How to design healthy and sustainable Food Systems?
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How to design healthy and sustainable Food Systems?

Monique A.V. Axelos and Hugo de Vries
Inra, scientific direction, France
Content

- Where are we?
- What do we need?
- What is a food system?
- What does it mean for food?
- And for food science and technology > radical innovations?
- Examples of potential solutions?
- A need for a food systems approach?
Where are we?

• An enormous challenge!

Earth overshoot day 2019 is July 29!
And yet in some alarming zones

The nine Planetary Boundaries - 2015

https://www.stockholmresilience.org/research/planetary-boundaries/about-the-research.html
And other major challenges?

*Exponential curves*

We are not heading towards a sustainable way of life

http://www.worldometers.info/
Challenge of climate changes:

**Boreal region**
- Increase in heavy precipitation events and river flows
- Increasing potential for forest growth but risks of forest pests and forest fires

**Continental region**
- Increase in heat extremes
- Decrease in summer precipitation
- Increasing risks of river floods
- Increasing risk of forest fires

**Atlantic region**:
- Increasing risk of heavy precipitation, river and coastal flooding,

**Mediterranean region**
- Large increase in heat extremes
- Increasing risk of drought and forest fires
- Decrease in crop yields, in precipitation
- Increased competition between different water users
- Increasing risks for livestock production
- High vulnerability to spillover effects of climate change from outside Europe

**Mountain region**
- Upward shift of plant and animal species
- High risk of extinction species
- Increasing risks of forest pests

Source: Marion Guillou, president of Agreenium
Challenges for Food:

Food systems emissions: 20-30% of total GHG emissions

Agriculture: the largest contributor of non-CO2 GHGs

30% by weight of all food produced is lost in the food supply chain!

- In low income countries: storage - transport and processing levels
- High-income countries: retail and consumer levels

57% of calories are not consumed
Challenge of malnutrition

Poor diets are associated with considerable health burdens and public expenditure in European countries.

- Overweight and Obesity
- Chronic diseases
- Lack of micronutrients

Source: OECD Obesity Update 2012
What do we need?

A viable planet!, in terms of:

• Healthy inhabitants
• A viable environment
• A pleasant & respectful socio-economic context
• An aesthetic image

• There is no one simple recipe !!

→ Systemic approach from the soil to the plate and back
What is a food system?

A food system considers all the elements (environment, people, inputs, processes, infrastructures, institutions) and activities that relate to primary producing, processing, distributing, preparing and consuming food; and the socio-economic and environmental outcomes of these activities. (HLPE, 2014)

→ look in a more integrated way at biophysical flows (food) – economic and institutional setting and health, environmental and economic outcomes
Input, manufacturers:
Machines, feed, fertilizers, pesticides, medicine

Food companies:
Food processing, biorefining, other processing

Retail / food service

Consumers: final consumption and evaluation

Regulatory, institutional and social environment

Government

Finance

NGOs

Legend

Products

Actors in a food system
Food system research

Yellow boxes: Main food systems outcomes → link to indicators

Grey boxes: Actors → link to leverage points

Input, manufacturers: Machines, feed, fertilizers, pesticides, medicine

Food companies: food processing, biorefining, other processing

Retail / food service

Food availability / affordability, satisfaction

Farmers income / competitiveness / rural livelihoods

Farmers and fishermen: primary food & biomass production

Natural resource use / environmental impacts

Consumers: final consumption and evaluation

Nutrition / Health impacts

Food environment

Government
Finance
NGOs

Objectives for future proofing
Food system:
• Sustainable
• Competitive
• Resilient
• Inclusive
• Diverse
• Responsible

Interdependencies

Interactions

Legend

Products
Money, influence, or demand
A future proof system needs:

• Involving citizen in food systems strategies: Understanding their perceptions and motivations to facilitate the transition: Diets can be a leverage point to a healthy and sustainable food system...
• ...but only if its combined with action in other sectors,
• Including the orientation of production priorities, cutting food loss an waste, and protecting nature
• Including cultural aspects, gastronomy – food as an art of eating and producing well, and something that connects people together
What does it mean for food? > we need to redefine the limits

Vitality / ‘richness’

Non-vital planet earth: chaos

Non-vital planet earth: rigid, lock-in effect

Food-secure viable planet

Scenario 1

Scenario 2

Net effect?

