Climate impacts on livestock production in a southern Africa region: model projections to 2050

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Climate Southern Africa

- Context & questions
- IMPACT & G-Range models
- Data
- Model simulations
- Relevance
- Next steps

Context

- Economic growth in countries in the selected region was 0.2% (South Africa) to 4.5% (Malawi) over 2013 – 2018.
  - (Malawi, Mozambique, South Africa, Zambia)
- Livestock demand is projected to grow 70% (South Africa) to 600% (Malawi) by 2050.
- 19.4 million poor in the region derive livelihoods from livestock (Robinson et al. 2011).
- Cropland, rangelands face climate change threats.
- Increased regional focus on development, employment, inequality, climate, policy (SA-TIED program).

Questions

Quantify plausible scenarios of climate effects on the livestock sectors of the selected region to help inform focus of regional development.

Using a global modelling framework:

- What are anticipated demand-induced adjustments to livestock production in the long-term?
  - Pasture, other feed demand
  - Interactions with climate effects
- What implications for supply of animal source foods?
- Possible trade-offs in regional objectives?

The IMPACT model

A system of linked models of global agriculture simulating multi-country multi-commodity markets, water and crop models

- Crops, Livestock, Feeds
  - ➢ Excludes pasture use/availability!
- Inputs
  - Population, income
  - Climate
- Outputs
  - Product demand, production, trade
  - Food security

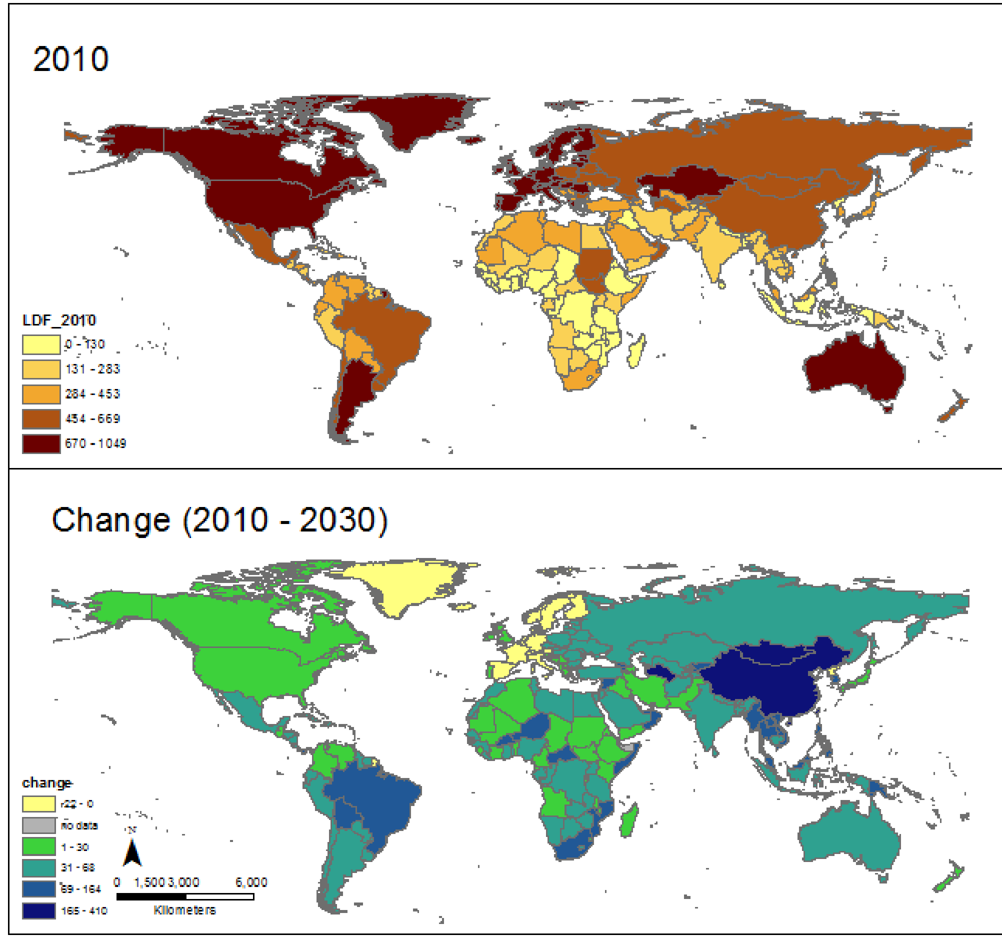

Figure 1: Projections of baseline LDF demand (Tarawali et al. 2018 based on Robinson et al. 2015)

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The G-Range model

A moderate complexity spatial ecosystem model quantifying global changes expected in rangelands under future climates

- Forage production
    - Anpp
- (not used)
    - Other forage indicators
    - Livestock distributions
    - Food security

