Dynamic Management Zones for Real-Time Precision Agriculture Optimization

Ahmed Harb Rabia[1,*] & Eman Eldeeb[1]

[1]Department of Agricultural and Biosystems Engineering, North Dakota State University, Fargo, ND 58102, USA

A paper from the Proceedings of the
16th International Conference on Precision Agriculture
21-24 July 2024
Manhattan, Kansas, United States

Abstract.

Precision agriculture has significantly transformed farming practices by optimizing resource utilization, enhancing financial returns, and mitigating environmental impacts. However, the dynamic nature of field conditions throughout the growing season presents ongoing challenges. Traditional static management zones often fail to account for temporal variations, leading to suboptimal resource allocation and reduced crop productivity. This research aims to bridge this gap by developing a Dynamic Precision Agriculture Management (DPAM) system that adapts management zones in near real-time based on evolving crop needs, thereby improving soil health and agricultural sustainability. The DPAM system leverages data from satellite and unmanned aerial vehicle (UAV) imagery, soil maps, weather data, and historical yield maps to generate real-time management zone updates. Advanced AI algorithms analyze this field data to adjust management zones, optimizing resource allocation and maximizing crop productivity. The integration of remotely sensed NDVI time series and soil moisture sensor measurements further refines the in-season delineation of dynamic management zones (DMZ). This approach supports dynamic variable rate irrigation (D-VRI) and dynamic variable rate application (D-VRA), enabling real-time adjustments in irrigation and resource application to meet the precise needs of crops. This research aligns with strategic priorities set by the Soil Health Institute and the Natural Resources Conservation Service (NRCS-USDA) by focusing on improving soil health through precision agriculture. Indicators such as organic matter, bulk density, soil structure, and nutrient levels will be monitored to assess the impact of DPAM on soil functionality and productivity. Bi-weekly drone flights and satellite image analysis ensure timely updates throughout the growing season. Preliminary findings highlight the significance of soil water content and spatiotemporal changes in the NDVI index as primary drivers of dynamics within management zones. The transformative impact of DPAM lies in its ability to revolutionize precision agriculture by addressing the dynamic nature of field conditions. By integrating UAV and satellite imagery with AI technologies, DPAM optimizes agricultural practices, enhances soil health, and promotes sustainability. This research represents a significant advancement in precision agriculture, demonstrating the potential to improve irrigation scheduling, enhance resource use efficiency, and optimize crop performance. Ultimately, DPAM introduces a new era of adaptive, data-driven agricultural practices, contributing to a more sustainable and resilient agricultural future.

Keywords.
Precision agriculture, Dynamic management zones (DMZ), Soil health, Remote sensing.

The authors are solely responsible for the content of this paper, which is not a refereed publication. Citation of this work should state that it is from the Proceedings of the 16th International Conference on Precision Agriculture. Rabia, A. H. & Eldeeb, E. (2024). Dynamic Management Zones for Real-Time Precision Agriculture Optimization. In Proceedings of the 16th International Conference on Precision Agriculture (unpaginated, online). Monticello, IL: International Society of Precision Agriculture.