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Modelling Life Cycle Inventories for Crop Production in Japan: Development of the NARO LCI database

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Motivation

- Increased attention to LCA in Japan
 - Policy support for sustainable and organic agriculture
 - Government policy about carbon footprint
- Lack of LCI database
 - Rough emission factors for background processes
 - IO tables
- The lack means ...
 - Limited application
 - Imprecise assessment

Purpose

- To illustrate how we developed LCI database
 - NARO LCI Database
 - Suitable to Japanese agriculture
 - No use of emission factors from IO tables
 - Background processes for agricultural production systems have to be modeled.
 - Connectable to LCI database for other countries
- To compare with the earlier methods and data to clarify the characteristics and usefulness

Contents

- Methods
- Structure of the database
- Comparisons for validating the database
 - Japanese Input-Output Tables
 - European background data
 - Foreign crop inventories
- Concluding remarks

Methods

- Modularization
 - Every related unit process has to be modeled.
 - All background processes have to be included.
- How to be original and how to "Japanize"
 - Development of original unit process data
 - Field experiments and surveys
 - Farm records prepared by extension services
 - Literature surveys
 - Specifications for buildings and machines
 - Adaptation of ecoinvent unit processes
 - Use of JLCA database for industrial products

Methods





- Agricultural crops
 - Paddy rice (conventional and organic)
 - Soybeans (conventional and organic)
 - Sugar beets (for food and energy)
 - Potatoes (for food and energy)
 - Sorghum (for food and energy)
 - Sweet potatoes (for food and energy)
 - Sugarcane (for food and energy)
 - ..
- Seeds and seedlings
 - Specialized inventories were prepared for rice, soybean, sugar beet, ...

- Fertilizers and pesticides
 - Major inorganic fertilizers and pesticides
 - Commercial organic fertilizers for JAS organic certification
 - Compost
 - Multifunctional compost
 - Ingredient-adjusted compost
- Work processes
 - Tillage, fertilizer application, pesticide application, harvesting, transport, ...
 - The production of agricultural machinery is referenced from the work processes.

- Infrastructure
 - Capital goods are included in the inventories because of their environmental relevance in impact assessment.
 - Survey data (e.g., specifications of machines)
 - Adaptation of ecoinvent data
- Direct field emissions
 - The national GHG inventory
 - Simple material balances
 - Nutrient flows from paddy fields
 - Crop-soil simulation models
 - SOILN-jpn

Improvement of agricultural practices An example for Comparison 1 and 2

Crop	Conventional	Improved
Sugar beet	Raising seedling Less pest resistance	Direct planting, Reduced ploughing Pest-resistant variety
Potato	Earthing up Less pest resistance	Sparse planting, Half earthing up Pest-resistant variety
Sorghum	Normal cultivation	Low-input cultivation
Sweet potato	Raising seedling	Preparation, Direct planting with ridging and mulching, Improving the variety
Sugarcane	Ratooning twice Variety for sugar production	Ratooning five times High-biomass variety

An example assessment Ecological Scarcity Japan (tentative)



- Impact assessment has also to be adapted to the region.
- Impact assessment should be exhaustive.
- GWP is used in the following two examples as an illustrative purpose.

Comparison 1 Results (NARO LCI) \Leftrightarrow Results (emission factors from IO)

Sugar beet, conventional NARO LCI 3EID 1.0 1.5 2.0 t CO₂ eq./kl 0.0 0.5 GWP

Potato, conventional Sorghum, conventional Sweet potato, conventional Sugar cane, conventional

Sugar beet, improved Potato, improved Sorghum, improved Sweet potato, improved Sugar cane, improved

Comparison 2

Results (JP Background data) \Leftrightarrow Results (EUR Background data)



Comparison 3 Possibility of international comparisons



Soybean production

Discussion

"Comparability" in comparative LCA

- Beyond simple comparison
 - Many comparisons become possible by developing LCI databases.
 - The comparisons should be useful for decision making.
- Confusions in previous examples
 - Greenhouse tomato x Field tomato (Japan)
 - Japan should import tomato?
 - Wheat x Rice (Global) "How Bad Are Bananas?"
 - Japan should stop rice cultivation?
- The key is the definition of criteria and alternatives
 - Criteria
 - Cautious about carbon footprint
 - Alternatives (scenarios, strategies)
 - Reality of the scenario
 - Does the land actually exist?
 - Relevance of alternatives
 - Rice and wheat are not necessarily competitive.
 - − Rice (paddy) \rightarrow wheat (upland) \rightarrow soybean (upland)

Concluding remarks

Whether to develop LCI is a decision problem.

- Whether to develop LCI?
 - Pros
 - Hierarchical detection of environmental hotspots
 - Detailed and precise comparisons
 - ...
 - Cons
 - Many human resources and costs
 - ...
 - Language is a matter.
- "Accumulation effect"
 - Accumulation of the database will induce the new development.
 - Agricultural LCI databases may be public resources.
 - International collaboration will accelerate the development.

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