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Options to reduce the environmental impacts of livestock production: effectiveness and implications

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The Role of Animal Agriculture in a Sustainable 21st Century Global Food System
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Maurits van den Berg, Elke Stehfest, Henk Westhoek (PBL)
Siwa Msangi (IFPRI)
Geert Woltjer (LEI/WUR)
Options to reduce the environmental impacts of livestock production: effectiveness and implications

Presentation overview

- Introduction
  - Environmental impacts of livestock production
  - Mitigation options
  - What was accomplished in previous work
- Current study
  - Approach
  - Results & discussion
- Lessons learnt
- Suggestions for further research
Global environmental impacts of livestock production

- Land conversion - Biodiversity loss
- Emissions of GHG
- Emissions of N (water and air) and P (water)
- Human health (zoonotic diseases, antibiotics, nutrition)
- Animal welfare
Global environmental impacts of livestock production

Contribution of livestock

Source: Rockström et al., Nature, 2009
Impacts expected to be exacerbated by population growth and economic prosperity

Source: FAO AT 2030/50
Mitigation options - rationale

To relieve environmental impacts:
- less expansion of agriculture into nature, and of crops into pasture;
- fewer livestock
- cleaner production methods

This can only be achieved by:
- Consuming less livestock products
- Consuming different products, with less impact
- Producing more efficiently (e.g. more product per ha per year)
- Reducing supply chain wastes & losses
What was accomplished in previous work
Land-use CO₂ Emissions and Uptake

b. Land use CO₂ emissions
Gtonne C per year

-3.5 -3 -2.5 -2 -1.5 -1 -0.5 0 0.5 1 1.5 2 2.5

-3.5 -3 -2.5 -2 -1.5 -1 -0.5 0 0.5 1 1.5 2 2.5

2000 2010 2020 2030 2040 2050

Reference
No animal products
No meat
No ruminant meat
Healthy diet (Willett)
Mitigation Cost under 450 ppm Stabilization

![Graph showing mitigation costs under the 450 ppm stabilization pathway.]

- **Reference**: 100%
- **No animal products**: 19%
- **No meat**: 26%
- **No ruminant meat**: 30%
- **Healthy diet (Willett)**: 46%

*Stehfest et al. 2009, Clim Change*
Effects not accounted for / uncertainties

- Change in trade patterns
- Agro-economic feedbacks
- Implementation costs or welfare changes (e.g. employment loss) associated with dietary changes
- Other options than diet change
- (Policy) instruments to accomplish changes
Objective
† Assess the effectiveness and implications of options to reduce the environmental impacts of livestock production

Scope
† Global, with special attention to EU
† Integrated; special attention to (animal) protein demand and supply
† Analytical
† Looking into ambitious transformations
† Focus on “what if”; not (yet) on “how to”.
## Options analyzed (until 2030)

<table>
<thead>
<tr>
<th>Option name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>Baseline</td>
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<tr>
<td>WHO Diet (EU)</td>
<td>Diet conform WHO in EU27</td>
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<tr>
<td>Substitution red meat (EU)</td>
<td>Substitution of red meat by white meat (EU beef consumption 40% lower than in baseline)</td>
</tr>
<tr>
<td>Animal Friendly (EU)</td>
<td>Shift to animal friendly produced meat and dairy (EU27) – increased feed needs</td>
</tr>
<tr>
<td>Organic (EU)</td>
<td>As Animal friendly + 25% organic agriculture (EU27)</td>
</tr>
<tr>
<td>Low wastage (EU)</td>
<td>Reduce food waste by 15% points (EU27)</td>
</tr>
<tr>
<td>Low wastage (global)</td>
<td>Reduce food waste by 15% points (Global)</td>
</tr>
<tr>
<td>High crop yield increase (global)</td>
<td>Increase of productivity growth arable land by 40%</td>
</tr>
<tr>
<td>Livestock Eff increase (global)</td>
<td>Livestock food conversion efficiency 15 % higher</td>
</tr>
</tbody>
</table>

**All transformations are phased in until 2020**
Production of crops and animal products
Intensification / Extensification

Scenario assumptions (trade agreements, consumption patterns etc.)

