference Vegetation Index (NDVI), first introduced by Rouse et al. [1], uses red and near-infrared (NIR) light to measure plant health, biomass, and overall "greenness." However, while NDVI shows how big a plant is, it does not directly measure its water content. To solve this problem, Gao [2] developed the Normalized Difference Water Index (NDWI). By combining NIR and shortwave-infrared (SWIR) bands, NDWI acts as a direct scanner for liquid water molecules inside the plant leaves. In the past, analyzing these indices over a long period required downloading terabytes of satellite images and using heavy supercomputers. Today, the Google Earth Engine (GEE) cloud architecture allows researchers to process massive satellite datasets instantly without downloading a single file [3].

3. Methodology

This study focused on monitoring an agricultural field during the main summer growing season (from May 1 to September 30). We used high-resolution (10-meter) multispectral imagery from the Sentinel-2 satellite, which provides excellent detail for precision agriculture. The entire data processing was automated using a JavaScript algorithm in the GEE platform. To ensure high data quality, a cloud-masking filter was applied to remove any images with more than 15% cloud cover. The algorithm then automatically calculated the NDVI and NDWI for every pixel inside the farm boundary. Finally, a time-series reduction function was used to extract the average index values and plot them dynamically, allowing us to see the exact physiological changes of the crop over five months.

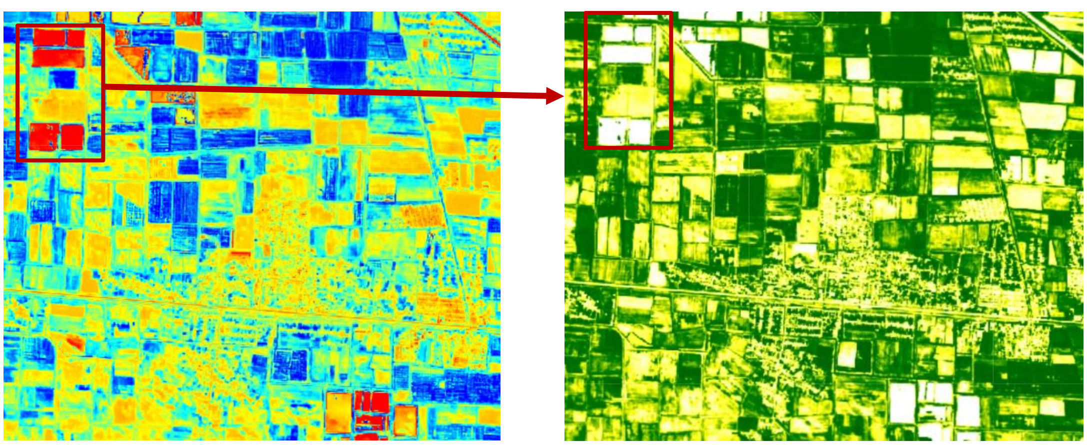

Figure 1. This map shows NDVI and NDWI index analysis

4. Results and Discussion

The time-series analysis generated a clear physiological "heartbeat" of the crop, revealing exactly how it responded to water availability during the hot summer months.

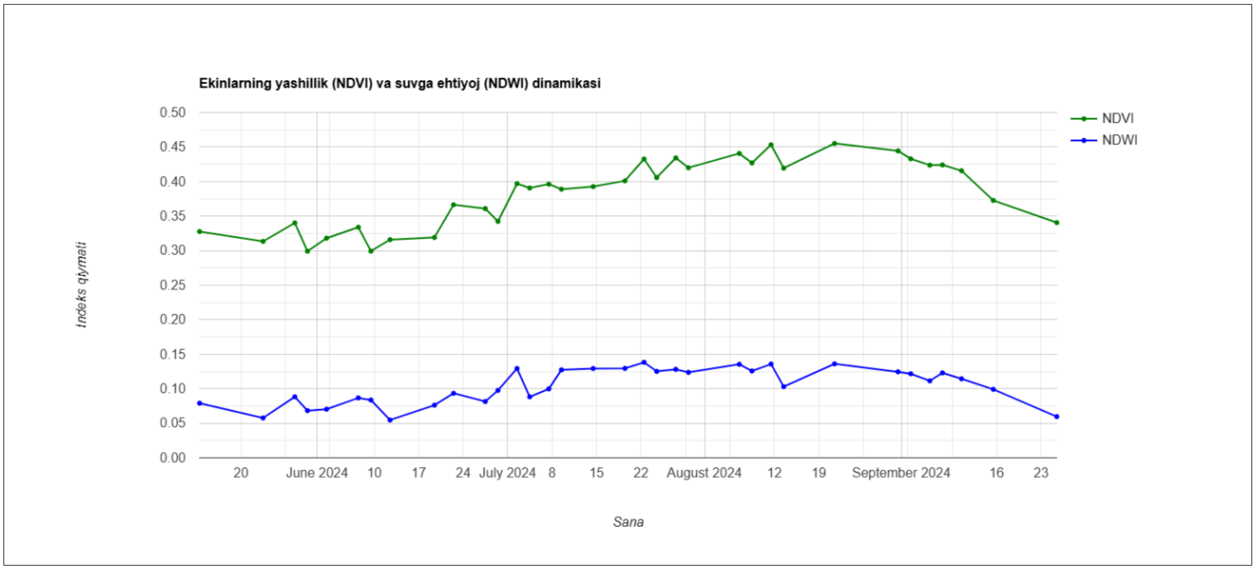

Figure 2. Time-series dynamics of crop greenness (NDVI, green line) and moisture (NDWI, blue line) during the summer growing season.

As shown in Figure 2, the two indices tell a complete story of the crop's lifecycle. The NDVI (green line) steadily increases starting from May, reaching its highest peak in mid-summer (July and August) as the crop reaches its maximum size and biomass. After September, the NDVI naturally drops as the crop enters the harvest or senescence phase.

More importantly, the NDWI (blue line) perfectly captures the crop's thirst. The sharp downward drops in the NDWI curve (for example, in early June and mid-July) clearly indicate periods of water stress when the field was drying out. Conversely, the sudden upward spikes in the NDWI show exactly when the farmer applied irrigation. By tracking these dynamic drops and spikes, this GEE algorithm successfully acts as an automated monitoring tool. This approach proves that remote sensing data can be seamlessly integrated into modern mobile applications, allowing farmers to receive real-time, automated alerts about their crops' water consumption directly on their smartphones.

References

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