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DATE: 20 – 22 August 2025

The use of Sentinel-2 combined with SAR remotely sensed data in assessing and quantifying soil moisture content for optimization of maize crop production in commercial farming systems

BY

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Introduction

- An increase in population growth and food insecurity has amplified the importance of farmers in ensuring food security, particularly in developing countries such as South Africa.
- Commercial farming systems in achieving national and regional food security have become increasingly important.
- Maize, a staple food and livestock feed, is primarily grown under rainfed conditions with limited resources, making it vulnerable to adverse climatic conditions and resource constraints (Mgbenka et al., 2016).
- Soil moisture availability is a major factor influencing maize growth, and proper monitoring of soil moisture plays a significant role in the development and final yield of the crop
- Remote sensing has provided a robust alternative for evaluating vegetation properties and soil moisture content.

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Aims and Objectives

This study aims to evaluate the potential of integrating Sentinel-1 and Sentinel-2 data to improve soil moisture estimation in commercial maize farming systems.

Objectives

- To investigate the synergistic potential of combining vegetation indices and SAR backscatter coefficients to improve soil moisture (SM) estimation accuracy for maize crops.
- Analyse soil moisture variability and its impact on maize health indicators (LAI, chlorophyll) across key growth stages.
- Develop and validate a Deep Neural Network model to predict soil moisture using satellite-derived predictors and field measurements.

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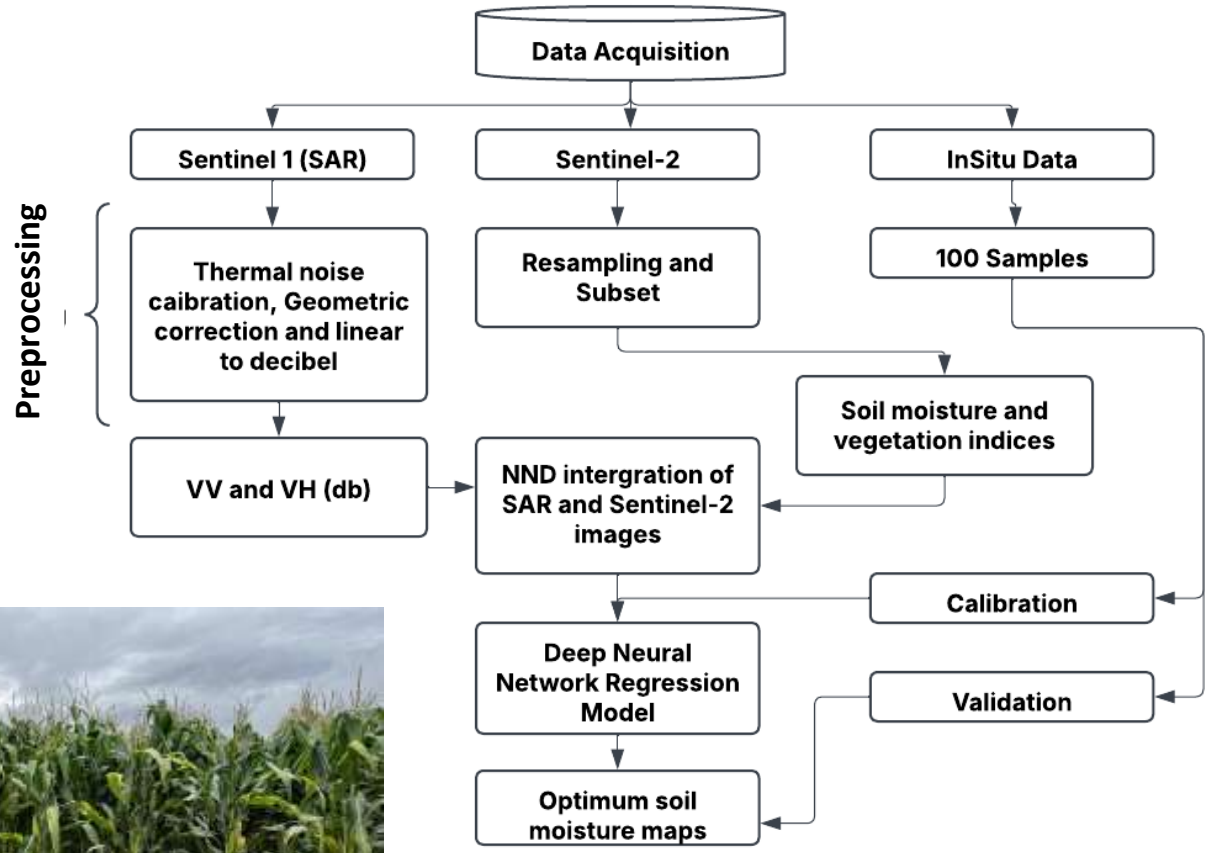
Material and Methods



