SCENARIOS AS METHOD TO ASSESS ENVIRONMENTAL IMPACT IN FUTURE MILK SUPPLY CHAINS

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Introduction

Milk and other dairy products are important ingredients in the Swedish diet. The Swedish National Food Administration recommend a daily consumption of milk of 0.5 litres milk or corresponding amount of other milk products. In recent years a trend of decreasing consumption of milk and increasing consumption of other dairy products is obvious. In 1985 the consumption of milk in Sweden was 150 kg per person and in 1999 the consumption was 110 kg. Considering soured milk products, the consumption in 1985 was 26 kg per person and in 1999 it was 30 kg per person. The cheese consumption has increased from 15 kg per person in 1985 to 17 kg in 1999, an increase corresponding to 20 kg milk (Swedish Board of Agriculture, 2000). This change in consumer behaviour affects the entire milk supply system, i.e. dairy processing, transportation, retail and household. Besides the change in consumption patterns, there have also been other changes in the milk supply chain; the dairies have become fewer and larger which bring about an increase in transports. When the structure of the milk chain changes, so does the environmental impact from it. In order to promote the development of sustainable food chains it is important to increase the knowledge about how different developments of the milk supply system affect the environment.

The question formulated was: “how will the supply chain of dairy products affect the environment in the future, and are there more sustainable solutions than today’s system”.

Methods

Obviously the question concerns the entire chain, as described above, so a systems analysis approach was appropriate. Moreover, the question regarded mainly future systems. Hence, the method chosen was modelling of the system in order to facilitate simulations of different systems. A material/substance flow modelling (MFA/SFA) approach was used since this mirrors the reality on a relevant level. In addition to that, Life Cycle Assessment (LCA) methods were largely used to aggregate the results from single substances into effect categories.

The model was then used to simulate different future systems, scenarios. The choice of these scenarios were crucial to the work, defining scenarios to quickly and without careful consideration of what questions the scenario should address would make the entire project less interesting.

Modelling

The model used was first developed for this project and is presented in Sonesson & Thuresson (2001). Shortly, it is a model that is made up of separate sub-models of the included systems parts. The model is divided in two levels, foreground system and background system. The foreground system is the system where the actual milk is transported and treated. It is also the

system we are interested in and were proposed changes are made. It consists of transports between farms and dairies, dairies, distribution, retail, home transports and households. The background system consists of systems needed to support the foreground system but are not affected by choices made within the milk supply chain. The model is depicted in Figure 1.

