A food system approach for the identification of opportunities to increase resource use efficiency

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ABSTRACT

The UNEP International Resource Panel has the objective to evaluate the current and projected use of natural resources and as well as to identify opportunities for improvements, using a food systems approach. These opportunities will probably not only include more technical and process oriented opportunities as typically identified with a LCA-approach, but will also include opportunities as the consumption side as reducing food losses and dietary changes. The concept of 'food system' includes all processes and infrastructure involved in feeding a population in a certain region; the global food system is composed of many, partly connected, local and regional food systems. The notion that food systems actors as food processing companies and retailers not only influence the how and where food is being produced, but also people's eating habits and diets, is gaining momentum. Other than in the food chain concept, which perceives the different actors in a more neutral way, the food system concept acknowledges that the actors influence each other, within a certain political, technological, environmental, cultural and institutional setting. Food systems have environmental, socioeconomic and health outcomes, which can, for example in case of undesired outcomes, lead to changes in the context. Given the large differences in regional food systems, a number of global regions (as sub-Saharan Africa, South-East Asia and Europe) are studied in more detail, partly by means of expert workshops.

Keywords: food system, sustainability, resource efficiency

1. Introduction

To most people in the world, current food systems deliver ample and safe food on a day-to-day basis, which can be regarded as a great achievement. This is possible thanks to a large number of actors as farmers, fishermen, processors, retailers and restaurant, as well as to the distribution sector. These actors together make a the food system in a certain region: the concept includes all processes and infrastructure involved in feeding a population in a certain region. The global food system is composed of many, partly connected, local and regional food systems. Governments support the functioning of food systems, for example by regulation on food safety and by investments in the knowledge infrastructure. However, still more than 842 million people are undernourished (FAO 2013), while the same time many people suffer from obesity and other food-related diseases mainly due to unhealthy eating habits. At the same time, food systems are a major user of natural resources, such as land, water and minerals (nutrients) (Foley et al. 2005; Molden 2007), as well as a major source of emissions (as greenhouse gases, pesticides and nutrients) (Bouwman et al. 2009; FAO 2006; Vermeulen et al. 2012). As a consequence of this, food systems are the main driver of global loss of biodiversity (PBL 2010). Due to growing population, increased welfare and urbanization, the environmental impacts are expected to increase. Due to the same drivers, vast changes in food systems are expected, such as supermarketization in developing countries (Reardon et al. 2012). Supermarketization not only affects the supply chain, but very often eating habits and product sourcing as well.

Life cycle assessments (LCA) are widely used to improve processes, support policy decisions and provide a sound basis for informed decisions. LCA can point at technical options to improve production processes and can provide objective and balanced information to compare different production techniques (for example organic versus conventional farming) and different products (for example beef versus poultry meat). Over the last several decades the scope of LCAs has been extended from more traditional subjects such as the use of energy and minerals to more complicated issues including greenhouse gas (GHG) emissions (de Vries and de Boer 2010), land use (Koellner et al. 2013; Mila i Canals et al. 2007); and even social issues as human well-being (Weidema 2006). LCAs of food products are usually quite complex for a number of reasons, but not limited to,:

(i) food production has a large number of environmental effects, including energy, land and water use, use and losses of plant nutrients (N, P and about 15 others), pesticides, GHG; (ii) the generation of co- products and by-products by agri-food production processes; (iii) the site specificity of agricultural production; (iv) the difficulty of defining the functional unit, especially when comparing different types of food, as for example calories or proteins do not cover all nutritional aspects and (v) the various social, cultural and economic aspects of agriculture and food. Thus, in spite of the many efforts to develop LCA for food systems (see e.g. Cowell 1998; Milà i Canals 2003; Brandão 2012), LCAs have been criticized for not being inclusive or complete enough, or for having a too "hard" structure biophysical focus not capable of capturing the wider socio-economic context or "soft" power relationships in value chains (Garnett 2013; Sim 2006). LCAs provide a system for systematically quantifying the relative costs of production for different products and production systems, and for analyzing the contributing factors.

To overcome a number (but certainly not all) of the issues the concept of 'food systems' might be helpful both in identifying opportunities to increase (overall) resource efficiency of food systems as well as to identify food system actors who could facilitate in taking advantage of these opportunities. This food system approach should not be seen as an alternative to LCAs, but as a complementary approach. Especially for more detailed analysis, LCAs remain very helpful, while the food system approach can place the results in a broader context.

