Combining Life Cycle Assessment and Linear Programming to explore sustainable farming regions

Ivonne Acosta-Alba, S. Lopéz-Ridaura, H. van der Werf.

INRA - Soil, Agro and hydroSystem (Rennes) and Innovation (Montpellier)

LCA food 2010, Bari September 24th 2010



Brittany... Breizh





- Climate: Temperate Oceanic
- Mean temperatures: 18 °C max., 5.8 °C min.
- Annual rainfall: 700 mm



FRENCH NATIONAL INSTITUTE FOR AGRONOMIC RESEARCH

Brittany... environmental concerns



- Region with greatest livestock production in France
- Largest producer of milk ≈5 billion liters in 2009 (21% of total)

 Several environmental concerns attributed to the agricultural sector, which is considered NOT SUSTAINABLE





- Tool for environmental decision making (guide systems towards sustainability)
- Include social and economic indicators (Highlight trade-offs between indicators)
- Explore scenarios of sustainable agriculture at a regional level
- Associate complementary production modes and other land uses



MGLP: Multi Goal Linear Programming

• Basic structure : linear programming model

(Lopéz-Ridaura *et al.*(2005); van Ittersum *et al.*(1998)

• **Optimization** model simulates scenarios satisfying more than 1 goal at the same time with the constraints set

 Allocate limited resources between several land use activities → Generate land occupation scenarios



MGLP: generating land occupation scenarios

Land occupation activities



Total area: optimized function → new land occupation



FRENCH NATIONAL INSTITUTE FOR AGRONOMIC RESEARCH

LCA Food 2010



LP is *"a powerful mathematical technique to be used as a tool in LCA"* Azapagic and Clift (1998)





Land occupation activities

Current
activities

(today scenario)

Dairy farms types	% of regional milk production area		
1.Organic (Org)	1.7		
2. Extensive (Ext)	11		
3. Large Semi Intensive (LSI)	24		
4. Semi-intensive (SI)	35		
5. Intensive (Int)	28		

Alternative activities

6. Exclusively Grass based dairy system (GB)	0.3
--	-----

Total	100

FRENCH NATIONAL INSTITUTE FOR

AGRONOMIC RESEARCH

LCA Food 2010

Indicators and variables



Indicators and variables: technical coefficients

	ΟΑ	GhG	NO ₃	ENR	Milk	MB
	ha	t CO ₂ eq	kg	GJ	t	Keuros
Int	0,2	7,4	67	24	5.7	1,9
SI	0,1	6,1	73	18	4,4	1,6
LSI	0,1	6,9	82	19	5,1	1,8
Ext	0,2	8,3	68	26	6,9	2,2
Org	0,1	5,3	39	12	4,0	1,4

<u>Constraints</u>: policy and regulations

Scenario for Brittany (2020)

- Reduce current GhG emissions by 20 % (EC)
- Reduce non renewable energy use by 20% (EC)
- Limit nitrate concentration in water to 25 mgl⁻¹ (EC)*

*(EC) European commitment

Maximize Milk production respecting these constraints

LCA Food 2010





LCA Food 2010



Today: baseline scenario



LCA Food 2010

2020 scenarios (1/2)

2020: GhG -20%; EU -20 %; NO₃ 25mg/l



FRENCH NATIONAL INSTITUTE FOR AGRONOMIC RESEARCH





2020: GhG -20%; EU -20 %; NO₃ 25mg/l

FRENCH NATIONAL INSTITUTE FOR AGRONOMIC RESEARCH

LCA Food 2010



FRENCH NATIONAL INSTITUTE FOR AGRONOMIC RESEARCH





2020: GhG -20%; EU -20 %; NO₃ 25mg/l

FRENCH NATIONAL INSTITUTE FOR AGRONOMIC RESEARCH

LCA Food 2010

Trade-offs and scenarios (3/3)



LCA Food 2010

Conclusions



- Combining LCA and MGLP can support a environmentally conscious decision making process
- MGLP highlights trade-offs between indicators (environmental, economic and social)
- Scaling LCA results to a regional scheme provides a wider vision of possibilities to stakeholders

LCA Food 2010







- Integrate other agricultural production systems and non-agricultural land uses
- Use food consumption patterns as constraints of production
- Environmental sustainability enlarged to include social and economic sustainability



LCA INRA - Rennes



FRENCH NATIONAL INSTITUTE FOR AGRONOMIC RESEARCH