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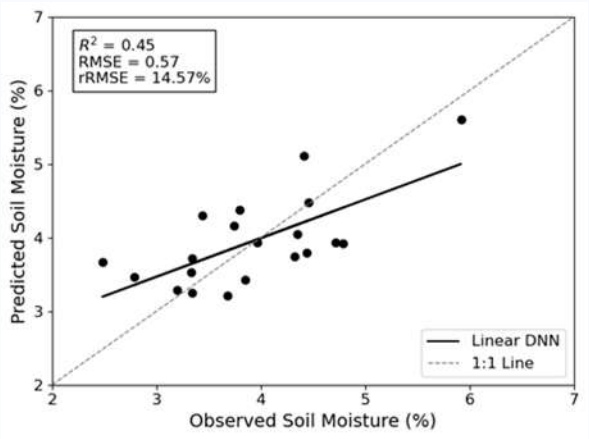
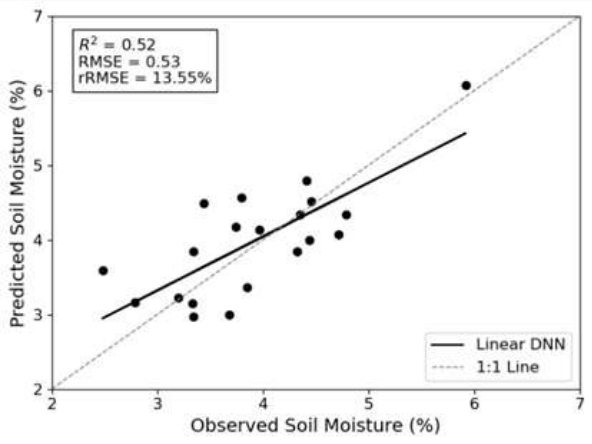
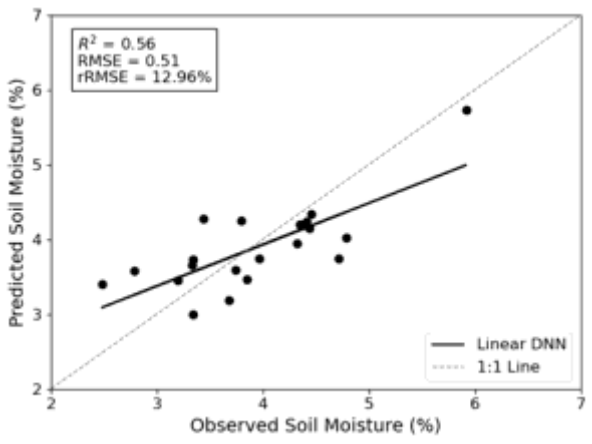
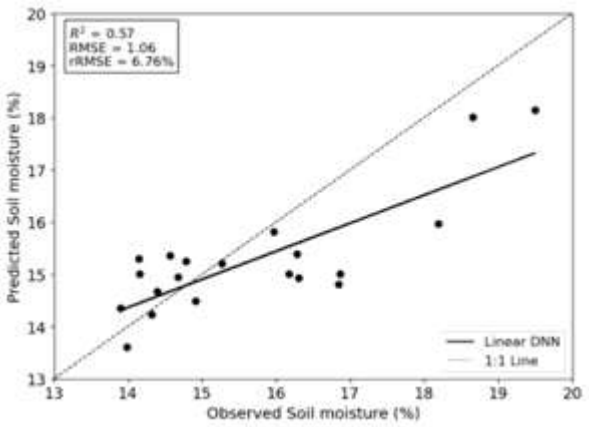
- **V8 and R2 phenological stages of the maize crop**