The notion that 'food systems' not only influence how and where food is being produced, but also people's eating habits and diets, is gaining momentum in the literature (Ericksen et al., 2010; Ingram, 2011; Pinstrup-Andersen and Watson II, 2011; Vermeulen et al., 2012). In contrast to the food chain concept, which perceives different actors in a more neutral way, the food system concept acknowledges that the actors influence each other, within a certain political, technological, environmental, cultural and institutional context. The objective of the UNEP International Resource Panel (IRP) is to evaluate the current and projected use of natural resources in regional food systems and the global food system as a whole. It also intends to identify opportunities for resource efficiency improvements using a food systems approach, for example by pointing at specific opportunities for certain food system actors. As part of this initiative, the IRP is collaborating with LCA experts in order to gain insights from this well-established methodological approach and cross-fertilize each discipline.

2. Methods

As the concept of 'food systems' and their interaction with natural resources are important, first a conceptual framework was developed, to help further structuring the research questions (Figure 1). Main elements of the food system, and their interactions with natural resources, and environmental and societal impact are depicted in a conceptual framework. Food systems usually can be divided into various food system activities, ranging from provision of inputs (as fertilizers and machinery), primary production (mainly by farmers and fishermen), food trading and processing (crushing of oil seeds, sugar refinery), food industry (preparation of 'food' as eaten by consumers, from bread to ready meals), retailing and food service, consumption and finally processing of food wastes. The different steps can often not be clearly separated, and also very much depending both on the types of food as well as on the regional food system. Food chains in rural areas in developing countries are often relatively short, especially in the case of subsistence farming, where most of the food production and processing (as milling and baking) is within households. In developed countries food systems are typically much more complex. Food systems necessarily depend on certain natural resources, such as land, water and minerals in the case of agriculture, or fish stocks in the case of fisheries. Due to emissions and the use (and sometimes overuse) of resources, food systems have environmental impacts. Life cycle assessment typically addresses the natural resource use and environmental impact of one type of product from input up to the point where it is sold to the consumer and/or consumed. Food systems also include aspects as food system outcomes (effect of food security and human health, farmers' income etc.) which affect general social welfare. Finally, and maybe most importantly, food systems research postulates that the food system are shaped by food system actors (as farmers, food companies and retailers). These actors operate in a certain socio-economic context. The food system is therefore not a neutral logistical food chain as the food system actors have large interests, which basically shape food systems. From a societal point of view, the food system outcomes are most important: to which extent do food systems deliver food security, incomes and are they capable of doing so not only now, but in the future as well.