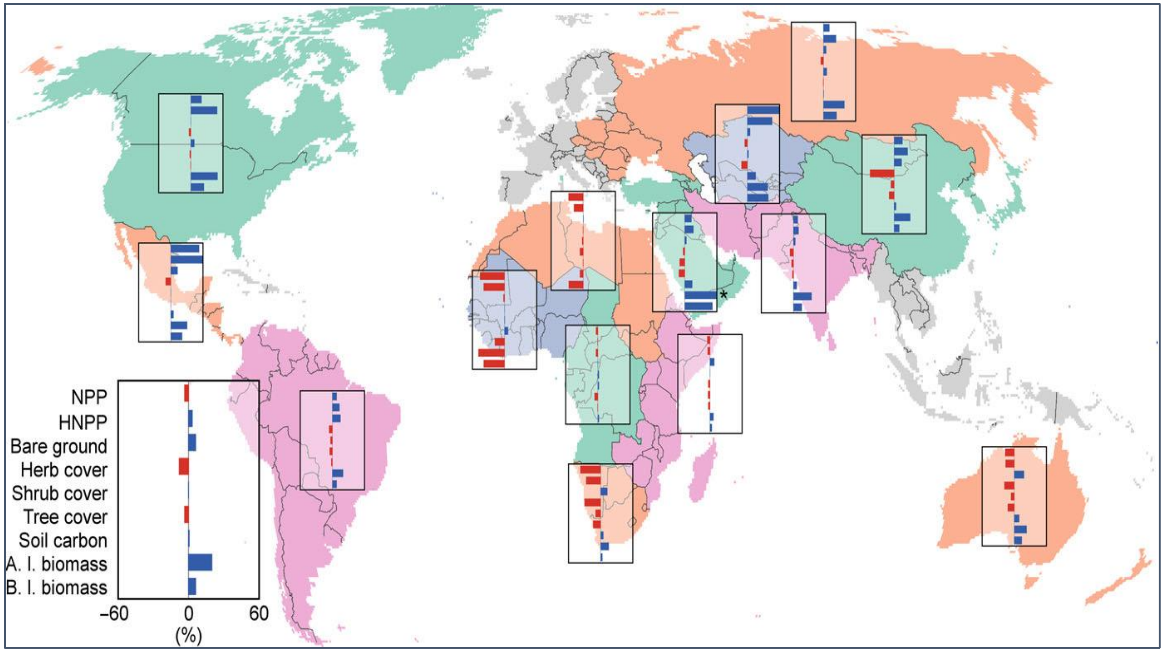


Figure 2: Regional percent changes in selected attributes from ensemble simulation results in 2050 (Boone et al., 2017)

Model simulations linking

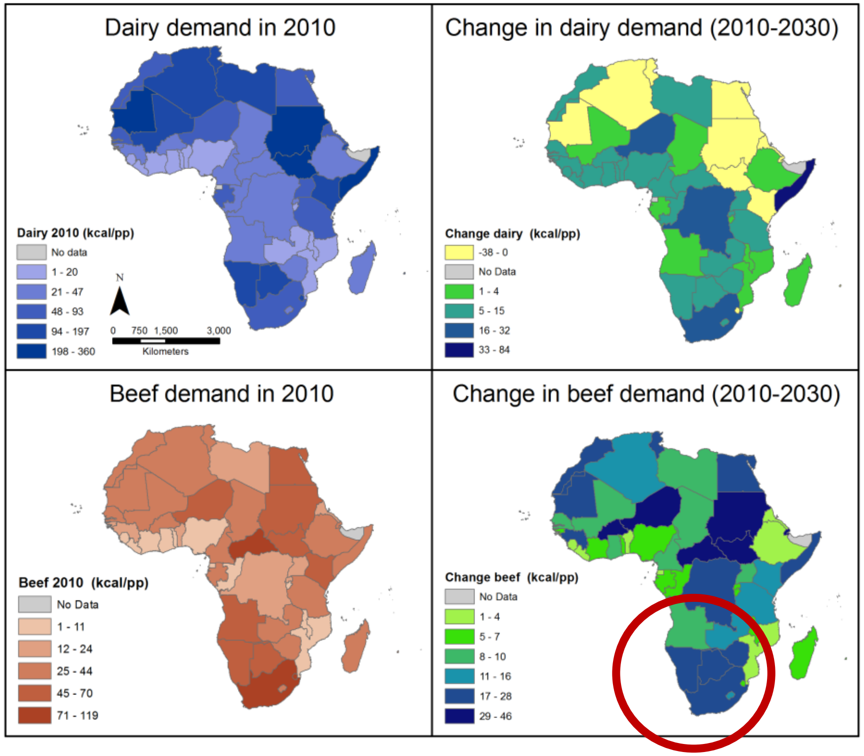
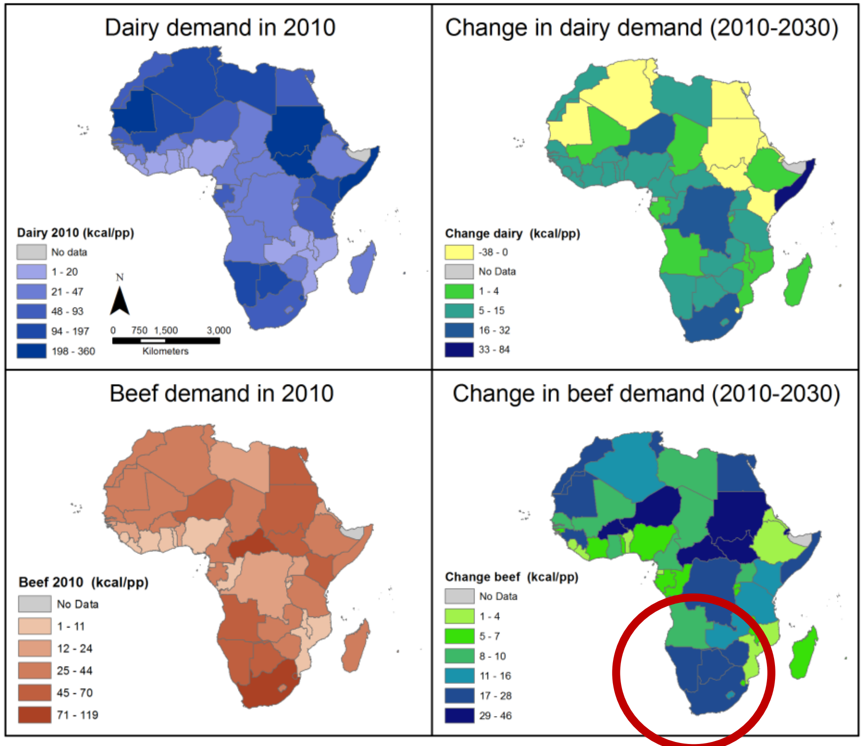


