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Analysis of the effects of rainfall variability on natural forage resources and the corresponding livestock production: Climate variability and livestock dynamics in Botswana

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Botswana's livestock sector is a cornerstone of the nation's economy and food security, which is primarily based on natural grazing resources. However, climate variability poses significant challenges by altering rainfall patterns, which directly affects forage availability and quality. Traditional farmers, often lacking access to advanced climate data, rely on intuition and historical rainfall trends, making them particularly vulnerable to these changes. Therefore, this study investigates the effects of rainfall variability on livestock production using a mathematical model for plant-herbivore interactions, derived from a prey-predator framework.

The model incorporates plant growth rates and regional rainfall data sourced from the Climate Engine, covering diverse climatic and vegetation conditions in Botswana. In addition, essential threshold values for coexistence were derived, with the average basic reproduction ratio, R_0, correlated to the dynamics of the livestock population. The observed decline in livestock populations from literature and historical data is also confirmed through R_0 analysis. The numerical solution of the model is used to explore the relationships between the timing and intensity of rainfall, plant biomass, and livestock populations.

The results reveal that early onset and higher intensity of rainfall positively influence livestock populations, while delayed or reduced rainfall results in population decline. The findings further suggest that adaptive livestock harvesting

strategies can serve as effective tools for sustainable grazing and livestock management.

Keywords: livestock production, non-autonomous plant-livestock model, climate variability, natural forage, prey-predator model

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