Green-house effect
Bio- & Food- diversity loss
Population growth

Luxurious products/services

Primary needs

Poverty
Food insecurity
Insufficient arable land
No drinking water
Hazards (microbial, chemical)

2015
Time
2050
Despite these multiple threats, we have a lot of opportunities to adapt to change through innovations

1. Avoiding unnecessary exploitation of resources
2. Efficiently transforming and using agro-resources
3. Valorizing new co-products and waste streams and re-valorizing all biomass to avoid waste
Radical innovations needed in Food systems / ruptures (I)

1. **Avoiding unnecessary exploitation of resources**: towards **alternative consumption patterns**

- Eating low density – high satiety food,
- Using alternative protein sources to decrease meat consumption
- using the richness of nature’s structures (**biomimetics**),
- **Moving from** products towards services & de-materialization,
- ..
Radical innovations needed in Food technology / ruptures (II)

2. Efficiently transforming and using agro-resources:

- targeted processes (not over-dimensioned)
- process intensification,
- new ICT driven processes (virtual design, domotics, 3D printing, ...),
- eco-efficient dynamic storage,
- waterless systems,
- novel biomaterials & packaging concepts, etc.
Radical innovations needed in Food systems / ruptures (III)

3. Valorizing new co-products and waste streams and re-valorizing all biomass:
   ➢ eco-pyramid valorization,

![Diagram of biomass cascading]

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>Crop yield kg/ha (fresh)</th>
<th>Residues kg/ha/a</th>
<th>Fractions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>8000</td>
<td>11800</td>
<td>20</td>
</tr>
<tr>
<td>Rye</td>
<td>3800</td>
<td>4400</td>
<td>10</td>
</tr>
<tr>
<td>Corn</td>
<td>8180</td>
<td>8700</td>
<td>20</td>
</tr>
<tr>
<td>Sugar cane</td>
<td>68000-88000</td>
<td>24000-37000</td>
<td>20</td>
</tr>
<tr>
<td>Sugar beet</td>
<td>69500</td>
<td>4700</td>
<td>10</td>
</tr>
</tbody>
</table>

Sources: Poyry and Sanders

Food Science becomes more and more trans disciplinary
(management, economics, genetics,...)
Eco-efficiency as a driver

Ex. waterless system: dry fractionation

Abecassis et al., 2013...

WHY RUPTURE? .... Integral use of biomass, no water added during processing (thus no drying), local applicability, avoiding water transport, local employment
Globular whey proteins: playing with t-T-shearing

<table>
<thead>
<tr>
<th>Primary aggregates</th>
<th>Low branched aggregates</th>
<th>Fractal aggregates $d_f=2$</th>
<th>Fractal aggregates $d_f=2.2$</th>
<th>Globular dense aggregates</th>
<th>Globular porous aggregates</th>
</tr>
</thead>
<tbody>
<tr>
<td>80 °C</td>
<td>80 °C</td>
<td>120 °C</td>
<td></td>
<td></td>
<td>Eco-efficient process</td>
</tr>
<tr>
<td>Static conditions (24 h)</td>
<td>Dynamic conditions (160 s)</td>
<td>Building units: primary aggregates</td>
<td>Building units: native WPI</td>
<td>0.003 M</td>
<td>0.1 M</td>
</tr>
</tbody>
</table>

Globular whey proteins: playing with t-T-shearing

Eco-efficient process
Examples: Innovation from the field to the plate:

- Rupture: New type of agriculture
- Reduction of fertilizers
- Dry fractionation

% wheat/legumes

Nutritional advantages

Approval?

ref: INRA « Flexiprocess » project
M.H. Jeuffroy & C Michon
Anne-Flore Monnet
Examples: Innovation from the field to the plate:

Rupture: New type of agriculture

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French National strategy for protein transition
Ex. alternative proteins sources & products

Meat alternatives on basis of new plant, algae and insect protein sources

WHY RUPTURE? .... Substantial reduction of environmental pressure due to protein-conversion factors and greenhouse gas emissions (CH4, etc.), challenges with texture and nutritional profiles, ...
Why rupture? Adiabatic heating >> time for processing enormously reduced & No re-packing > treatment in the package itself

EU IP FP6 NovelQ: To develop and successfully demonstrate - eco-friendly - novel processing technologies (HPP, PEF, Plasma, microwave, radio frequency, ohmic heating and new packaging materials) for improved quality food and new products (fresh-like character, extended shelf-life)
WHY RUPTURE? .... Valorization of largely unused co-products (approx 50% of all biomass) and waste (plus replacing synthetic materials, potential benefits due to biodegradability, ...)

Ex. biodegradable packaging materials

FP7 European project, Gontard et al
Need for food systems approach

World food systems as *Intelligently Navigated Complex Adaptive Systems* (INCAS)
- Summary IFSET Special Issue 5, France, 2018
- De Vries, 2017
We need inspiration & creativity

Diversity interconnected

Thinking in spirals, not in circles

Changing the landscapes & melting zones

Creating ruptures
Many thanks for your attention

- Bioeconomy conference, Paris, 29 – 30 October 2019
- EFFoST Conference on sustainability & food, Rotterdam, The Netherlands, 12 – 14 November 2019

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