Climate Change and Agriculture: Implications for France

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Key messages

1. Not so small!

2. Not that expensive! (if done right)

3. Not much is currently done to get it right

4. Mitigation and adaptation are linked
GHG emissions from French agriculture
**GHG emissions in France (2011)**

- **Sources**
  - Energy; 10.5
  - Agricultural soils; 48.4
  - Manure management; 14.7
  - Enteric fermentation; 28.3

- **Sinks**
  - Settlement; 14.3
  - Cropland; 16.6
  - Forestland; -65.0
  - Grassland; -7.5
  - Wetland; -3.5

**Source:** CITEPA (2013)
French emissions from AFOLU

Synthetic fertilisers (N$_2$O)
[cumul 1993-2003, tCO$_2$eq/ha]

Source: Chakir et al. (2011)
French emissions from AFOLU

Enteric fermentation (CH$_4$) [cumul 1993-2003, tCO$_2$eq/ha]

Source: Chakir et al. (2011)
Manure mang’t and spreading ($N_2O+CH_4$)
[cumul 1993-2003, tCO$_2$eq/ha]
French emissions from AFOLU

LULUCF (CO$_2$)
[cumul 1993-2003, tCO$_2$ eq/ha]

Source: Chakir et al. (2011)
French emissions from AFOLU

Net AFOLU emissions [cumul 1993-2003, tCO₂eq/ha]

Source: Chakir et al. (2011)
GHG emissions in France (1990-2011)

Agricultural emissions ($N_2O+CH_4$)

Source: CITEPA (2013)
GHG emissions in France (1990-2011)

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GHG emissions in France (1990-2011)

Source: CITEPA (2013)

Agricultural emissions ($N_2O+CH_4$)

Emissions from other sectors (excl. LULUCF)

Net emissions
GHG emissions in France (1990-2011)

Agricultural emissions (\(\text{N}_2\text{O}+\text{CH}_4\))

2020 Non-ETS target: -14% /2005

Source: CITEPA (2013)
GHG emissions in France: Projections to 2020

Agricultural emissions (N₂O+CH₄)

Source: De Cara, Thomas (2008), Forslund et al. (2009)
Mitigation
Mitigation potential and costs

- Evaluating the ‘technical’ mitigation potential is necessary... but not sufficient
- Marginal abatement costs are key to cost-effectiveness
- MAC are not directly observable => models
  - Supply-side, farm-level models
    [e.g. De Cara, Jayet, 2000; 2011; De Cara et al., 2005]
  - Partial or general equilibrium models
    [e.g. McCarl, Schneider, 2001; Golub et al, 2011]
  - Practice-based, ‘engineering’ studies
    [e.g. Moran et al, 2011; Bamière, Pellerin et al, 2013]
- The modelling approach matters (Vermont, De Cara, 2010)
MAC: A model-based assessment

- Supply-side, farm-level model of EU agriculture
- Emission coverage:
  - \( \text{N}_2\text{O} \) (synthetic and organic N)
  - \( \text{CH}_4 \) (enteric ferm., manure, rice)
- Mitigation options: crop allocation, N use, animal feeding, animal numbers
- 10% reduction obtained at ~35 €/tCO2eq

Source: De Cara and Jayet (2011)
MAC: A model-based assessment

- Supply-side, farm-level model of EU agriculture
- Emission coverage:
  - N₂O (synthetic and organic N)
  - CH₄ (enteric ferm., manure, rice)
- Mitigation options: crop allocation, N use, animal feeding, animal numbers
- 10% reduction obtained at ~35 €/tCO₂eq
- MAC slightly lower than in the rest of the EU MAC (10% red. at ~45 €/tCO₂eq)

Source: De Cara and Jayet (2011)
MAC: A practice-based assessment

- Recent study conducted by INRA for ADEME and the ministries of agriculture and environment

- Mitigation potential and cost of 10 actions (26 sub-actions) regarding crop, livestock, soil C and energy use

- Practice-based assessment of abatement potential and costs in 2030 relative to 2010 levels

- Approach:
  - National resolution
  - No major changes to the productive capacity
  - Emission accounting: current inventory rules + higher tier, direct and indirect emissions

Source: Pellerin, Bamière et al. (2013)
MAC: A practice-based assessment

Abatement cost (€/tCO₂ eq)

Energy savings
Grassland mang’t
Animal Feeding (proteins)
Legume crops
Nitrogen fertiliser mang’t
Reduced tillage
Anaerobic digester
Agroforestry
Cover crops
Lipid, additives

Mitigation potential (MtCO₂ eq)

Total mitigation potential (excl. indirect emissions):
~32 MtCO₂ eq
(But only 10 MtCO₂ eq w/ current inventory rules)