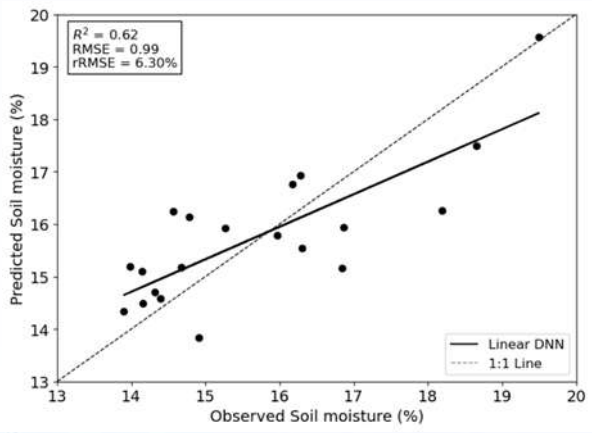
Sentinel 2 | **Sentinel-2 + VV** | **Sentinel-2 + VH**

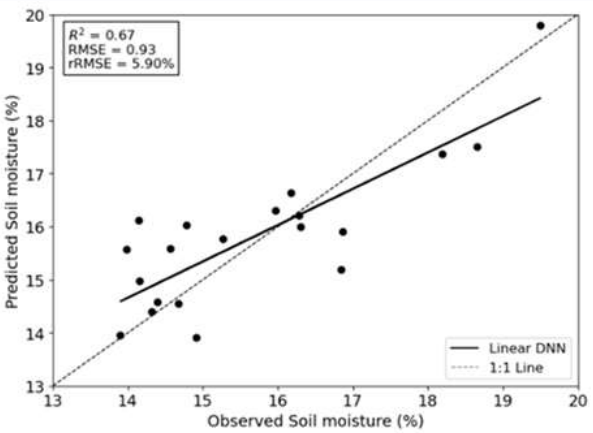












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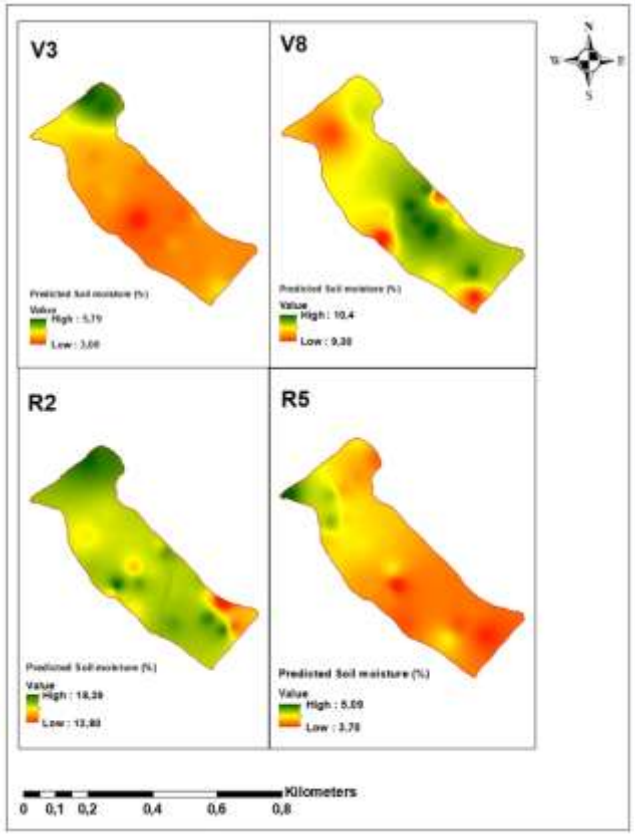
Results

The spatial distribution of predicted soil moisture across the phenological stages.



- The resulting distribution maps indicate an increase in soil moisture from the V8 to the R2 stages, with a slight decline observed at the V3 and R5 stages.
- This pattern aligns with the prediction accuracy, where higher accuracy was noted during the V8 and R2 stages and lower accuracy during the V3 and R5 phenological stages.

