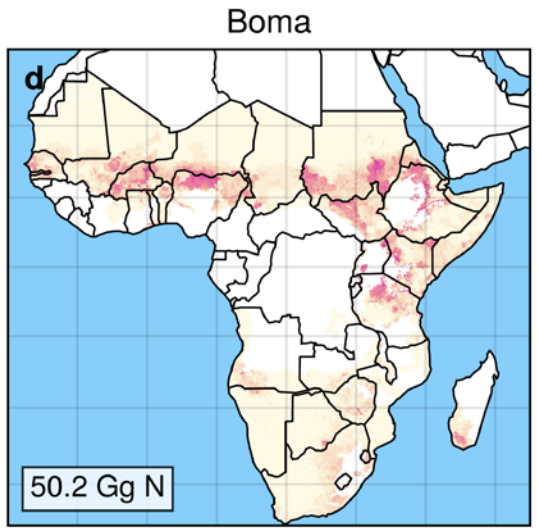
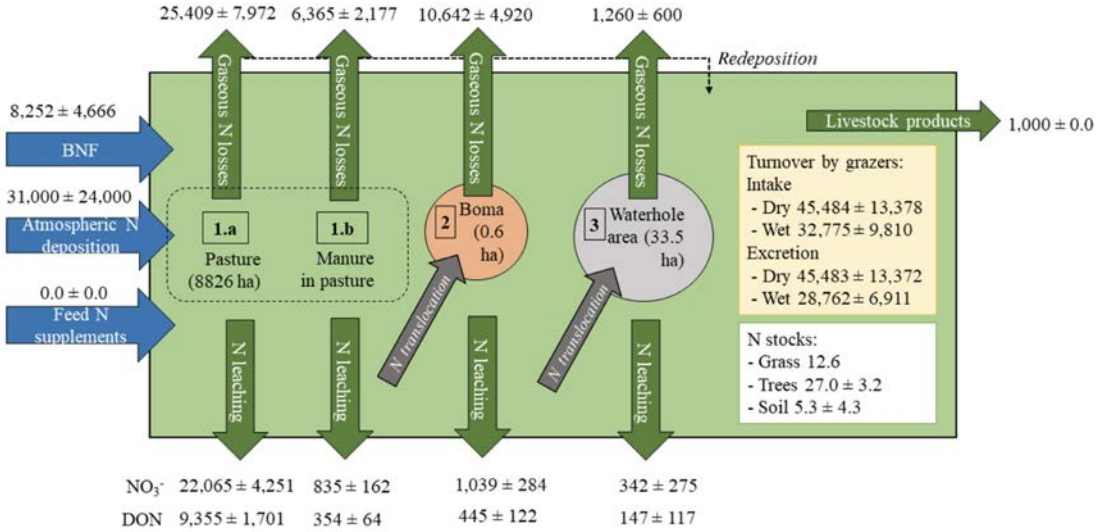
N cycling and N_2O emission hotspots in grazed tropical savanna systems in East Africa - opportunites for mitigating environmental N losses

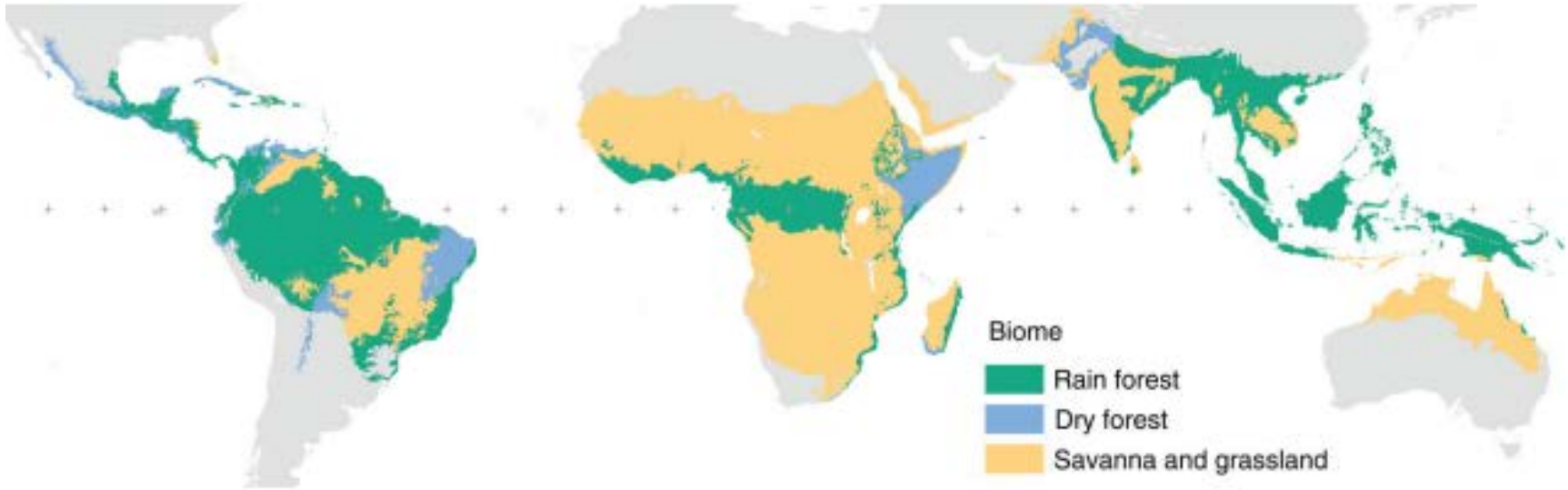
Klaus Butterbach-Bahl[1,2], Gretchen Gettel[3], Ralf Kiese[2], Sonja Leitner[4] & Lutz Merbold[5]

[1]Pioneer Center Land-CRAFT, Agroecology, Aarhus University, Denmark, [2]KIT Institute of Meteorology and Climate Research, [3]IHE Delft Institute for Water Education, [4]International Livestock Research Institute, Kenya, [5]Agroscope, Switzerland





Tropical savanna – environmental importance

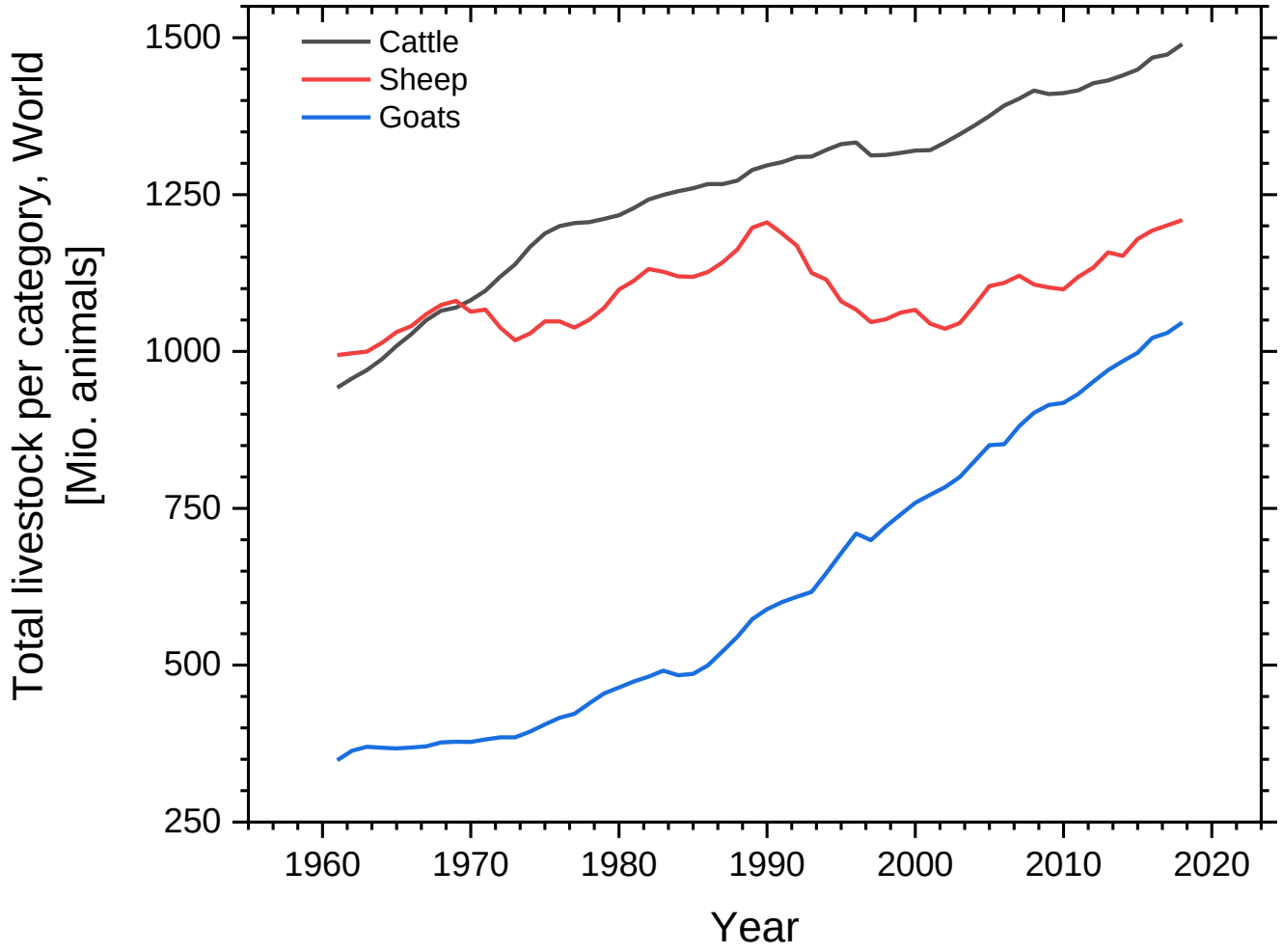


Pennington et al., 2018, Curr. Biol.28, 541-R545

- About a third of global population lives in seasonally dry tropical areas
- Over-grazing drives large scale deterioration/ desertification of savannas
- High rainfall savanna of SSA next frontier for agriculture
- Savanna exceed major control on global carbon cycle

