International Journal of Advances and Applications in Convergent Studies & Transdisciplinary (IJ-AACST)

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IoT- and ML-Based Fertilizer Recommendation for Sugarcane: A Focused Review

DOI: https://doi.org/ 10.5281/zenodo.24103563

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ABSTRACT

Sugarcane is a long-duration crop that removes large quantities of nutrients from the soil, yet fertilizer is still commonly applied by uniform, calendar-based rules that ignore how soil supply and crop demand change across a field and across a season. This paper reviews how low-cost soil sensors, wireless connectivity and machine learning (ML) can be combined to make nutrient recommendations that are specific to a site and a growth stage. We discuss evidence on split and band-placed fertilizer application in plant and ratoon crops, ML-based nitrogen estimation from drone imagery, and the reliability of inexpensive NPK probes. Three themes emerge: stage-wise scheduling matters more for sugarcane than a single seasonal dose; imagery-based nitrogen models give moderate, variety-dependent accuracy; and commercial NPK probes have rarely been checked against laboratory analysis and, where they have, performed poorly. Building on these themes, we outline a conceptual five-layer architecture (AIFRF-SC) that treats growth stage and plant-versus-ratoon status as model inputs and that returns a dated application schedule with an explanation of the sensor readings behind it. The architecture is a proposal for future work and has not been field-tested.

KEYWORDS: sugarcane; fertilizer recommendation; precision agriculture; Internet of Things; machine learning; ratoon; site-specific nutrient management.

1. INTRODUCTION

Sugarcane (*Saccharum officinarum* L.) is an important agro-industrial crop in tropical and subtropical regions and contributes meaningfully to the Indian rural economy [1]. It stays in the field for most of a year, produces large biomass, and draws heavily on soil nitrogen (N) and potassium (K). Because of this, errors in fertilizer management are costly: under-application limits cane and sugar yield, whereas over-application raises input cost and increases nutrient loss to water and air [1].

Recommendations given to growers are usually written for an agro-climatic zone and expressed as a

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