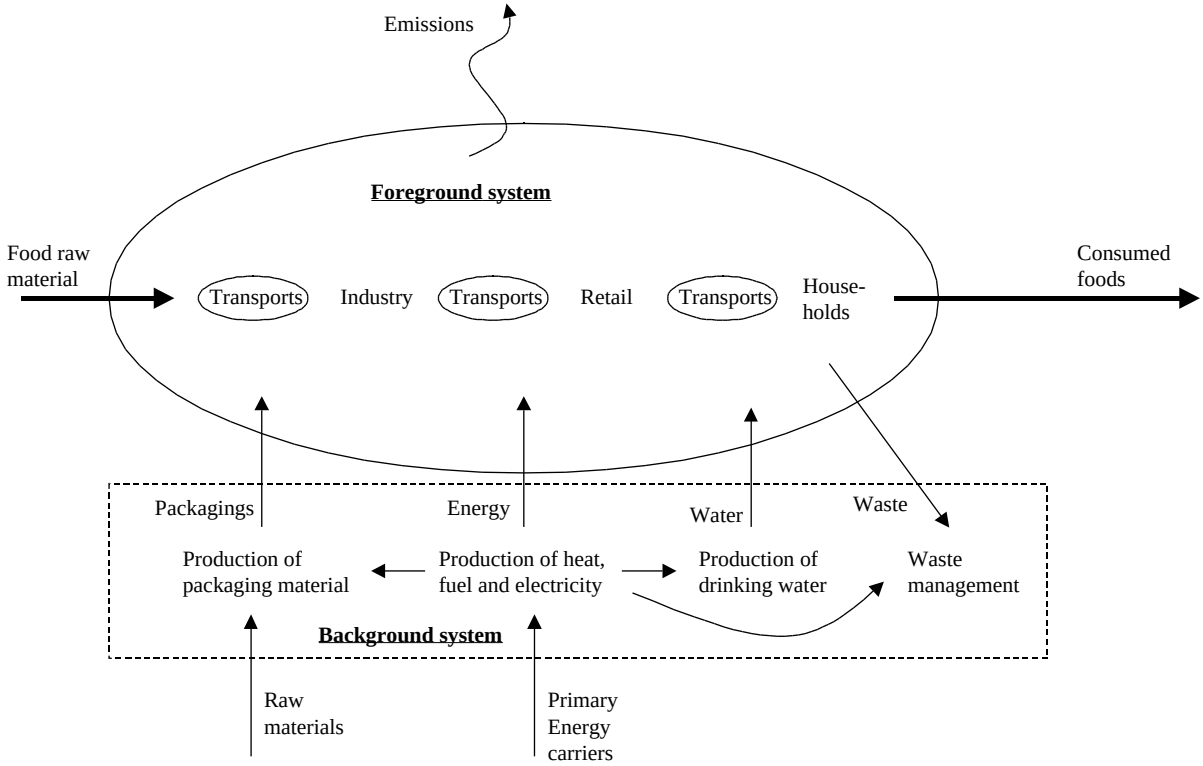

Figure 1. The system under study, Foreground system within oval, background system within dotted square.

The foreground system is based on environmental reports from dairies and research reports on transports and retail. The flow of product through a sub-model drives the calculations of emissions and resource use as well as need for support from the background systems.

The model uses a vector of 60 different substances and materials, both single substances and materials as different packaging and waste. The latter is to describe packaging and other materials that are added to the milk flow, while the former is used to describe the milk flow itself. The energy is also described with a vector to facilitate keeping different forms of energy apart and also use different production means for e.g. electricity.

LCA data are used for the background system, i.e. data from previously published LCA's are used and the amount of support (as kWh electricity or m^3 of water) the foreground system needs are multiplied with these LCA data.

The results from the model are total emissions to air and water and amount of raw material used and energy carriers ("fuels") used. These results are also generated on sub-model level, i.e. it is possible to see the results for each part of the system individually. Since the model uses single substances first and thereafter aggregates them into effect categories, it is possible to analyse the emissions on a substance level as well as aggregated into effect categories. Conclusively, the model generates results that can be analysed from substances emitted from single processes to the entire systems impact on effect categories.

Scenario development

Scenarios are always constructed in a way that several questions can be assessed in the same scenario. The basic idea is that not all possible choices in a system are independent, several choices are connected and by finding theses connections a smaller amount of combinations are possible. But still the number of combinations is too high to facilitate simulations and analyses of all of them. So by identifying larger trends or possible futures only a few combinations are relevant and these are the scenarios to study. The term "scenarios" mean the description of the physical parameters that affect the environmental impact of the dairy supply chain. The most important are:

- Transport distances, between farms and industry, industry to retail and between retail and households. These are a result of localisation of dairies which in turn depends on the number of dairies, i.e. scale. Also the structure of the retail chains affects the distribution transports as do the occurrence of "e-shopping" (groceries are ordered via Internet and delivered to individual households by the retailer).
- Performance of the industry itself, i.e. energy and water use, wastage and waste generation. Technological development must be assessed.
- Performance of transports, how efficient is future means of transports?
- Consumption patterns, i.e. what products are consumed. This affects the efficiency of dairies, distribution transports, retail, consumer transports and wastage in all parts.
- Choice of packaging, e.g. conventional one-litre cartons or plastic pouches.
- The consumers use of cars, how large part use cars and how often do an average household go to the grocers. If e-shopping is common this will affect the consumer transports since it involves a completely different way of transporting the products to individual households.
- Choice of waste management system. To what extend is the waste recycled, incinerated or put into a landfill.
- Choice of energy system, i.e. how is electricity produced, is heat from incineration replacing oil in district heating, what fuels are used.

A scenario is basically a quantitative description of all points mentioned above. Often today's system is used as a base (since we know how it performs) and the assessment of future systems is of the form "10% better than today". Since no data on future systems is available one has to use all possible information and compile an assumption of the kind mentioned above.

Our choice of method for defining scenarios was that we made a relatively broad search for different views of environmental problems as well as trends within the dairy sector. This was done in a series of steps:

- First a number of stakeholders within the milk supply chain was visited and interviewed, it was not a large number of people, representatives from a dairy company, a major food retail company, one company supplying the dairy industry with equipment, an environmental consultant and researchers working within related areas, a total of five people. This group of people are from now on referred to as the "reference group"
- The questions raised and the trends mentioned in the interviews were used as basis for a first set of preliminary scenarios. The scenarios were constructed in a way that they should answer the most important questions and cover the main trends also mentioned.

