Resource use in a low-input organic vegetable food supply system in UK - a case study

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Key words: vegetables, emergy, box scheme, supermarket, food supply

Abstract

The sustainability of a small-scale low-input organic vegetable farm in United Kingdom with high crop diversity and a related box scheme food supply system was assessed by emergy evaluation, an environmental accounting method based on the direct and indirect use of solar equivalent joules. The main questions for this study were how much the considered system contributes to society by taking advantage of local renewable flows, and how much it depends on input from society. By understanding the dynamics of this system we contribute to bridging the gap between practice and scientific knowledge. Our study is an example of how systems today need to take advantage of current cheap energy to avoid getting out-competed, while at the same time maintaining autonomy and freedom of action should any of the large scale systems supplying transport, money, energy or labour fail.

Introduction

Contemporary food production and distribution systems are due to their fossil fuel dependency inherently unsustainable. It has for instance been shown that more than four joules of fossil energy is used to produce and transport one joule of food energy in the Danish food production system (Markussen et al. 2013). In a fossil fuel deprived future, sustainable systems need to adapt to reduced availability of high quality energy input by relying more on local and renewable resources. In this study we assess the resource use of a vegetable production and distribution system which represents a fundamentally different way of producing and distributing vegetables than the dominating supermarket-driven mass distribution systems. The resource use in the system is evaluated based on emergy assessment (Odum 1996). A benchmarking of this system against two modelled organic farming systems which distribute vegetables via supermarkets may be found elsewhere (Markussen et al 2014).

Material and methods

The small stockless organic farm studied (Figure 1) covered 6.4 ha of which 5.6 ha were cropped. The farm produced more than 48 different vegetable crops. Data on all purchased goods for crop production and distribution, as well as a complete list of machineries and buildings were collected by on-farm interviews. In the analyses, data from 2009 and 2010 were averaged. The farm was managed to reduce inputs as much as possible. All seedlings were grown on the farm based on own produced potting compost and the use of imported animal manure was completely avoided. Soil fertility was maintained by the use of fertility-building crops in 7- or 9-year crop rotations. The only purchased materials for soil-fertility enhancement were 100 m^3 woodchips, which were composted on the site, and small amounts of lime and kali vinasse which were primarily used for seedling compost production. More details about the case study are described elsewhere (Markussen et al. 2014).

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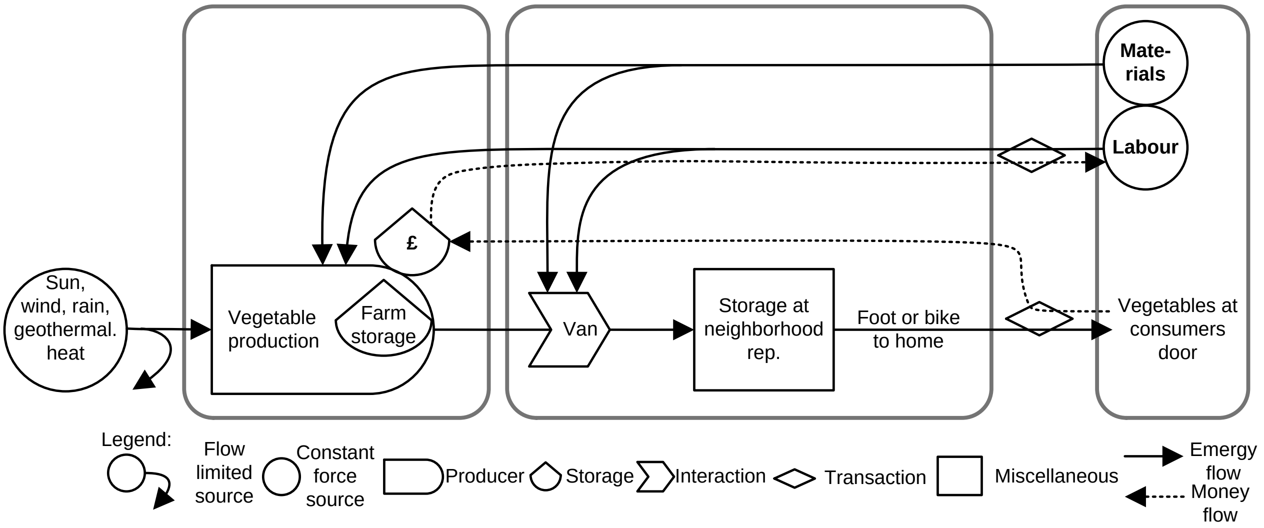

Figure 1. The studied system consists of a farm producing vegetables and the distribution of the vegetables via a box scheme

The farm managed its own box scheme where bags of vegetables were packed every week with a well-defined content depending on the season. These bags provided vegetables to 200-300 customers. The products were distributed through neighbourhood representatives within a 50 km radius, which means that once a week boxes were delivered to collection points throughout the delivery area. Customers could then pick up the vegetables at these places preferably by bike or on foot.

The resource use was assessed by emergy (spelled with an “m”) accounting. Emergy is defined as ‘the available solar energy used up directly or indirectly to make a product or service’ (Odum 1996). The emergy support required to provide a product or service is calculated by adding up all kinds of available energy (exergy) used after converting them to the same unit of solar equivalent joules (seJ). The conversion factor, the transformity (seJ/J), measures at the same time the efficiency of the corresponding processes in transforming solar energy into useful energy. Emergy assessment is particularly useful for studying agricultural systems as it accounts for non-commercialized natural resource inputs (e.g. solar irradiation, rain, soil etc.) as well as inputs from human-dominated systems (refined fossil fuels, goods, labour). From an emergy perspective, agricultural systems capture and transform local renewable available energy into products that are useful for society.

