NDVI-Based Crop Stress Analysis: Nakuru Region, Kenya

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# Summary

This report presents a comprehensive analysis of crop health in the Nakuru region of Kenya using Normalized Difference Vegetation Index (NDVI) derived from Sentinel-2 satellite imagery. The analysis identifies significant patterns of crop stress across the agricultural landscape, with approximately 45% of croplands showing signs of severe stress (red zones), 40% exhibiting moderate stress conditions (yellow zones), and only 15% displaying optimal plant health (green zones). These findings highlight the urgent need for targeted agricultural interventions and precision farming approaches to address declining crop conditions in the region.

## 1. Introduction

### 1.1 Background

Nakuru County is a critical agricultural zone in Kenya's Rift Valley, known for its diverse farming activities including maize, wheat, potatoes, vegetables, and dairy farming. Agriculture is the backbone of the regional economy, with smallholder farmers comprising the majority of agricultural producers. However, various environmental challenges including inconsistent rainfall patterns, soil degradation, and emerging pest issues have threatened agricultural productivity in recent years.

### 1.2 Project Objectives

This analysis aims to:

* Identify and map areas of crop stress across the Nakuru region
* Quantify the severity and extent of agricultural distress
* Provide actionable insights for targeted interventions
* Establish a baseline for future monitoring and evaluation efforts

### 1.3 Methodology Overview

The analysis employs Sentinel-2 multispectral satellite data processed through Google Earth Engine (GEE) and QGIS to generate NDVI maps. NDVI serves as a reliable proxy for plant health and vigor, with values ranging from -1 to +1, where higher values indicate healthier vegetation.

## 2. Data Acquisition and Processing

### 2.1 Satellite Data Specifications

* Data Source: Sentinel-2 Surface Reflectance (SR) Harmonized Collection
* Temporal Range: February 1, 2024 - April 30, 2024
* Cloud Cover Threshold: <10%
* Spatial Resolution: 10 meters
* Bands Used: Band 8 (NIR) and Band 4 (Red)

### 2.2 Processing Workflow

1. Area of Interest (AOI) Definition: The Nakuru region was delineated using administrative boundaries.
2. Data Filtering: Sentinel-2 imagery was filtered by date range, cloud cover percentage, and spatial extent.
3. Composite Creation: A median composite was generated to minimize cloud influence and atmospheric anomalies.
4. NDVI Calculation: Applied the formula NDVI = (NIR - Red) / (NIR + Red) using bands 8 and 4.
5. Stress Classification: NDVI values were classified into three categories:

* Red (0.0-0.3): Severe stress/sparse vegetation
* Yellow (0.3-0.6): Moderate stress/developing vegetation
* Green (0.6-1.0): Healthy vegetation

### 2.3 Software Tools Utilized

* Google Earth Engine (GEE): Cloud-based platform for initial data processing and NDVI calculation
* QGIS: Desktop software for detailed spatial analysis, classification, and map production

## 3. Results and Analysis

### 3.1 Spatial Distribution of Crop Stress

The NDVI map reveals distinct spatial patterns of crop health across the Nakuru region:

* Western Sectors: Predominantly characterized by severe stress (red), particularly in the northwestern quadrant, suggesting potential irrigation deficits, soil quality issues, or recent harvesting.
* Central Areas: Display a mixed pattern of severe and moderate stress, indicating variable agricultural conditions possibly related to different farm management practices or crop types.
* Eastern Zones: Primarily showing moderate stress (yellow) with isolated patches of healthy vegetation (green), potentially reflecting better water access or more suitable soil conditions.
* Southern Region: Exhibits a heterogeneous pattern with small clusters of healthy vegetation interspersed among moderately stressed areas.

### 3.2 Quantitative Assessment

| Stress Level | NDVI Range | Color Code | Area Coverage  (%) | Estimated Area(km2) |
| --- | --- | --- | --- | --- |
| Severe | 0.0- 0.3 | Red | 45% | 202.5 |
| Moderate | 0.3 - 0.6 | Yellow | 40% | 180.0 |
| Healthy | 0.6 - 0.10 | Green | 15% | 67.5 |

### 3.3 Temporal Context

This analysis captures the late growth stage of the short rain season crops and early preparation/planting of the long rain season. The higher prevalence of stress indicators may partially reflect normal seasonal transitions but the extensive red zones suggest additional concerns beyond typical seasonal patterns.

