Modeling the transition of French Agriculture in a 4per1000 future

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Storing carbon in French agricultural soils
Potential and cost of additional storage

- Identify soil organic carbon storing practices
- Assess and map their potential for additional carbon storage in soils, at the region and national level
- Assess their implementation costs
- Cost-effectively allocate the C storing effort

- 30 scientific experts from fields ranging from agronomy and soil sciences to economics
**Soil C storing practices**

**Arable crops:**

- **Expansion of cover crops:** increase frequency and duration of ground cover
- **No-tillage:** suppression de tout travail du sol sauf contrainte technique et sauf pour la destruction des prairies et des cultures intermédiaires
- **New organic C inputs:** not already spread on agricultural soils under current management practices (e.g. composted greenwastes, sewage sludges and biowastes, digestates)
- **Expansion of temporary grasslands:** at the expense of silage maize, or increase in existing temporary grasslands lifespan
- **Agroforestry:** 75 trees/ha, 24 m inter-row, soils > 1m, plots >1ha
- **Hedges:** plots >8ha
Soil C storing practices

Permanent Grasslands:

- **Moderate intensification of extensive grasslands**: +50 kg N/ha
- **Animal grazing instead of mowing**: substitution of 1-2 mowing by grazing

Vineyards:

- **Grass cover of vineyards**: expansion of permanent or temporary cover on every row
Methodology: overview

1. Baseline and current practices description
   C storing practices description
   - Agro-pedo-climatic context
   - Technical and economic context
   - Modifications in management practices
   - Applicability criteria

2. Potential applicability (ha)

3. Additional C storage (tC/ha/C storing practice)
   - STICS – PASIM – Expert calculation
   - Crops – Grassland – Forest

4. Technical cost (€/ha/C storing practice)
   - Crops – Grassland – Forest

5. C storing practice efficiency (€/tC)

6. "Technical" C storage potential at the national level

7. "Economic" C storage potential
   - Minimizing the total cost of C storage
   - BANCO

Region level
Methodology: soil C storage assessment

- Additional C storage \((\text{tC/ha/yr}) = \frac{(C \text{ stock storing practice} - C \text{ stock baseline})}{30}\)

- For each C storing practice, a complete greenhouse gases budget is calculated.
Methodology: implementation cost assessment

« additional cost » = « cost » C storing practice – « cost » current practice

Cost = loss or gain for the farmer

❖ Δ overheads
  ▪ Δ inputs (fertilizer, feedstuff, …)
  ▪ Δ crop management operations (labour, machinery, fuel)
  ▪ Dedicated investments (e.g. tree planting)

❖ Δ revenue
  ▪ Δ yield
  ▪ New revenue (e.g. sale of wood)
  ▪ Change in land allocation (e.g. crop area substituted with trees or hedges)

❖ Excluding « optional subsidies »
  ▪ E.g. Common Agricultural Policy payments, agri-environmental measures, regional subsidies

❖ Constant annuity with a 4.5% discount rate
Methodology: assumptions and data sources

Costs calculated assuming constant land allocation and livestock numbers, constant technological context and price system, all corresponding to the 2009-2013 reference period

- Static historical reference period 2009-2013: 5 year average

- Use of public statistics and data sources:
  - Crop areas: Annual statistics of agriculture
  - Reference yields, prices, and crop gross margins: Farm Accountancy Data Network
  - Cropping practices: National survey on cropping practices

- Impacts of C storing practices on yields
  - Simulated yield variation (%) applied to the reference yield
  - Constant milk and meat yield => adjustment of the feed ration
  - Yield variations of temporary grasslands and sillage maize are compensated with a substitute feed ration
## Additionnal C storage potential and costs

<table>
<thead>
<tr>
<th>SOC storing practices</th>
<th>Additional soil C storage (tC/ha/yr)</th>
<th>Additional soil C storage (tCO2e/ha/yr)</th>
<th>Complete GHG budget (tCO2e/ha/yr)</th>
<th>Cost for farmer ($/ha/yr)</th>
<th>Soil Carbon Storage cost ($/tC)</th>
<th>Soil Carbon Storage cost ($/tCO2e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expansion of temporary grasslands</td>
<td>0.192</td>
<td>0.703</td>
<td>-0.903</td>
<td>98 (-43; 284)</td>
<td>511 (-261; 1 800)</td>
<td>139 (-71; 491)</td>
</tr>
<tr>
<td>Moderate intensification of extensive grasslands</td>
<td>0.213</td>
<td>0.781</td>
<td>0.010</td>
<td>30 (13; 41)</td>
<td>140 (65; 1 284)</td>
<td>38 (17; 350)</td>
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<tr>
<td>Grazing instead of mowing (permanent grasslands)</td>
<td>0.362</td>
<td>1.328</td>
<td>-1.054</td>
<td>79 (-91; 158)</td>
<td>219 (-3 014; 560)</td>
<td>59 (-822; 152)</td>
</tr>
</tbody>
</table>

1€ = 1.08 US$
Cost-effective allocation of the additional C storage effort

Cost for farmer (region, practice) $/ha/yr
Additional C storage (region, practice) tC/ha/yr
Potential applicability (region, practice) ha
Compatibility (practice, practice')

Crop and grassland models
Litterature
Experts

Cost minimizing model (BANCO)

National additional C storage target

Uptake level (region, practice) (ha)
Cost of the last ton of C stored ($/tC)
Total C storage cost ($/yr)

« carbon storage supply curve»

C storage target (MtC/yr)

Tonnes de C stocké (tC)
Marginal C storage cost curve

Cost of the last ton of C stored ($/tC)

- 0 $/tC
- 59 $/tCO2e = 218 $/tC
- 270 $/tCO2e = 990 $/tC
- 246 M$/yr
- 172 M$/an
- 4,06 MtC/an
- 8,17 MtC/an
- 8,43 MtC/an
- 0,66 MtC/yr

France métropolitaine, courbe de coût marginal de stockage de carbone dans le sol (horizon 0-100 cm)

- 4073 $/tC
- 2481 M$/yr
- 21st February 2020

≈ 31 MtCO2e /yr
≈ 6,8% of nat. GHG emissions
≈ 41% of agricultural sector emissions

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Conclusion and policy implications

- There is no "one-size-fits-all" solution to increase carbon storage in soils …
- … rather a combination of good practices at the right place

=> It is important to account for heterogeneity for the design of a cost-effective policy

- Study used in the frame of the EU Common Agricultural Policy reform for the design of the French national voluntary eco-scheme

- In France, high soil C storage targets can only be achieved with the full enforcement of cover crops and agroforestry, and with the expansion of temporary grasslands in crop rotations.

- Need to ensure coherence between existing policies and, ideally, account for bundles of ecosystemic services in an integrated policy.

- A policy aiming at supporting additional C storage in arable land must not come at the expense of the preservation of existing carbon stocks in permanent grasslands and forests
Thanks for your attention!

http://institut.inra.fr/Missions/Eclairer-les-decisions/Etudes/Toutes-les-actualites/Stocker-4-pour-1000-de-carbone-dans-les-sols-francais