Results

The farm distributed in average around 45 tonnes of vegetables per year. Based on the nutritional value for each type of vegetables, the total food energy produced annually was calculated as 74.3 GJ, of which 87% originated from storable crops and the remaining 13% from fresh crops. In total this amount corresponds to the food energy needed for 19-23 people for one year (based on a daily intake of 8.8-11 MJ recommended by United Nations (2012) and disregarding the diet composition).

Based on emergy accounting, the total environmental and societal flows supporting the system were calculated. The emergy used for supporting direct labour within the system and indirect labour for manufacturing and supplying inputs made up 89% of total emergy used. As these numbers are based on the environmental support to the total UK economy, this reflects more the high national resource consumption than the specific business. Further, they emphasise that environmental support for labour in an industrial economy is inherently resource intensive. To avoid distorting the results of the actual system with the implications of being embedded in the UK economy, we considered in the following emergy indicators without accounting for labour.

Purchased materials for production constituted 87% of total emergy support without accounting for labour. Fuel used for cultivation, including irrigation, and electricity used for production of seedlings were the largest single flows with 26% and 11%, respectively, of total emergy used (Figure 2). Irrigation used in total 24% of all resources. Of these, 72% was water consumption (17% of total emergy flow). The woodchips used as soil-fertility enhancement and to produce potting compost contributed with 94% of the soil-fertility enhancement (10% of the total emergy flow). Seed and seedlings, farm assets and distribution of the vegetables (mainly diesel consumption) each contributed with 7-8% of the total emergy flow. The direct energy use for distribution was estimated to 465 l/year. The fuel use for tractors, delivery vehicles and other machinery corresponded to around 7.5 litres per year per family supplied with vegetables and the total electricity use on the farm corresponded to that of an average household.

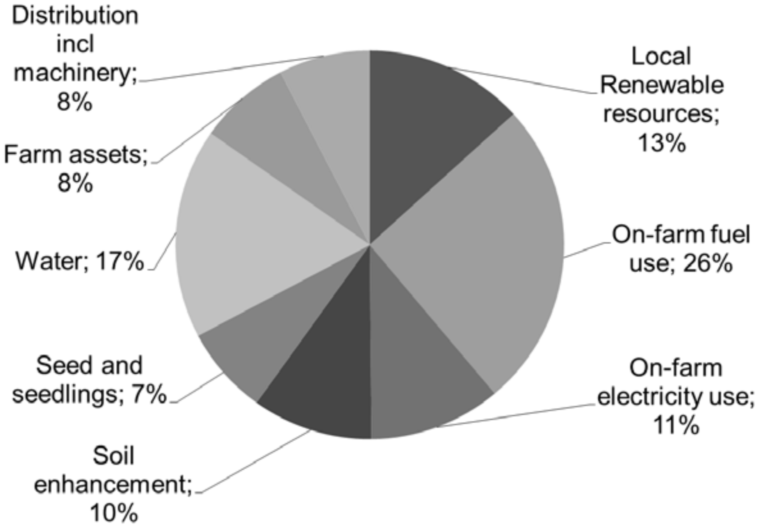

Figure 2. Emergy profile visualizing the different inputs required from society and the renewable inputs received by the farm area

The transformity (seJ/J) summarizes the efficiency of the system in transforming renewable and societal resource into vegetables. To produce 1 J of vegetables, 5.54E+05 seJ were required (not accounting for labour). This efficiency was somewhat better than for a typical organic production system delivering a comparable amount in food energy of less diverse vegetables distributed via supermarkets (Markussen et al. 2014). The ratio of the total emergy flow to the emergy invested from society equalled 1.15 indicating that free local environmental services contributed with 0.15 seJ for each seJ invested from the society. In other words, the final service was based more on fossil fuel subsidized inputs from society than on sun, rain, wind and geothermal heat received locally on the farm area. The share of local renewable resources was only 13 % of total emergy input. These results are notable as the farm was managed with focus on energy savings and a strong preference to minimise external inputs and utilize local renewable resources.

The largest potential for improving the percentage of local renewable resources is to reduce the amount of imported fuels. However, also producing the woodchips or part of them within the geographical boundaries of the farm would improve the net-benefit for society. The woodchips were supplied from a nearby gardener who pruned and trimmed local gardens. In the present society, these woodchips are considered as a waste but in an emergy assessment they are considered as a resource which has required a large amount of solar energy to be produced outside the considered system boundaries.

Discussion

The emergy assessment provides a way to determine to which degree vegetables are produced and distributed based on local renewable resources as opposed to imported fossil fuel subsidized resources. Our study has shown that even this dedicated low-input system got 87% of the total environmental support from the society. While it is attractive to reduce fossil fuel subsidized inputs to enhance resilience and adaptability towards foreseeable constraints on high quality energy resources, the results also show that these inputs provide essential services. For instance, it is unlikely that delivery of vegetables by foot or bike or substituting diesel powered tractors with human or animal power is economically feasible. However, due to the focus on renewable resources and the local supply chain, the studied food supply system is likely to be in a better position to adapt to future environmental constraints than the dominating mass distribution systems which depend on economy of scale and large throughput of goods and fuel.

Acknowledgement

This study was supported by EU grant no. KBBE-245058-SOLIBAM. Special thanks go to the farmer contributing with data.

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