In-season nitrogen management: Leveraging data visualization for precision agriculture.

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Abstract.

The agricultural sector nitrogen management-related research has been extensively high by experiencing a data revolution, with an increasing influx of information from diverse sources like sensors, satellites, and Unmanned Aerial Vehicles (UAVs) imaging technologies. In this context, effective in-season nitrogen data management has become a critical factor. Here, we will introduce the "Ag Data Visualization" web application, a user-friendly and innovative tool designed to empower stakeholders in the farming sector with actionable insights, focusing on Eastern Nebraska Research, Extension, and Education ENREEC) fields.

The application uses UAVs with multispectral cameras and satellite imageries to capture high-resolution imagery for advanced geospatial analysis, generating shape files for precise delineation of treatment areas and crop variations. A key feature is the Sufficiency Index (SI), which evaluates the effectiveness of nitrogen treatments, enabling informed decisions on resource allocation and nutrient management. The app integrates field information, nitrogen application data, and yield data into an interactive geospatial interface, allowing real-time pattern and trend identification.

Developed with the R Shiny software framework, the application prioritizes user accessibility and intuitive interaction, catering to a diverse audience, including farmers, agronomists, and policymakers. The results demonstrate enhanced crop health assessment, optimized resource allocation, and improved yield analysis. This tool represents a significant advancement in precision agriculture, emphasizing the importance of data visualization in effective nitrogen management.

Keywords. *Data Visualization, Nitrogen Management, Sufficiency Index, R Shiny, Decision Making*

1 Introduction

Modern agriculture is increasingly data-intensive, generating information from sensors, satellites, and imaging technologies. This data influx offers opportunities to optimize farming practices and enhance crop yield, but the complexity of the data and the need for efficient analysis present challenges. Agronomists and newcomers struggle with analyzing agricultural treatments, such as nitrogen (N) applications, especially in fields like those at the Eastern Nebraska Research, Extension and Education Center (ENREEC). The specialized knowledge required for in-depth data analysis creates barriers for many agricultural professionals lacking a data science or geospatial analysis background.

The "Ag Data Visualization" web application tool addresses this challenge by simplifying the visualization and analysis of N treatments and their impact on ENREEC fields. It integrates UAV and satellite imagery-derived shapefiles, advanced geospatial analysis, and metrics like the Sufficiency Index (SI) into an intuitive interface. This allows users to compare treatments, identify trends, and make informed decisions to optimize resource allocation and improve crop yield. This paper details the design, functionality, and applications of this tool, highlighting its potential to revolutionize in-season nitrogen management and precision agriculture.

2 Methodology

Figure 1, the flow diagram of this application, provides a detailed representation of the data flow and integration process, particularly focusing on how different data sources are utilized and processed to generate insightful visualizations for agricultural management. During the 2023 growing season, data visualization is being implemented on one field of the ENREEC, representing half-pivots (80 acres). Additionally, two new fields are being utilized this year.

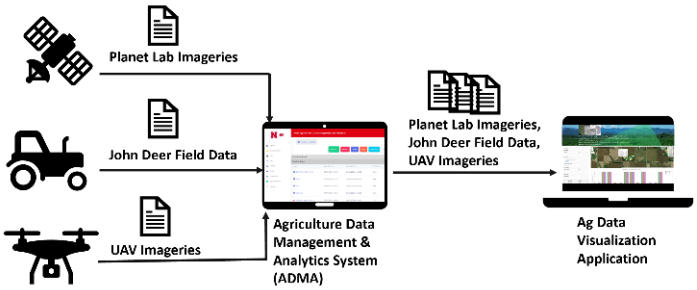

Figure 1 The System Diagram

2.1 Data collection, integration, and management

Imagery for the entire plot is collected weekly from May to late September using UAVs with multispectral cameras and Planet Labs' PlanetScope satellite constellation (Planet Labs PBC, 2024). UAV images have a 12 cm per pixel resolution, while satellite images have a 3 m per pixel resolution. Field data, including applied data and nitrogen rates, is gathered using the John Deere Operations Center (John Deer, 2024). All data, in GeoTIFF or Shapefile format, is automatically stored in the Agricultural Data Management Analytics System (ADMA) for processing and visualization (IANR Agriculture Data Management and Analytics, 2024).