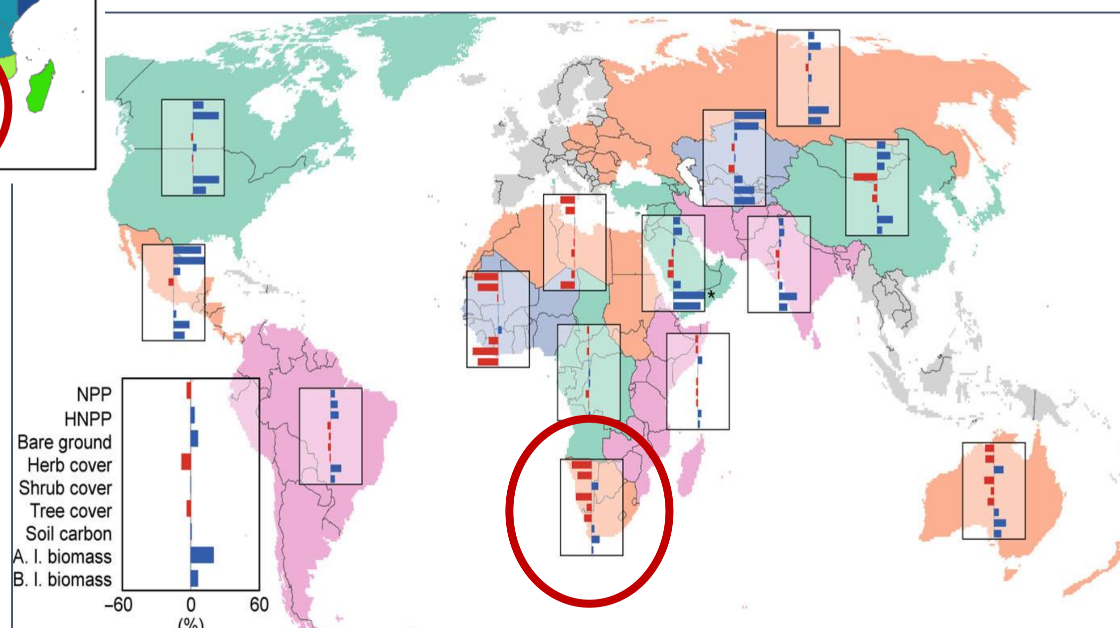
Figure 3: Illustration of simulations linking. Source: Authors

- IMPACT
  - Beef, Milk demand, supply, trade
  - Livestock numbers
  - Feed demand, supply
  - 2010 values disaggregated using Herrero et al (2013)

Model simulations linking



- IMPACT
  - Beef, Milk demand, supply, trade
  - Livestock numbers
  - Feed demand, supply
  - 2010 values disaggregated using Herrero et al (2013)
- G-Range
  - Forage production
- Joint scenarios in 2050