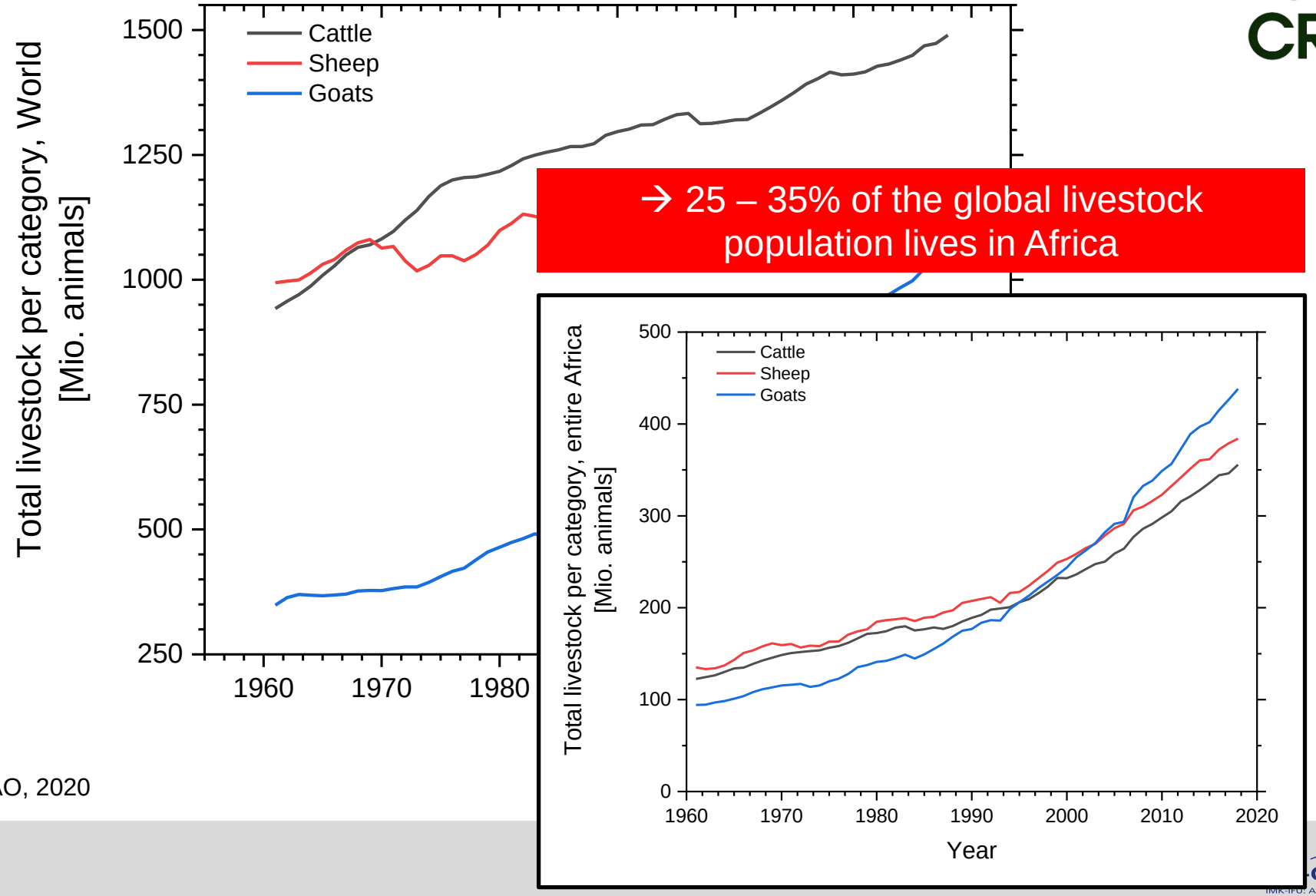
→ Given their global importance, these systems are dramatically understudied

Global livestock population



FAO, 2020

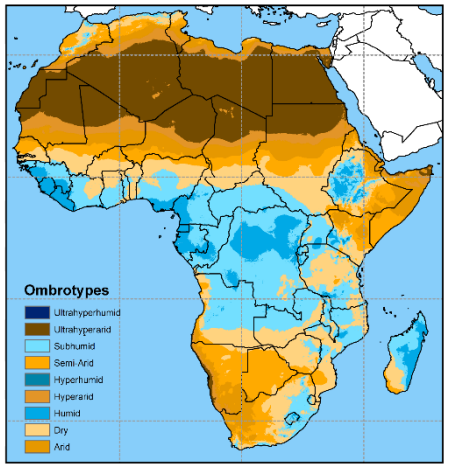
Livestock population: Global versus Africa

