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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/plantary-boundaries/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
Food system research

Yellow boxes: Main food systems outcomes → link to indicators

Grey boxes: Actors → link to leverage points

Regulatory, institutional and social environment

Government

Finance

NGOs

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

Food companies:
food processing, biorefining, other processing

Retail / food service

Consumers: final consumption and evaluation

Farmers income / competitiveness / rural livelihoods

Farmers and fishermen: primary food & biomass production

Natural resource use / environmental impacts

Nutrition / Health impacts

Food availability / affordability, satisfaction

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

Legend

Products

Money, influence, or demand

Interdependencies

Interactions

Local food – direct sales
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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’

Food-secure viable planet

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

Non-vital planet earth: chaos

Scenario 1

Scenario 2

Net effect?

Time

2015 2050

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)
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 showing biomass cascading and value]

   *Sources: Poyry and Sanders*

**Food Science becomes more and more trans disciplinary**

*(management, economics, genetics,...)*
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

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<th>Low branched aggregates</th>
<th>Fractal aggregates $d_r=2$</th>
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<td>Dynamic conditions (160 s)</td>
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<td>Building units: native WPI</td>
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<td>0.1 M</td>
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</tbody>
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- **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
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French National strategy for protein transition

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, ...

Example: BBI Green Protein Project;
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, ...)

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*

  [Email addresses provided]

[INRA logo]