Machine Learning Model for Maize Yield Prediction in Marondera, Zimbabwe

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR

SOFTWARE ENGINEERING (HONS) BSEH BY THE ZIMBABWE OPEN UNIVERSITY

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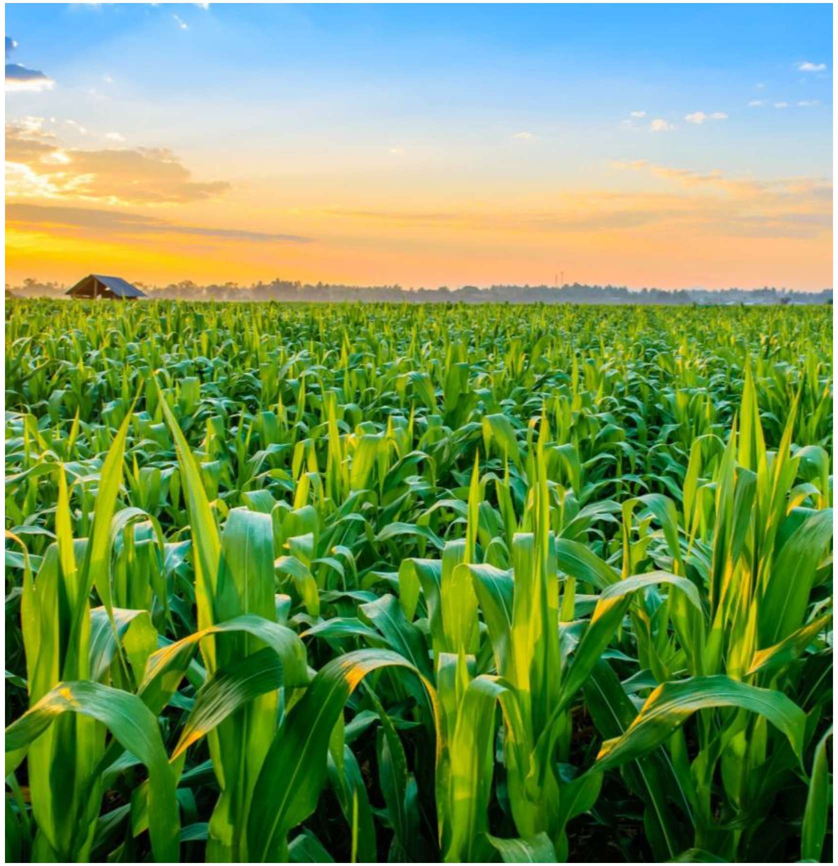
1.0 Introduction

Agriculture is the backbone of Zimbabwe's economy, with maize being the country's staple crop. Smallholder farmers contribute significantly to maize production, but their yields are often affected by unpredictable weather patterns, poor soil fertility, and lack of access to timely agronomic advice. In the digital age, machine learning (ML) offers promising solutions to enhance agricultural productivity through predictive modeling and data-driven decision-making. This project focuses on developing a machine learning-powered maize yield prediction system for Marondera District, Zimbabwe, incorporating historical weather data and soil nutrient profiles to guide farmers toward optimal crop management.

