Innovating for Sustainability

Life Cycle Assessments and sustainable food systems

Henk Bosch
DSM Nutritional Products, Kaiseraugst, Switzerland

Key messages

> Feeding the growing global population in a sustainable way is an enormous challenge.

> Many different approaches to improve the sustainability of food production and consumption are required and are currently being investigated.

> Choosing the best solutions requires a sound data and methodology foundation; Life Cycle Assessments provide such a foundation.

Sustainable food challenges

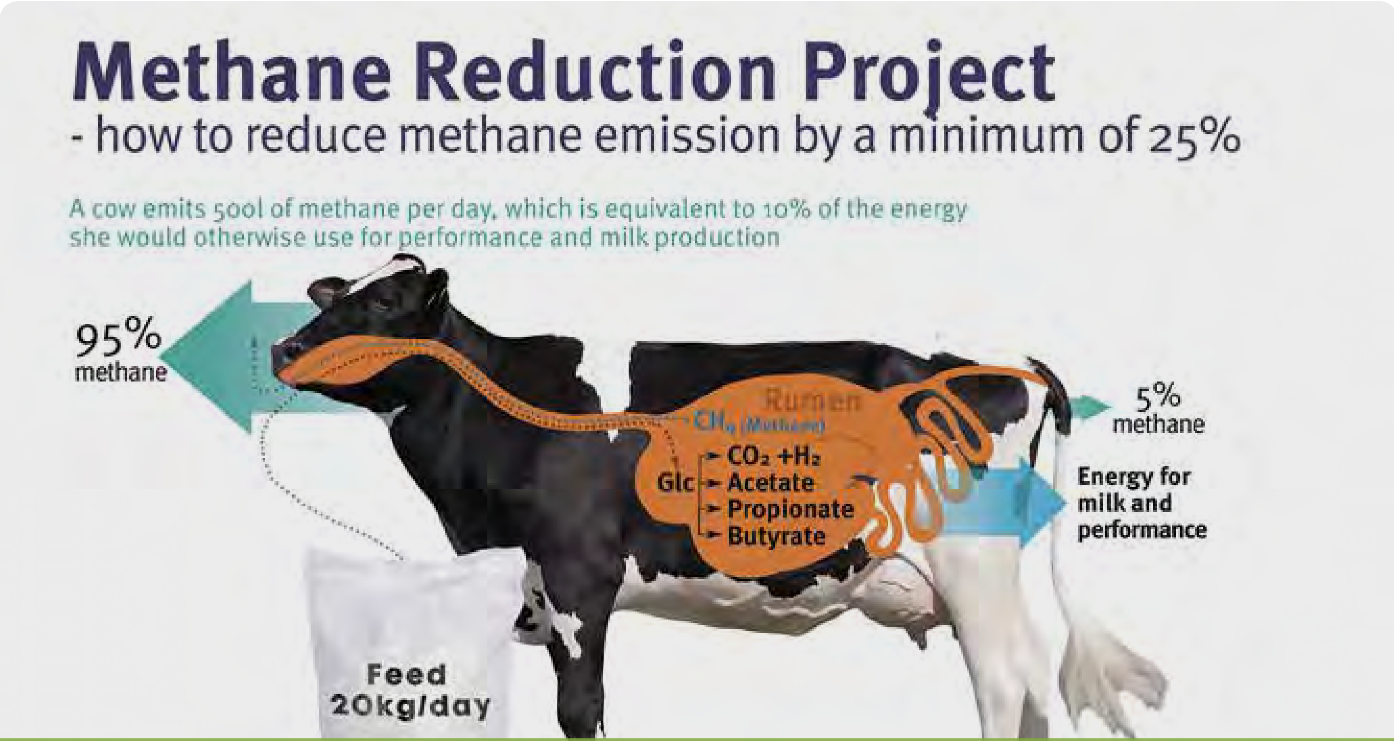
Hunger and malnutrition have not been eliminated by any means, but we are slowly making progress, as can be seen from various contributions in *Sight and Life* magazine. We are learning how to improve the global supply of nutritious food and how to reduce the vulnerability of food provision in situations of man-made as well as natural disaster. New challenges have emerged, however. The global population is growing, raising questions about the sufficient availability of arable land for growing crops for food and animal feed. The growth of the middle classes is a great sign of success, but it also increases demand for more nutrient-dense food, such as animal-source protein, which requires more land and water to produce. The threats posed by climate change do not make things any easier. Crop yields and quality may decrease and harvests may fail because of changing rainfall and temperature patterns. On top of this, the fight against climate change increases land use for the production of renewable fuels.