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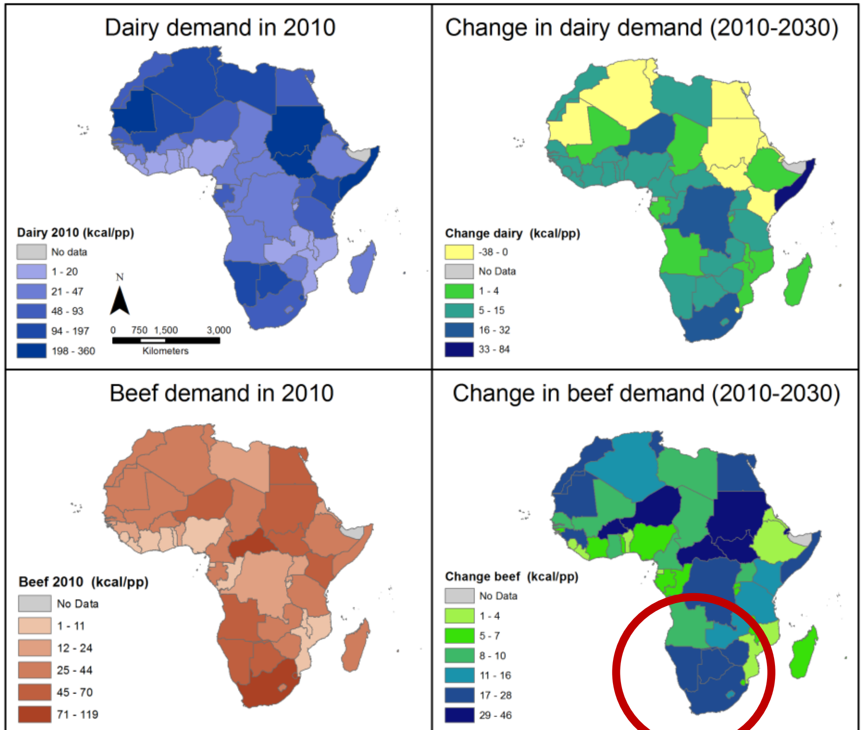
Model simulations linking



- IMPACT
  - ASF demand, supply, trade
  - Livestock numbers
  - Feed demand, supply
- G-Range
  - Forage production
- Joint scenarios in 2050
- No feedbacks

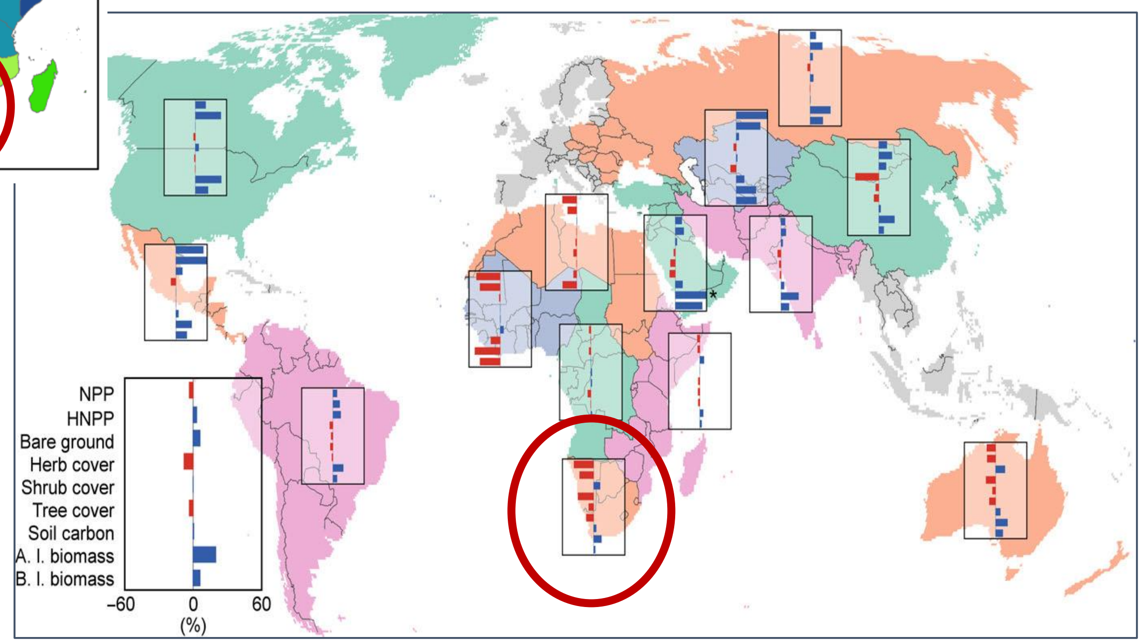


Figure 3: Illustration of simulations linking. Source: Authors

Linked Scenarios

- Economic growth
  - Base
  - Slow
  - Fast
- IPCC climate scenarios
  - RCP 4.5 – intermediate
  - RCP 8.5 – extreme
  - Using (4) climate models
    - HADGEM (Hadley center, UK)
    - IPSL (Institut IPSL, France)
    - MIROC (Japan COP)
    - GFDL (GFDL-Princeton, USA)

