Livestock and climate change: can we steer a path between the devil and the deep blue sea?

Philip Thornton

Livestock and climate change: current knowledge and policy challenges

EAAP, Belfast, 30 August 2016
Outline

• The food challenge

• Impacts of climate change on livestock

• Impacts of livestock on climate change

• Issues around livestock’s goods and bads

• What we need to do
The challenge to produce enough food will be greater over the next 50 years than in all human history.

- Estimated total food production demand of 730 Exacal over the 2010–2060 period.
- Estimated total food production demand of 677 Exacal over the 1500–2010 period.
## The demand for livestock products to 2050

<table>
<thead>
<tr>
<th></th>
<th>Annual per capita consumption</th>
<th>Total consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Year</td>
<td>Meat (kg)</td>
</tr>
<tr>
<td>Developing</td>
<td>2002</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>2050</td>
<td>44</td>
</tr>
<tr>
<td>Developed</td>
<td>2002</td>
<td>78</td>
</tr>
<tr>
<td></td>
<td>2050</td>
<td>94</td>
</tr>
</tbody>
</table>

*Rosegrant et al. 2009*
The challenge is ...

• ... to increase food production
  ▪ in the face of climate change
  ▪ whilst reducing the carbon cost of farming
  ▪ but not simply by farming at lower intensity and taking more land (because there isn’t enough)
Livestock messages from the IPCC’s Fifth Assessment

- Prior conclusions confirmed (like crops): more evidence, higher confidence
- Only limited, semi-robust evidence (unlike crops) for impacts on livestock systems already: livestock disease, disease vectors
- For future impacts, widespread negative impacts on forage quality at both high and low latitudes → impacts on livestock productivity, production, incomes, food security
- Robust evidence for negative effects of increased temperature on feed intake, reproduction, performance across all livestock species

IPCC (2014)
Livestock messages from the IPCC’s Fifth Assessment

• Impacts of increasing climate variability on downside risk, stability of livestock production, human well-being, have not been robustly elucidated

• Summaries of impacts on livestock systems with / without adaptation still not available

• Many adaptation options possible in livestock systems tailored to local conditions (like cropping, fishery systems)

• Costs, benefits (social, private) of adaptations not known, although:
  • Substantial benefit, particularly if implemented in combination
  • Benefits in managing crop-livestock interactions in mixed systems

IPCC (2014)
Livestock systems in some places face major challenges related to climate change

- **Disease** and pest distributions
- Quantity, quality, and composition of feed
- Increased **cost** of housing and feed
- **Water** availability and quality
- Decreased productivity due to heat stress
- Impaired reproduction/increased mortality

Livestock production system in areas projected to undergo over 20 per cent reduction in Length of Growing Period to 2050

Ericksen et al. (2011)
Livestock systems in some places face major challenges related to climate change

• Greatest impacts will be felt in grazing systems in arid/semi-arid areas

• Changes in range-fed livestock numbers proportional to change in annual precipitation
  - Several GCMs project precipitation decreases of 10-20% in semi-arid zones of Africa

Areas in East Africa where a) rain per rainy day may increase by more than 10 per cent and b) rain per rainy day may decrease by more than 10 per cent
Herd evolution in Kenyan rangelands under two scenarios of climate variability: (1) a drought once every five years, and (2) a drought once every three years.

Thornton & Herrero, 2010
Direct agricultural emissions

Non-CO₂ agricultural emissions are about 6,100 million metric tonnes of carbon dioxide equivalent (MtCO₂e) per year—about 11 percent of total global greenhouse gas emissions and 56 percent of global non-CO₂ greenhouse gas emissions. 

US-EPA, 2011

Agriculture responsible for 19-29%
Part of the problem, natural source for solutions too

Big Facts
Where agriculture and climate change meet
ccafs.cgiar.org/bigfacts

Livestock alone is responsible for 8-18% of all global anthropogenic GHG emissions

Range arises from **methodological differences**

- Inventories vs. life cycle assessments, attribution of land use to livestock, omissions, misallocations, ...