"The production of food has many effects on the environment"

Beyond its impact on the availability of arable land, the production of food has many other effects on the environment. Agriculture introduces nutrients into nature that disturb ecosystems. The demand for phosphate fertilizer is rapidly decreasing the extractable amount of phosphate rock in the world. Crops transpire a lot of water, which is often replenished by irrigation, causing shortages of potable water downstream. The use of pesticides endangers bees, which in turn are critical for agricultural production. Production of animal-source protein requires feed from crops; and ruminants, while making efficient use of cellulosic materials (vegetable matter that is not digestible by monogastric animals or humans) emit significant amounts of methane, which is a much more powerful greenhouse gas than carbon dioxide. The ocean is a rich resource for healthy seafood, which has a very low carbon footprint, but for many fish species, the regenerative capacity of the oceans is already fully exploited or even overexploited, seriously threatening marine ecosystems and biodiversity. Aquafarming is only a partial solution, because it still requires wild-caught fish as input and has significant effects on water quality and the availability of other resources.

The awareness of consumers, especially educated and wealthy ones, about the healthiness and sustainability of food is growing, and is already leading to changes in consumption patterns, which do not always improve the situation. Trendy "superfoods" such as quinoa, which are nutrient-rich, usually cannot deliver the yield

Pack-Age® from DSM is a moisture-permeable, breathable membrane for ripening cheese, without the risk of mold and yeast growth. Using it helps reduce food loss.



Clean Cow from DSM: an innovative feed additive that reduces enteric methane emission in ruminants

levels of common crops, and therefore call for extra land. They are typically transported over long distances, thus increasing their environmental impact. In addition, such cash crops may reduce the food security in the countries in which they are grown by replacing crops meant for local food purposes. Organic products are increasingly popular and reduce many of the impacts of farming, but they certainly increase land use, at least in the short term. Animal welfare also receives a lot of attention, but increasing animal welfare usually boosts environmental impact as well. Genetically modified crops offer great potential to improve yields in various ways and thereby reduce land use, water dependence, and pesticide use. Acceptance of genetic modification varies strongly geographically, depending partly on the public perception of its potential effects on consumer health and ecosystems and partly on the public perception of the economic power of suppliers. There is a strong trend toward switching to vegetarian, vegan, or flexitarian eating patterns. This has the potential to reduce the environmental impact of the food consumed, but it creates new challenges to shape a healthy balanced diet. In the process, some of the potential benefits of switching from animal- to plant-based protein will be sacrificed, because we cannot survive on staple foods with low nutrient density.

