Reconnecting agriculture to food systems for global sustainability

the example of long term experimental crop rotations of AgricultureIsLife

De Clerck C., Dumont B., Beckers Y., Bodson B., Colinet G., Cornelis J.T., Dufrêne M., Monty A., Pierreux J., Bindelle J.
Pression démographique sur la planète

LA BOMBE HUMAINE

Octobre-novembre 2019
Unmanaged natural ecosystems could provide food for 600 million people.
The other 7 billion CANNOT be sustained without agriculture
Through History, mankind has developed a wide variety of food systems.
Nowadays, food systems are increasingly converging toward the agro-industrial model.


Colonna et al., 2013 https://doi.org/10.1017/CBO9781139567688
Our diets are not environment-neutral

- Agriculture uses 40% of ice-free land, of which ¾ are used for livestock only
- Agriculture, forestry and other land use are responsible for 23% of anthropogenic GHG
- Agriculture holds the largest share of global methane and nitrous oxide emissions
- Agriculture is the largest driver of biodiversity loss
The world is not enough

Agriculture is almost already at its maximal expansion
How can we start walking on the dotted path?

(Barnovsky et al., 2012. Nature)
Need to reduce the gap between dietary patterns and health boundaries

Eat-Lancet Commission, 2019
Urgent need to (re)-connect healthy diets with sustainable agricultural systems
Considering societal claims

Mainly on livestock and pesticides
Suicides chez les agriculteurs : des chiffres qui font froid dans le dos

Sur le plateau du 12/13, Anne-Claire Le Sann détaille les chiffres alarmants et croissants du suicide chez les agriculteurs.

Les chiffres des suicides chez les agriculteurs sont alarmants et la réalité est encore plus sinistre pour une profession frappée par la solitude des exploitants, les conditions de vie difficiles, mais aussi les difficultés financières récurrentes. "Ce serait plus de deux suicidés par jour, selon les chiffres de la Mutualité sociale agricole parus cet été. Elle évoque 605 suicides chez agriculteurs, exploitants et salariés", appuie en plateau Anne-Claire Le Sann.
Not forgetting social justice
Questions for AgricultureIsLife?

Can we design cropping systems for the silty region of Hesbaye (Belgium) that
1. supply sustainable food systems
2. with and without animals
3. relocalizing agriculture?

Can we effectively manage these systems over time while getting rid of pesticides?
What pieces do we have to start with and solve this puzzle?

• People
• Crops
• Livestock
Food in the Anthropocene: the EAT-Lancet Commission on healthy diets from sustainable food systems


Published Online: October 10, 2018
https://www.thelancet.com/journals/lancet/article/PII/S0140-6736(18)32942-6/fulltext
This online publication has been updated to include corrections. Please see Author contributions.

EAT-Lancet Commission on Healthy Diets from Sustainable Food Systems

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Jensen, and 29 co-authoring organisations.

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Jensen, and 29 co-authoring organisations.
Agronomical constraints

- 3 to 8 years
- Maximization of intercrops
- Intercrops possible only before crops that are sowed in spring
- Periodicity of legumes >= 3 years
- Alternance of botanical families:
  - Solanaceae/Brassicaceae/Amaranthaceae,/Cannabaceae, Fabaceae
  - except for Poaceae
- No constraints on fertility
<table>
<thead>
<tr>
<th>Year</th>
<th>Crop 1</th>
<th>Crop 2</th>
<th>Crop 3</th>
<th>Crop 4</th>
<th>Crop 5</th>
<th>Crop 6</th>
<th>Crop 7</th>
<th>Crop 8</th>
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<tbody>
<tr>
<td>1</td>
<td>Potatoes</td>
<td>Sugarbeets</td>
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</table>

**Crop List:**
- Silage
- Cereal
- Sugarbeets
- Potatoes
- Grassland Temp.
- Hemp
- Sugarbeets
- Winter wheat
- Winter barley
- Winter
- Spring Pea
- W.wheat
- W.pea
- Pea/Faba bean
- W.wheat + W.pea
- W.wheat + W.wheat
- W.wheat + W.pea
- W.wheat + W.wheat
- W.wheat + W.pea
- W.wheat + W.pea
- W.wheat + W.pea
Connecting diets to cropping system

Livestock concentrate diets composition
Livestock production cycle, forage and concentrate requirements & yields
Crop rotation & yields

