Designing sustainable production systems at
the interface between agricultural systems
and food systems

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Outline

1. Agricultural Systems are worth to consider to work on Food Systems.

2. Innovation in Food Systems can be a major driver of innovation in Agricultural Systems

3. Diversity as a driver of sustainability of Agri-Food Systems.

4. Conclusion: a plee for integrated analysis, assessment and design
1. Agricultural Systems are worth to consider to work on food systems

(adapted from Meynard et al., 2015. FSD5 )
Food production is only one challenge for AS
Agricultural Systems (AS)

- **Complex systems** based on plant and/or animal production.

- Increasingly **Multifunctionals** (provision of ecosystems services in a trade-off with production)

- Intrinsically **controlled systems** (a pilot at farm level) → combine three sub-systems (Le gal et al., 2010)
  - Biophysical (process-based operating system)
  - Technical (technique-based managed system)
  - Decisional (human-based decision system)

- **Sustainability** and **innovation** can only **emerge** from the combination of these three domains

(Wery et al., 2015. FSD5 ; http://fsd5.european-agronomy.org/video/FSD/index.html)
Agricultural Systems can be analysed at various levels

Scale
- Global
- Region
- Farm
- Field
- m²

Biophysical
- Environment

Technical
- Economy

Decisional
- Social

Agricultural Systems Domain

Sustainability Domain

Socio-ecosystem
- Foodshed
- Farm System
- Activity
- Cropping System
- Landscape
- Watershed

(Wery et al., 2015. FSD5)
The concept of Activity in a farm

- A technical sub-system or component using
  - farm resources (land, labour, money),
  - inputs (fertilizers, pesticides, energy…)
  - Natural resources (land, water, biodiversity…)

- To provision a service to the system
  - money from direct selling (e.g. Wheat grain)
  - resource to an other activity (e.g. Forage from cropping system provided to the animal sub-system)
  - Money from non productive services
    - On farm tourism
    - Environmental Services (C sequestration)
    - Off farm work

- To provision a service (or dis-service) to another system
  - Watertable
  - Landscape
  - Biodiversity

(Wery et al., 2015. FSD5)
Input and Output of an Activity

Input → Activity → Output (in and off farm)

- Pasta - Industry
- Animals
- Energy
- Soil (fertility, C sequestration)
- Nitrate Leached

Input:
- Person with wheelbarrow
- Fertilizer
- Fuel

Activity:
- Wheat

Output:
- Pasta Industry
- Animals
- Energy
- Soil (fertility, C sequestration)
- Nitrate Leached
A dual-purpose activity (supply chain and watershed)

Vignoble de la Voie d'Héraclès
A multifunctionnal Farm Systems based on four activities

Activity

- Groundwater
- Wildlife Conservation
- Safe foods
- Social cohesion

Service

Triple M Ranch: http://www.albafarmers.org/farms.html
Food production may not be the major driver of the system

Valensole Plateau - South East France (mediterranean)
2. Innovation in Food System can be a major driver of innovation in Agricultural Systems
Ex. 1: The food legumes paradox

- « marvelous » crops
- Good for our health
- Marginal in our meals and in our cropping systems
- Traditionnal countries (e.g. North Africa) import food legumes with a tendency to cereal monoculture

→ A lock-in in the Agri-Food System
Pasta with legumes could create a breakthrough in cropping systems

> 13% proteins

Three actions of chickpea to reduce N fertilizers
Ex. 2: When food systems « lock in » the agroecological transition
Pesticides can be reduced but not suppressed

One of the lock-in is in your hand!

(Virginie Barrière, 2015. Thèse INRA PSH Avignon)
The second is in your pocket

<table>
<thead>
<tr>
<th>CPS</th>
<th>Gross yield (t.ha⁻¹)</th>
<th>Marketable lettuces (%)</th>
<th>Marketable yield (t.ha⁻¹)</th>
<th>Residue Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional</td>
<td>51.5 (±15.2)</td>
<td>71.4 (±28.5)</td>
<td>36.3 (±6.7)</td>
<td>3.50 (±1.1) b</td>
</tr>
<tr>
<td>Intermediate</td>
<td>47.9 (±13.7)</td>
<td>82.9 (±24.2)</td>
<td>39.9 (±6.3)</td>
<td>4.83 (±0.8) a</td>
</tr>
<tr>
<td>Low-input</td>
<td>45.8 (±11.0)</td>
<td>78.3 (±10.1)</td>
<td>36.0 (±10.7)</td>
<td>2.50 (±1.4) b</td>
</tr>
<tr>
<td>P-value</td>
<td>0.9599</td>
<td>0.3212</td>
<td>0.7378</td>
<td>&lt; 0.05</td>
</tr>
</tbody>
</table>

Same profit $\rightarrow +13\%$ for Intermediate and $+10\%$ for low input.

Are you willing to pay for it?

(Barrière et al., 2015)
The innovation?
3. Diversity as a driver of sustainability of Agri-Food Systems

- **Plant diversity** (including trees) in the field (in time and space), in the farm and in the landscape
- **Activity diversity** in farm and in a region (including plant and animal combinations)
- **Farm diversity** in a region
The three pillars of sustainable agriculture

« Crop » the plant diversity

Soil and Organic Matter at the core of the Agrosystem

« Engineer » the trade-offs between Productivity and Input efficiency
« Crop » plant diversity (the example of vineyard)

Intercropping « service plants »

Rotation with food crops

Field Level

Limite/suppres pesticides

Compatibility ?

Combination with crops and trees

Farm Level
Economic and work efficiency has (an will) drive(n) simplification

A company producing and selling a 1000 ha of melon

60 family farms producing 50 ha of Durum Wheat for a cooperative

Monocropping  Economic Efficiency
Farm diversification driven by local organic market
(Ferme en coton, Gers, France)

Chicken production

Pig production

Direct selling

Social activity

Crops for feed
Can we feed our cities with permaculture?

- Risk of bias in the calculation?
- Limits in the extrapolation to the whole country?
- New circularities and solidarities?
Design new systems combining international markets, specialized farms and plant diversity in the field?

- 3000 ha
- 1000 ha
- 4000 ha of land
- 3 years
- 60 family farms
- 1 year
- 1 cooperative
- 1 company
8T/ha of rice without any fertilizer and pesticides!
When sustainability upscale the problem

Conv.

Organic

Year 1

Year 2

Year 3

Year 4

Impacts at farm level? At regional level? Solutions to unlock the system?

→ A need for Integrated Assessment of Agricultural Systems
(Delmotte et al., 2016; Agricultural Systems)
Which priority in input reduction?
4. Conclusion: a plee for integrated analysis, assessment and design of Agricultural Systems (IAAS)

« Farm-centered » Multi-scale and multidomain system’s analysis
(adapted from van Ittersum et al., 2008. Agricultural Systems)

http://fsd5.european-agronomy.org/
Food Systems can drive innovation if Agricultural Systems are properly considered.
Combining field/farm data and modelling

Meta-models for scenario analysis

Durum Wheat in Syria

Knowledge on Processes

(Ben Zekri et al., submitted)
To Design Agricultural Systems, Food Systems and Policies in a « contextualized » Nexus

Food Production

Nitrogen

Land Use

Climate and Society

Water

- Wheat monoculture
- 4 years rotation with chickpea

(Ben Zekri et al., 2016)
With Mediterranean students and institutions