Energy eco-balance of horticultural sectors

Appropriate methodology

After the first questions were asked in the 1970s following the 'oil shocks', energy and the environment have become a strong concern in the present context and are increasingly calling into question the sustainability of farming systems and sector organisation. Features include the exhaustion of natural resources, strong environmental impacts, a structural increase in the price of energy, socioeconomic effects, inter-generation equity and economic competitiveness.

Increased ecological and individual awareness of the absence of a future for the dominant technological models has been seen in recent years. This has resulted in an increase in social, institutional and political pressure, as can be seen in the growing number of initiatives for sustainable development such as environmental labelling (Casino, Leclerc, Tesco), the multiplication of environmental and sanitary standards for products, inputs and techniques and the decisions of the 'Grenelle' Environmental Meeting in France in October 2007.

Energy and environment at the heart of discussions

Although stress is now laid on the nutritional interest of fruit and vegetables, energy and environmental problems lead to questioning the appropriateness of the choice of farming systems and the location of production zones in relation to centres of consumption. In other words, as regards sustainable development, is it better for production to be close to consumption zones, often requiring heating and the sheltering of crops, or should production be located in zones where soil and climate conditions are more favourable, with allowance for the transport costs involved?

Energy and the environment are likely to become a growing part of technical and organisational innovation in the near future and hence strategic and determinant in terms of competitive advantage. These questions should therefore be addressed methodically, with care taken not to use just any old tool that might give biased results. This is particularly important as horticultural production chains are fairly specific and have the following features among others:

- very perishable, seasonal produce;
- numerous varieties of each fruit and vegetable;
- considerable variability of farming systems and geographical sources and hence in crop management sequences and economic aspects;
- logistics organised on a 'just in time' basis;
- sector steered by retail distribution with the latter sector imposing its approaches and strategies.

A complex combination of these parameters results from this, explaining the many different cases observed. This requires consideration of the sector as a whole.

A proposed appraisal method

Given the strategic importance of energy and environmental problems, there is a great risk in the use of existing data and reference material that were not created for horticultural production chains. The worst case would be erroneous results that would validate certain idées reçues and falsehoods. It therefore seemed necessary to propose reliable, transparent tools for impact assessment and above all tools that allow for the specific features of these production chains.

The method is inspired by the life cycle assessment (LCA) or environmental accounting approach (ISO 14040/14044). This framework for analysis consists of the assessment of environmental impacts through the life cycle of a product or service by counting incoming (resources) and outgoing (emissions and wastes) flows.

As the field of research is very broad, only the energy aspect has been studied so far.

In an energy eco-balance, the cost of the various energy consumption categories is evaluated. Consumption can be of three kinds:

- direct energy (electricity, fuel, etc.),
- indirect energy (inputs),
- and energy induced by capital (material, infrastructure).

Evaluation of the energy balance of horticultural chains

The organisation of horticultural production and supply chains and more specifically the question of the location of production zones in relation to consumption zones has been examined with regard to the energy variable. A preliminary study conducted at CIRAD had shown the limits of existing methods and the lack of methodology for multicriterion environmental evaluation of fruit and vegetable chains. CIRAD and CSIF (Chambre Syndicale des Importateurs Français de Fruits et Légumes) worked together to test and validate a method for the evaluation of the energy balance of the various supply sources of Rungis wholesale market, using the tomato chain as the case examined. A number of key variables were shown. The study also makes it possible to model the parameters to be used and hence transpose the evaluation method to other horticultural chains.

The principle consists of transposing the various types of consumption in a production cycle (energy, inputs and capital) into energy cost by the application of a coefficient representing the energy consumption required from production to supply of the item in question. The coefficient is expressed in megajoules per unit. The energy cost in MJ is obtained by multiplying the quantity of the element concerned by the coefficient.

MJ/kg (of produce) is used as the common accounting unit in the comparison of the various elements of the energy balance of horticultural production chains. The joule is the reference unit in the Système International and kg of produce is a unit used through the chain, in contrast with the unit of area, especially as production yield is determinant and weights results.


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Three phases are examined: production, packing and transport

The system consists of the three phases production, packing and transport, each of which has a number of key parameters (see diagram).

In production, account is taken of the type of installation (open field, plastic greenhouse with a steel or wooden frame, glasshouse, etc); this reveals a certain technological level on which the following variables depend:

- fertiliser (N, P, K),
- pesticides (herbicides, insecticides and fungicides),
- plants,
- substrate (organic and inorganic),
- plastic mulch,
- irrigation system (trickle, furrow, sprinklers, drainage, recycling of nutrient solutions, etc.),
- machinery (tractor, spreader, sprayer, etc.),
- wastes (plants, cultivation substrates and plastics).

Unused fertilisers and pesticides are not taken into account as a national study has found that the quantities of the former are not significant and the latter are not quantifiable. According to the same source, the volumes of packing of these products are also very approximate and difficult to evaluate.