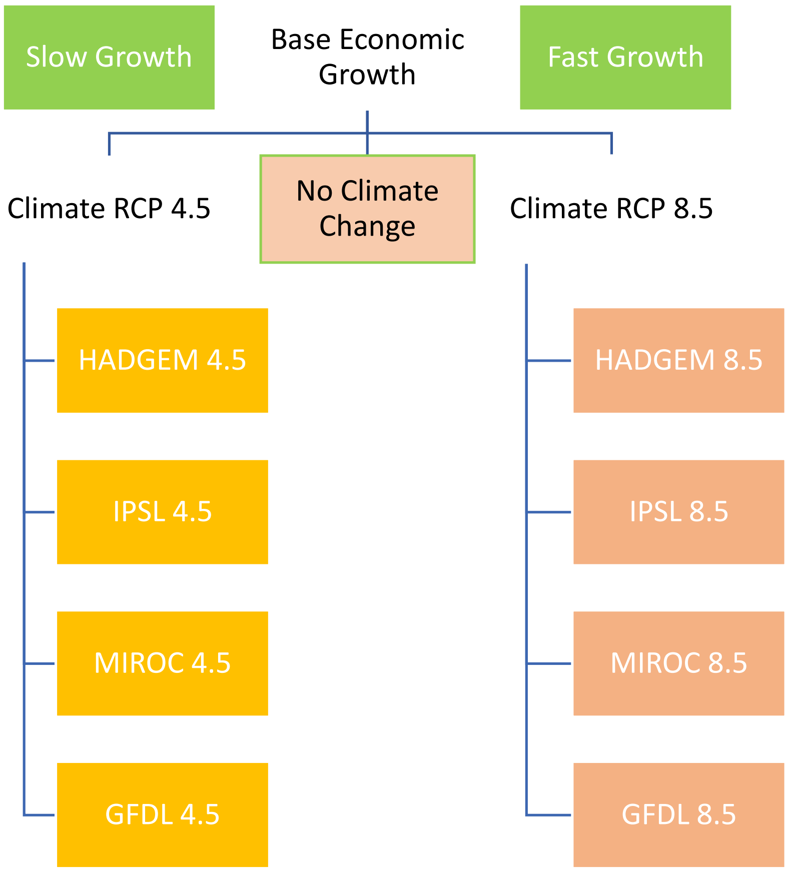


Figure 4: (11) Scenarios of 2050 included in the analyses of climate effects (solid boxes)

Baseline conditions in 2010

- South Africa holds 49% of population and 91% of GDP in region
- 40% of regional cattle stocks and 30% of beef production is in rangelands
- Forages make up bulk of feed demand in rangelands (60 to 99%)
- Rangeland stocks are 2/3 cattle pop in ZAM; imports are 1/3 beef demand in MOZ

Table 1: Some socio-economics and livestock statistics

	GDP per capita, USD	Population, millions	Beef and Dairy Cattle Stocks, 1000 heads	Cattle Stocks, % in Rangelands	Beef production from rangelands	Beef net imports % demand (exports % production)
Malawi	795.53	14.90	1,070	11%	12%	12%
Mozambique	822.72	23.39	1,277	33%	12%	27%
South Africa	9,470.06	50.13	13,731	41%	37%	1%
Zambia	1,383.80	13.10	3,100	65%	40%	9%
4Cty Region	5,161.62	101.51	19,178	42%	30%	2%

