Global rangelands at threat under climate change

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Rangelands are one of the Earth's major ice-free land cover types. They provide food and support livelihoods for millions of people, in addition to delivering important ecosystems services. However, rangelands are under climatic threat, although the extent of the potential impacts is poorly understood. In this study, we use the global rangeland model G-Range in combination with livestock and socio-economic datasets to identify where and to what extent rangeland systems may be at climatic risk.

Methods

Vegetation outputs from the global rangeland model G-Range (Boone et al., 2018) under climate change scenarios* were analysed and combined with spatially explicit global datasets: ruminant stocking rates (Gilbert et al., 2018) and milk and meat productivities per unit area (Herrero et al., 2013), Gross Domestic Product - Purchasing Power Parity (GDP-PPP; Nordhaus and Chen, 2016) and projected human population density by 2050 under the Shared Socioeconomic Pathways SSP2 (Jones and O'Neill, 2017). Further details on methods and results are presented in Godde et al. (2020, Environ. Res. Lett.).

Results

Overall, herbaceous biomass mean is projected to decrease by 2050 while its year-to-year and month-to-month variabilities are projected to increase

The amount of change in G-Range output values varied under the different climate change scenarios tested*, but the spatial patterning of the temporal trends was similar enough to portray in this poster responses under RCP 8.5 with HadGEM2-ES climate projections and effects of changes in atmospheric CO_2 on vegetation accounted for. Overall:

- **Herbaceous biomass mean** is projected to **decrease** (-4.7%, from 156.9 to 149.5 g/m^2), with 74% of the 1846 Mha of global rangelands considered showing a decreasing trend.
- **Year-to-year variability in herbaceous biomass** is projected to **increase** (+21.3%, from 1.37 to 1.67), with 64% of global rangelands showing an increasing trend.
- **Month-to-month variability in herbaceous biomass** is projected to **increase** (+8.2%, from 0.21 to 0.23), with 54% of global rangelands showing an increasing trend.

Half of global rangelands are projected to experience **simultaneously a decrease in mean herbaceous biomass and an increase in its inter-annual variability (Figure 1)** — both vegetation trends are potentially harmful for livestock production as they can limit the animal carrying capacity of the land.