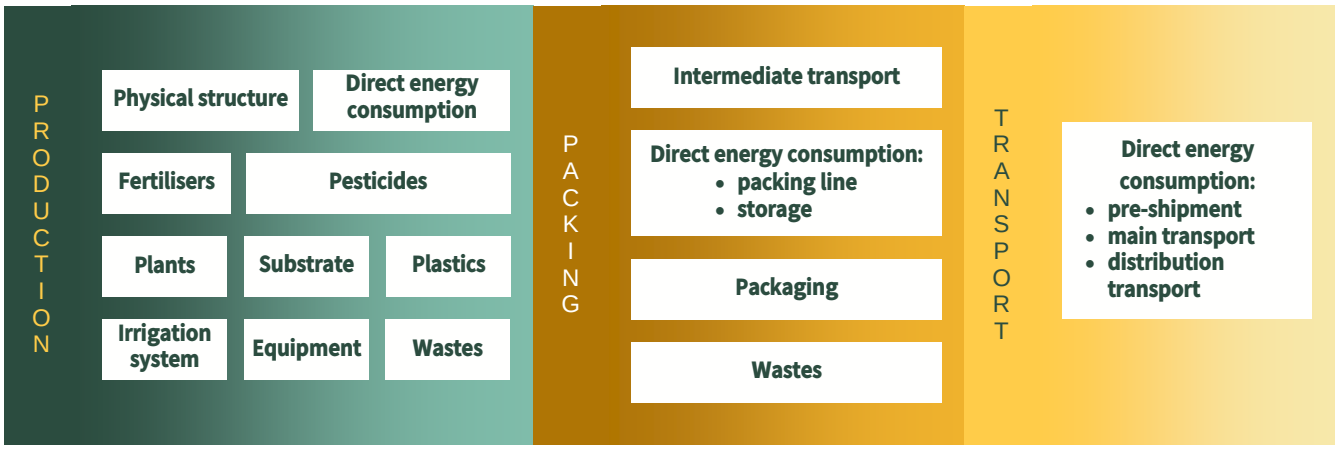
As regard packing, intermediate transport is between the farm and the packing station and depends on the size of the production zone. Direct energy consists of the energy for the packing line and the packaging equipment and above all that used by cold stores. Packaging is also taken into account, and the final item is wastes (plant wastes, plastics, cardboard boxes, wood).

Only direct energy consumption is measured in the transport stage. Distinction is made between three levels: preliminary transport from the packing station to the export loading point and then the main link in the chain (from the loading point to the point of unloading in the importing country) and finally distribution.

Limits remain

The first limit of this methodological work lies in the quality of the energy coefficients and their lack of homogeneity. Indeed, some coefficients are imperfect for reasons of their construction (organic fertilisers), others are uncertain (plant, substrate, packaging) or even nonexistent (coconut fibre, packaging other that cardboard trays or plastic crates). In addition, it is difficult for these coefficients to take into account the

The three phases of the system



location of production zones in relation to the zones of use and hence the transport aspect. However, fertilisers, pesticides, plastics, etc. may require different transport depending on the zone studied.

The second limit concerns the quality of the data. First, the variability of some features is too great, making it difficult to define median situations. This is the case of pesticides and electrical consumption by cold storage facilities. It is also difficult to gain access to and assemble primary data. As these data are of strategic importance, sector stakeholders are not always willing to provide them.

A sometimes rigid framework

The method used (LCA) is exhaustive and hence very expensive and cumbersome to set up. Choices must be made. For example, the seasonal dimension of crops is little or not taken into account for the moment.