Projections of animal source food (ASF) demand

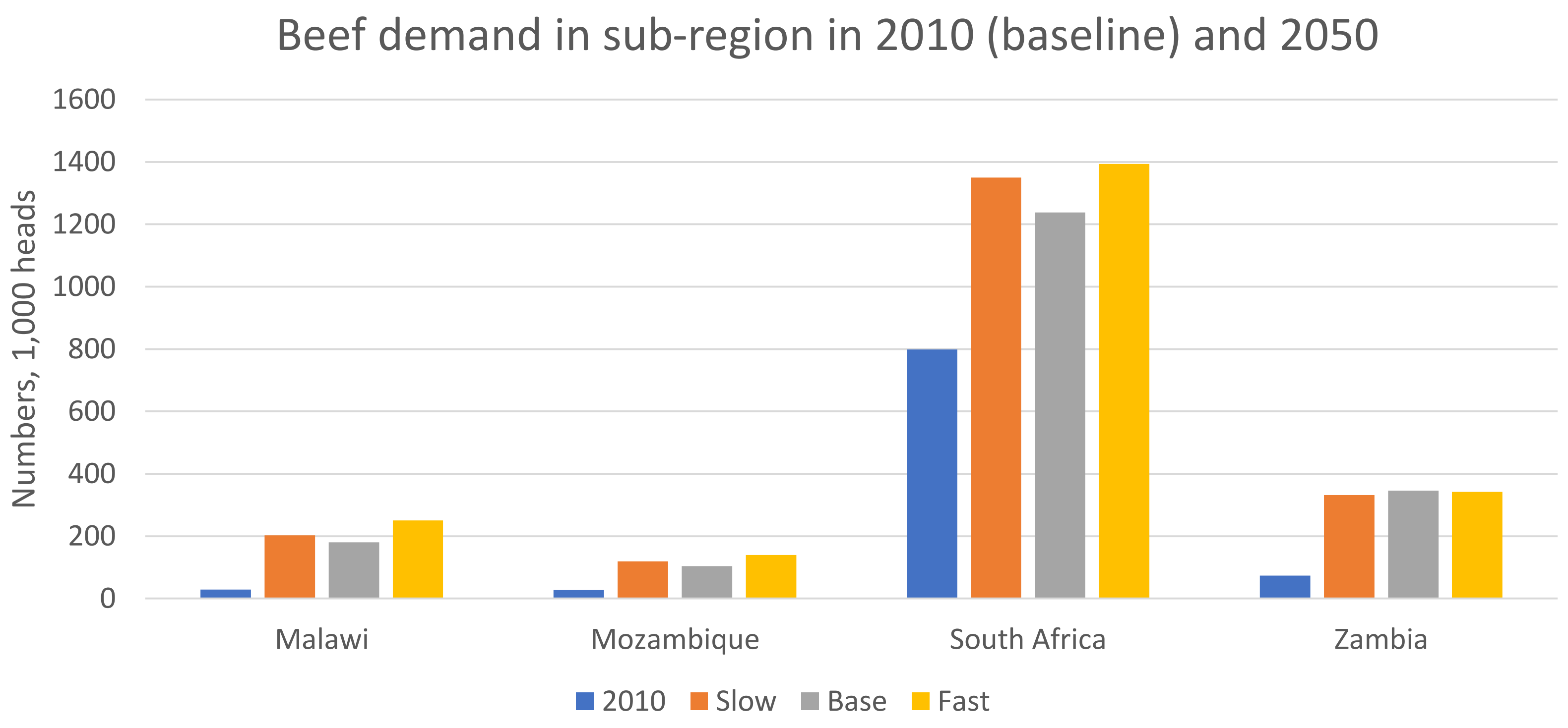


Figure 5: Beef demand in 2050 under baseline and economic growth conditions

Livestock production & forage supplies

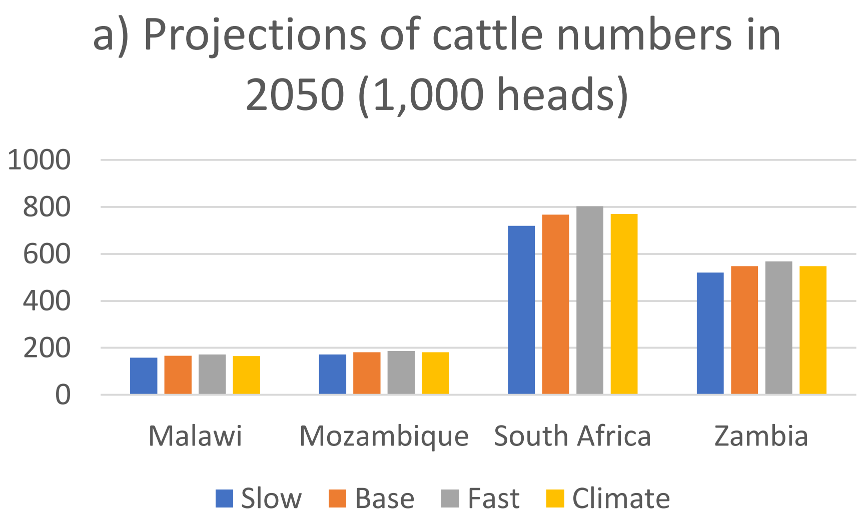


Figure 5a: Projections of cattle numbers in 2050