## 4. Discussion and Implications

### 4.1 Agricultural Interpretation

The widespread severe stress patterns observed in the analysis could be attributed to several factors:

1. Water Stress: Insufficient rainfall or irrigation during the February-April period
2. Pest and Disease Pressure: Potential outbreaks affecting crop development
3. Soil Degradation: Nutrient depletion or structural issues limiting plant growth
4. Farming Practices: Variations in farm management, including input application and tillage methods
5. Land Use Changes: Recent harvesting, fallow periods, or land preparation activities

### 4.2 Economic Implications

The identified stress patterns raise concerns regarding:

* Potential yield reductions for staple crops
* Food security implications for local communities
* Economic impact on smallholder farmers and the regional economy
* Increased vulnerability to market price fluctuations

### 4.3 Limitations of Analysis

While NDVI provides valuable insights, several limitations should be acknowledged:

* Reflectance variations among different crop types may influence interpretation
* Soil background effects in areas with sparse vegetation
* Limited ability to distinguish between specific stress causes
* Snapshot nature of the analysis compared to full season dynamics

## 5. Recommendations

### 5.1 Short-term Interventions

1. Targeted Irrigation: Prioritize water distribution to severely stressed areas
2. Nutrient Management: Deploy soil testing and precision fertilizer application
3. Pest Surveillance: Implement monitoring in high-risk zones identified by the analysis
4. Extension Services: Concentrate agricultural advisory efforts in red zones

### 5.2 Long-term Strategies

1. Water Management Infrastructure: Develop additional irrigation capacity and water harvesting systems
2. Climate-Smart Agriculture: Promote drought-resistant varieties and conservation agriculture
3. Regular Monitoring: Establish a continuous monitoring program using similar NDVI analysis
4. Agro Ecological Zoning: Refine crop selection based on identified stress patterns

### 5.3 Future Analysis Needs

1. Multi-temporal Assessment: Compare NDVI patterns across multiple growing seasons
2. Integration of Additional Indices: Combine NDVI with other vegetation indices for comprehensive analysis
3. Ground Truthing: Validate satellite observations with field data collection
4. Crop-Specific Analysis: Refine approach to account for different crop types and growth stages

## 6. Conclusion

The NDVI-based crop stress analysis of the Nakuru region provides compelling evidence of widespread agricultural challenges. The predominance of severe to moderate stress conditions across the landscape underscores the need for immediate attention and intervention. These findings serve as both a warning system and a decision support tool for agricultural stakeholders, including government agencies, extension services, and farming communities.

By implementing the recommended interventions and adopting precision agriculture approaches, stakeholders can work toward mitigating crop stress, improving agricultural resilience, and enhancing food security in this critical Kenyan agricultural region.

## Appendices

### Appendix A: Technical Details of GEE Code

javascript

// STEP 1: Define AOI (drawn or uploaded)

// Change this or import your shapefile

var nakuru = /\* imported or drawn geometry \*/;

// STEP 2: Load Sentinel-2 SR ImageCollection

var s2 = ee.ImageCollection('COPERNICUS/S2\_SR\_HARMONIZED')

.filterBounds(nakuru)

.filterDate('2024-02-01', '2024-04-30')

.filter(ee.Filter.lt('CLOUDY\_PIXEL\_PERCENTAGE', 10))

.median(); // Take median composite

// STEP 3: Compute NDVI

var ndvi = s2.normalizedDifference(['B8', 'B4']).rename('NDVI');

// STEP 4: NDVI Visualization Parameters

var ndviVis = {

min: 0.0,

max: 1.0,

palette: ['red', 'yellow', 'green']

};

Map.centerObject(nakuru, 12);

Map.addLayer(ndvi.clip(nakuru), ndviVis, 'NDVI (Feb-Apr 2024)');

// STEP 5: Export NDVI to GeoTIFF (for QGIS)

Export.image.toDrive({

image: ndvi.clip(nakuru),

description: 'NDVI\_Maize\_Nakuru\_2024',

folder: 'GEE\_Exports',

fileNamePrefix: 'NDVI\_Nakuru',

region: nakuru,

scale: 10,

crs: 'EPSG:4326',

maxPixels: 1e13

});

### Appendix B: Additional Resources

Sentinel-2 User Guide: https://sentinel.esa.int/web/sentinel/user-guides/sentinel-2-msi

Google Earth Engine Documentation: <https://developers.google.com/earth-engine/guides>

NDVI Technical Background: https://www.usgs.gov/landsat-missions/landsat-normalized-difference-vegetation-index

This report was generated using Sentinel-2 satellite imagery processed through Google Earth Engine and QGIS. The analysis represents conditions observed during February-April 2024.

### Appendix C: Layout Map