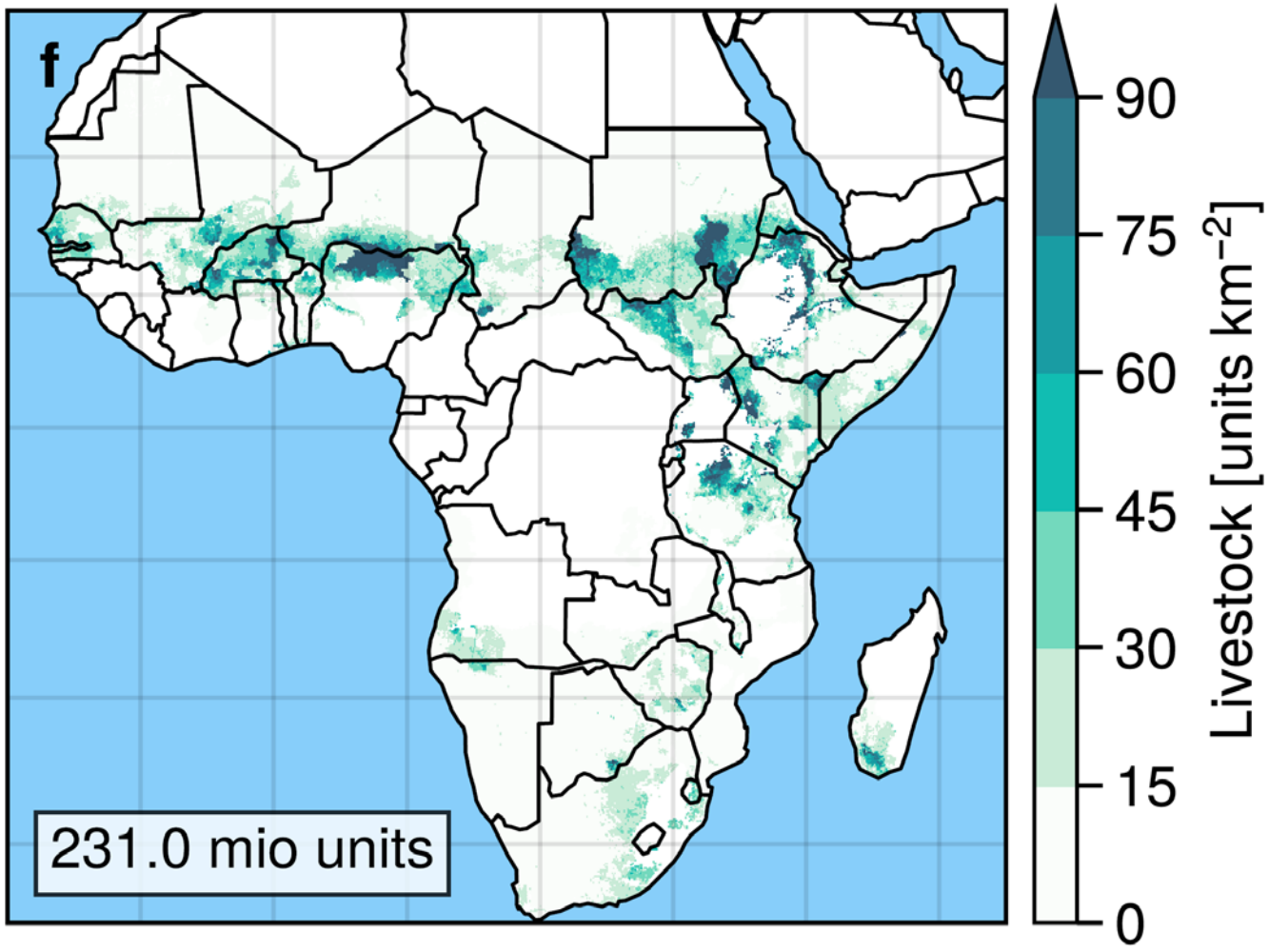


→ 25 – 35% of the global livestock population lives in Africa

FAO, 2020

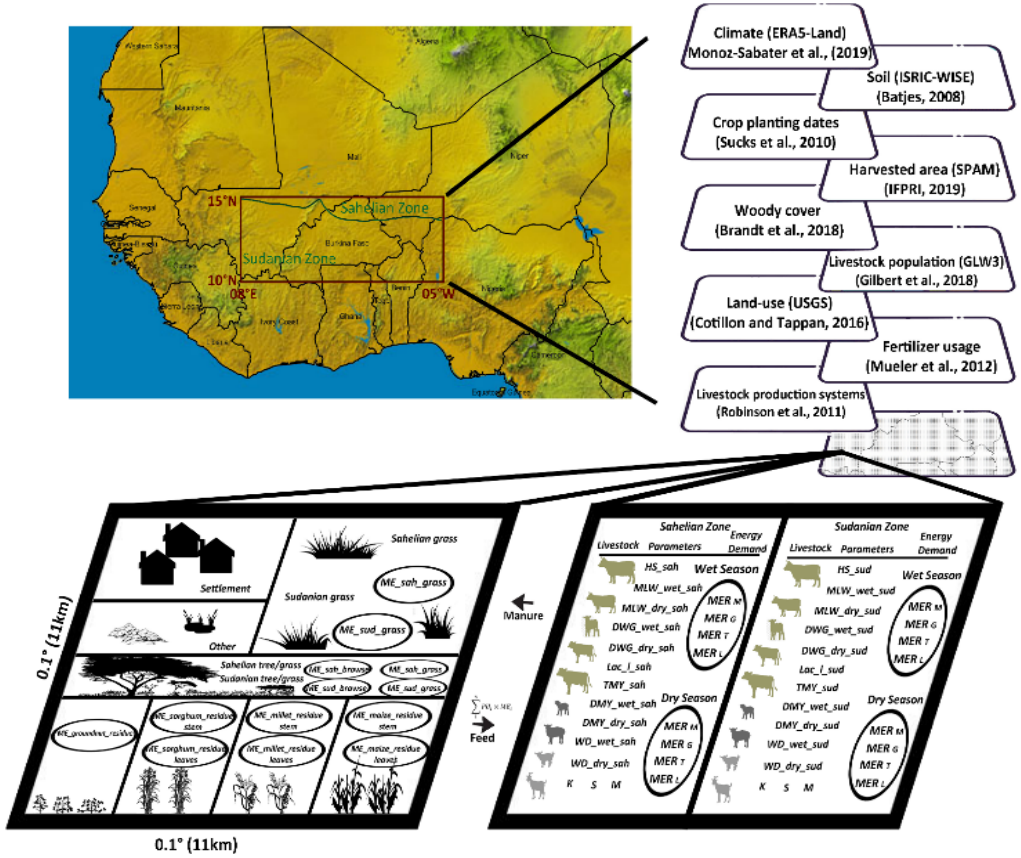
Approx. 40% of African livestock lives in semi-arid environments

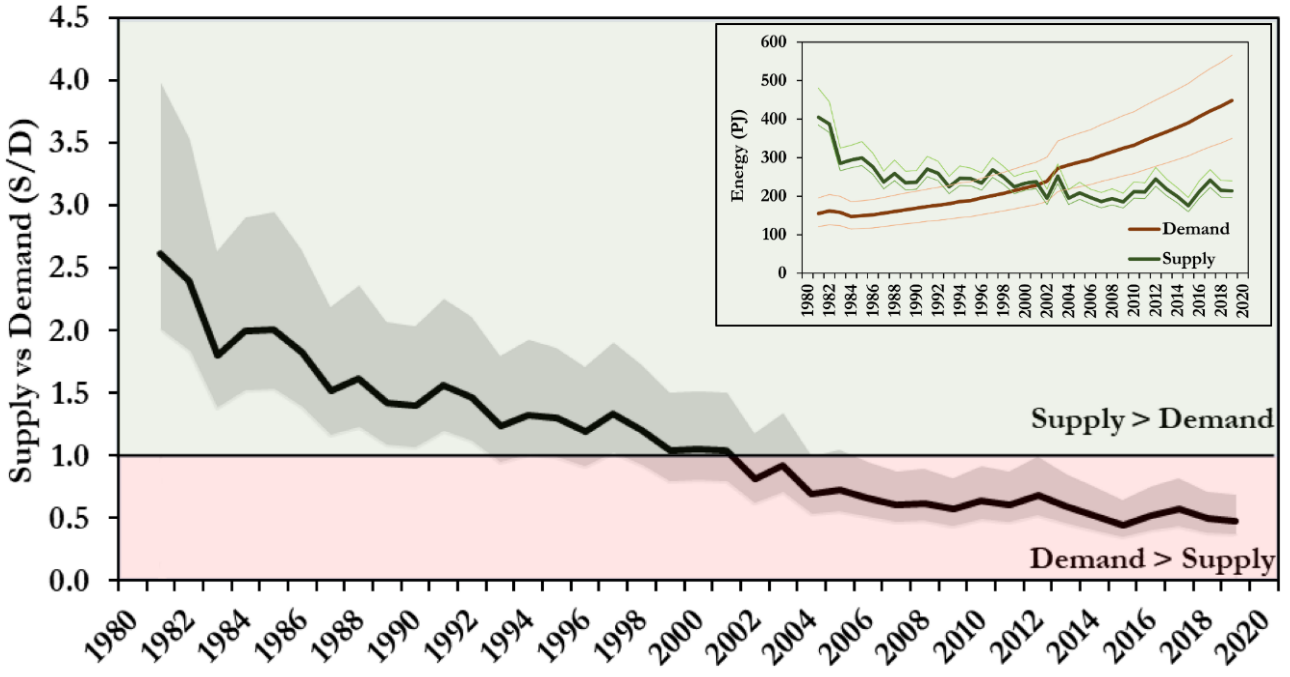




Butterbach-Bahl et al., 2020

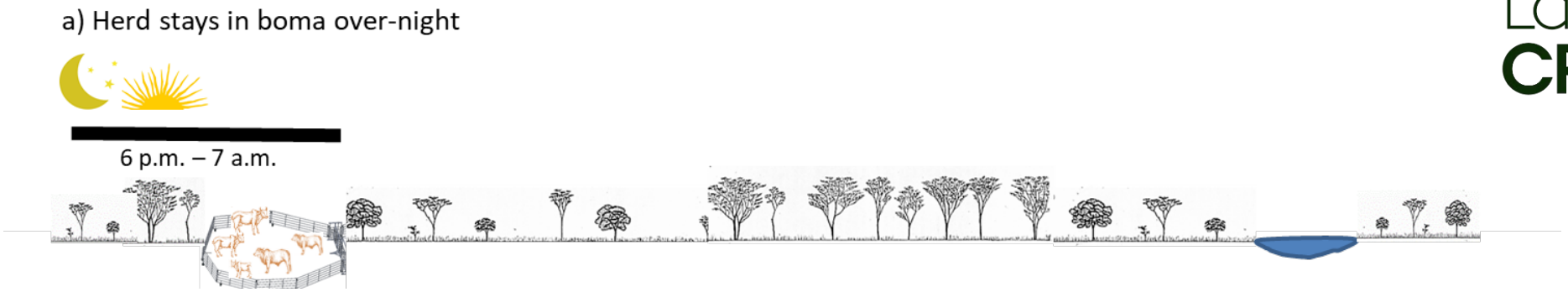
Increase in livestock numbers and climate change drives savanna system degradation





Rahimi et al., 2021, Beyond livestock carrying capacity in the Sahelian and Sudanesian zones of West Africa. Scientific Reports 11, 22094

Herd management by pastoralists

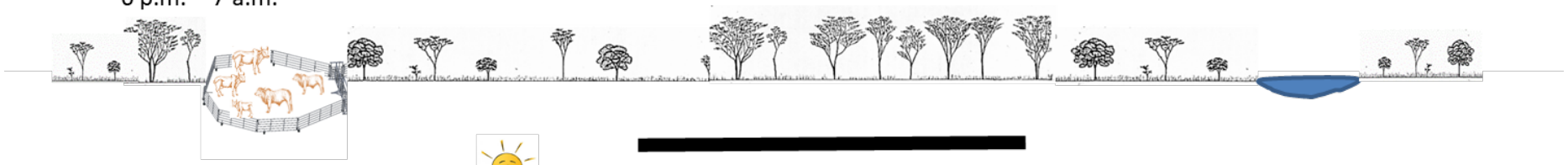


Butterbach-Bahl et al., 2020

Herd management by pastoralists

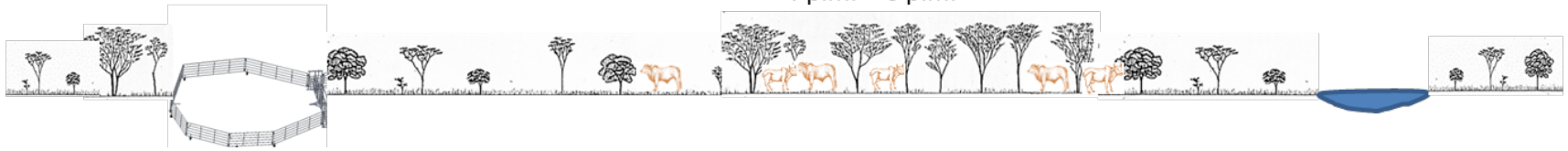
a) Herd stays in boma over-night

6 p.m. – 7 a.m.



b) Herd is roaming and grazing in open savanna

7. a.m. – 9 a.m.
+
10 a.m. – 3 p.m.
+
+4 p.m. – 6 p.m.