<table>
<thead>
<tr>
<th>Wholegrains*</th>
<th>Macronutrient intake (possible range), g/day</th>
<th>Caloric intake, kcal/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rice, wheat, corn, and other</td>
<td>232 (total gains 0-60% of energy)</td>
<td>811</td>
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<tr>
<td>Tubers or starchy vegetables</td>
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<tr>
<td>Potatoes and cassava</td>
<td>50 (0-100)</td>
<td>35</td>
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<tr>
<td>Vegetables</td>
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<td>All vegetables</td>
<td>300 (200-500)</td>
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<td>Dark green vegetables</td>
<td>100</td>
<td>23</td>
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<tr>
<td>Red and orange vegetables</td>
<td>100</td>
<td>30</td>
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<td>Other vegetables</td>
<td>100</td>
<td>35</td>
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<td>Fruits</td>
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<td>All fruit</td>
<td>126</td>
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<td>Dairy foods</td>
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<td>Whole milk or derivative equivalents</td>
<td>250 (0-500)</td>
<td>153</td>
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</table>

Protein sources:
- Beef and lamb: 7 (0-14) g
- Pork: 7 (0-14) g
- Chicken and other poultry: 20 (0-45) g
- Eggs: 13 (0-25) g
- Fish: 20 (0-10) g

Legumes: Dry beans, lentils, and peas - 50 (0-100) g

Seeds: Soy beans, peanuts, and tree nuts - 25 (0-50) g

Added fats: Palm oil - 6 (0-40) g

Unsaturated oil - 40 (0-20 g)

Dairy fats (included in milk) - 0

Lard (tallow) - 0

Added sugars: All sweeteners - 31 (0-230) g

Table 4. Composition (g/kg DM) of some example concentrate feeds

<table>
<thead>
<tr>
<th>Dairy cows</th>
<th>Beef cattle and sheep</th>
<th>Pig</th>
<th>Broiler chickens</th>
<th>Laying hens</th>
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</thead>
</table>

Statbel, 2018

Willett et al., 2019
https://doi.org/10.1016/S0140-6736(18)31788-4

Wilkinson, 2011
https://doi.org/10.1017/S175173111100005X
Optimization of the total biomass use efficiency of each rotation

• To feed 25 people per ha eating the diet suggested by the EAT-Lancet commission

• Objective
  • Minimization of the excess (possible exports) and deficits (required imports) of food and feed commodities
Some first observations

- Shorter rotations are “wasting” more biomass
- But huge diversity for a same duration

![Graph showing absolute difference between DM produced and used to feed 25 people per ha](graph.png)
Excess and deficit in commodities

- Rice, wheat, corn, and others
- Potatoes and cassava
- Dry beans, lentils and peas
- Unsaturated oils
- All sweeteners
- Cereal by-products
- Oilseed-meals
- Other by-products
- Forage

Kg DM/ha vs Rotation number
Longer rotations address the recommendations to reduce animal-based foods better.
Going vegan?

Graph showing the lack or excess in commodities between a non-vegan diet and a vegan diet. The vegan diet includes more rice, wheat, corn, and other foods; less red and orange vegetables; and less from dry beans, lentils, and peas. The non-vegan diet includes more red meat and dairy products.
Not all crop products are edible
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33
BAU- open agricultural system for an open feed and food system
Livestock-banning food system re-localizing agriculture
Food system re-localizing agriculture, using livestock as agroecological lever in the rotation
Are all these systems manageable and stable without pesticides?

Tracy et al., 2018 10.2135/cropsci2017.05.0317
Implementation on a 30-ha zone with a bunch of agroecological practices to support production

**Within the design of the rotations**
- Long term crop rotations
- Intercropping
- Mixed crops
- Temporary (grazed) pastures

**Applying specific practices**
- Reduced tillage
- Green manure
- Nutrients cycling through crops and animal components

**Implementing specific infrastructures**
- Agroforestry
- Flower strips
Conclusions

- Designing crop rotations for Wallonia based on the EAT Lancet dietary requirements, it seems feasible (on paper) to sustain the whole population with locally produced food.
- But...
  - Crop rotations should be refined and diversified to include potatoes and more oilseeds.
  - Only long-term monitoring will determine whether agroecological levers can efficiently manage weeds, pests, and fertility.
  - Stability of such systems need to be demonstrated.
  - Other food commodities must be produced elsewhere, e.g., fruits, vegetables, and fish.
  - The health claims of the EAT-Lancet commissions are debatable.
L’agriculture, c’est la base de la culture

Maurice Béjart