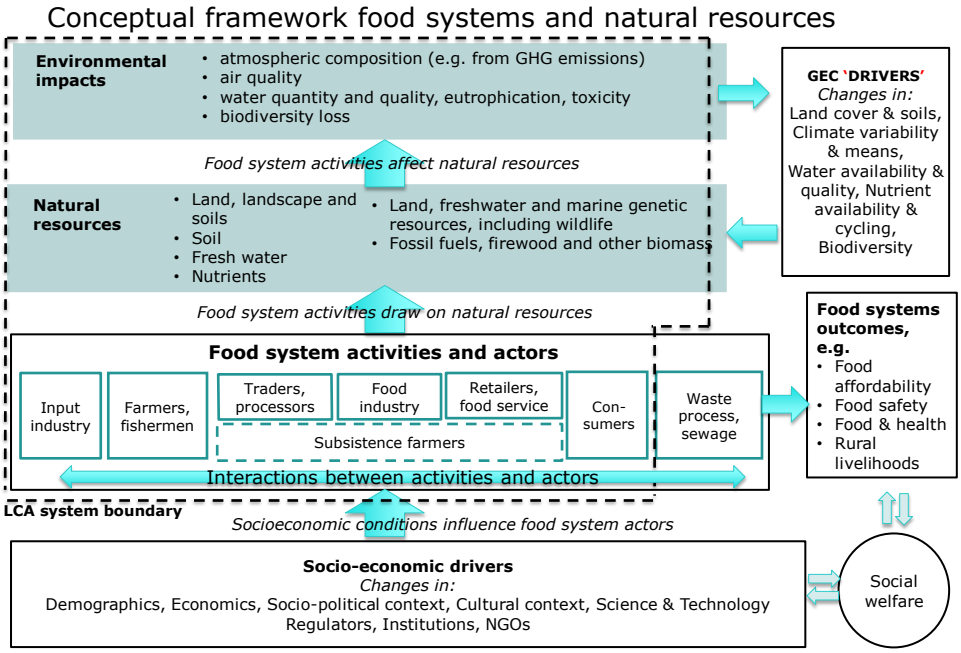

Figure 1. Conceptual framework of food systems, their interaction with natural resources and environmental impacts and food systems outcomes. Also the system boundaries of a typical food LCA study are indicated.

In order to be able to fulfill the objective, for main research question were defined: (i) What is the present and projected use of resources in the various regional food system; (ii) what are the options in biophysical terms to make this reduce this use, or to make the use more sustainable; (iii) how are current food systems functioning, in terms of institutions, technology and relationships (iv) what are the major opportunities within food systems for the various actors to improve the resource efficiency of food systems. The study was mainly based on existing literature, added by expert knowledge. Part of the input of expert knowledge was organized in the form of regional workshops.

Ad (i): The use of resources and environmental impacts were assessed for both the present as well for the future situation. For this agro-economic projection, such as the medium term FAO-OECD Outlook (OECD and FAO 2013) as well as scenario studies focusing on natural resource use have been used (Bouwman et al. 2009; Schmitz et al. 2014). The focus was on a limited number of resources: land, minerals, water, genetic resources and marine resources and environmental impacts (GHG, emission of minerals, biodiversity). Ad (ii): Also based on literature, the major options have been identified to improve the resource use efficiency or to reduce the environmental impacts. These not only include supply-side options (mainly related to production), but also demand-side options as the reduction of food wastes or dietary shifts. Ad (iii): Given the large differences in regional food systems, a number of global regions (as sub-Saharan Africa, South-East Asia and Europe) were being studied in more detail, partly by means of expert workshops. Ad (iv). Based on the previous collected information, the major opportunities for food system actors were identified. The opportunities were not only evaluated in terms of impact on resources use (for which amongst others an LCA-type information was used), but also in terms of broader societal outcomes, where aspects such as food security, health, resilience of farmers and food sovereignty were assessed.

3. Results

Results as synthesized from peer-reviewed articles and state-of-the-arts reports will be used to analyze the present and projected use of resources. Where possible, a disaggregation per region or per commodity will be made, in order have a better understanding of the drivers of resource use and environmental impacts. Examples of the latter are available for nitrogen use and losses (Leip et al. 2013) and greenhouse gas emissions (Lesschen et al. 2011).

In a second step the potential of biophysical options will be evaluated. Where possible and logic the options will be differentiated per region, as not all options are relevant for each region. Both options and the demand side as well on the supply side will be evaluated. The effect of the various options on the selected natural resources and impact will be assessed, when possible based on peer-reviewed articles or otherwise expert judgment. Examples of demand side options are the reduction of food losses (FAO, 2013; Rutten et al., 2013) and dietary shifts (Stehfest et al. 2013; Stehfest et al. 2009; Westhoek et al. 2014). A first evaluation shows that options at the demand side typically have a positive effect on the use of all resources and environmental impacts (Table 1). Supply side options might have certain trade-offs on other resources. An example is increasing crop yields by increasing fertilizer input, which could lead to higher nutrient losses if this is not done correctly (Mosier et al. 2004; Yang 2006).

Table 1. Provisional estimated effect of a number of biophysical options to increase the resource efficiency of food systems, or to reduce the environmental impacts.