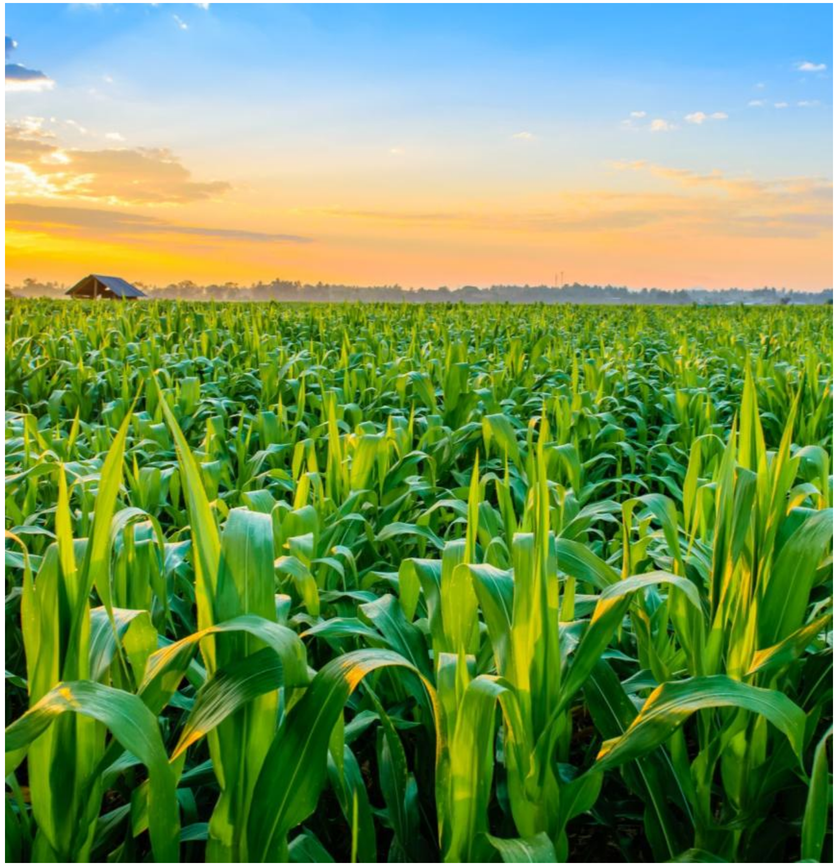


1.2 Background

Marondera District, located in Mashonaland East Province, has fertile soils and favorable climate conditions for maize farming. However, yield fluctuations are common due to inconsistent rainfall, climate change effects, and sub-optimal fertilizer use. Previous studies highlight the potential of ML models in crop yield forecasting by leveraging environmental data. Globally, countries like the USA use AI-driven farming systems extensively, but in Zimbabwe, adoption is still in its infancy. Addressing these gaps with a mobile-based solution tailored to Zimbabwean conditions could significantly improve yield predictability and input use efficiency.

1.3 Problem Statement

Despite Marondera’s strong agricultural potential, maize farmers continue to struggle with yield unpredictability, largely due to reliance on traditional farming practices and the absence of localized, data-driven agronomic support. The lack of accessible tools that integrate historical weather patterns and soil nutrient data limits farmers’ ability to make informed decisions. This results in suboptimal fertilizer application, inefficient irrigation, and frequent crop failures, undermining food security and economic stability. There is a pressing need for a machine learning-based maize yield prediction model tailored specifically for Marondera to enhance forecasting accuracy and support precision farming.



1.4 Project Aim

The aim of this project is to develop a machine learning model that predicts maize yields in Marondera District based on historical weather patterns and soil nutrient data, providing actionable insights such as fertilizer recommendations and irrigation requirements.

1.5 Research Objectives

1. To collect and preprocess historical weather and maize yield data for Marondera District (2003–2022).
2. To train a machine learning model utilizing Random Forest Regression for maize yield prediction.
3. To integrate fertilizer and irrigation advisory based on soil and weather analysis.
4. Integrate live weather data for the Marondera District from API
5. To develop a Web app enabling farmers to access predictions and recommendations.

1.6 Research Questions

- What are the key weather and soil factors influencing maize yields in Marondera?
- How accurately can an ML model predict maize yield based on historical data?
- What are the optimal fertilizer strategies recommended based on soil nutrient profiles?
- How can a Web app effectively deliver yield predictions and recommendations to farmers?

1.7 Research Hypothesis

H0: Machine learning models using historical weather and soil data do not significantly improve maize yield predictions in Marondera District.

H1: Machine learning models using historical weather and soil data significantly improve maize yield predictions in Marondera District.

1.8 Significance of the Study

This study addresses critical gaps in agricultural technology adoption in Zimbabwe by providing a localized, data-driven solution for yield forecasting.

The outcomes can empower smallholder farmers to make evidence-based decisions, improve maize productivity, and optimize resource use (fertilizer, water).

Policymakers, agronomists, and stakeholders can also leverage the system for planning and extension services.

1.9 Scope

The project focuses on Marondera District and targets maize cultivation only.

It uses fixed soil nutrient profiles and historical weather data (2003–2022).

The web app is designed for all devices with English-language support.

1.10 Assumptions of the Research

Farmers provide accurate field and planting details.

Soil data remains relatively stable over the years.

Weather data used (2003–2022) is reliable and representative of long-term trends.

1.11 Limitations

- Limited to maize crop prediction (no multi-crop analysis).
- Fixed soil data may not reflect micro-variations within the district.
- The accuracy of yield prediction depends on data quality and completeness.
- App adoption may be constrained by smartphone penetration and digital literacy.

1.12 Definition of Terms

Yield Prediction: Estimating future crop output based on input data.

Machine Learning: A subset of AI where models learn patterns from data to make predictions.

Soil Nutrient Profiles: Data on essential nutrients (for example, N, P, K) in soil.

Fertilizer Recommendation: Guidance on type and quantity of fertilizer based on soil and crop needs.

Irrigation Requirement: Additional water needed to meet crop water demands beyond rainfall.

Flutter App: A cross-platform mobile app built using Google's Flutter framework.