Economic growth
Population growth

Land availability from IMAGE (for LEITAP)

Change in average yields due to climate change and expansion of agriculture

Land Use and environmental development (IMAGE)

Demand, production and trade in agricultural products (IMPACT/LEITAP)

Social, economic, and environmental consequences

Sectoral technical progress

Demand, production and trade in agricultural products (IMPACT/LEITAP)

Land Use and environmental development (IMAGE)
## Comparison LEITAP x IMPACT

<table>
<thead>
<tr>
<th></th>
<th>LEITAP</th>
<th>IMPACT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Organisation</strong></td>
<td>LEI (Wageningen UR)</td>
<td>IMPACT (IFPRI – CGIAR)</td>
</tr>
<tr>
<td><strong>Type / approach</strong></td>
<td>• Global CGE model;</td>
<td>• Partial equilibrium model;</td>
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<tr>
<td></td>
<td>• Changes in monetary flows are central</td>
<td>• Volumes of product flows are central</td>
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<tr>
<td><strong>Trade</strong></td>
<td>• Accounts for bilateral trade</td>
<td>• Pools net trade globally</td>
</tr>
<tr>
<td><strong>Expansion of agricultural land</strong></td>
<td>• Endogenised (determined by $\Delta$ production and yields)</td>
<td>• largely exogenously driven</td>
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<tr>
<td><strong>Input markets</strong></td>
<td>• endogenous (e.g. fertiliser prices, wages, labour)</td>
<td>• exogenous</td>
</tr>
</tbody>
</table>
Results (baseline)
Global production of livestock products (expressed in dry matter eq)
Results (baseline)
Global crop production (expressed in dry matter eq)
Results (baseline)
Land use

<table>
<thead>
<tr>
<th></th>
<th>FAO 2000</th>
<th>IMPACT 2030</th>
<th>LEIT AP 2030</th>
<th>FAO 2000</th>
<th>IMPACT 2030</th>
<th>LEIT AP 2030</th>
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<tbody>
<tr>
<td>Mha</td>
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<td>Food crops</td>
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<tr>
<td>Grass &amp; fodder</td>
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<tr>
<td>Sub-Saharan Africa</td>
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<td>South Asia</td>
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<tr>
<td>Rest OECD</td>
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<td>North Africa and West Asia</td>
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<tr>
<td>FSU</td>
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<tr>
<td>China+</td>
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<tr>
<td>C&amp;S America</td>
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<tr>
<td>EU27+</td>
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</tbody>
</table>

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Change in global agricultural area compared to baseline (2030)

IMPACT

- WHO diet (EU)
- Substitution red meat (EU)
- Low wastage (EU)
- Low wastage (global)
- High crop yield increase
- Livestock Eff increase

LEITAP

- WHO diet (EU)
- Substitution red meat (EU)
- Low wastage (EU)
- Low wastage (global)
- High crop yield increase
- Livestock Eff increase

Difference in area compared to baseline (Mha)

EU27+  C&S America  China+  FSU  North Africa and West Asia  RestOECD  South Asia  Sub-Saharan Africa

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Example: Low waste, global: Change in production and areas

*LEITAP*

1. **grass & fodder**
   - production
   - land use

2. **food crops**
   - production
   - land use

1. **ruminant products**
   - production
   - land use

2. **food and feed crops**
   - production
   - land use

*IMPACT*

1. **grass & fodder**
   - production
   - land use

2. **food crops**
   - production
   - land use

1. **ruminant products**
   - production
   - land use

2. **food and feed crops**
   - production
   - land use

-16,0% -14,0% -12,0% -10,0% -8,0% -6,0% -4,0% -2,0% 0,0%
Feedbacks: Chain of events

EU
- Reduction of meat consumption
- Shift to other food categories
- Reduction of livestock production
- Extensification of production
- Lower feed consumption

Rest of the world
- Higher meat consumption
- Higher cereal consumption

World market
- Lower meat prices
- Lower cereal prices
Global land use related GHG emissions compared to baseline (cumulative 2000 - 2030)

**IMPACT**

- WHO Diet (EU)
- Substitution red meat (EU)
- Low wastage (EU)
- Low wastage (global)
- High crop yield increase
- Livestock Eff increase

**LEITAP**

- EU27+
- C&S America
- China+
- FSU
- North Africa and West Asia
- Rest OECD
- South Asia
- Sub-Saharan Africa

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Lessons learnt

- Integrated assessment helps to understand effects and side-effects of options analysed
- Large differences between models reflect strengths & weakness AND differences in world views
- Common denominators:
  - Options analysed do contribute to mitigation of environmental impacts
  - Indirect ‘leakage’ effects (strongest in IMPACT) reduce effectiveness by roughly 50%
  - Effects of EU options mainly outside EU
  - Hotspots of change tend to coincide: Latin America, Africa
  - Effects of EU options may strongly be affected by future CAP and WTO arrangements
- Strong effects on prices could undermine implementation
- .. suggesting that
  - measures that reduce pressure on land should be combined with measures to discourage land conversion (e.g. nature reserves, REDD).
  - Internationally coherent policies are needed to sustain effects
Opportunities for further research & development

