Development and Implementation of an automated web tool for SBF Yield Analysis Using ArcGIS Model Builder and Python Scripts

Sreeja Vinod[1], Joe Luck[2]

Biological System Engineering Department, University of Nebraska - Lincoln, USA

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Abstract

Effective management of agricultural data and optimization of crop yields are recurring challenges faced by the agricultural sector. Sensor-based fertigation (SBF) represents a promising approach to enhance productivity by precisely applying nutrients based on real-time sensor data. SBF technique offers predictive capacity within a responsive N management framework[1]. However, manual analysis of SBF data is labor-intensive, time-consuming, and prone to errors, limiting the efficiency and scalability of this approach. This gap underscores the critical need for an automated agricultural data analysis tool that can process large geospatial datasets and generate the precise outcomes required for comprehensive SBF yield analysis.

The paper presents the development and implementation of an innovative automated web tool for Sensor-Based Fertigation yield analysis using geospatial data. The tool aims to enhance agricultural data management and analysis, making it publicly accessible through a comprehensive data management platform called ADMA (Agriculture Data Management and Analytics) for experts within and outside the Institute of Agriculture and Natural Resources (IANR). The tool was developed using ArcGIS Model Builder and Python scripts. It systematically processes geospatial data and automates field study analysis, significantly reducing the manual effort and time required for SBF yield analysis and ensuring consistent and accurate results.

ArcGIS Enterprise 11.2 was utilized to share the web tool with the cloud and establish the pipeline to ADMA, ensuring seamless data integration and accessibility. This integration facilitates a user-friendly approach to advanced geospatial data analysis among agricultural experts. Key features of the tool include its ability to handle large datasets efficiently, perform complex spatial analyses, and generate comprehensive reports that support decision-making in precision agriculture. Automation with Python scripts enhances the reproducibility of geospatial data processing, allowing agricultural experts to integrate advanced data analysis steps seamlessly.

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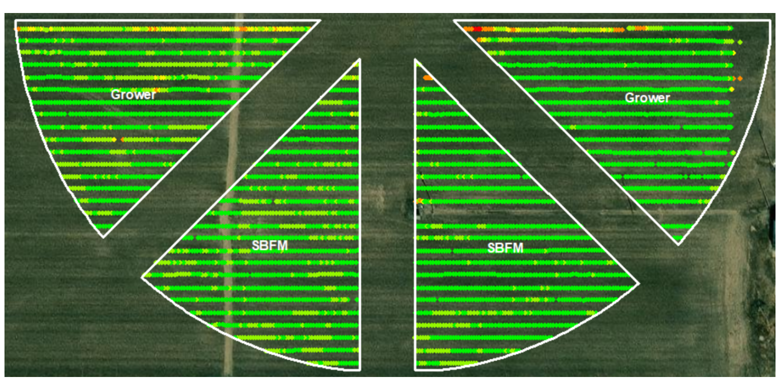
Introduction

Effective use of advanced technology is vital in precision agriculture to enhance resource efficiency and crop productivity. SBF integrates real-time data to optimize nutrient application, improving NUE, crop yield, and profitability while minimizing environmental impacts[2]. Recent developments in SBF yield analysis tools leverage GIS, remote sensing, and machine learning to process large datasets, providing actionable insights. This paper presents an automated SBF yield analysis web tool using GIS technologies and Python. It is deployed within ADMA to provide a user-friendly experience for agricultural experts and researchers to perform advanced geospatial analysis. This paper details the development and implications of the tool, highlighting its potential to transform agricultural practices and support sustainability and productivity goals.

Methodology

An automated SBF yield analysis web tool was developed using the ArcGIS model builder and Python scripts. The tool processes user-provided input layers, including shapefiles with clean yield data, treatment sector files, and fertigation Excel files. A buffer operation on treatment sector data creates an inward buffer to identify areas influenced by fertigation practices and minimize adjacent field impacts. Users can define buffer distances based on specific requirements. The buffered output undergoes spatial join and data integration with yield and fertigation data (Figure 1). Key steps include integrating nitrogen (N) base and fertigation rates from field data for growers and sentinel sectors, followed by computing total nitrogen rates. Summary statistics provide insights into fertigation practices, including metrics such as mean yield, mean moisture, and total nitrogen. NUE, PFP, and MNR are calculated to evaluate the effectiveness of fertigation practices, helping to improve resource management and enhance crop yields. The workflow is automated and shared in the cloud using ArcGIS Enterprise 11.2, establishing a seamless pipeline to the ADMA platform. This facilitates collaboration and data sharing among agricultural experts within and outside IANR.

Figure 1 An aerial view of a buffered field showing two different irrigation management treatments [1].



Results

A user-friendly automated SBF yield analysis tool was developed and implemented in ADMA to enhance the use of geospatial technologies to analyze agricultural data. The results include a detailed table that includes mean values of yield, moisture, and total nitrogen for each treatment, along with NUE, PFP, and MNR (Table 1). The table also provides mean values for differences between treatments. Incorporating these metrics into the automated tool for SBF yield analysis allows agricultural experts to understand the efficiency and effectiveness of their fertigation practices comprehensively. This information enables data-driven decisions that enhance productivity, optimize resource use, and promote sustainable agricultural practices. The ability to calculate and analyze NUE, MNR, and PFP supports the broader goal of improving crop yields while minimizing environmental impact and resource wastage. Deploying tools on the ADMA platform provides a user-friendly experience for agricultural experts to conduct advanced geospatial analysis. The tool has the potential to handle large datasets effortlessly and perform advanced geospatial data analysis. It makes processing time efficient and less labor intensive. Automation with Python scripts enhances the reproducibility of geospatial data processing, enabling agricultural experts to integrate advanced geospatial data analysis steps seamlessly.

Figure 2 shows the SBF yield analysis tool deployment and integration to ADMA

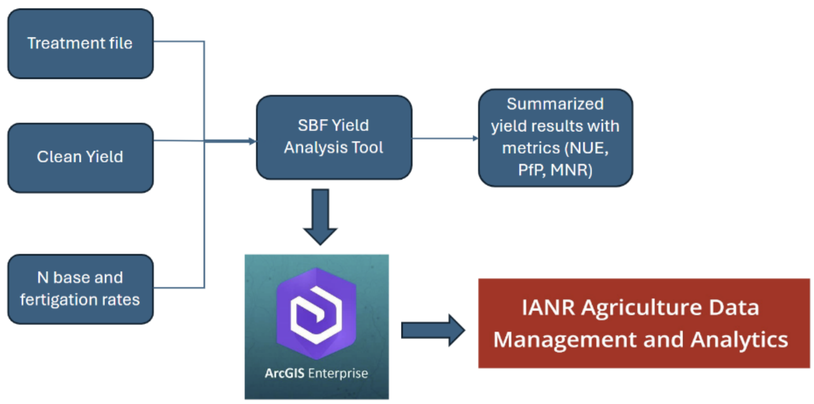


Table 1 showing final results and comparison between treatments applied.

	Scott_Field	Avg_Yield	Avg_Moisture	Avg_TotalN	NUE	PfP	MNR
1	Grower	274.0489	17.88591	184	0.6714131	83.40618	1254.32444
2	Sentinel	259.2758	17.18169	115	0.4435432	126.25603	1223.92890
3	Gr_Sen	NA	NA	NA	0.2278699	NA	NA
4	Sen_Gr	NA	NA	NA	NA	42.84985	-30.39553

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