Modeling Boran Cattle Populations under Climate Change and Varying Carrying Capacity in Ethiopian Rangelands

Samuel Tuffa[ab] and Anna C. Treydte[bc]

[a]Yabello Pastoral and Dryland Agriculture Research Centre, P. O. Box 85, Yabello, Ethiopia;

[b]University of Hohenheim, Department of Agroecology in the Tropics and Subtropics, Garbenstr. 13, University of Hohenheim, 70599 Stuttgart, Germany;

[c]Nelson Mandela African Institution of Science and Technology, Arusha, Tanzania.

www.foodsecurity.de

1. Introduction

❖ Most population models assume that individuals in a population have equal vital rates.

❖ In a semi-arid environment, both demographic and environmental factors are stochastic.

❖ External factors such as marketing characteristics are regulated by drought events besides herders' decision.

❖ Drought is the prime climatic factor prescribing the dynamics of Boran cattle population, but no model has been developed considering its influence on the Boran cattle dynamics.

❖ Objectives:

✓ To model cattle population dynamics under varying environmental conditions;

✓ To identify the target animal classes on which management efforts should be focusing to ensure a long-term and sustainable productivity of Boran cattle.

2.1. Model description

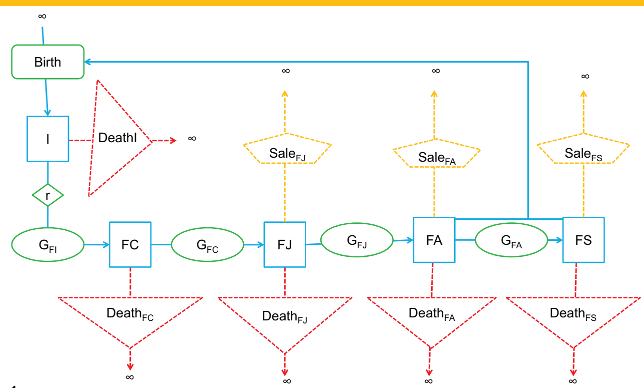

Fig. 1
Schematic illustration of Boran cattle (*B. indicus*) population dynamics including rates of production and survival as well as sale rates. Five age-cohorts are distinguished: I = infants; FC = female calves; FJ = female juvenile; AF = adult female; FS = senescent female; as well as respective processes: GFI = growth of female infants; GFC = growth of female calves; GFJ = growth of female juvenile; GFA = female adult growing old; r = sex ratio; Death = death of respective age-cohort; Sale = sale of respective age-cohort.

2.2. Model calibration and validation

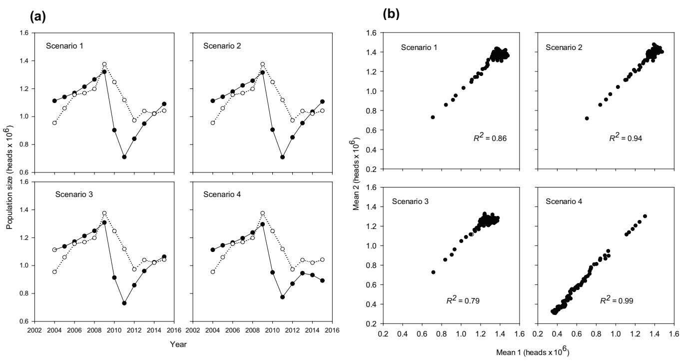

Fig 2 (a) Simulated (solid circles) and observed (open circles) numbers of cattle under four different scenarios, 1, 2, 3 and 4 over the first 12 years of model simulation. The solid line represents the optimal fit through validation of the simulated population trajectory based on 100 runs. The dashed line represents the real population (observed).

(b) Mean internal validity values of the model after two separate (Mean 1 and 2; x- and y-axes, respectively) 100 model runs under the four scenarios. The R^2 values represent unity, i.e., the closer the values to 1 the better the repeatability of the model after multiple runs. Scenario 1 = drought frequency once every 20 years; Scenario 2 = drought frequency once every 15 years; Scenario 3 = drought frequency once every 10 years; Scenario 4 = drought frequency once every 5 years.

2. Methodology

❖ We collected data on demographic and environmental factors and market values affecting the current and future Boran cattle population from Ethiopian central statistical agency and literature.

❖ We generated stochastic models under different drought scenarios (scenarios 1-4) and assessed the future development of the cattle population.

❖ In our population model, heterogeneity in vital rates affected attributes of the population process under stochastic environment.

❖ We presented changes in age- and sex-cohorts of Boran cattle population by randomly disturbing the trajectory at different drought frequencies on vital rates, carrying capacity and marketing.

3. Results

❖ Under high drought frequencies population crashes.

❖ Model outcomes were most sensitive to sale rate of juvenile and mature females compared to vital rates.

❖ Hence, thorough monitoring of demographic and environmental factors can improve predictions of cattle population development over time.

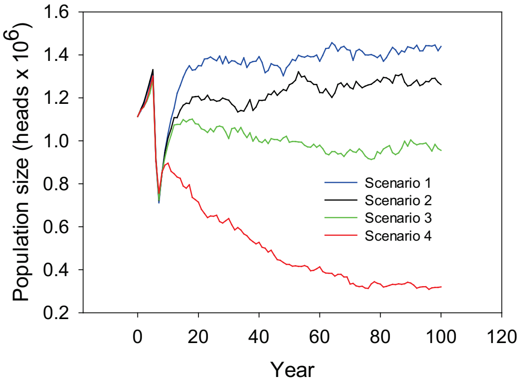

Fig. 3 Mean cattle population trajectories under four different scenarios with an initial population size of 1.11 mio subjected to perturbation generated through 100 model runs. The line graphs indicate the trends in population size over 100 years.

4. Conclusion

❖ We observed high herd crashes under scenario 4, which is the most likely to happen in the face of climate change.

❖ Management should focus on lowering herd crashes through increasing sale of mature males that increases feed availability to females during drought years in the Ethiopian Rangelands.

❖ Drought early-warning systems and market information must be strengthened so that pre-planned selling can be realized for the fair and sustainable use of the animal resource.

❖ Rangelands should be managed to enhance resilience after drought through marrying scientific and indigenous knowledge.

Acknowledgements

Research funds were provided by the Dr. Hermann Eiselen Foundation Fiat Panis. This work is an output of the scholarship from the Food Security Centre, University of Hohenheim, which is supported by the German Academic Exchange Service (DAAD) and the German Federal Ministry for Economic Cooperation and Development (BMZ). We are grateful to Ralph Gäbler, Joachim Ingwersen, Ana Salvatierra, Wayne Getz, Ignas Heitkönig, Carsten Marohn , Abule Ebro, Solomon Desta and Joseph Ogutu for their valuable inputs.

Federal Ministry for Economic Cooperation and Development

exceed EXCELLENCE CENTERS FOR EXCHANGE AND DEVELOPMENT

DAAD Deutscher Akademischer Austausch Dienst German Academic Exchange Service

CONTACT
Samuel Tuffa Kawo
Email:
ST_Kawo@uni-hohenheim.de