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**Range of GHG intensities for livestock commodities**

- Highest variation occurs for **beef**, due to variety of production systems
- Ruminants require more fossil energy use, emit more CH$_4$ per animal

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*Source: de Vries and de Boer (2009)*
A food-chain perspective of GHG emissions

• Emissions from **feed production**
  - chemical fertilizer fabrication
  - chemical fertilizer application
  - on-farm fossil fuel use
  - livestock-related deforestation
  - C release from ag. soils

• Emissions from **livestock rearing**
  - Methane from enteric fermentation
  - Methane and Nitrous Oxide from manure

• **Post harvest** emissions
  - slaughtering and processing
  - international transportation

IPCC attribution

- Industry and energy
- Agriculture
- Energy
- Forestry
- Agriculture
- Agriculture / livestock
- Industry and energy
- Transport and energy

Steinfeld, 2011
Livestock: some big numbers

• 20 billion domestic animals globally (FAOSTAT 2016)

• 45% of the Earth’s surface (excluding Antarctica) occupied by livestock systems (Reid et al. 2008)

• 33% of global cropland used for feed production

• 8-18% of global greenhouse gas emissions (FAO 2006, 2013, Herrero et al. 2013, O’Mara 2013)

• 72% of deforestation (Nepstad et al. 2011)

• 30% of global freshwater consumption (Steinfeld et al. 2006)
What’s on the other side of the balance?
Livestock’s socio-economic benefits

• Livestock are a significant global asset: value >$1.4 trillion (excluding infrastructure that supports livestock industries) (Thornton and Herrero 2008)

• Livestock industries organised in long market chains that provide incomes and/or employ at least 1.3 billion people (LID 1999)

• Livestock GDP: 30-40% of agricultural GDP (Nigeria 7%, Tanzania 26%, Ethiopia 25%). In developing countries, most livestock production is from ruminants (Nigeria 73%, Eth 93%, TZ 90%)

• Livestock important as a risk management tool, especially for the poor: ~430 million poor livestock keepers (Thornton in FAO/ILRI 2011)

• Livestock are key for nutritional security: 17% of the global kilocalories and 33% of protein (FAOSTAT 2008); Africa, 8% of calories
African and Asian livelihoods continue to depend on livestock

- E Africa: 40-50% meat comes from pastoral systems, but transitioning to mixed crop-livestock
- Concentrated in arid/semi-arid zones
- Use of animals for draft power has increased over most of Africa: from 350,000 to 2 million oxen in the past 50 years in W Africa alone

**Table:**

<table>
<thead>
<tr>
<th>COUNTRY AND YEAR</th>
<th>SHARE OF RURAL HOUSEHOLDS OWNING LIVESTOCK</th>
<th>SHARE OF INCOME FROM LIVESTOCK</th>
<th>SHARE OF LIVESTOCK PRODUCTION SOLD</th>
<th>NUMBER OF LIVESTOCK HELD PER RURAL HOUSEHOLD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ghana (1998)</td>
<td>50</td>
<td>4</td>
<td>23</td>
<td>0.7</td>
</tr>
<tr>
<td>Madagascar (1993)</td>
<td>77</td>
<td>13</td>
<td>47</td>
<td>1.6</td>
</tr>
<tr>
<td>Malawi (2004)</td>
<td>63</td>
<td>9</td>
<td>9</td>
<td>0.3</td>
</tr>
<tr>
<td>Nigeria (2004)</td>
<td>46</td>
<td>4</td>
<td>27</td>
<td>0.7</td>
</tr>
</tbody>
</table>

FAO 2011
Density of “poor livestock keepers” using national rural poverty lines, 2010

>430 million PLKs globally. Thornton in Robinson et al. (2011)
Diversification in low-rainfall areas of East Africa

Net Income (‘000 Ksh yr⁻¹)

Activity diversity (# per farm)

\[ y = -10.9x^2 + 168x - 383 \]

\[ R^2 = 0.70 \]

(Rufino et al. 2014)
Climate-induced livelihood transitions out of crops into livestock?

Areas where cropping of an indicator cereal may become unviable between now and 2050 and where farmers may have to rely more on livestock as a livelihood strategy

Jones & Thornton (2008)
Livestock a key ingredient of diverse, sustainable and healthy diets?