Butterbach-Bahl et al., 2020

Herd management by pastoralists

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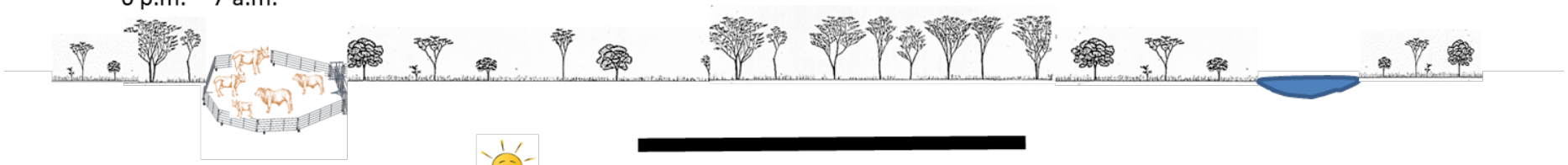

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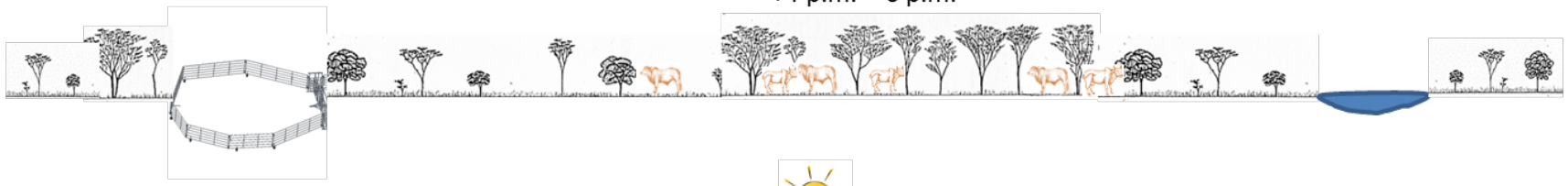
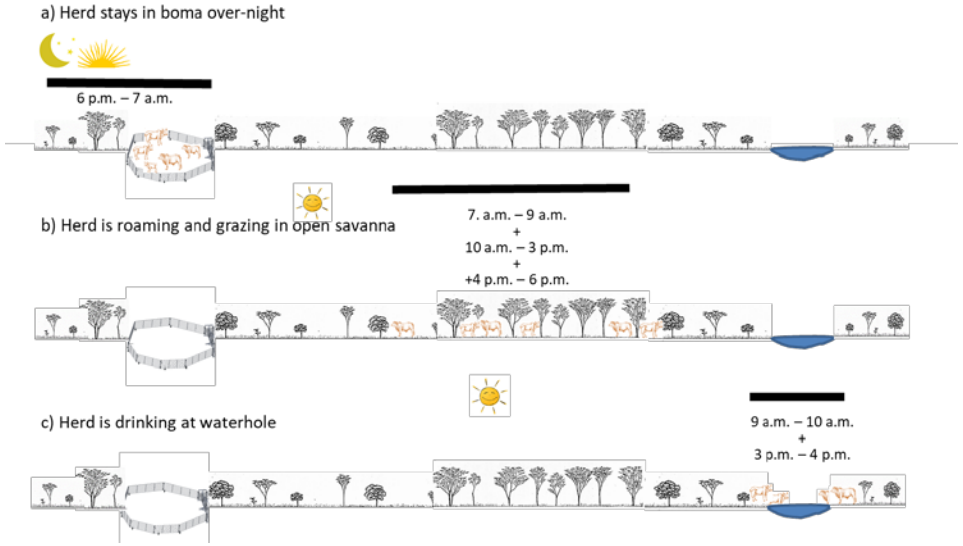


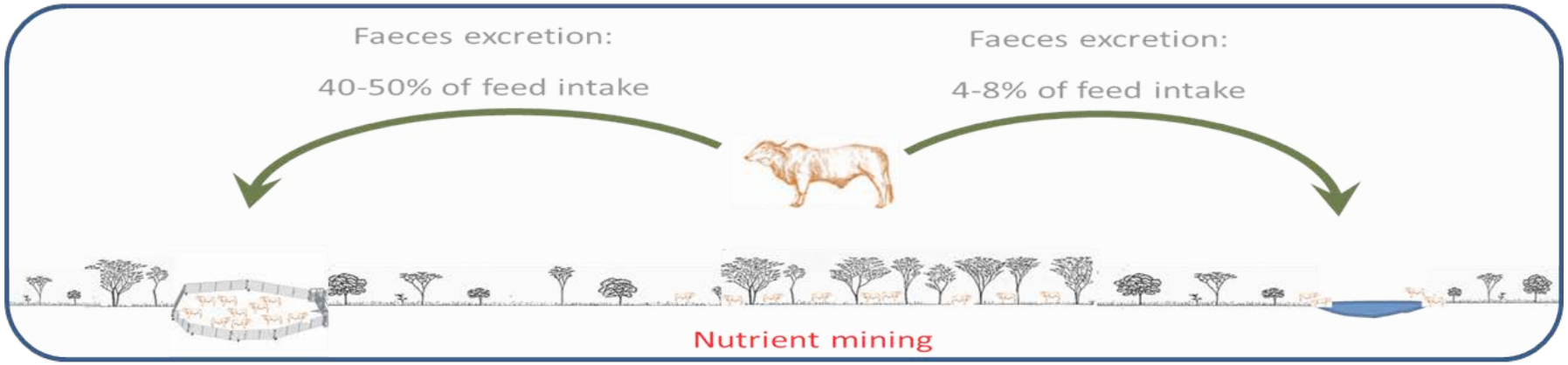
c) Herd is drinking at waterhole

9 a.m. – 10 a.m.
+
3 p.m. – 4 p.m.

Butterbach-Bahl et al., 2020

Herd management by pastoralists – nutrient flows





Butterbach-Bahl et al., 2020

Pastoralist Africa – Inner Mongolia

Pastoralists manure management – Africa – Inner Mongolia

No manure management

Use of manure as fuel

Magnitude of N_2O emissions from livestock enclosures?

???? kg N_2O-N ha^{-1} yr^{-1}

80 – 105 kg N_2O-N ha^{-1} yr^{-1}

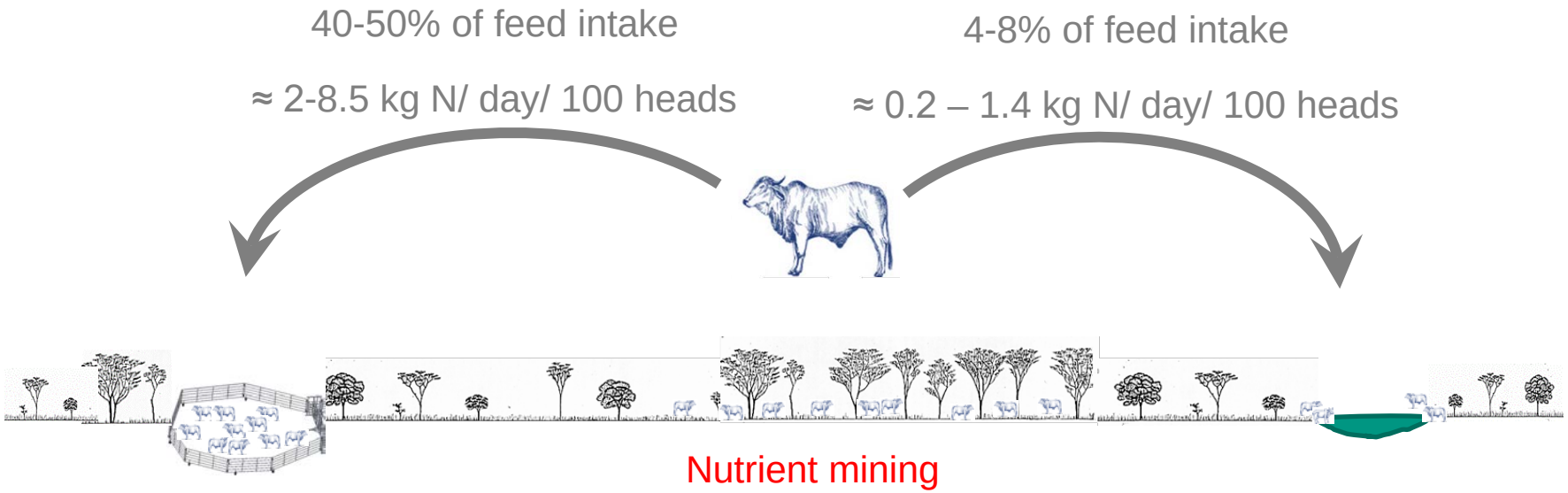
Plant Soil (2011) 340:291–301
DOI 10.1007/s11104-010-0367-5

REGULAR ARTICLE

Annual emissions of greenhouse gases from sheepfolds in Inner Mongolia

Weiwei Chen · Benjamin Wolf · Nicolas Brüggemann · Klaus Butterbach-Bahl · Xunhua Zheng

Research questions

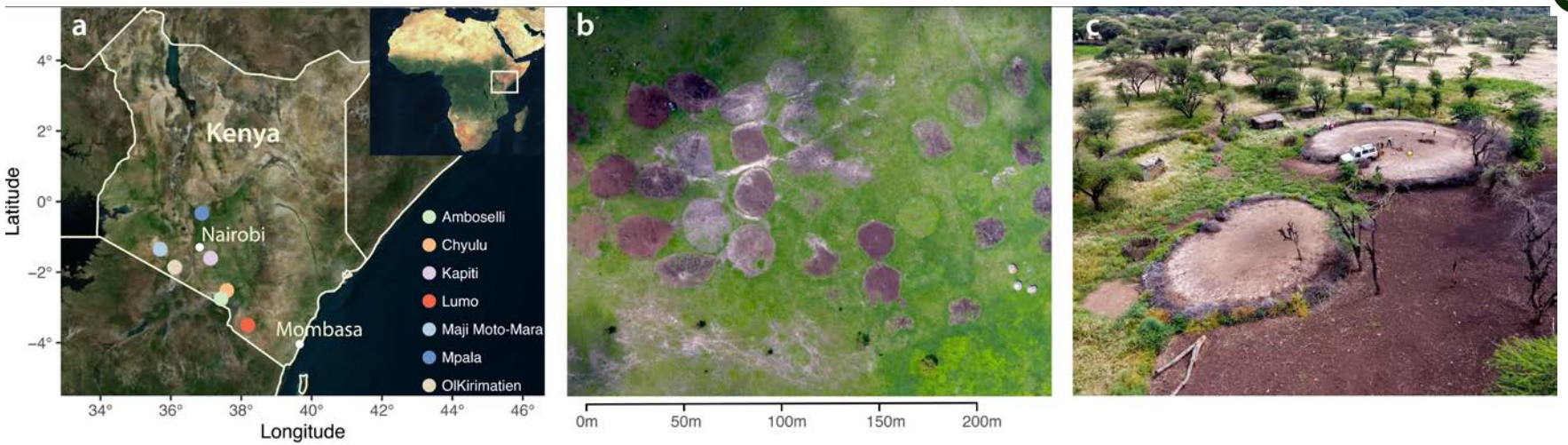


How does nutrient allocation affect environmental N losses in form of N_2O?

How many years do N_2O emissions stay elevated?