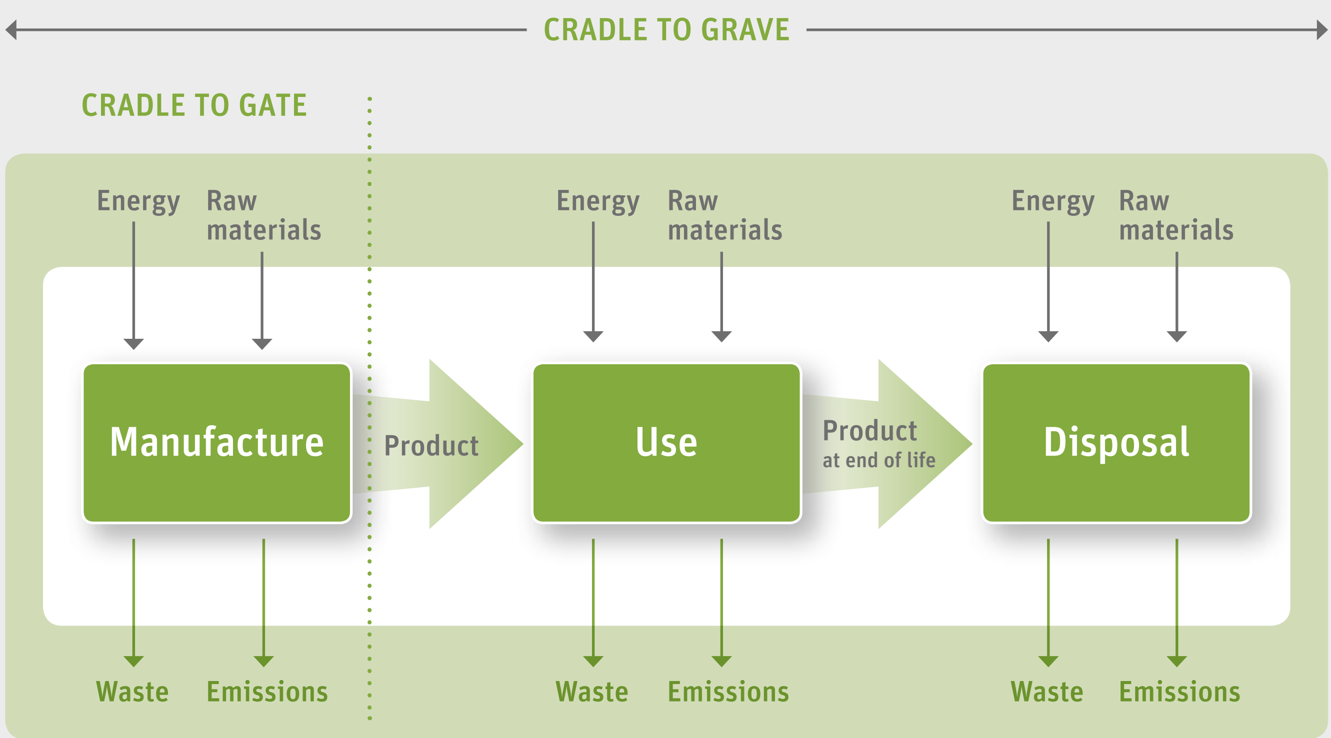
> "We cannot survive on staple foods with low nutrient density"

Many consumers are truly engaged and want to make the right decisions. The trade-offs are unfathomable to most, and in the media, there are abundant contributions highlighting one solution or the other, often with conflicting information. Scientists, authorities, non-governmental organizations and commercial companies try to help by developing and providing knowledge and new solutions. They also work together in platforms such as EAT[1] and FReSH.[2]

There are many approaches to tackle these challenges, and we need them all. Many of them require innovation. Starting on the consumer side, dietary shifts are required to replace foods with high environmental impact and low nutritional value with items with higher nutritional value and lower environmental impact. This requires more transparent and also simpler information for consumers. Nutrition scientists around the globe are developing easy parameters to capture the nutritional value of food items, while others are trying to combine nutritional value and environmental impact in comprehensive parameters. At DSM, we are interested to see whether and how micronutrients used as supplements or fortificants can help shrink the environmental footprint by providing nutrients that can otherwise only be sourced from food items with a large footprint. For example, we industrially produce quantities of vitamin C that cannot be produced on realistically available land by growing oranges or the currently popular source crop acerola.

Closer to the consumer, innovative techniques are applied to better preserve food quality and prevent waste caused by food

FIGURE 1: The scope of Life Cycle Assessments



being thrown away because it is spoiled, expired, or no longer looks attractive. Retailers should develop ways of presenting and pricing products such that they do not have to throw away leftovers or expired food. Logistic chains must be optimized to reduce time from primary production to consumption. Improved storage and transport condition control will also contribute to the solution.

Throughout the value chain, improvements in energy efficiency and shifts to renewable energy will reduce energy-related impacts. Improvements in animal nutrition will improve animal feed efficiency and reduce emissions from animals and manure. These include, for example, the application of enzymes to improve the digestibility of proteins, phytates, and carbohydrates, also enabling shifts to lower-quality (residual) feed ingredients with a smaller footprint. Precision farming and improved manure management (more precise fertilizer and pesticide application, stable exhaust air washers, manure injection instead of spreading) will reduce inputs into, and emissions from, farms. Improved breeding techniques will increase the efficiency of livestock and crops.

Sustainable fishery schemes will improve, and will ensure that fish species are not exploited beyond their regenerative capacity. Fishing techniques will become more precise, reducing the amount of bycatch of endangered species. Aquaculture dependency on fish will be reduced by developing alternatives for essential feed ingredients for aqua-farmed fish, such as long-chain omega-3 fatty acids,[3] which today are still mainly sourced from fish.

Despite the many potential solutions mentioned above and many more that are around the corner or will be developed in the future, it is by no means certain that we will be able to meet the challenges we face. Moreover, these solutions have environmental impacts of their own and may have impacts on areas which are not immediately apparent. Finally, not all these solutions can be combined without reducing their effectiveness, or even making the situation worse.