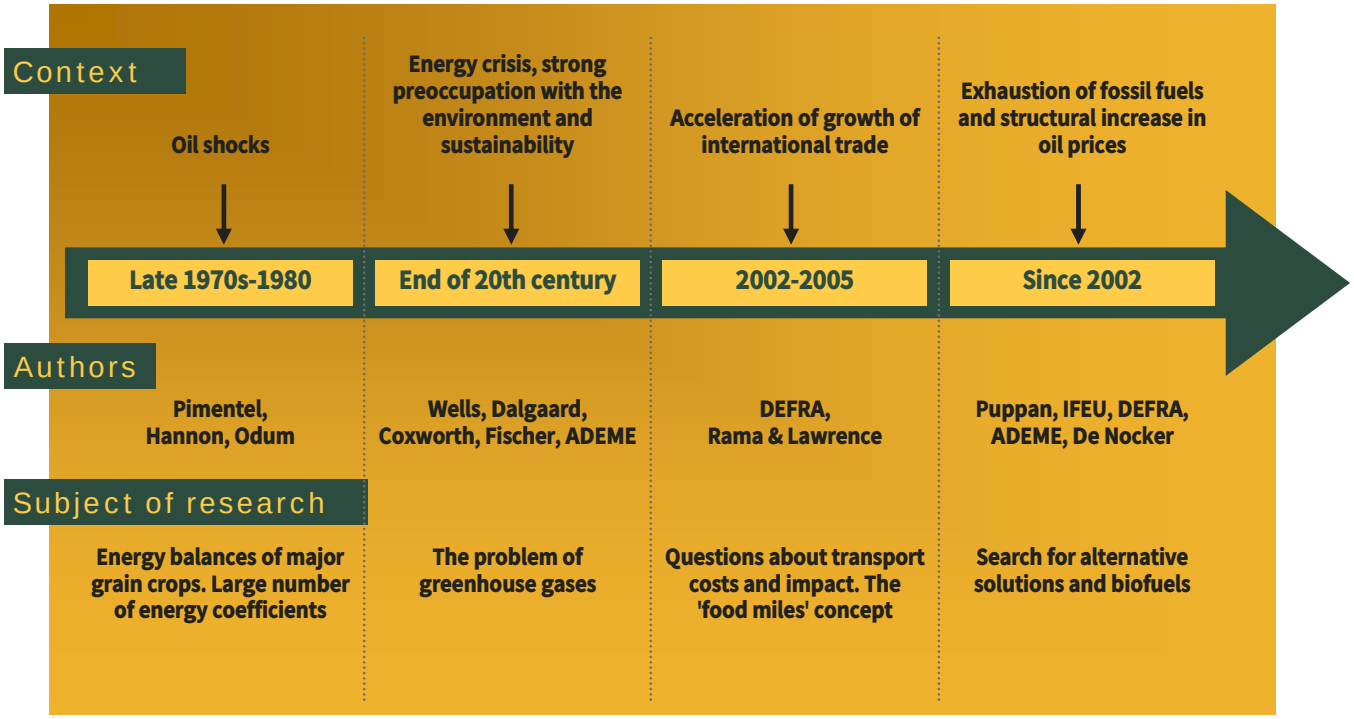
In addition, the scope of the system studied can be reduced. The approach is thus centred solely on the chains supplying supermarkets. It has not been developed for comparing the energy eco-balance of distribution by supermarket chains and the short chains in which producers and consumers have much more dense geographic and organisational relations (small farmers' direct sale associations, etc.). The aim was that of comparing different supply and import chains from the point of unloading in the destination country. It was considered that the distribution from this point was the same, whatever the origin of the produce.

Unsuitable methods

The current methodological range includes much work and tools related to environmental or energy balance evaluation. The first studies were performed at the end of the 1970s in response to the oil shocks and since then the question of energy has been the subject of research at different levels depending on the context and the preoccupations of the moment (see diagram).

However, for various reasons these methods were found to be unsuitable for the specific features of the fruit and vegetables sector:

- a micro-analytical approach has been used in most of this work, with the scope limited to production or transport, while horticultural chains are characterised by the linking of many scenarios during the various stages;
- no special studies have been devoted to fruit and vegetable production for reasons of its complexity; as a result, certain parameters such as storage, cushioning, refrigerated transport, greenhouse type installations, etc. have not been assessed;
- the energy coefficients calculated for other types of product are often obsolete, dating back to the 1970s and 1980s and their content is somewhat obscure and so they cannot be used;
- finally, some indicators are much questioned but are still used as they have a strong impact on consumers. For example, 'food miles' has been found to be an incomplete notion. It indicates the distance travelled by a foodstuff but is not standardised by a unit of volume, whereas energy consumption and greenhouse gas emission do not have a linear relation with the distance travelled.



An innovative systemic, generic study

The originality of this study lies in its systemic, generic approach in response to the specific features of horticultural chains. It thus makes it possible to link local and global scales in a context of a trend towards deseasonalisation and the relocation of crops in the southern hemisphere. In addition, given the future environmental regulations (environmental labelling of produce in France by 2011), this work lays the foundations for a decision aid tool for sector stakeholders (reorientation of technological and commercial strategies) and institutional partners (public policies). Finally, it is innovative as it addresses a hitherto little explored field, given the complexity of the horticultural sector and recent research on the multicriterion evaluation of agricultural produce.

However, thanks to their high value-added, horticultural crops are an opportunity for local development and the fight against poverty and are involved in major nutritional and health issues (heart disease, obesity, etc). As a result, the energy aspect—indubitably a variable that is determinant for the economic and financial side of agriculture—and, more generally, the environmental aspect, cannot alone discriminate between one farming system or chain in comparison with another. Features involving socio-economics, society and even nutrition must be taken into account. Today, this transverse, multidimensional field of study is largely unexplored. CIRAD, again in collaboration with the sector (in particular with the Chambre Syndicale des Importateurs Français de Fruits et Légumes, CSIF) is continuing the work undertaken with the aim of being able to characterise the sustainability of chains and their governance from both the environmental and socio-economic viewpoints ■

Main features

An energy balance is complex and must allow for both direct energy consumption (production and transport) and also indirect consumption (inputs).

Environmental balances cover a very broad range of potential indicators: eutrophisation, global warming, acidification, etc. They provide information about the variability of farming systems. It is thus not possible to discriminate between systems on the basis of just one of these criteria, and especially the direct energy use criterion (production and transport).

It has been seen in the study that the production phase is determinant in the energy balance. In contrast with idées reçues and the food miles approach, transport is not necessarily the phase in which the impacts are the most negative.

Finally, social and economic aspects must also be taken into account in characterising the total sustainability of a sector or a product. This has not yet been done.

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