SUSTANABILITY AND ORGANIC LIVESTOCK - MODEL (SOL-M)

Concept Note

Natural Resources Management and Environment Department
Food and Agriculture Organization of the United Nations
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Background

Food insecurity, climate change and biodiversity loss belong to the grand challenges for sustainable development of mankind (Rockström *et al.*, 2009). In particular, livestock production systems contribute to many environmental problems (Steinfeld, 2006) and extensive and grassland-based livestock systems negatively affect climate change (Gerber, 2010). Such critical judgments of livestock production is attributed to life-cycle perspectives that focus on environmental impacts per unit of produce (e.g. t CO_2eq/kg milk). Such an approach provides important information on livestock production systems, but neglects relevant drivers for environmental change at global scale, such as limited availability of arable land compared to grassland, and other aspects of importance for an encompassing sustainability assessment of food systems, such as market interactions, malnutrition or food waste.

Organic and primarily grassland-based livestock production systems could actually deliver a promising contribution for a globally sustainable food production due to: (i) their multiple beneficial environmental impacts and ability to conserve natural resources (Mäder *et al.*, 2002; Stolze *et al.*, 2000); (ii) potential for improving productivity and profitability of farming activities in developing countries as compared to traditional systems (Badgley *et al.*, 2007; Bolwig und Gibbon, 2009; UNCTAD, 2009); and (iii) ability to contribute to sustainable rural livelihoods as they generate higher product prices (Krystallis und Chryssohoidis, 2005; Nemes, 2009).

The assumption of organic livestock production could have an interesting role in addressing sustainable development challenges, however, needs to be clarified with regards trade-offs and synergies between food security, climate change, biodiversity, natural resource use and socio-economic drivers and effects. Considering that global assessments are still lacking to adequately grasp the specific characteristics and potentials of organic production systems, arguments pro or against organic livestock production are often made, without the full range of facts at hand.

Objectives

This SOL-m project of the Natural Resources Management and Environment Department of FAO aims at closing this research gap. It builds up a model, which is capable to illustrate the potential impacts of a global conversion of livestock to organic management on food availability, climate change mitigation, biodiversity and the use of natural resources (water, non-renewable energy, fertile land, nutrients). In addition, it addresses socio-economic effects, such as impacts on labor requirements. Furthermore, this project uses this model for analyzing a range of future global and regional scenarios of organic agricultural production in order to analyze their consequences on food security and the environment.

In order to efficiently build the SOL-model and to ease comparability of results with the results of existing models, the project will build on and seek linkages to relevant existing projects, data sources and assumptions as far as possible, both within and outside FAO.

Thus, the main objectives of the project are:

- To model the potential impact of up-scaling organic livestock production globally on food availability, greenhouse gas emissions, biodiversity loss, resource use (i.e. land, water, non-renewable energy) and socio-economic wellbeing (e.g. labor);
- To study the macro-environmental and economic trade-offs and synergies resulting from global conversion to organic livestock management;
- To clarify the potential role of organic livestock systems within global food production in addressing global sustainability challenges.

Modeling approach

In order to address the above-mentioned objectives, a comprehensive land use model is under development. The Sustainability and Organic Livestock Model (SOL-Model) is especially designed for an integrated analysis of environmental and socio-economic aspects and their inter-linkages. Thus, both food availability and environmental impacts of food production at country, regional and global scale can be modeled. The model is structured into a food supply, food demand and food balance module (see Figure).