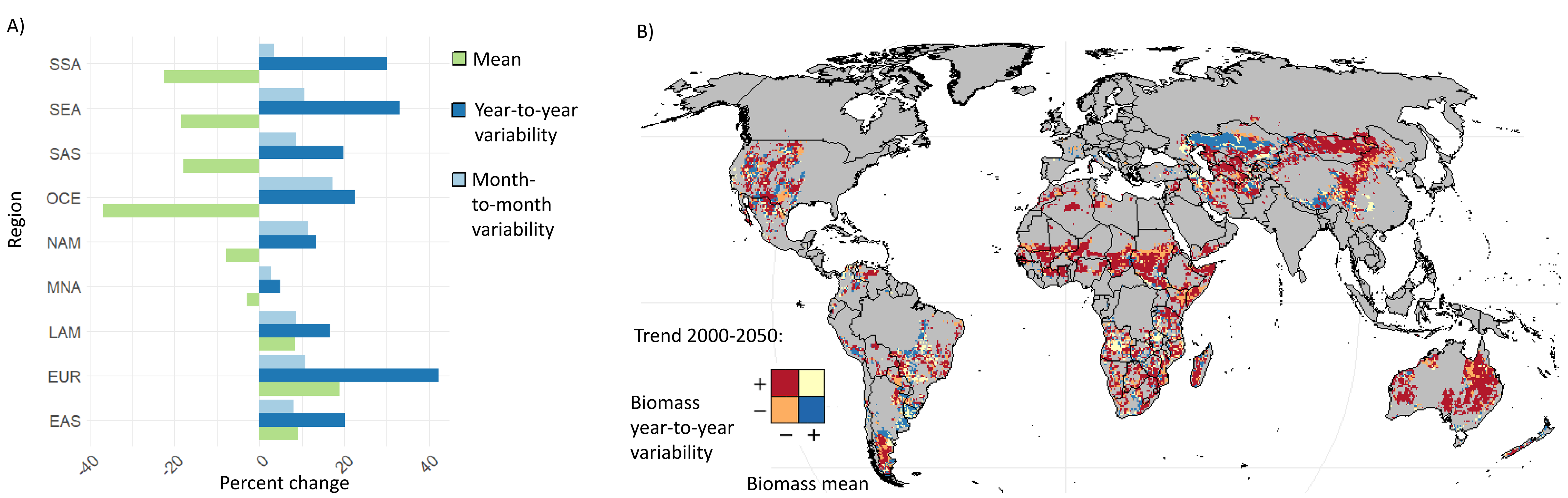


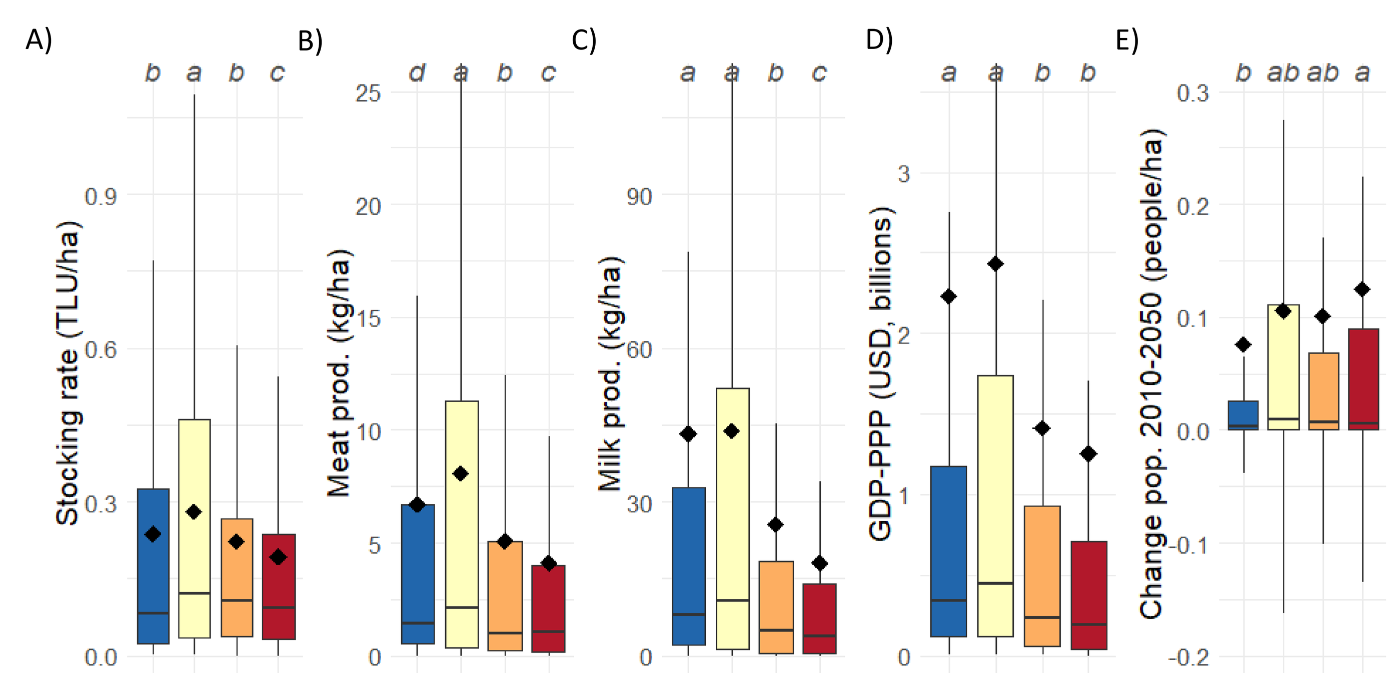
Figure 1: Trends in herbaceous dynamics as projected by G-Range by 2050. Panel A shows regional percent changes (data-points weighted by their amount of land devoted to rangelands). Panel B highlights dynamics at the pixel level. The sign (+) indicates an increase in the vegetation variable value by 2050 and (-), a decrease. EAS: Eastern Asia, EUR: Europe and Russia, LAM: Latin America and the Caribbean, MNA: the Middle East-North Africa, NAM: North America, OCE: Oceania, SAS: South Asia, SEA: Southeast Asia, SSA: sub-Saharan Africa.

The communities currently the most vulnerable, as per the socio-economic variables considered, may also experience the most harmful vegetation trends for livestock production

The vulnerability of rangeland communities depends not only on the potential climate impacts on ecosystems processes but also on the ability of these communities to change in response to or cope with changes.

Regions that **may experience simultaneously a decrease in mean herbaceous biomass and an increase in its year-to-year variability** are regions that, on average, currently have the lowest livestock productivities and economic development levels and the highest projected human population growth by 2050 (Figure 2, red colour).

Regions with the highest stocking rates, lowest livestock productivities and GDP-PPP or the highest population growth by 2050 are also **projected to experience the greatest rates of decrease in herbaceous biomass by 2050** (not shown on this poster).



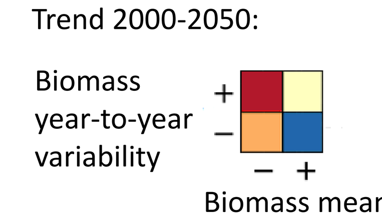


Figure 2: Trends in herbaceous dynamics as projected by G-Range by 2050 and selected current rangeland socio-economic characteristics. The sign (+) indicates an increase in the vegetation variable value by 2050 and (-), a decrease. For instance, on panel D, the areas projected to experience simultaneously a decrease in mean herbaceous biomass and an increase in year-to-year variability (red) are areas that, in 2010, have on average the lowest GDP-PPP values. Number of data-points in each boxplot: 1856 (blue), 1221 (yellow), 1659 (orange), 6203 (red). Within each of the five panels, groups that were found to have means statistically significantly different from all other boxes in pairwise comparison do not share the same letter (a-c) (Tukey HSD test, p-value<0.05).

Discussion

In the face of global warming, the existing suite of adaptation strategies may not be enough. Barriers to implementation are also significant and may be stronger in areas with low economic development, which this study finds to also potentially experience the most harmful vegetation trends for livestock production. The deepening of our understanding of the climate vulnerability of the ecological and socio-economic components of rangelands is a necessary step to identify successful adaptation pathways in times of climate change and other future uncertainties.

*Climate change scenarios tested in this study: (1) Representative Concentration Pathways (RCP) 8.5, Generalised Circulation model: HadGEM2-ES, with effects of changes in atmospheric CO_2 on vegetation accounted for, (2) RCP 8.5, NorESM1-M, with CO_2 effect, (3) RCP 8.5, HadGEM2-ES without CO_2 effect, (4) RCP 2.6, HadGEM2-ES with CO_2 effect (van Vuuren et al., 2011; Warszawski et al., 2014).

Reference list available at: