Climate-smart approach to affordable, nutrient-dense foods: the SoyaKit and SoyCow

Malnutrition Matters has been deploying woman-empowering and rural-appropriate food technology solutions since 2000. These micro-enterprise-based approaches enable hyper-local processing of soy foods with a financially self-sufficient approach; the result is affordable and sustainable protein-rich foods accessible to communities with higher rates of malnutrition.

The SoyaKit (Malnutrition Matters copyrighted term for the appropriate technology that it has designed and distributes) has been documented in the journal *Food and Nutrition* as an appropriate technology for rural settings that enables women entrepreneurs to earn a reasonable profit, such that they can repay the cost of the equipment and operate a long-term sustainable business[i]. Overview information here for the SoyaKit and the SoyCow, and a SoyaKit Concept Note and a SoyaKit Video. Retail prices of the soy foods produced, on a per-gram-of-protein basis, are typically 50% less than those of dairy foods, eggs or other animal-based proteins. Cultivation of soy produces twice as much protein per acre than any other major vegetable or grain crop, and 5 to 15 times more protein per acre than land set aside for dairy or meat production[ii]. The World Health Organization states that soy protein is the only plant-based protein that has an amino-acid profile equivalent to that of dairy, meat and eggs[iii]; the US FDA endorses the quality of soy protein[iv].

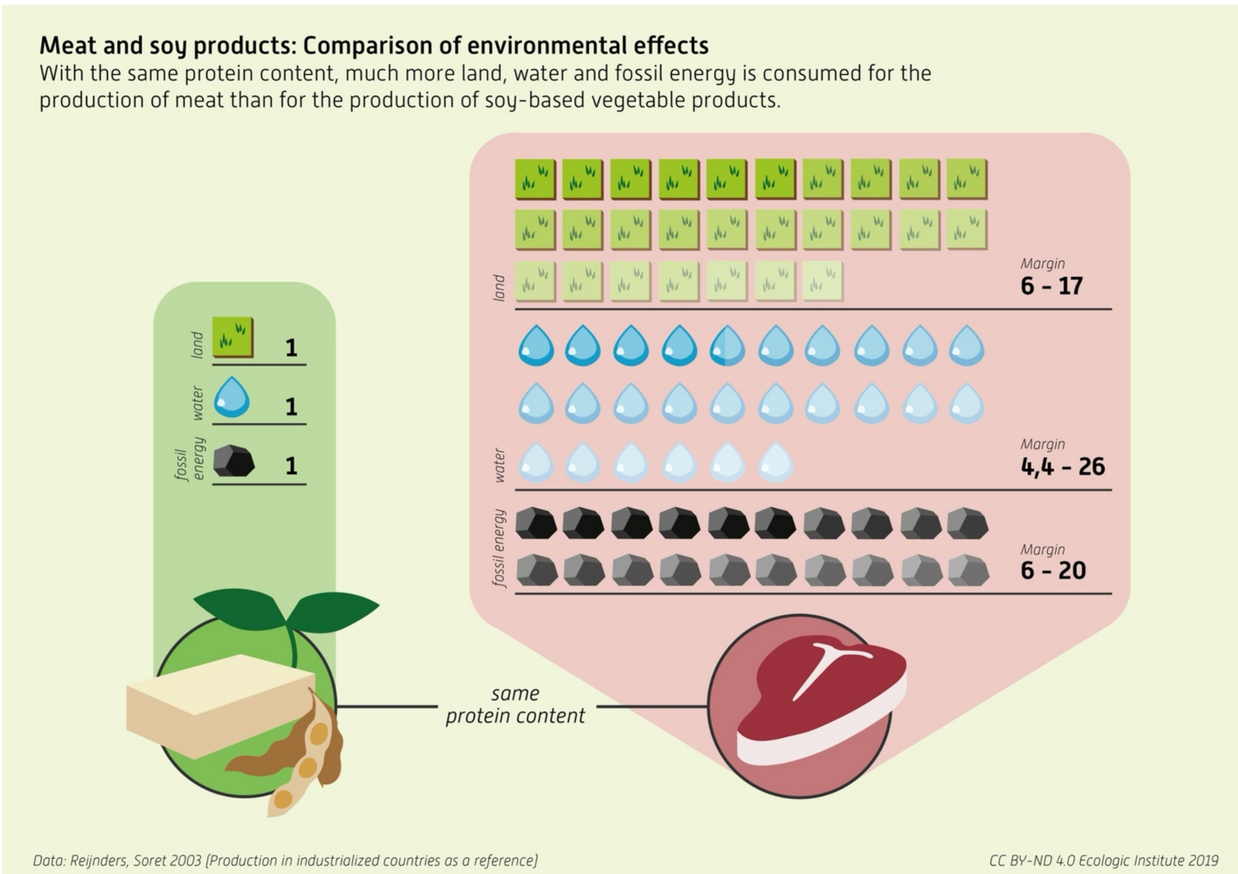
The hyper-local soya processing approaches are also climate-smart in that they use 5% to 7% of the fossil fuel energy compared to dairy milk production for example[v] , and 12% of the water required for meat production[vi], before even accounting for the methane emissions of dairy cows or beef cattle. This means that dairy milk or meat production can result in 15 or more times the GHG emissions required for production of soyfoods, before accounting for ruminants' methane production. The studies quoted compare production in industrialized countries – they do not account for additional GHG reductions associated with the SoyaKit. The SoyaKit uses a heat-retention cooking bag, reducing fuel required for cooking by 50%, further reducing GHG emissions from these comparatively low levels[vii]. Similarly, when compared to eggs, soymilk production results in only 25% of GHG emissions[viii].

Production of soyfoods, compared to production of animal-based proteins including dairy products, eggs and meat, results in these significant savings, which directly and indirectly mitigate climate change:

- Energy savings, directly reducing GHG emissions
- Water saving
- Land saving
- Zero waste
- Saving of methane emissions from ruminants, pigs and poultry
- Reduced use of fertilizer due to nitrogen-fixing property of soybean cultivation.

The figure on the next page illustrates the substantial difference in resources required for soyfood production vs animal protein[ix].

Cultivation of soybeans, as part of a crop rotation, also facilitates regenerative agriculture by naturally improving soil health, enabling production of high quality, nutrient dense food, and ultimately leading to productive farms and healthy communities and economies. By saving land otherwise used in the inefficient production of animal-based proteins, the further deforestation required to support animal protein production can be prevented. When used as a rotation crop, soybean can lower the fertilizer requirement for a complementary crop such as maize. Soybean, as is true for other legumes, fixes nitrogen in the soil, which is available to be absorbed by a rotation crop in the next season.



Production of soyfoods using the SoyaKit or SoyCow results in output of various foods (soymilk, yoghurt, tofu, sour milk, puddings, ice cream etc) and a fibrous by-product, okara. The okara is cooked, and contains some protein and is usable for human consumption or for animal feed. It can be used in soups, bread, deep-fried snacks or biscuits. It can also be sold directly for animal feed for cows, goats, chickens or pigs. Therefore, the entire soybean is consumed – no waste remains, as opposed to meat production where up to 1/3 of the animal weight is not consumable.

The energy savings associated with soybean cultivation and direct human consumption of soyfoods is quite substantial; these energy savings are directly associated with a reduction in GHG emissions. When measured on a 'global biomass' basis, direct human consumption of soyfoods is 30x more energy efficient than animal protein production[x].

One of the main reasons for the vastly greater amounts of GHG emissions in animal-based protein production is the Feed Conversion Ratio[xi]. This measures the ratio of calories and protein fed to animals to the live weight or edible weight produced. The ratio of protein production for various edible weights is shown here:

Feed Conversion Inefficiencies

	Chicken	Pork	Beef
Feed conversion (feed/live weight)	2.5	5	10
Feed conversion (feed/edible weight)	4.5	9.4	25
Protein content (% of edible weight)	20	14	15
Protein conversion efficiency (5%)	20	10	4

Source: Vaclav Smil, 2008. Eating meat: Evolution, Patterns and Consequences

This shows us that the protein conversion ratio for chickens per unit of feed is 20 (i.e., 100 units of feed produces 20 units of edible protein), and is worse for pork (ratio of 10) and even worse for beef (ratio of 4).

Currently 62% of land under cultivation is used to support animal protein production[xii]; using a feed conversion ratio of about 12 (between 4 and 20), these lands produce only 5% of calories and 10% of protein than the same amount of land used for plant-based food.

The USAID-funded AgDiv project in Malawi, with assistance from Malnutrition Matters, currently has over 5,000 women entrepreneurs locally producing and selling soymilk and yoghurt in their neighbourhoods. Current production is over 600,000 liters per month, or about 3.5M servings (protein equivalent to one egg, i.e., 5 grams), serving about 170,000 consumers daily. **Estimated GHG savings using figures in the above references are 120 metric tons of CO_2 equivalent per month**. This estimate assumes:

- Average family income in rural communities in Malawi is $45 /month; estimated money available for protein-rich food is $0.15 per day (3 servings of soy milk or 1.5 eggs)
- Most affordable local protein is eggs, as dairy is rarely available/accessible
- Twice as much soymilk equivalent would be consumed as eggs, given the limited household budget for protein in most diets (and therefore losing half of the potential GHG savings)
- GHG emissions of 150g per egg vs 37g per serving of soymilk (x2 as shown above =74g), means 76g of GHGs saved per two servings of soymilk (about 30 servings / kg of GHGs saved)
- Savings may be higher as the 50% fuel savings realized by the use of the heat-retention cooking bag are not included.

References:

i) Chungmann Kim, BS, Peter Goldsmith, PhD, The Economics of the Soy Kit as an Appropriate Household Technology for Food Entrepreneurs, Food and Nutrition, April 21, 2021

Article link with preface from Malnutrition Matters: https://www.dropbox.com/s/m7s3bgvebdm07er/SoyaKit%20Journal%20Article.pdf?dl=0

ii) National Soy Research Laboratory, U. of Illinois, *All About Soy,* Nov 20, 2015

https://web.archive.org/web/20151120072618/http://nsrl.illinois.edu/content/benefits-soy

Soybeans can produce at least twice as much protein per acre than any other major vegetable or grain crop, 5 to 10 times more protein per acre than land set aside for grazing animals to make milk, and up to 15 times more protein per acre than land set aside for meat production.

iii) Protein Quality Evaluation: Report of the Joint FAO/WHO Expert Consultation, Bethesda, Md., USA 4-8 December 1989

https://books.google.com/books?hl=en&lr=&id=ieEEPqffcxEC&oi=fnd&pg=PA1&ots=IvCFOavYEh&sig=T7dQSQ3ouvfkSQtIJDiuuRRQPEM#v=onepage&q&f=false

iv) Henkel J. , Soy health claims for soy protein, questions about other components. *FDA Consum.* 2000;34(3):13-15.

v) Friedlander, J., Soy versus dairy: what's the footprint of milk? *The Conversation*, August 27, 2012

https://theconversation.com/soy-versus-dairy-whats-the-footprint-of-milk-8498

Cornell University scientist, David Pimentel, has found it takes about 14 kilo-calories (kcal) of fossil-fuel energy to produce 1kcal of milk protein using conventional milk production. Organically produced milk might require a little less than 10kcal of fossil-fuel energy per kcal. In comparison, Pimentel's data suggests that in a conventional soybean production system, one kcal of fossil energy invested produces about 3.2kcal of soybean. For 1kcal of fossil energy invested in *organic* soybean production, you get an average of 3.8kcal of soybeans. This means it takes between .26 and .31kcal of fossil fuel to make 1kcal of soybeans (contrasted with 10-14kcal to make 1kcal of dairy milk protein). Pimentel states that soy protein accounts for about 35% of those kilocalories, **so making soy protein is 15x more energy-efficient than dairy protein.**

vi) The Food Transformation, Harnessing consumer power to create a fair food future, OXFAM International, July 2012

https://oi-files-d8-prod.s3.eu-west-2.amazonaws.com/s3fs-public/file_attachments/food-transformation-grow-report-july2012_4.pdf pages 22, 39 for references regarding water use of soy vs meat