* South Africa estimates * 0.25

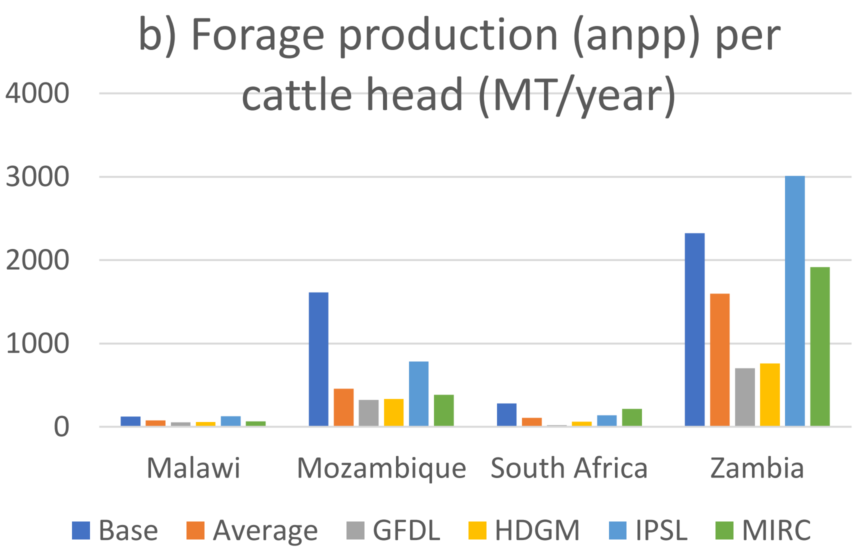


Figure 5b: Projections of forage supply in 2050
*Base values * 0.1

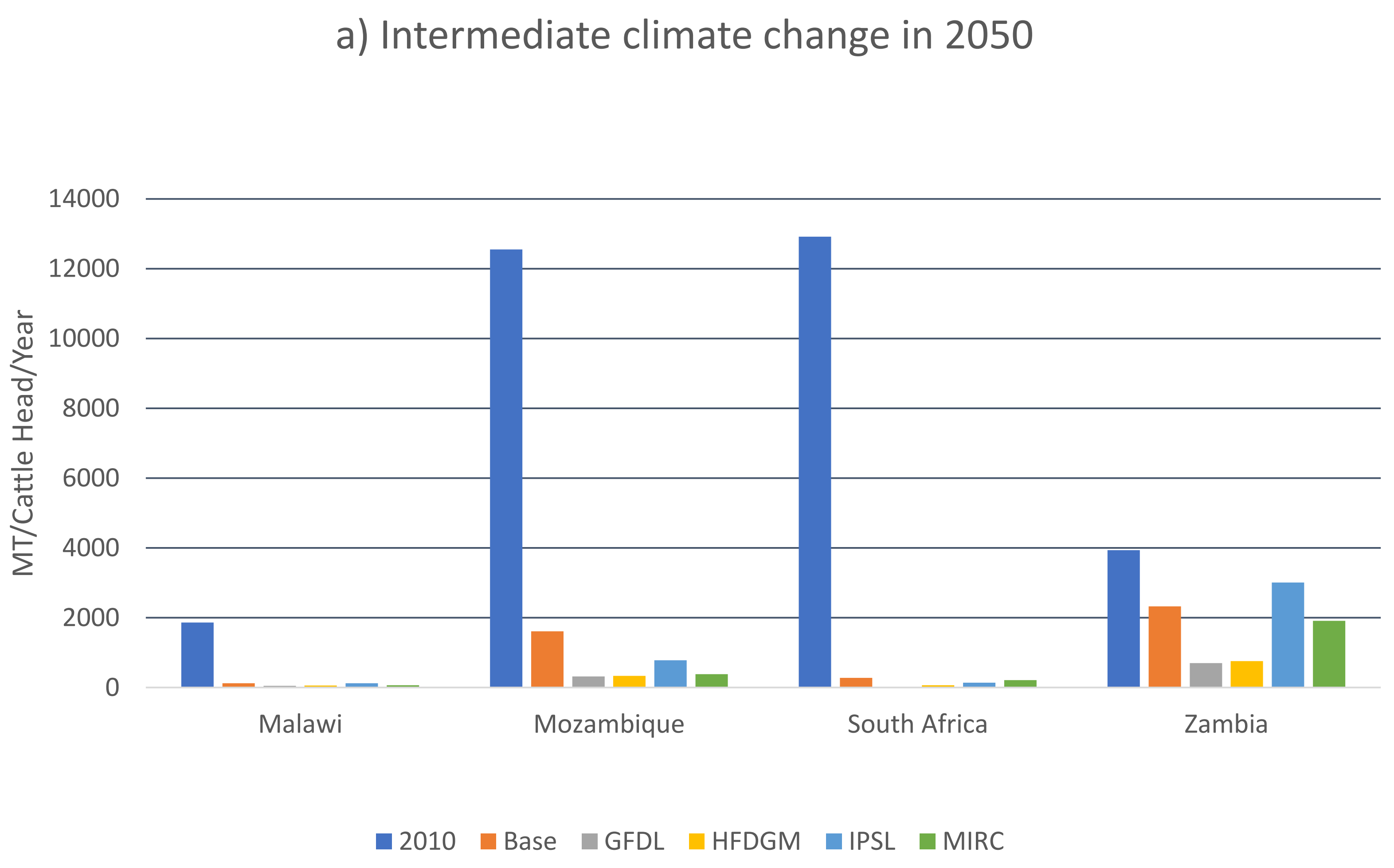


Figure 2a: Projections of forage supply (MT/cattle head) under intermediate climate change in 2050, *Base values * 0.1

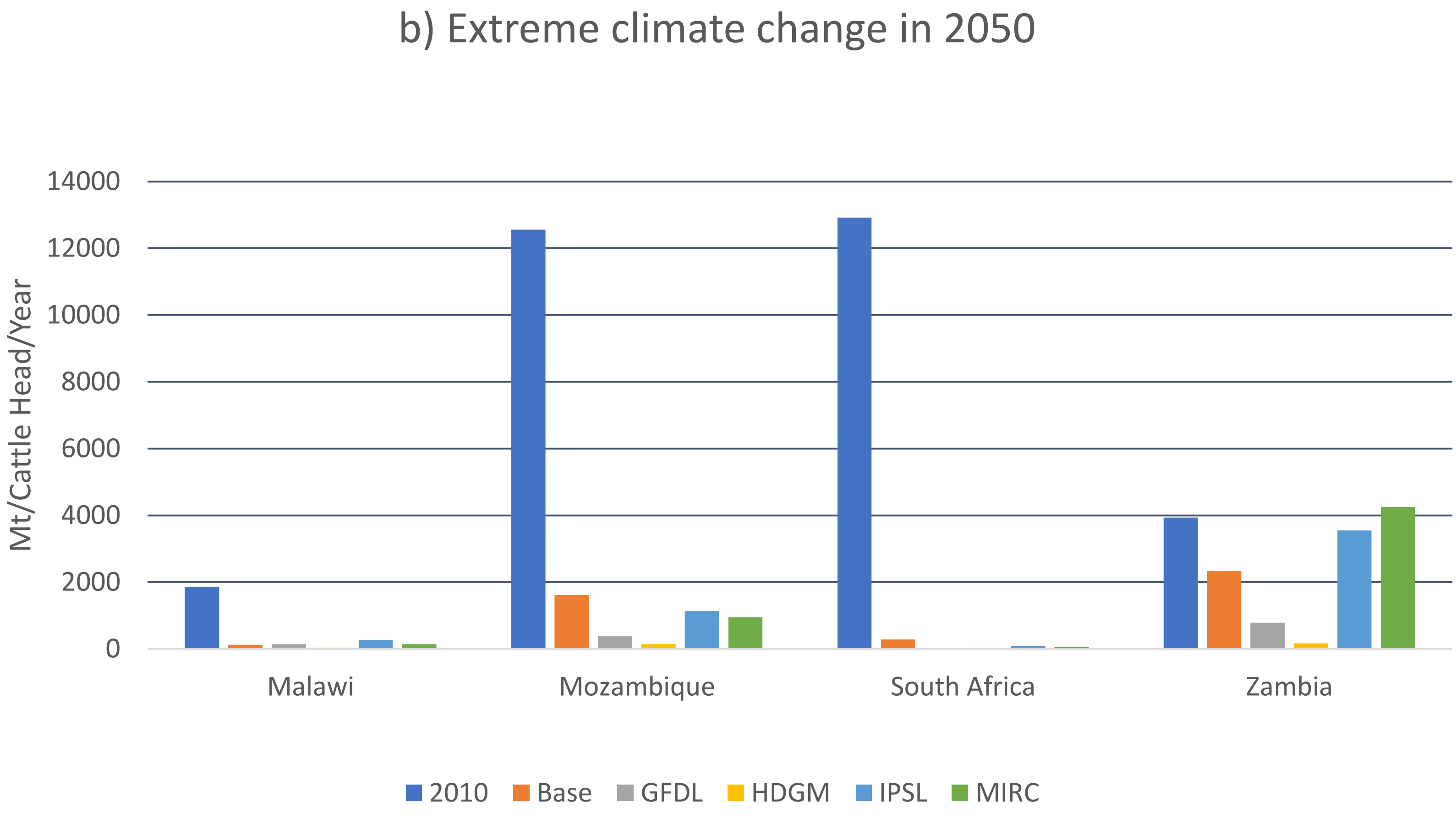


Figure 2a: Projections of forage supply (MT/cattle head) under extreme climate change in 2050, 2010 values scaled * 0.01

Trade-offs under climate change

Table 2: Changes in feed supply, ASF trade and food security indicators in 2050 under climate change (compare to baseline)

	Pasture 'sufficiency'	**Stover 'sufficiency'**	**Feed grains 'sufficiency'**	**Imports as % beef demand (exports as % beef prod)**	**Food security (ASF supply per capita)**
Malawi	down	down	down	+	down
Mozambique	+	+	+	+	down
South Africa	down	+	down	(down)	+
Zambia	down	+	+	+	No change
4Cty Region	down	+	down	+	down

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Early Results

- Under climate change, regional forage supply is more constrained in 2050 (grains as well)
  - up to 100X in some countries/systems compared to 2010
  - feed accessibility, usability could further widen gaps
- Forage constraints could limit expansion of livestock production
  - Imports likely even higher than standard projections
  - Limited capacities to realize opportunities from ASF demand
- Market adjustments lead to higher imports
  - negative effects on food security persist in 2/4 countries
  - non-ag sector (exogenous) growth could mitigate effects but potentially constrains livestock sector further.

Next steps

- This paper
  - Refine the calculations of feed sufficiency, food security
  - Better quantify the trade-offs

- Follow-up research
  - Model feed substitution possibilities*
  - Disaggregate livestock + forage modeling by production system
  - Analyze scenarios of investments in forage/feed technology
  - Investigate agriculture/livestock versus non-agriculture trade-offs

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