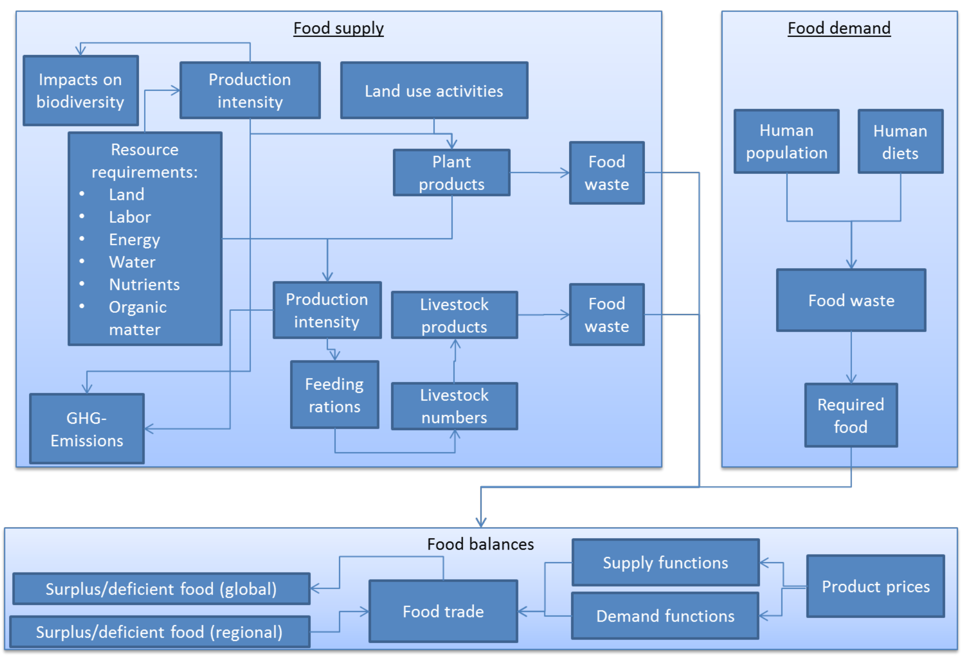

Figure: Overview of the SOL-Model

The **Food Supply Module** calculates food production and utilization at country level based on crop, land use and livestock activities. These activities are subdivided in intensity classes (i.e. extensive, medium, intensive) and/or farming systems (i.e. certified organic, non-certified organic, conventional systems). The activities and intensities are characterized by different input requirements (i.e. energy, water, land, feedstuffs, labor and nutrients) and outputs (i.e. edible products, feed and foodstuffs, greenhouse gas emissions, nutrient surpluses and biodiversity impacts). The model is thus able to address the specific aspects of organic production, such as grassland-based livestock systems with low concentrate feed levels, the importance of mixed farming systems, where manure plays an important role as fertilizer, and closed nutrient cycles with use of crop residues and biomass waste as fertilizers. The last point is of particular relevance in the context of scenarios with strongly increasing bioenergy use. Outputs such as agricultural raw products are transferred to nutritional units, considering losses in supply chains due to waste and food processing. Linkages between plant production activities and the livestock sector are covered by a feed balance within the supply module. Environmental impacts are derived from the aggregated inputs, natural resource uses and emissions due to agricultural activities.

The **Food Demand Module** estimates country-level food supply according to population numbers and nutrition requirements. Nutrition requirements are expressed as dry matter, energy and protein quantities for human digestion. Furthermore, waste factors are included in order to account for food waste in households. Population numbers and nutrient requirements are varied in different scenarios according to official forecasts, e.g. for 2012, 2030, and 2050. Furthermore, specific food choices can be formulated in the SOL-Model, for instance minimum shares of the protein stemming from vegetarian origin.

Finally, the **Food Balance Module** matches food supply and demand. It calculates the surplus/gap in dry matter, energy and proteins that theoretically exists at country, regional and global level. Based on the surplus or gap in each country or region, regional and global commodity flows for balancing food supply are suggested by the model. In a second development stage, this trade module will take into account economic considerations of consumers and producers, based on product prices and estimated demand and supply elasticities. This will capture the dynamic that rising or falling prices have on resource efficiency, waste shares and consumption patterns.

Data sources and classifications used

A major challenge of the project is to compile and harmonize the large set of different data sources to a common database for the analysis with the SOL-Model. Country classifications are based on FAOSTAT and the United Nations Statistical Division. Land use activities are subdivided into crops (arable, permanent), grassland and pastures (temporary, permanent) and livestock activities. Inputs and outputs of each activity are based on FAOSTAT and other FAO datasets where possible. Further necessary assumptions are built on scientific and grey literature (e.g. Bouwman *et al.*, 2005; Erb *et al.*, 2007; Erb *et al.*, 2009; Krausmann *et al.*, 2008; Kruska *et al.*, 2003; Mekonnen und Hoekstra, 2010; Schader, 2009) and datasets (e.g. Sere and Steinfeld 1996, Global Landcover Classification System, Gridded Livestock of the World, Land Degradation Assessment for Drylands). Land use, as well as input and output data, on organic activities is based on the most accepted and recent scientific publications and databases (e.g. Badgley *et al.*, 2007; Mäder *et al.*, 2002; Willer *et al.*, 2011).

Modeling environmental impacts

Environmental impacts are captured by the following indicators: GHG-emissions, eutrophication, pesticide use, water use and biodiversity. Non-renewable energy use and GHG emissions will be based on IPCC methodology of different tiers, ecoinvent and other life cycle inventory data. N and P eutrophication potential will be estimated using country-specific input-output balances. Pesticide use will be modeled based on FAO pesticide statistics. Biodiversity will be based on estimating the most relevant drivers for biodiversity loss (MEA, 2005; TEEB, 2010), land use (deforestation pressure) and pollution (N and P eutrophication potential, pesticide use).

Software platform

The model is programmed and run using the General Algebraic Modeling System (GAMS). GAMS is nowadays the most frequently used software package for economic modeling. GAMS allows integrating and processing large amount of data in a transparent way. Furthermore, GAMS enables to quickly optimize large equation systems. This will allow optimizing land use in different scenarios.

Progress to date and work ahead

The project runs from August 2011 until December 2012. It is divided into four steps:

1. **Literature survey and expert consultations:** This step aims at identifying the state of the art knowledge, relevant models and datasets and establishing collaborations with the other modeling teams (June 2011 – August 2011).
2. **Design of the modeling framework:** This step provides the blueprint for the model to be set up in Step 3. The framework is designed considering existing models and datasets (September 2011- October 2011).
3. **Elaboration and testing of the SOL-Model include:** collection of the relevant datasets are integration into the model; writing the model programming code; and testing the model and the plausibility of the results, with the support of external experts (November 2011 – August 2012).
4. **Assessments applying the SOL-Model:** The model scenarios with respect to the objectives formulated above are calculated and published (August 2012 – December 2012).

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