- Simulations were performed with the model described above and a preliminary report was distributed among the group of stakeholders.
- A seminar was held together with the reference group were the results were presented and discussed.
- The scenarios were adjusted to comply with the new or re-formulated questions that had been presented at the seminar.
- A set of final scenarios were constructed and simulated.
- The results were presented for the reference group in a final seminar.
- The report was written, taking into account the discussions at the final seminar.

There were five scenarios studied in this project, of which one was today's system. The other was a result of the above mentioned iterative process; "Reference" is today's system. "Large-Large" is a picture of a continuing development against larger units, both industrial and within retail involving more car transport for consumers. "Splendid Times" is the same as Large-Large but added that more people are prepared to pay extra for service and exclusive product quality, including more developed dairy products. The use of private cars are higher since people shop more often "Harsh Times" depicts an economic recession, leading to denser living with services more close to dwelling areas. The industry is large scale. A decreased use of cars is significant as is consumption of less developed dairy products. "Lean Society" attempts to mirror a situation were re-valuation of consumption has occurred; less materialistic lifestyles are more common. Energy prices have risen sharply, there are only small economies of scale within industry, and thus the structure of the dairy industry is more small scale. Private transport by car is not as common as today mainly due to an increase in e-shopping followed by home deliveries. However, car transport is more common than in Harsh Times.

Results

In this paper we present results mainly to exemplify what types of results a study of this kind generates, in Sonesson & Berlin (2002) and Sonesson & Thuresson (2001) more detailed presentations of the results are found.

The results from the simulation shoved that some systems parts are more important than others for most of the effect categories included, while other systems parts were only dominating in one or two effect categories. In this presentation only three effect categories is presented, global warming potential, acidification and formation of photo-oxidants, these three are considered representative for the results.

In Figure 2 the results are summarised, the reference scenario's net result is presented as 100 for each effect category. Note that there are negative emissions for heat production due to incineration of wastes, the sum of the bar for "Reference" is however 100.