Are bomas hotspots of N_2O emissions at continental scale?

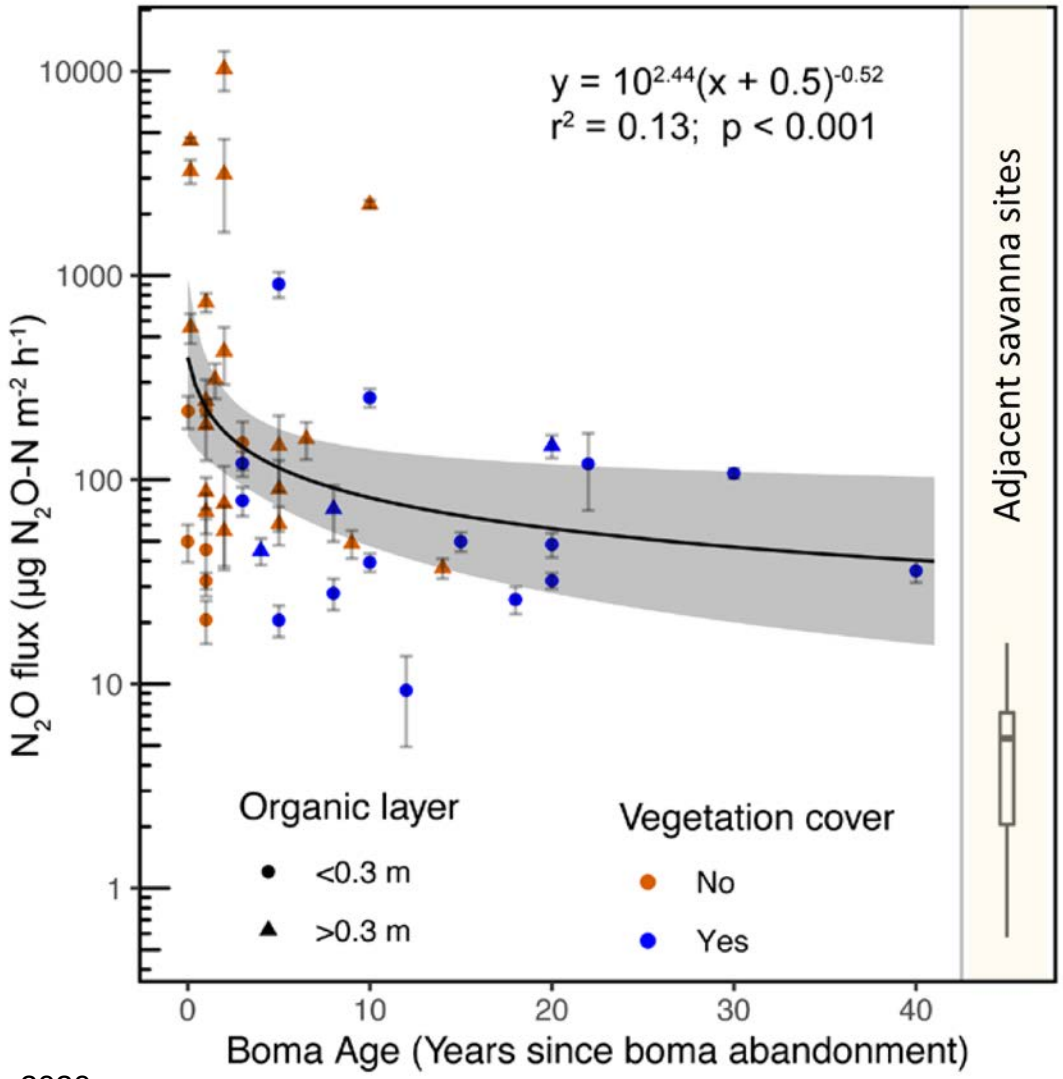
Research design



- Having fun and find representative sites
- Check for chronosequences
- Consider diurnal patterns and re-wetting
- Upscale emissions to SSA
- Identify importance of boma N_2O fluxes

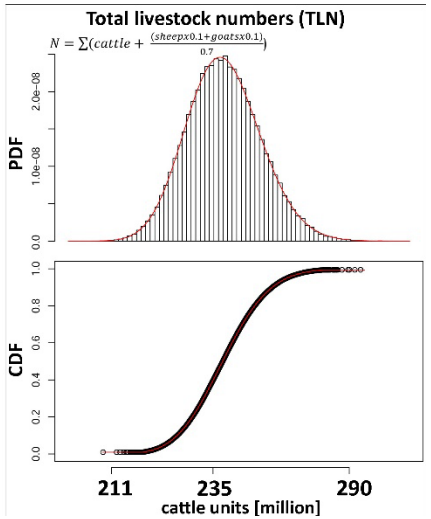
Boma chronosequence

Boma age matters



Butterbach-Bahl et al., 2020

Scaling findings to SSA



Butterbach-Bahl et al., 2020

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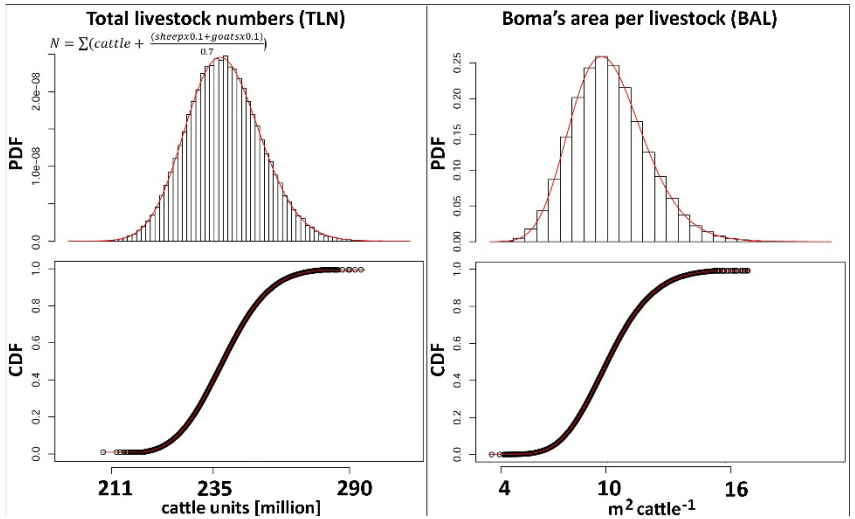
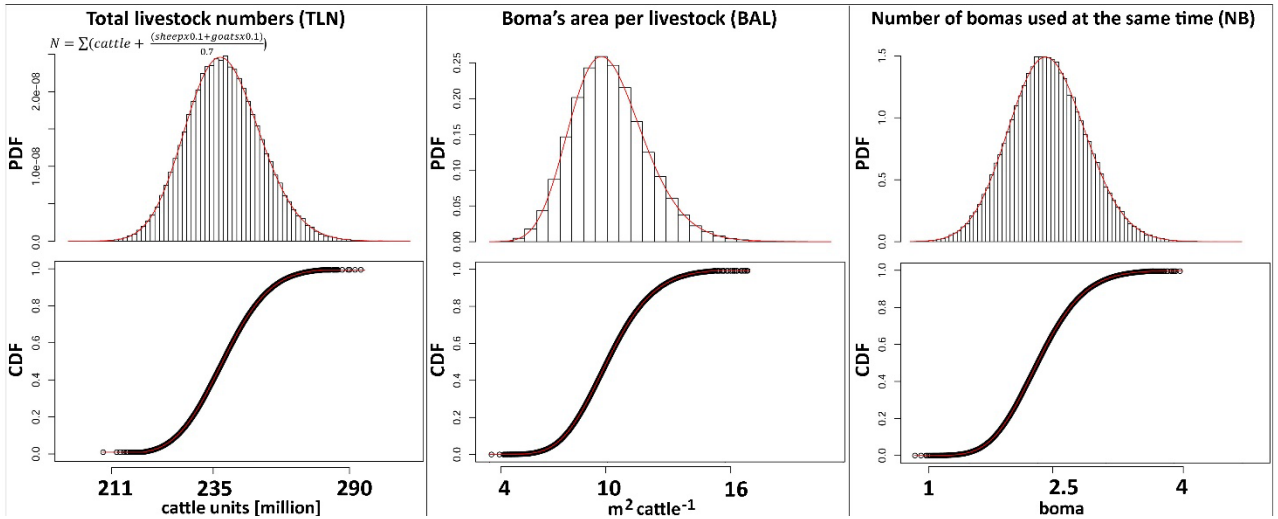