So how can an innovator know that his or her solution is really improving sustainability?

Sustainability in innovation

For many companies, the commitment to sustainability focuses on creating competitive advantage, new markets, and business opportunities. For DSM, however, it goes beyond that. It is also about ensuring that the company fulfills its mission to create brighter lives for people today and for generations to come.

Through a long-standing commitment to sustainability-driven innovation, DSM is at the forefront of addressing the challenges of rising consumption, resource scarcity, overexploitation of ecosystems, and climate change.

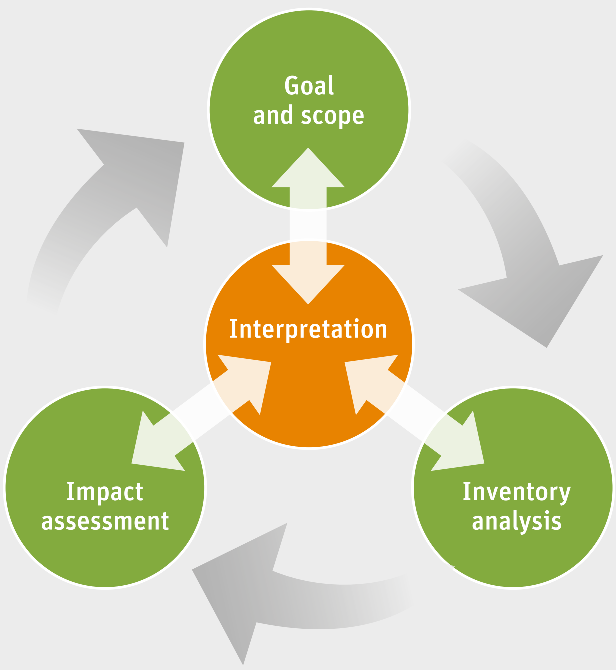
DSM realizes the potential value of meeting its customers' sustainability criteria: over 80% of its innovation portfolio consists of *Brighter Living Solutions* – products that are environmentally or societally superior to competing mainstream solutions. Because of these initiatives, DSM has been consistently recognized as an industry leader by the Dow Jones Sustainability Index.

"A Life Cycle Assessment identifies the material, energy, and waste flows associated with a product or process over its entire life cycle"

Life Cycle Assessment (LCA)

DSM's sustainability strategy is supported by the use of Life Cycle Assessments (LCAs). An LCA identifies the material, energy, and waste flows associated with a product or process over its entire life cycle to determine environmental impacts and potential improvements; this full life cycle approach is also referred to as "cradle to grave." It is also possible to assess a partial life cycle of a product or process, with the most common type being the "cradle to gate" assessment, which focuses on the environmental impacts of a manufacturing process without accounting for the use phase or end-of-life impacts (**Figure 1**). There are many different environmental impact categories that can be assessed using LCAs; at DSM, the standard approach is to evaluate the carbon footprint and the eco footprint.

FIGURE 2: The LCA process



Carbon footprint (CFP) and eco footprint (EFP)

The carbon footprint (CFP) is the weighted sum of greenhouse gas (GHG) emissions and GHG uptake of a process or a product system, expressed as kg CO_2 equivalents. GHGs include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). The CFP is a very important parameter because it is directly correlated to global warming and climate change.

The eco footprint (EFP) is a more complete summary of the impact of an activity on the environment. The EFP is divided into three categories: **(1)** human health, e.g., carcinogenic and respiratory problems; **(2)** ecosystem quality, e.g., biodiversity and land occupation; and **(3)** resource depletion, e.g., minerals and fossil fuels.

Performing an LCA

LCAs are iterative processes in which the goal must be clearly defined at the beginning (**Figure 2**).

The goal of the LCA determines what to include in its scope. Typically, the LCA will assess environmental impacts from cradle to gate or cradle to grave, although different scopes are sometimes required. For example, the scope of a cradle-to-gate LCA of a product requires first a cradle-to-gate footprint of the individual raw materials used. These partial LCAs are used as the input for the cradle-to-gate LCA of the product. In a similar way, the scope can be expanded to cradle-to-grave by including downstream products, distribution processes, retail, use by consumers, and end-of-life treatment. *Inventory analysis* is a thorough bookkeeping of a production process, i.e., what quantities of raw materials, energy, and water are used. The impact assessment is the actual calculation of the CFP and EFP of the production process according to the selected method.