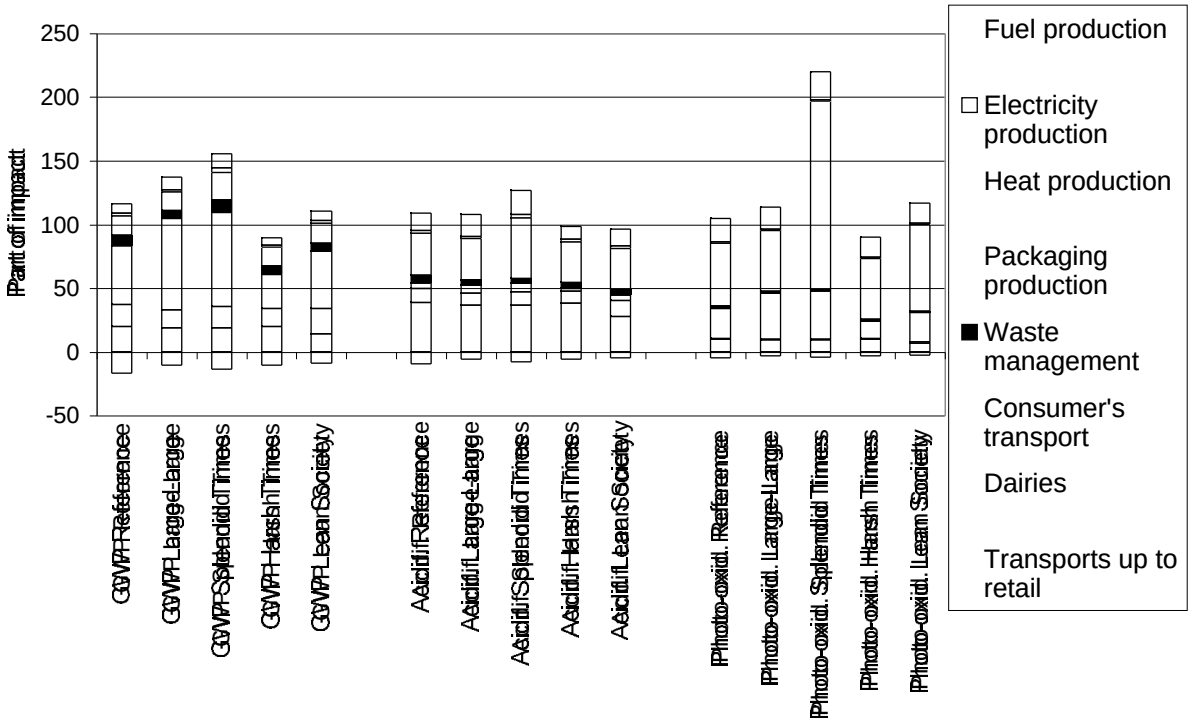

Figure 2. Simulation results for the five scenarios, relative values. The reference scenario's result is 100 for each effect category.

What can be seen is that packaging production and fuel production was significant for all three effect categories presented here. Consumers transport was dominating the GWP and also had large impact on photo-oxidant formation, while its contribution was small to acidification. The reason for this is mainly emissions from petrol cars. A similar picture applies to "Transport up to retail" and "Dairies", but it is GWP and acidification that is most affected by these two activities, in this case it is the emissions of NO_X that is the major explanation for acidification and CO_2 for GWP.

Discussion

Discussion on results

The production of packaging materials is an important part of the system for milk supply in the studied area, for all three effect categories included. Moreover, it is an important user of resources as wood for paper production and oil for production of plastic. Taking this into account it would be interesting to study a scenario with e very low use of packaging, such a study would however require a thorough investigation of how the other part of the system would be affected, as deliveries, consumer transports and last but not least the wastage in the consumer stage.

The consumer transport is based on assumptions and rather aggregated statistics thus the results should be regarded as indices rather than hard figures. However, in the scenario "Lean society" the use of cars was restricted but nevertheless the consumer transport was an important contributor.

Discussion on use of scenarios

When defining scenarios it is important to use a "cornerstone approach", that is to make the scenarios in some sense extreme, and let each scenario make up the cornerstone of a fictive

playground of possible futures. The risk is to define scenarios that are realistic, but are rather similar. Large differences between scenarios are important to articulate the differences in results.

Using scenarios makes it possible to build relatively detailed models with a large number of parameters, which makes the results more reliable than more aggregated models, and still get the overview of the system. The reason is that when using scenarios, it is not necessary to change all parameters to cover the field of study, scenarios provide a method to change several parameters at the same time in a logical and structured way.

The way to formulate scenarios worked out well and had a positive influence on the simulation results, the scenarios were based on a broader view of the problem, thus generating more interesting results. However, the scenarios were not based in any structured analysis of the surrounding world, which was a weakness, we did not check for consistency with global trends so we face the risk of lacking the most interesting scenario.

Using scenarios are a very successful way of studying future management of large systems, we see no realistic alternative. The results from a scenario study must not be looked upon as being the truth or even very close to reality, they must be perceived as directions and large differences between scenarios can be significant. The most important result from a scenario study is that the systems behaviour is mapped, and the important parts and connections are identified. The second result is also very important but depends on the way the study is performed. In a study of the type described here, with involvement of stakeholders, the work with scenario development and result discussion are important in making the involved stakeholders aware of the system they work in, at the same time as the researcher gets new and deeper insight in the reality of the stakeholders.

Conclusions

The use of scenarios gives a more comprehensive view of different paths of development and their impact on the environment. Since the number of factors that can possible be changed are so large, scenarios is the only way of dealing with these future issues, to analyse all possible outcomes is impossible due to sheer number of combinations.

The construction of scenarios is crucial for the outcome of a study. Hence the method of developing scenarios must be thoroughly planned and presented. A more elaborated methodology should be useful, a guideline on how to build scenarios, taking into account the questions posed in the beginning of the project.

Using a global scenario study (e.g. Raskin et, al. 2002, Ritchey, 1997) as a base for the “dairy-specific” scenarios could be an interesting approach.

It is obvious that a systems perspective is important when assessing environmental impact of changes within the food chain, if only one part is considered, as the dairy, there is a risk that the conclusions are if not wrong at least not the most important ones.

The consumer transport should be more thoroughly investigated since it is very important from an environmental point of view and at the same time based on less documented data. This is presently done within a joint project between SIK and Uppsala University.

Packaging is very important for the environmental impact from the dairy chain, as is transports, especially consumer transports.

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