Butterbach-Bahl et al., 2020

Scaling findings to SSA



Butterbach-Bahl et al., 2020

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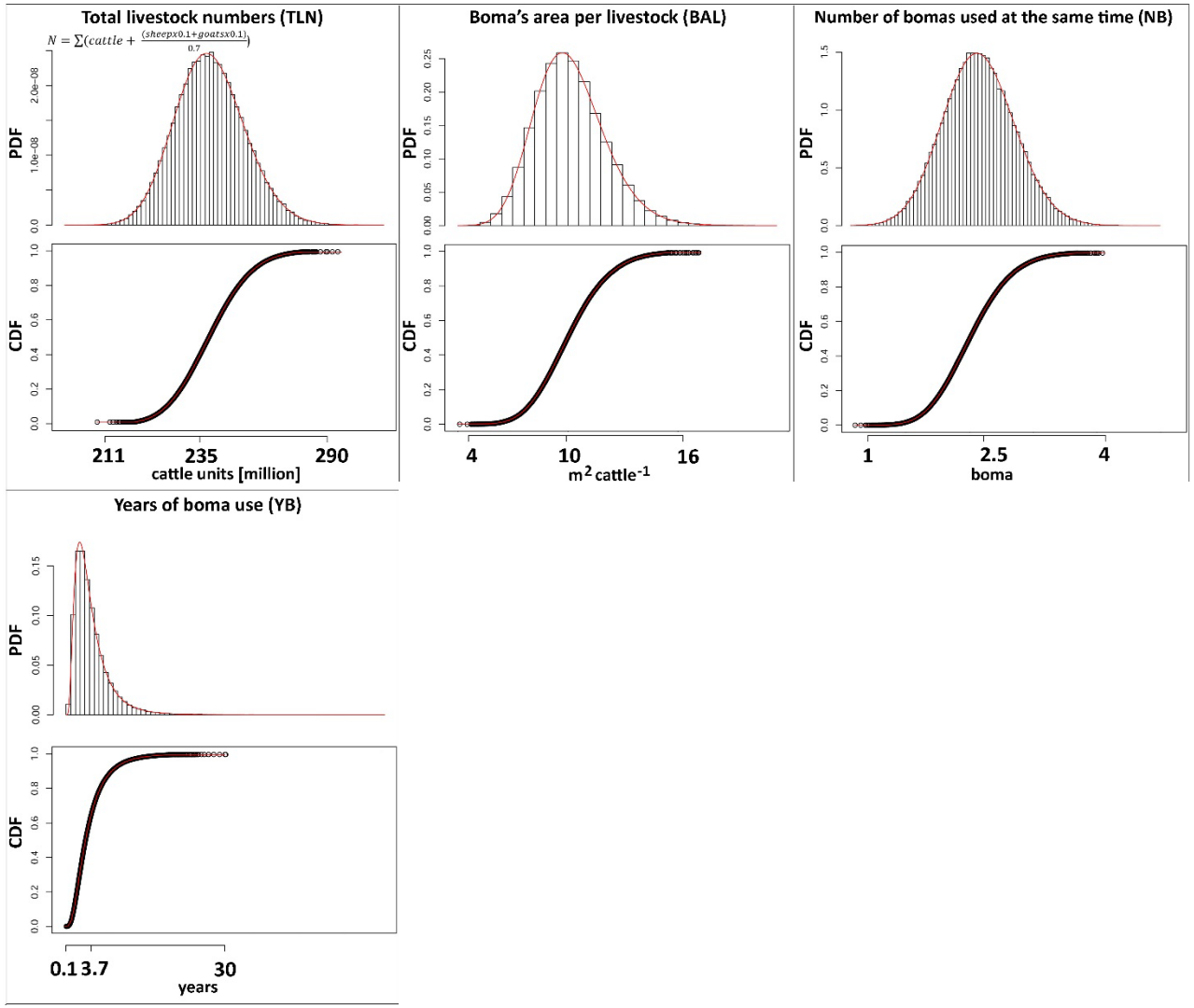
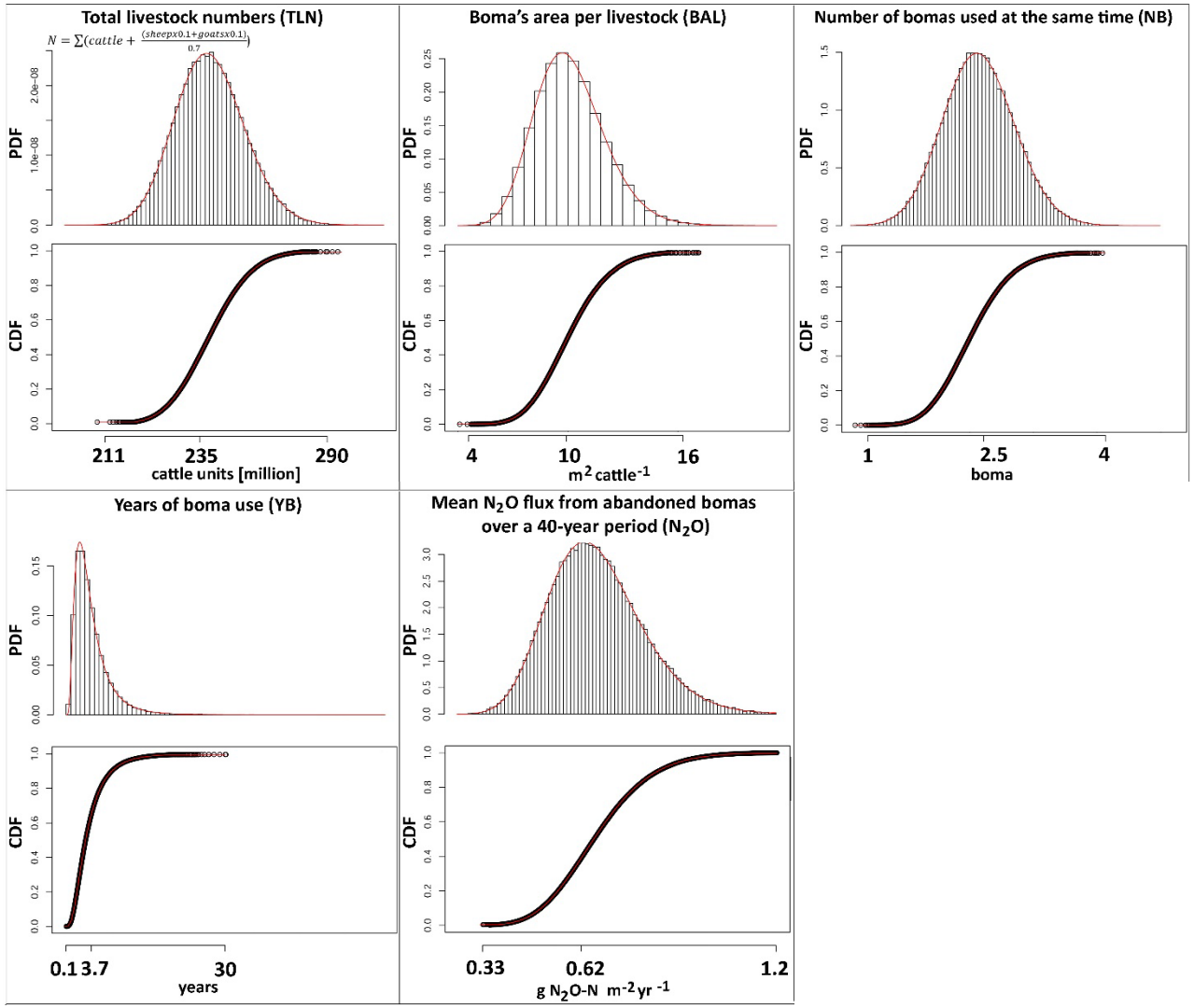