Source: Pellerin, Bamière et al. (2013)
MAC: A practice-based assessment

- Increase in input-use efficiency (N, energy)
- Require investments and/or changes in practices (possible additional income)
- Require investments and/or changes in practices (no additional income)

Abatement cost (€/tCO₂eq)

Mitigation potential (MtCO₂eq)

Source: Pellerin, Bamière et al. (2013)
Policy instruments

- Agricultural emissions largely excluded from existing climate policy instruments (ETS, carbon tax project)
  - Some up-/down-stream sectors covered by ETS
  - Some JI projects (alfalfa, linseed in anim. feeding)
- Biofuel & bioenergy
  - Incorporation of liquid biofuel
  - Development of anaerobic digesters
- Agricultural measures
  - Reduce N surplus
  - Increase energy efficiency
  - Protect grassland

Source: DGEC (2013)
Cost-effective policy instruments

- Cost-effectiveness requires that farmers include the value of emissions in their production decisions.
- Large heterogeneities: large gains to be expected from economic instruments.
- Inclusion of agriculture could reduce the total cost of meeting the overall mitigation target (De Cara, Vermont, 2011).

Issues:
- Monitoring, reporting & verification
- Transaction costs & barriers to adoption
- Uncertainty in emission accounting
- Leakage
Climate impacts and adaptation
Climate impacts on agriculture

- Climator results on yields (Brisson, Levrault, 2010)
  - Wheat: (shorter cycle, less frost, CO₂ effect)
  - Maize: (water stress, esp. in the South West)
  - Rapeseed: (but sensitive to droughts)
  - Grassland:

- Adaptation: agricultural practices (e.g. irrigation, timing, etc.) but also land-use change

- Econometric Ricardian model of land use (Ay et al., in prep.)
  - Land rents linked to climate and soil characteristics
  - Land use model (Teruti data, multinomial logit, five LU categories)
  - Projections to the mid-21st century (scenario A1b)
Ricardian model: Results (2053-1993, A1b)

Cropland: + 4.65 Mha

Source: Ay et al. (in prep.)
Ricardian model: Results (2053-1993, A1b)

Grassland: -8.49 Mha

Source: Ay et al. (in prep.)
Ricardian model: Results (2053-1993, A1b)

Forestland: +0.27 Mha

Source: Ay et al. (in prep.)
Ricardian model: Results (2053-1993, A1b)

Perennial crops: +1.65 Mha

Source: Ay et al. (in prep.)
Ricardian model: Results (2053-1993, A1b)

Urban: +1,91 Mha

Source: Ay et al. (in prep.)
Key messages

1. Not so small!
   *Importance of agriculture for French & EU emission*

2. Not that expensive! (if done right)
   *There is a potential to reduce these emissions cost-effectively*

3. Not much is currently done to get it right
   *Current measures do not provide the right incentives to realise this potential cost-effectively*

4. Mitigation and adaptation are linked
   *Land-use change due to climate change may have important impacts on mitigation*
References
References (1/2)


De Cara, S. (in prep.), 'Minimum emission threshold to limit transaction costs in emission trading schemes: An application to EU agricultural GHG emissions', Working paper, INRA, UMR Economie Publique, Grignon, France.
References (2/2)


Key facts & figures

- **French mitigation targets**
  - 2050: -75% (“Facteur 4”) / 1990
  - 2020: -14% for non-ETS emissions / 2005

- **GHG emissions from French agriculture:**
  - ~20% of French GHG emissions
  - ~20% of EU-27 agricultural emissions
  - Due to both crops ($N_2O$) and livestock ($N_2O$ and $CH_4$)

- **Net LULUCF sink**
  - ~10% of French GHG emissions
  - ~15% of EU-27 LULUCF sink
  - Largely due to existing forest (~16 Mha)

- **Climate projections (Terray, Boé, 2013)**
  - 2100: from +2° to + 4° (winter), from +2° to + 6° (summer)
  - Reduction in summer precipitations (South), slight increase in winter precipitations (North)
Per-farm GHG emissions ($N_2O$, $CH_4$)

**Lorenz curve**

- Large number of ‘small’ emitters

**Share in total emissions**

<table>
<thead>
<tr>
<th>FR (1000 farms)</th>
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<tbody>
<tr>
<td>N</td>
</tr>
<tr>
<td>Mean (tCO₂eq.farm⁻¹.yr⁻¹)</td>
</tr>
<tr>
<td>[min; max]</td>
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- Source: De Cara (in prep., based on FADN)
Per-farm GHG emissions (N$_2$O, CH$_4$)

Source: De Cara (in prep., based on FADN)