2.1 Data processing

The application processing and visualization are done using the R Shiny software framework. Each field is divided into management sectors, where different N treatment variations are deployed and tested against grower rates. One commonly used sensor-based model in Nebraska, based on Holland and Schepers (Kyle H. Holland, 2012)describes an N fertilizer response function correlating vegetation index with N rate. This model utilizes an SI, calculated by dividing the vegetation index, Normalized Difference Red Edge (NDRE), by a reference value obtained

when N was not limiting crop growth (Eq.1).

$$\text{SufficiencyIndex(SI)} = \frac{\text{NDRE(Field)}}{\text{NDRE(Refernce)}} \quad (1)$$

To get reference value indicator block methodology (Stansell,2021), a canary plot (high N rate strip) and a reference plot (low N rate strip) within each field are employed. By analyzing the SI, which compares NDRE values collected via UAV or satellite imagery from the two strips, this methodology helps identify N stress in the crop.

3 Results

The data visualization tool allows users to select fields and treatment or SI dates from dropdown menus. Various map data options include field details, nitrogen treatment, SI, and yield. The central map shows a satellite view of fields divided into sectors, each with specific N treatment data. Hovering over a sector reveals details like the N treatment method, base rate, applied N rate, SI, and yield. A color-coded legend helps quickly identify these metrics across sectors. Interactive plots at the bottom visually compare each, using different colors for clarity (Fig.2).

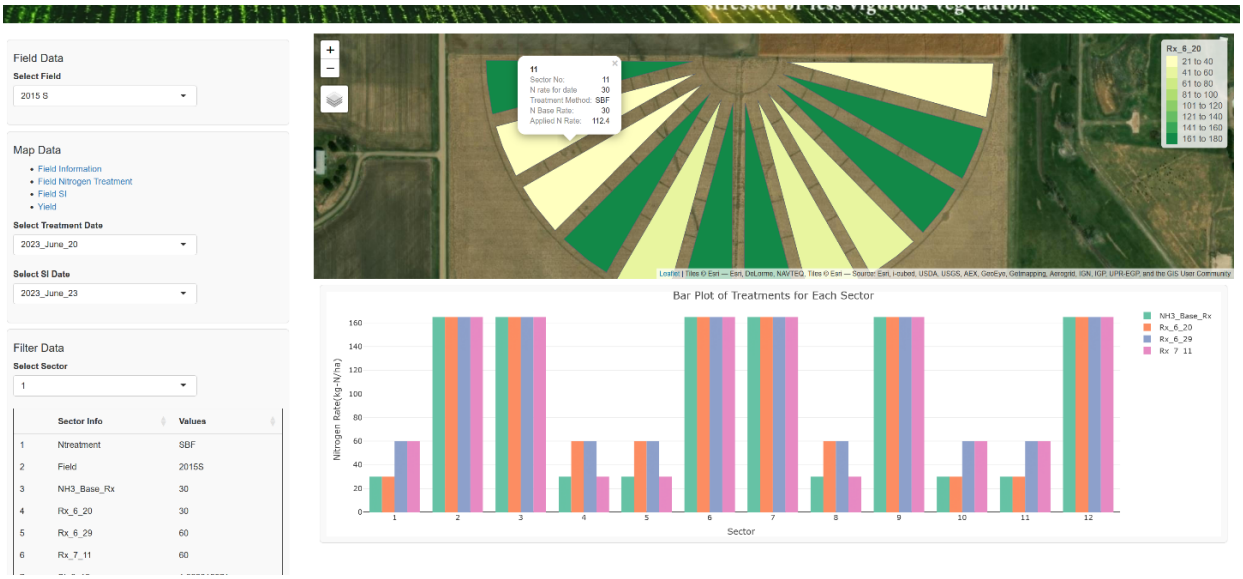

Figure 2 Ag Data Visualization Application Front End

4 Conclusion

The "Ag Data Visualization" web application tool revolutionizes N management in agriculture by offering an intuitive platform for visualizing and analyzing complex datasets in ENREEC Fields. The tool enables precise crop management and resource allocation by integrating UAV and satellite imagery with advanced geospatial analysis and metrics like the SI. It enhances crop health assessment, optimizes resource use, and improves yield predictions, all through an accessible interface that doesn't require extensive knowledge. Future enhancements will include more data sources, interactive features, and reporting capabilities, further advancing precision agriculture and data-driven decision-making.

5 References

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