During the entire LCA process, continuous interpretation of the data and the results is required to ensure the data gathered and results obtained are in line with the goal and scope.

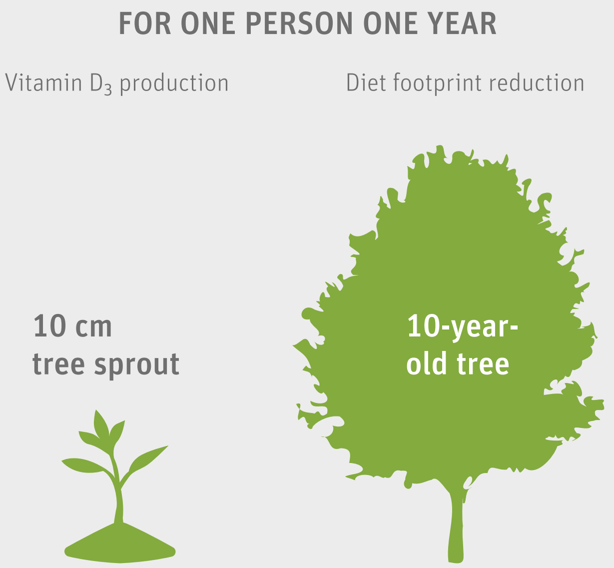
DSM uses SimaPro software and internationally standardized assessment methods to conduct LCAs.

"LCAs are a powerful tool with many applications and benefits"

Using LCAs

LCAs have many applications and benefits. They can be used in innovation and development processes as a decision support tool to highlight the most sustainable options. They can also be used to analyze the efficiency and environmental impacts of existing products and processes to identify hot spots where impacts can be mitigated. Comparative LCA studies can determine

FIGURE 3: Vitamin D supplementation can reduce the environmental impact of a diet



whether a competing product has a better or worse environmental footprint, highlighting opportunities for good environmental performance to be communicated to stakeholders.

To illustrate, not long ago DSM looked at the potential of vitamin D_3 supplements to provide a full recommended dietary allowance (RDA) of this nutrient with a reduced footprint. Under ideal conditions, the human metabolism can produce sufficient vitamin D_3 from direct exposure to sunlight. However, with a modern lifestyle at higher latitudes, particularly during the winter, this is not sufficient, so the RDA has to be consumed to prevent deficiency. It turned out that the footprint of a fully sufficient diet can be reduced by using supplements. This is because vitamin D_3 is not present in many foods. Its main sources are fish, eggs, and milk. For a sufficient intake of vitamin D_3, most people would need to increase their consumption of these foods. Even though fish has a very low footprint compared to other animal proteins, its footprint is still higher than that of plant-based protein. By using supplements, less animal-source food has to be consumed and more plant-based protein can be utilized, thus reducing the overall footprint. The environmental impact avoided by this menu change is 70,000 times greater than the added impact resulting from producing the supplement. In **Figure 3**, the effect for one person for one year is illustrated in terms of the amount of carbon dioxide embodied in a growing tree.

Conclusion

Providing sustainable, nutritious food to the growing world population is a tremendous challenge. Many solutions are currently under development. To determine if these indeed have a net positive contribution and to select the best ones, sound methods are needed to assess sustainability. The Life Cycle Assessment is the preferred method. It is a powerful tool for quantifying the trade-offs involved.

Correspondence: ***Henk Bosch,*** *Sustainability Manager,*
DSM Nutritional Products, Wurmisweg 576,
4303 Kaiseraugst, Switzerland
Email: *Henk.Bosch@dsm.com*

References

01. eatforum.org [homepage]. The EAT Foundation; 2018. Internet: eatforum.org/ (accessed 11 April 2018).
02. WBCSD. The FReSH program. Version current 11 April 2018. Internet: www.wbcsd.org/Projects/FReSH (accessed 11 April 2018).
03. World Fishing & Aquaculture. Natural EPA & DHA production established. Version current 8 February 2018. Internet: www.worldfishing.net/news101/fish-farming/natural-epa-and-dha-production-established (accessed 11 April 2018).

Further reading and many references can be found on Wikipedia: *https://en.wikipedia.org/wiki/Life-cycle_assessment (accessed 11 April 2018).*