- More focus on ‘how-to’ question (identification, effectiveness and acceptance of policy instruments)
- More attention for socio-economic impacts (e.g. human nutrition, employment, GDP, poverty alleviation)
- More attention for regional differentiation in opportunities for change
- Up-scaling, down-scaling and cutting across scales
- Improving the models; where can one model learn from the strengths of the other?
Thank you
Global environmental impacts of livestock production

Causes of biodiversity loss, baseline

Pressures
- Crops
- Pasture
- Forestry
- Infrastructure, encroachment and fragmentation
- Nitrogen deposition
- Climate change

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Global environmental impacts of livestock production

Causes of biodiversity loss, baseline

MSA (%)

Pressures
- Crops
- Pasture
- Forestry
- Infrastructure, encroachment and fragmentation
- Nitrogen deposition
- Climate change

Total losses
Attributed to livestock production

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EU 27: GHG per livestock sector

deze slide weg of in context met productie laten zien

Calculations based on Miterra-CAPRI

Source: Lesschen et al (in prep)
a. Livestock production
Mtonne dry matter per year

- Ruminant_meat
- Other_meat&eggs
- Milk

Stehfest et al. 2009, Clim Change
All GHG Emissions and stabilization target

a. All GHG emissions (CO₂-equivalent)
Gtonne C per year

- Reference
- No-AP
- No-M
- No-RM
- Hdiet
- 450ppm

Stehfest et al. 2009, Clim Change
Land Use

Million ha

- Cropland
- Grassland
- Energy_crops

Stehfest et al. 2009, Clim Change
Approach

- Time horizon: 2030 / 2050
- 8 “options” of transformations in food production or consumption
- 2 models to assess regional and global effects on production and consumption
- 1 model to assess environmental effects:
  - Land use / land use change
  - GHG emissions
  - Biodiversity indicators (MSA; extent of natural areas)
  - Emissions of N and P
Results (baseline)
Global production of livestock products (expressed in dry matter eq)
## Results (baseline)
Global crop production (expressed in dry matter eq)

<table>
<thead>
<tr>
<th></th>
<th>Reference</th>
<th>00- Baseline</th>
<th>00- Baseline</th>
<th>Reference</th>
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</thead>
<tbody>
<tr>
<td>Tropical cereals</td>
<td></td>
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</tr>
<tr>
<td>Temperate cereals</td>
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<td></td>
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<tr>
<td>Roots &amp; tubers</td>
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<tr>
<td>Rice</td>
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<tr>
<td>Oil crops</td>
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<tr>
<td>Maize</td>
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<tr>
<td>Pulses</td>
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- Tropical cereals
- Temperate cereals
- Roots & tubers
- Rice
- Oil crops
- Maize
- Pulses

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Results (baseline)
Land use

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<thead>
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<th>2000</th>
<th>2030</th>
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</thead>
<tbody>
<tr>
<td>food crops</td>
<td>1.000</td>
<td>1.500</td>
<td>2.000</td>
<td>2.500</td>
</tr>
<tr>
<td>grass &amp; fodder</td>
<td>3.000</td>
<td>3.500</td>
<td>4.000</td>
<td></td>
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</tbody>
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- FAO
- IMPACT
- LEITAP

Mha

- Sub-Saharan Africa
- South Asia
- Rest OECD
- North Africa and West Asia
- FSU
- China+
- C&S America
- EU27+

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Results
Global crop production (expressed in dry matter eq)

β Comparisons between options and reference for 2030
β % change compared to world total or EU total in baseline
β Aggregated based on physical quantities [e.g. t dry matter], not values
Example: Changes in EU Beef demand (2030)
Example: Changes in global Beef demand (2030)
Example: Change in global Beef production (2030)

- WHO Diet
- Substitution red meat
- Animal Friendly
- OrganicEU27
- Low wastage (EU)
- Low wastage (global)
- High crop yield increase
- Livestock Eff increase

IMPACT

LEITAP

C&S America  China  Europe  FSU  NorthAfrica and West Asia  Rest OECD  South Asia  SSA

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Example: Change in EU Beef production (2030)
Example: Change in EU grassland + fodder area (2030)

- 01a WHO Diet
- 02- Substitution red meat
- 03a Animal Friendly
- 03b OrganicEU27
- 04a Low wastage (EU)
- 04b Low wastage (global)
- 06- High crop yield increase
- 07- Livestock Eff increase

IMPACT

LEITAP

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