Using Remote Sensing to Detect Land Degradation in Agricultural Lands: A Case Study in Manhattan, KS

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Introduction

Agricultural land degradation is a significant global issue in the 21st century, characterized by the loss of soil productivity due to diminished soil fertility and biodiversity (Maximillian et al., 2019). A major contributing factor to land degradation is soil erosion, which is dependent upon factors like the slope of the land, soil characteristics, precipitation intensity, and amount of vegetative cover (Montgomery, 2007). Remote sensing techniques can be used to accurately identify land degradation over large spatial areas, to aid in remediation efforts.

Objectives:

- Determine if remote sensing can be used to detect land degradation
- Explore how this data can be used to inform management/restoration practices

Materials and Methods

Study Area:

The study site, shown in Figure 1 below, is located at the KSU Agronomy North Farm. The field is about 60 acres and is currently being used to grow sorghum.

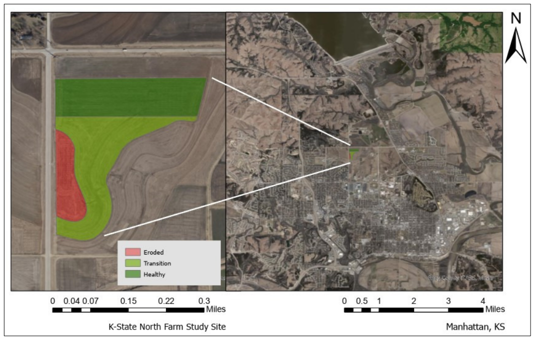

Figure 1: Map of the Study Site

Datasets:

Satellite Imagery: Data gathered from March to September, 2022.

- Sentinel-2 Data: Via Google Earth Engine and Copernicus Open Access Hub
- DEM Data: Provided by the Ciampitti Lab.

Field Survey: A field survey was conducted in mid-September. Three distinct areas were identified: an eroded area with a high slope (Figure 2), a more moderately sloped, healthy area (Figure 4), and a transitional area (Figure 3). Soil data (SOM, pH), management data (N, P, K), and vegetation data (plant biomass) was collected for each site.

Figure 2: Eroded Area

Figure 3: Transition Area

Figure 4: Healthy Area

Methodology:

- Vegetative Indices: NDVI, SAVI – processed in Google Earth Engine and ArcGIS
- Terrain Indices: TWI – processed in QGIS
- Management Practices and Restoration Assessment: literature review

Remote Sensing Results

Vegetative Indices Time Series:

The NDVI (Figure 5) and SAVI (Figure 6) time series plots are shown below. The sorghum planting date is on day 168; Figure 7 below shows the corresponding sorghum growth stages. The healthy and transition areas show very similar time series results, while the eroded area has significantly lower NDVI and SAVI values for the majority of the growing season. The NDVI plot is very similar in shape to the SAVI plot, which shows that interference due to soil reflection is not a significant concern with this study site.

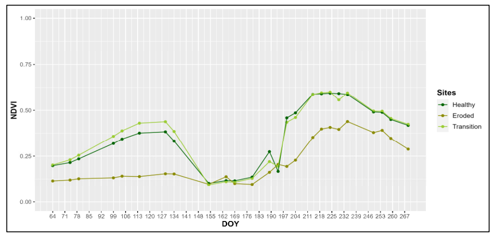

Figure 5: NDVI Time Series Plot

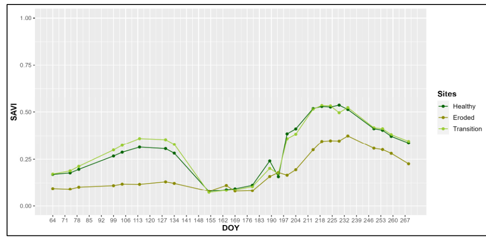

Figure 6: SAVI Time Series Plot

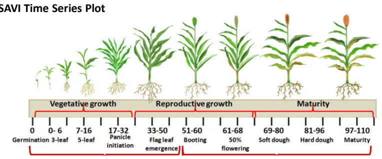

Figure 7: Sorghum Growth Stages (Nonye, 2022)

NDVI:

The NDVI maps (Figure 9) confirm the results shown in the time series above. The eroded area of the map has a consistently lower NDVI value compared to the transition and healthy areas.

Slope & TWI:

In Figure 8 below, the map on the right is the slope map, which shows the higher grade slopes as a darker color. The TWI map on the left shows the higher accumulation of water as a lighter color.

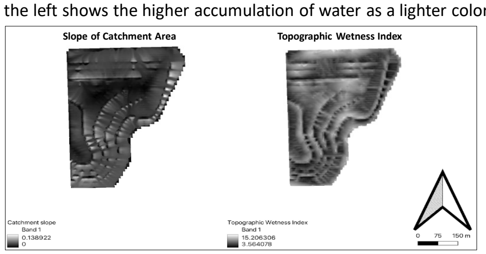

Figure 8: Slope and TWI Maps

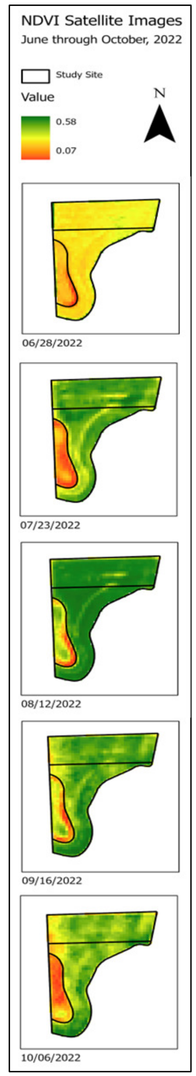

Figure 9: NDVI Maps

Field Data Results

Soil Lab Testing Results:

The results of the lab testing are shown in Table 1 below. The eroded area has lower SOM and K levels, contributing to lower sorghum biomass overall. The healthy and transition areas show very comparable nutrient values, with slightly higher nutrient values in the healthy area.

Table 1: Results of the Soil Lab Tests

	Soil Data		Soil Nutrients			Sorghum Biomass (per 1.625 m²)	
Sample ID	Soil pH	SOM %	N%	P%	K%	Dry Weight (g)	Sample Area (m²)
Eroded	7.0	2.5	1.11	0.180	1.69	365.26	1.625
Transition	6.5	3.2	0.61	0.187	2.25	393.66	1.625
Healthy	6.2	3.5	0.81	0.137	2.61	405.86	1.625

Soil Profile Comparison:

In addition to the chemical composition of the soil, the texture and structure of the soil plays an important role in the health of plants. The soil profile of the eroded area (Figure 10) shows deposited layers of soil with very little structure, which does not promote healthy root structure. The transition area (Figure 11) shows more structure and organic matter, and the healthy area (Figure 12) shows good soil structure and biodiversity (a worm is shown being held in the picture).

Figure 10: Eroded Soil Profile

Figure 11: Transition Soil Profile

Figure 12: Healthy Soil Profile

Conclusion and Recommendations

- Remote sensing is an effective way to identify agricultural land degradation over large spatial areas.
- Data gathered via satellite imagery can be processed using vegetation and/or terrain indices to identify trends in land degradation and locate areas of high risk.
- The field results show that remote sensing can be a good alternative to field testing in areas where testing is impractical or unavailable.

Recommendations:

Recommendations for management/restoration of degraded cropland includes:

- Cover Crops: To protect the soil surface and improve water infiltration
- Plant growth promoting rhizobacteria: To increase stress-tolerance
- Prairie Strips: To promote biodiversity, protect the soil, and improve infiltration

Reference

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Ciampitti Lab

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