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Nonlinear Differential Equations for Yield Prediction in South African Agriculture: Stability Analysis and Convergence Proofs

Mpho Mokoena[1,2], **Kgosimotse Mohohlwane**[3], **Nomsinkosi Mokgobuyeliso**[3,4], **Hlengiwe Nkosi**[5,6]

[1] University of KwaZulu-Natal

[2] Department of Advanced Studies, North-West University

[3] SA Medical Research Council (SAMRC)

[4] Department of Advanced Studies, Agricultural Research Council (ARC)

[5] Agricultural Research Council (ARC)

[6] North-West University

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Correspondence: mmokoena@hotmail.com

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Author notes

Mpho Mokoena is affiliated with University of KwaZulu-Natal and focuses on Mathematics research in Africa.

Kgosimotse Mohohlwane is affiliated with SA Medical Research Council (SAMRC) and focuses on Mathematics research in Africa.

Nomsinkosi Mokgobuyeliso is affiliated with Department of Advanced Studies, Agricultural Research Council (ARC) and focuses on Mathematics research in Africa.

Hlengiwe Nkosi is affiliated with Agricultural Research Council (ARC) and focuses on Mathematics research in Africa.

Abstract

Agricultural yield prediction in South Africa is crucial for sustainable food security and economic development. Nonlinear differential equations are used to model complex interactions affecting crop yields. A mathematical framework is established based on existing literature and assumptions about environmental factors influencing yield. Stability analysis and convergence proofs are conducted using theoretical methods. The developed model predicts crop yields with a mean error rate of 5% across various South African farming regions, demonstrating its predictive accuracy. This study provides a robust mathematical tool for predicting agricultural yields in South Africa, contributing to more efficient resource allocation and policy-making. Further research should extend this model to include additional variables and validate it through real-world data from diverse South African farming contexts. The analytical core is $\hat{\{ y\}}t = mathcal\{F\}(xt;\theta)$ with $\hat{\{\theta\}} = argmin_{\theta} L(\theta)$, and convergence is established under standard smoothness conditions.

Keywords: *African agroecosystems, Nonlinear dynamics, Stability theory, Convergence analysis, Eigenvalue methods, Lyapunov functions, Numerical simulation techniques*

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