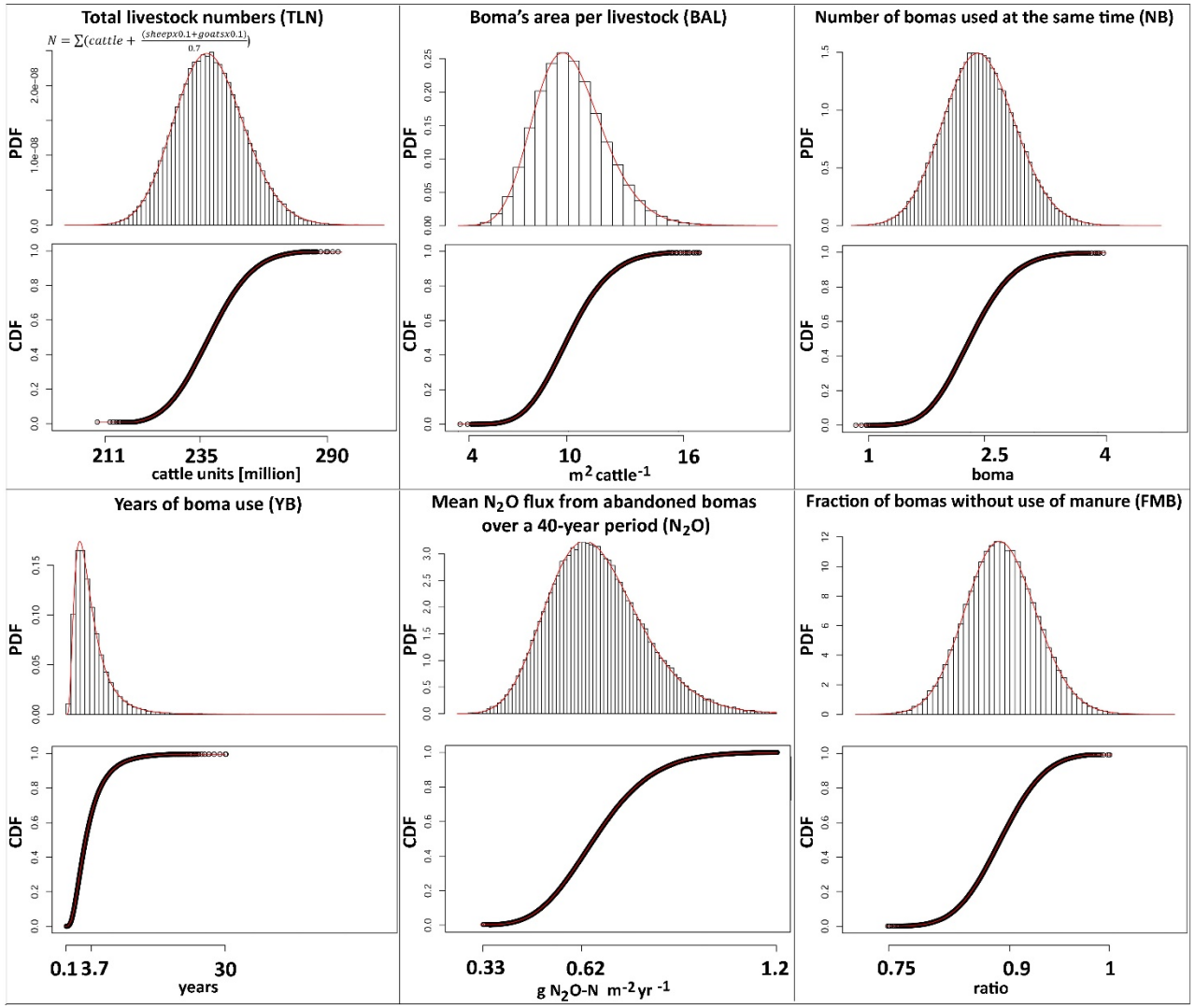
Butterbach-Bahl et al., 2020

Scaling findings to SSA



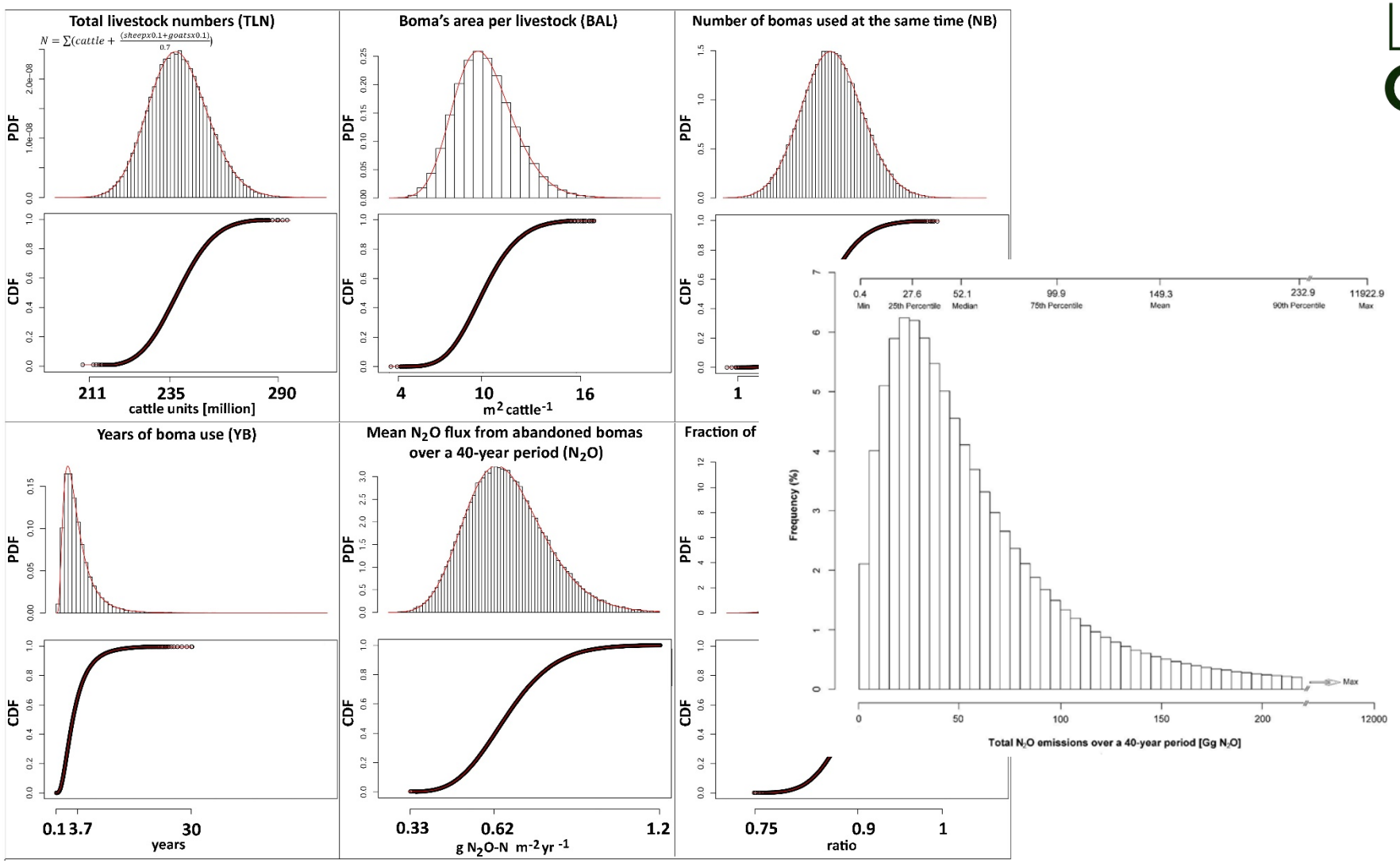
Butterbach-Bahl et al., 2020

Scaling findings to SSA



Butterbach-Bahl et al., 2020

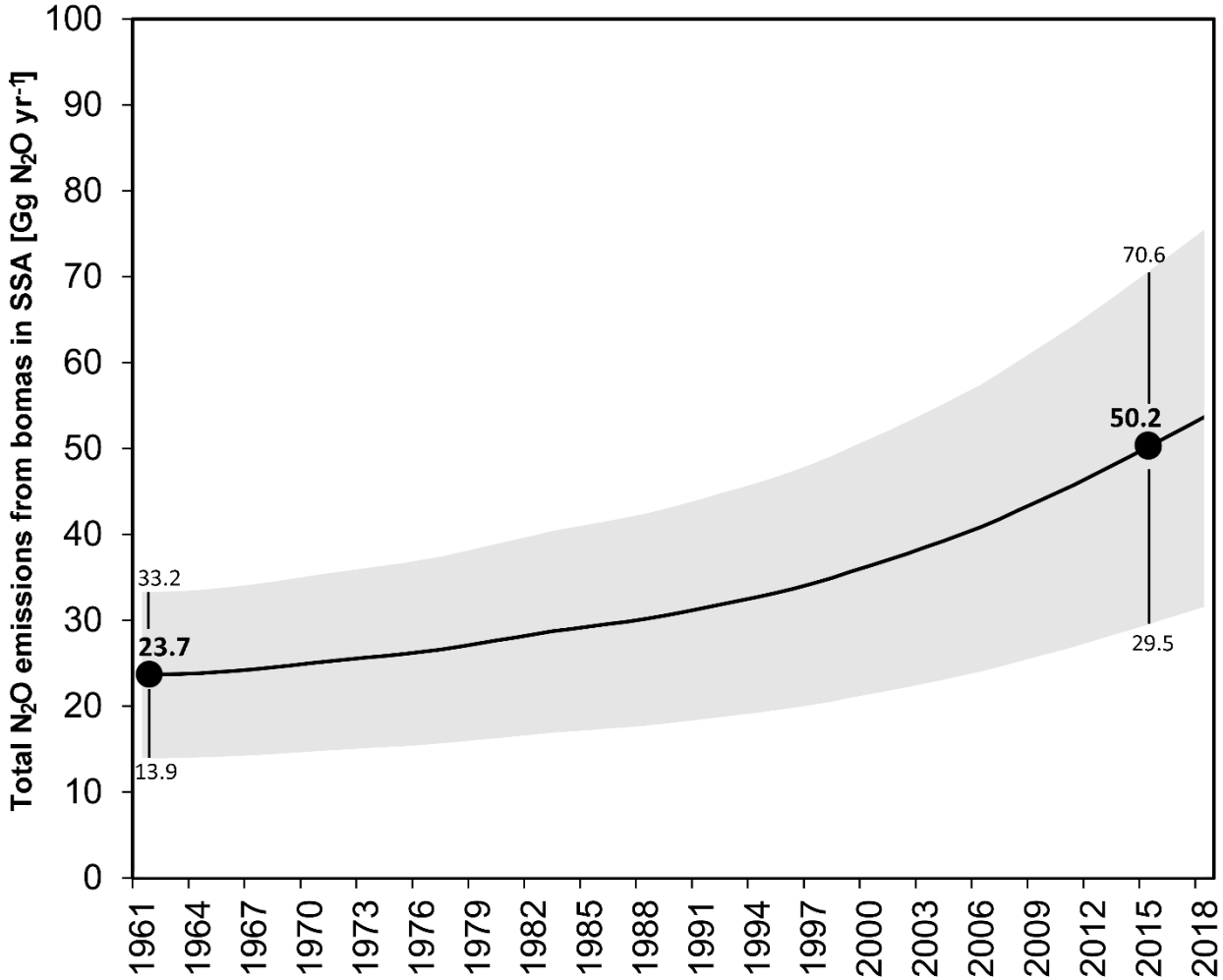
Scaling findings to SSA



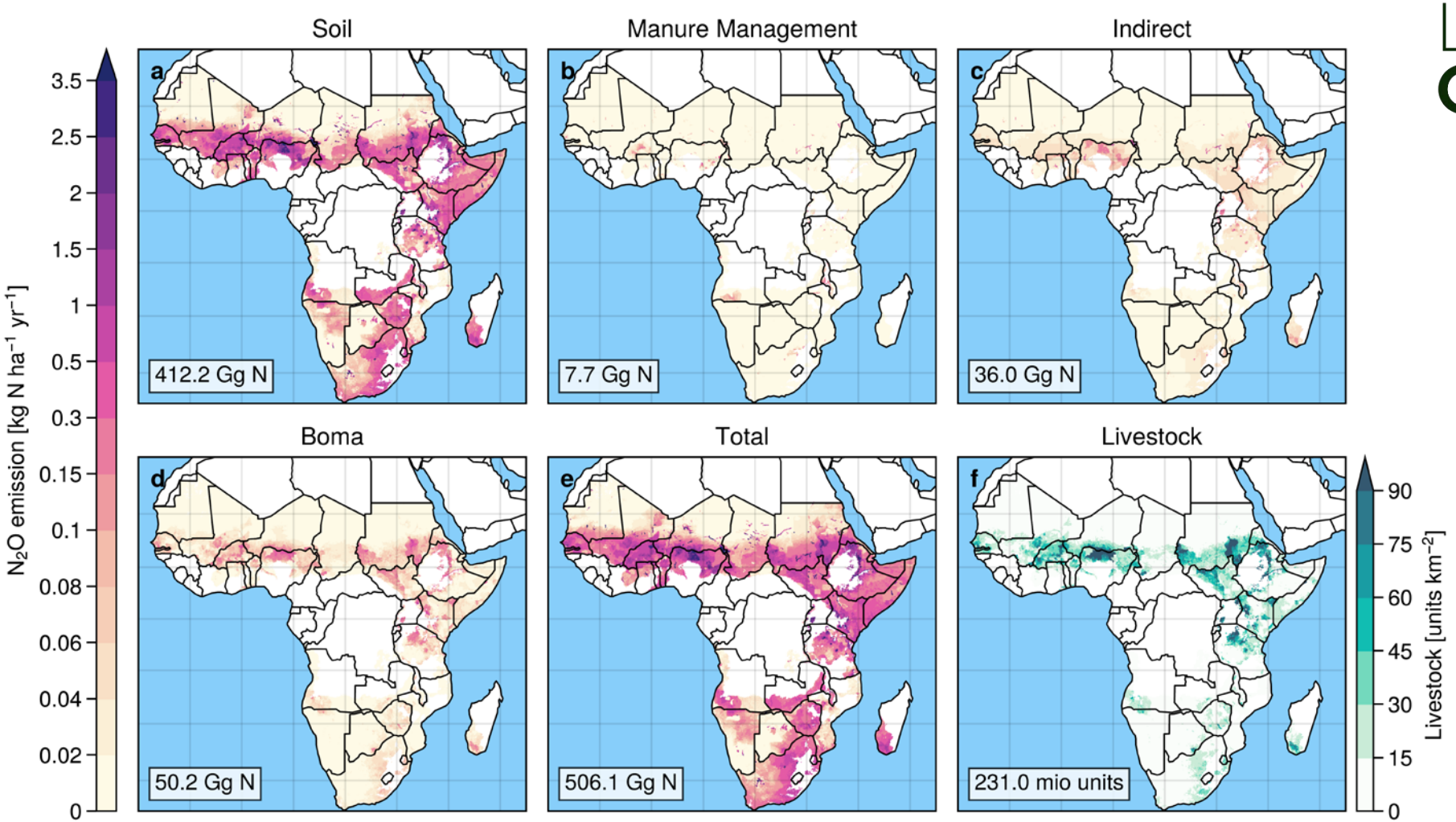
Butterbach-Bahl et al., 2020

KIT-Campus Alpin
IMK-IFU: Atmospheric Environmental Research

Decadal changes in boma N_2O emissions

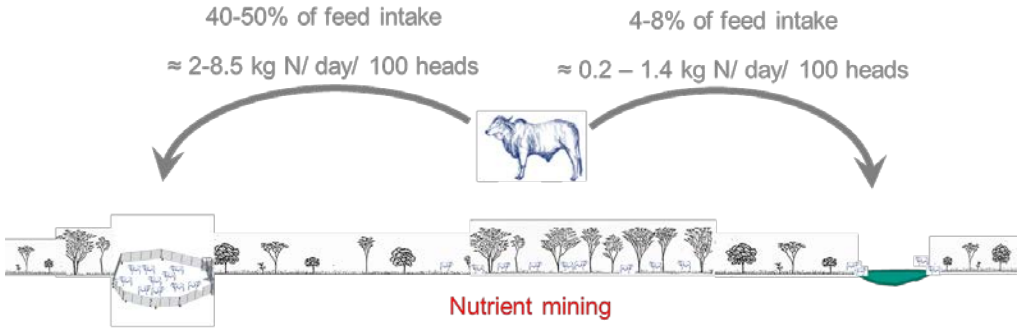


Spatial distribution of fluxes and importance



Butterbach-Bahl et al., 2020

Summary



How does nutrient allocation affect environmental N losses in form of N_2O?

→ *Nutrient allocation results in highly elevated N_2O emissions*

(with emissions from enclosures being at least one magnitude higher as from surrounding ecosystems)

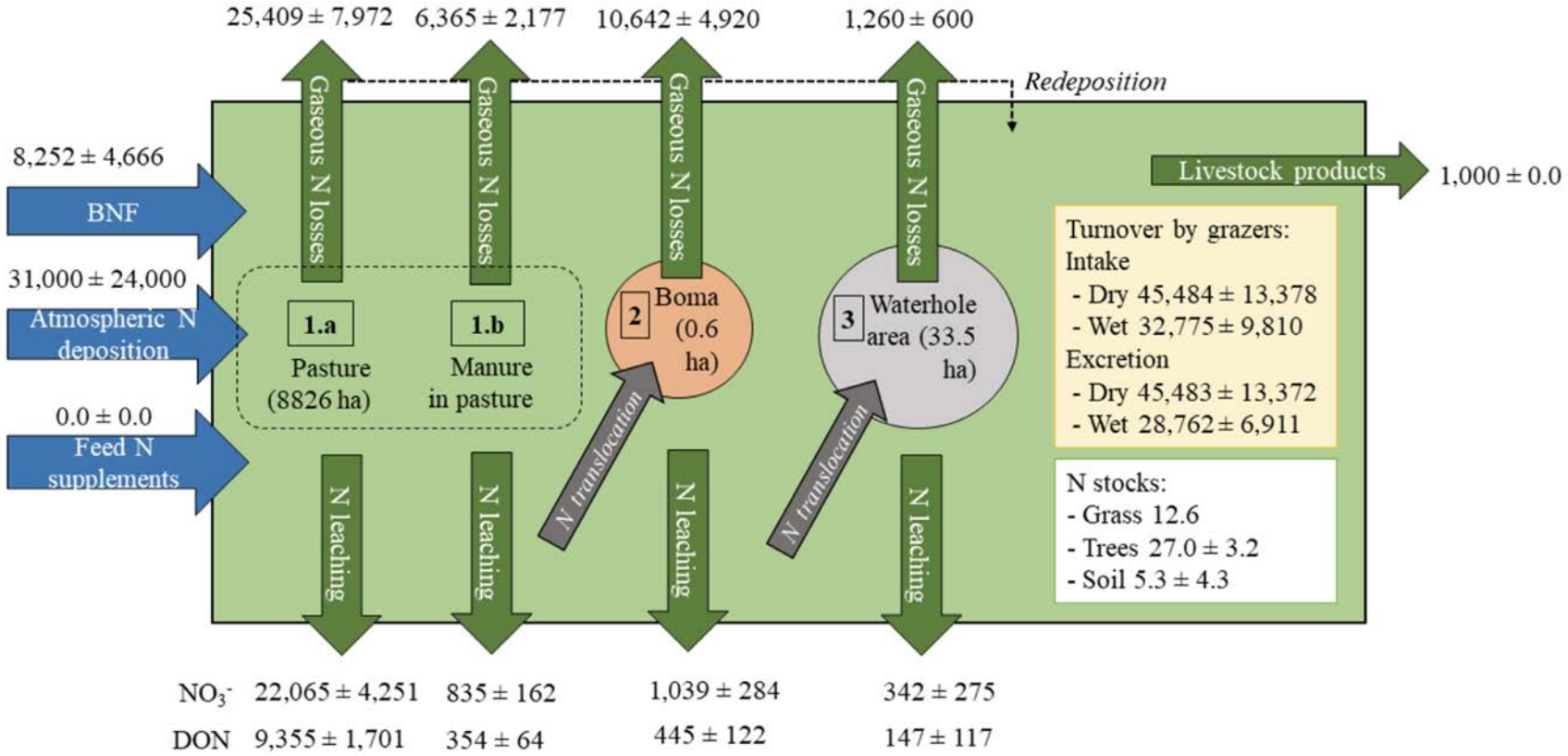
How many years do N_2O emissions stay elevated?

→ *Evidence provided that fluxes stay elevated for 40 years*

Are bomas hotspots of N_2O emissions at continental scale?

→*Indeed, contributing ~5% of the current estimate of total anthropogenic N_2O emissions for all of Africa*

Bomas play a key role to understand N cycling in grazed savanna systems



Carbonell et al., 2021, Nitrogen cycling in pastoral systems in Sub-Saharan Africa: knowns and unknowns. Ecol. Applic. 31, e02638