	Reduction of resource use			Reduction of environmental impact			
	Land	Water	Minerals	GHG emissions	Water pollution	Bio-diversity	Examples
Demand side							
Reduce food losses and waste	+	+	+	+	+	+	Reduce post-harvest losses
Reduce consumption of livestock products	+	+	+	+	+	+	Reduce portion size, hybrid products
Supply side							
Increase crop yields	++	+?	+ / -	+	-?	+	Improved fertilization; precision farming techniques; improved seeds
Sustainable land management	++	+	+	+	+	+	Soil and water conservation practices
Improve recycling minerals, including reduction of emissions	0?	0?	++	+	++	++	Improved integration of animal manure in crop production
Increase feed efficiency livestock	++	++	++	++	+?	++	Better feeding techniques
Improve transport efficiency	0	0	0	+	0	0	Smart logistic

Consequently, the current food systems in different regions will be examined, as well as projected changes in these. Reardon and Timmer (2012) distinguish food systems in traditional versus modern, while pointing at an intermediate system too. Key findings for Sub-Saharan Africa suggest the trends of urbanization and "supermarketisation" becoming prevalent in the region, which will lead to a significant change of the more traditional food systems. Among others, these trends are leading to changes in diets, increased food wastage at the retail stage, and an increase of globally sourced food in detriment to local sources. The vast majority of energy used for cooking depends directly on local biomass, which is linked to deforestation; in addition 60-70% of this energy is lost in the cooking phase due to inefficient appliances, pointing to a significant potential improvement opportunity.

In terms of opportunities, the food systems approach highlights opportunities which might result from better cooperation between food system actors, leading for example to reduction of food wastes and losses and to a better recycling of nutrients. Other opportunities might arise when downstream actors help farmers to adopt better practices, which might lead to higher crop yields and higher farmers' income. One example is when

smallholder farms would be better connected to urban markets, which could not only lead to higher incomes, but could also reduce food losses (through better storage and logistics) and facilitate the provision of inputs as fertilizers. The workshop also identified the role that large companies and global supply chains may play through investing in sustainable sourcing certification schemes. Capacity building to mainstream Good Agricultural Practices linked to these certification schemes is an essential element to enhance yields and reduce environmental impacts related to excessive nutrient losses and/or inadequate pesticide use. In addition, certification facilitates access to markets, which is usually found as a key reason behind pre- or post-harvest food losses. A last example of an opportunity of improved resource use within food system would be the case where retail and food service companies help consumers by making the healthier and environmentally logical choice for consumers. Apparently, corporate interests are not always aligned with optimal societal outcomes of food system. This might be addressed by governments if it is better known under which conditions private actors food systems can deliver better outcomes.

4. Discussion

The food systems approach facilitates consideration of the perspectives of all different actors in the food value chain, and thus the identification of improvement opportunities leading to enhanced resource efficiency, social fairness and economic benefits, in the delivery of the key outcomes. By identifying the key actors of change in specific regional systems, the most adequate opportunities may be leveraged. When considering these actions, the interests of the different key actors should be understood. These interests are often the key to understanding the way the current food system operates, and why certain societal undesired outcomes occur.

Whereas LCA already has clearly defined methods and procedures, the methodology to assess the effect of food systems and potential changes in these, mainly still has to be developed. Given the complexity of food systems, one can even doubt whether a full evaluation can ever be possible. Nevertheless, some aspects or components of food systems can be modeled, for example by using bio-physical or macro-economic models, or combination of these. Examples are the attempts to model on food prices and food security interventions as changes in trade regimes (Anderson 2010; Schmitz et al. 2012; Verburg et al. 2009), investments in agro-food systems in developing countries (IAASTD 2008) and biofuel policies (Bouët et al. 2010; Hertel et al. 2013). Some other studies have focused more on the biophysical aspects, like studies on potential changes in dietary patterns, looking especially at reducing meat consumption (Stehfest et al. 2013; Stehfest et al. 2009). Besides quantitative methods, a large number of more qualitative methods exist, based in thinking from disciplines as political science, sociology and other behavioral sciences and institutional economics. The food system approach has the potential to expand the identification of opportunities for improving the sustainable use of natural resources beyond the more food product based approach as is typically done with LCA studies. Examples of such opportunities in a more bio-physical sense are the reduction of food losses, dietary shifts towards less meat. Moreover, the food system approach offers new perspectives to address a number of issues by involving other agents of change such as food companies and retailers. This could lead to the identification by scientists of opportunities for both policy makers as for actors in the private sector policy-making, thus enhancing the science-policy interface, and maximizing the potential impact of improvement opportunities. Whereas LCA-type analyses have a well-defined methodology, the methodology for food systems analysis largely still has to be developed. This means that the two approaches should be seen as complementary.

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