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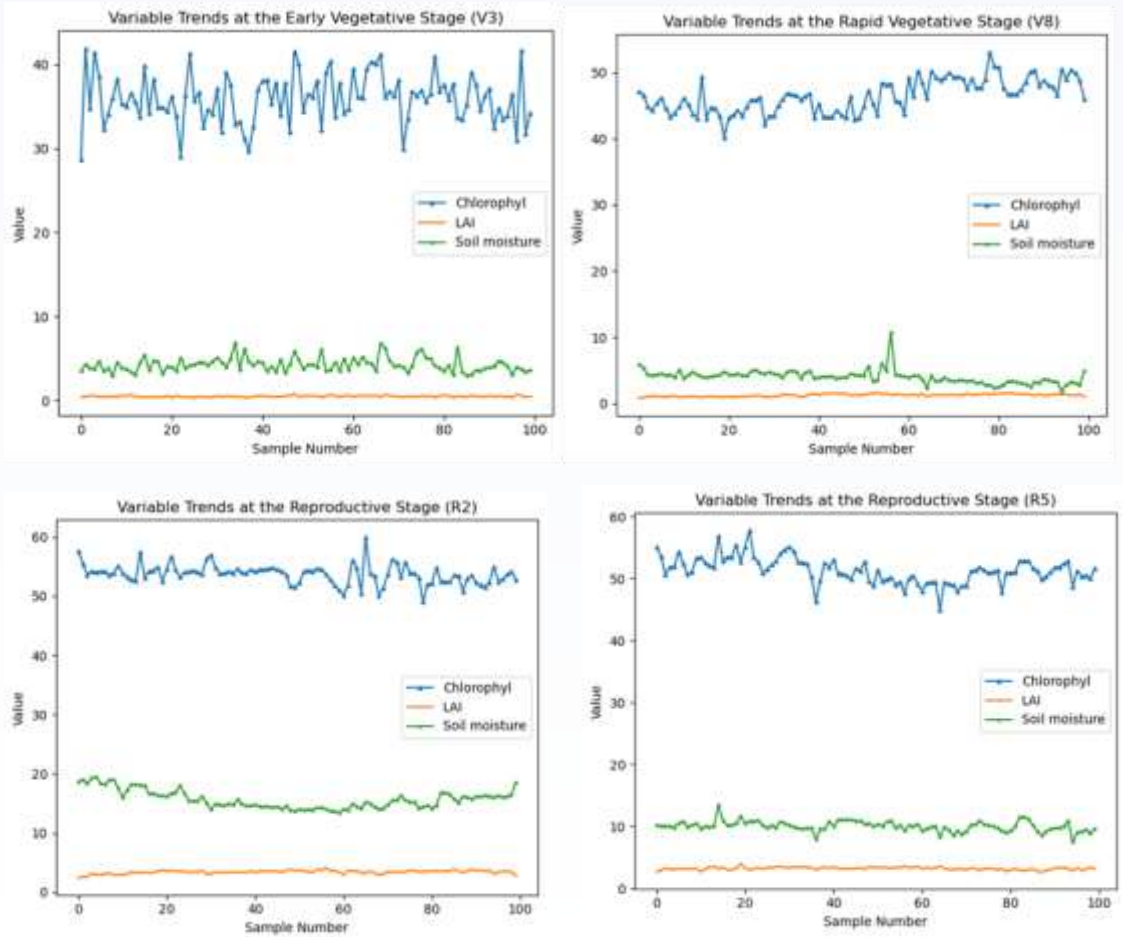
Results cont….

Soil moisture variability and its impact on maize health indicators (LAI, chlorophyll) across key growth stages.



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Discussion

- The results show that in comparison to the use of Sentinel-2 MSI as a standalone dataset, the fused image can improve the prediction of soil moisture.
- Results show that Sentinel-2 achieved an (R^2=0.45 and RMSE=0.57 kg/m2), however, when fused with VV and VH datasets, the prediction accuracy increased (R^2=0.52 and RMSE=0.53 kg/m2) and (R^2=0.56 and RMSE= .51 kg/m2) in the V8 phenological stage.
- The findings of the study can also be attributed to the fact that SAR images provide valuable backscattering data that is sensitive to vegetation biophysical characteristics.
- The variations in soil moisture content were consistently linked to corresponding increases or decreases in both LAI and chlorophyll content across all growth stages, with the most pronounced effects observed during the reproductive stages V8 and R2.
- Based on the overall RMSE and rRMSE% achieved in this study, the DNN model had minimal prediction errors (< 10%) in the R2 and R5 stages.

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Conclusion

- The V8-R2 phenological stages are optimal for soil moisture assessment prediction when vegetation reflectance is at peak.
- The SAR backscatter coefficients (VV and VH) improve the prediction accuracy of soil moisture assessment and can therefore be used in soil moisture estimation.
- The variability in soil moisture influences the LAI and chlorophyll.

The findings of this study provide valuable insights for advancing precision agriculture, particularly in commercial systems.

The findings of this study fill a gap in existing studies by applying smart agriculture approaches to the global south for improved maize production and sustainability.

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