ARTICLE

https://doi.org/10.1038/s41467-020-18359-y OPEN

Check for updates

Livestock enclosures in drylands of Sub-Saharan Africa are overlooked hotspots of N_2O emissions

Klaus Butterbach-Bahl[1,2✉], Gretchen Gettel[3], Ralf Kiese[2], Kathrin Fuchs[2], Christian Werner[2], Jaber Rahimi[2], Matti Barthel[4] & Lutz Merbold[1]

Ecological Applications, 31(6), 2021, e02368

Nitrogen cycling in pastoral livestock systems in Sub-Saharan Africa: knowns and unknowns

Victoria Carbonell,[1,2,3] Lutz Merbold,[2,4,7] Eugenio Díaz-Pinés,[5] Thomas P. F. Dowling,[6] and Klaus Butterbach-Bahl[2,3]

Check for updates

OPEN

Beyond livestock carrying capacity in the Sahelian and Sudanian zones of West Africa

Jaber Rahimi[1✉], Edwin Haas[1], Rüdiger Grote[1], David Kraus[1], Andrew Smerald[1], Patrick Laux[1], John Goopy[2] & Klaus Butterbach-Bahl[1,2]

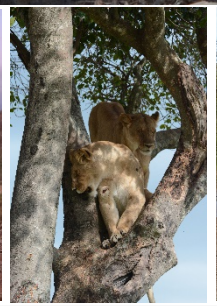
https://doi.org/10.1038/s43016-022-00543-6

Check for updates

OPEN

A shift from cattle to camel and goat farming can sustain milk production with lower inputs and emissions in north sub-Saharan Africa's drylands

Jaber Rahimi[1✉], Erwann Fillol[2], John Y. Mutua[3], Giuseppina Cinardi[4], Timothy P. Robinson[4], An M. O. Notenbaert[5,6], Polly J. Ericksen[7], Michael W. Graham[7] and Klaus Butterbach-Bahl[1,7,8]



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