<table>
<thead>
<tr>
<th>Country</th>
<th>Edible protein fed to livestock 1000 MT (A)</th>
<th>Edible protein provided by livestock 1000 MT (B)</th>
<th>Ratio (B/A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethiopia</td>
<td>9</td>
<td>150</td>
<td>16.9</td>
</tr>
<tr>
<td>New Zealand</td>
<td>70</td>
<td>709</td>
<td>10.1</td>
</tr>
<tr>
<td>India</td>
<td>4,403</td>
<td>1,023</td>
<td>4.3</td>
</tr>
<tr>
<td>Brazil</td>
<td>3,304</td>
<td>3,854</td>
<td>1.2</td>
</tr>
<tr>
<td>Netherlands</td>
<td>752</td>
<td>773</td>
<td>1.0</td>
</tr>
<tr>
<td>China</td>
<td>11,129</td>
<td>8,454</td>
<td>0.8</td>
</tr>
<tr>
<td>United States</td>
<td>16,158</td>
<td>8,543</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Steinfeld, based on FAOSTAT (2005-2007 average)
Steering a path between the devil and the deep blue sea: can we sustainably balance livestock’s goods and bads?
Yes, in several (often additive) ways, including:

1. **Increasing productivity (managing the supply side)**
   - Sustainably intensify production, e.g. improve ruminant diets, shifts in which livestock products are produced and where
   - Decrease GHG emissions intensity of livestock products in developing countries → reduce livestock numbers
   - Carbon sequestration in degraded grasslands: enhances land productivity, can improve lives of poor livestock farmers/pastoralists, requires carbon payments and institutional innovation
Evaluating options by different livestock production systems
Thornton & Herrero (2014)

1. Diet intensification: stover digestibility improvement

2. Diet intensification: grain supplementation

3. Diet intensification: use of agroforestry species

4. Use of cross-bred dairy animals

Thornton & Herrero (2014)
Yes, in several (often additive) ways, including:

2 Reducing losses and waste in livestock product value chains

• Markets, packaging, labelling, avoiding waste
• Methane from liquid waste can be captured and used as a source of energy (large-scale pig and dairy units)

3 Consuming more sustainable diets (managing the demand side)

• Modifying what we eat could reduce resource use, reduce GHG emissions, and have important health and nutritional benefits
• Double burden of malnutrition
Issues to be resolved 1: complexity of quantifying impacts, costs, benefits

### Carrying capacity of different diets in the US

<table>
<thead>
<tr>
<th>Diet Type</th>
<th>Carrying Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy-friendly vegetarian</td>
<td>807 million</td>
</tr>
<tr>
<td>Egg and dairy-friendly vegetarian</td>
<td>787</td>
</tr>
<tr>
<td>Omnivorous (20%)</td>
<td>769</td>
</tr>
<tr>
<td>Omnivorous (40%)</td>
<td>752</td>
</tr>
<tr>
<td>Vegan</td>
<td>735</td>
</tr>
<tr>
<td>Omnivorous (60%)</td>
<td>669</td>
</tr>
<tr>
<td>Omnivorous (80%)</td>
<td>548</td>
</tr>
<tr>
<td>Omnivorous (100%)</td>
<td>467</td>
</tr>
<tr>
<td>Reduced fat and sugar diet</td>
<td>421</td>
</tr>
<tr>
<td>Current diet</td>
<td>402</td>
</tr>
</tbody>
</table>

Issues to be resolved 2: the future of livestock systems in different places

Cropping history in 12 agro-pastoral systems in East Africa

- Samburu: 523
- Kajiado: 655
- Baringo: 658
- West Pokot: 717
- Kwale: 787
- Singinda: 827
- Kishapu: 875
- Mbarara: 898
- North Pokot: 935
- Nebbi: 1058
- Masaka: 1061
- Machakos: 1205

History of cropping (years)

Annual average rainfall (mm)

Rufino et al. (2014)
Issues to be resolved 3: how to provide appropriate incentives for change for institutions, governance, the private sector?

Working with partners to change opinions and worldviews

- Research evidence
- Working with partners to understand what works
- Engagement & Communication
- Policy and Institutional Change
- Implementing "appropriate" agriculture
- Working with partners to make it happen
- Research
Issues to be resolved 4: modifying discourses around climate change and livestock

• Burgeoning literature on global change communications: framing, psychology, values, attitudes, beliefs, political ideologies, ...

• Tap in to new skills in discourse analysis and understanding gender norms, addressing beliefs, values, worldviews (both individual and shared)

• Backed up by appropriate engagement and communications: getting the message right for different stakeholders

• This will involve combining “softer” social science with “harder” biophysical science in effective ways (importance of process and buy-in)
And what about technological game-changers?

- Artificial meat
- N-fixing cereals
- Ruminants producing less methane
- ...

Kurzweil, nd