Cultivation / harvesting of **500g soybeans uses 818 liters of water**

Production of **500g beef uses 6800 liters of water**

P 40 shows how much methane a cow produces

vii) SoyaKit© : Home Business in a Box, Malnutrition Matters, May 2017

https://www.dropbox.com/s/9ehx1t5fb0ugsxu/Soya%20Kit%20overview%2001-21.pdf?dl=0

viii) Carlsson-Kanyama, A., González, A. D., Potential contributions of food consumption patterns to climate change, *The American Journal of Clinical Nutrition*, Volume 89, Issue 5, May 2009, Pages 1704S–1709S, https://doi.org/10.3945/ajcn.2009.26736AA Published:01 April 2009

TABLE 3

Carbon dioxide, methane, and nitrous oxide emissions from farm to table for 22 items commonly consumed in Sweden

This table showed .92kg of Co2 emissions per kg of cooked soybean vs 2.5 for eggs, 4.3 for chicken, 9.3 for pork and 30 for beef. However, the soybeans were shipped from Nebraska and the meat products were all local. The shipping contributed .32kg of C02 (1/3 of total). When we subtract that we see that the factor for increased GHGs is:

4x for eggs
7x for chicken
15x for pork
50x for beef

ix) Reijnders, Soret, 2003; copied by Ecologic Institute 2019

https://www.ecologic.eu/16618

x) Changing global diets is vital to reducing climate change, University of Cambridge, Aug 31, 2014

https://phys.org/news/2014-08-global-diets-vital-climate.html

"The average efficiency of livestock converting plant feed to meat is less than 3%, and as we eat more meat, more arable cultivation is turned over to producing feedstock for animals that provide meat for humans. The losses at each stage are large, and as humans globally eat more and more meat, conversion from plants to food becomes less and less efficient, driving agricultural expansion and land cover conversion, and releasing more greenhouse gases. "

xi) Feed-to-Meat Conversion Inefficiency Ratios, A Well-Fed World Foundation, 2022
https://awellfedworld.org/feed-ratios/

FCR Mainstream Examples

Live Weight

- 6:1 – beef cows – *Beef Magazine* (industry)
- 6:1 – beef cows, 3.4:1 – pigs, 2:1 – poultry – Noble Foundation (industry)
- 7:1 – beef cows, 4:1 – pigs, 2-1 – chickens – Brown (advocate)
- 8-12:1 – beef cows, 5-6.5:1 – pigs, 2-2.5:1 – chickens – Smil (p.157) via Cassidy (p.6)

Edible Weight (more accurate)

- 16:1 – beef cows – Lappe (Diet for a Small Planet, 1991, p.69) – (frequently-cited advocate)
- 25:1 – beef cows,
- 9.4:1 – pigs,
- 4.5:1 – chickens
- – Smil (EM/2008 via UKY) (researcher)

More Comprehensive FCRs

Percent/Units of Edible Output per 100 Units of Feed

- Poultry – Calories – 11% – Protein 20%
- Pigs – Calories – 10% – Protein 15%
- Cows/Beef – Calories – 1% – Protein – 4%

Source: World Resources Institute (w/UN & WB): Creating a Sustainable Food Future, p.37

New, more comprehensive methods show that even the high-end of commonly cited FCRs are highly conservative.

xii) Uwe R. Fritsche, Ulrike Eppler, Leire Iriarte, Sabine Laaks (International Institute for Sustainability Analysis and Strategy (IINAS)), Resource-Efficient Land Use – Towards a Global Land Use Standard (Globalands), *Umweltbundesamt* (Germany), October, 2015

https://www.umweltbundesamt.de/sites/default/files/medien/378/publikationen/texte_82_2015_resource_efficient_land_use.pdf

Page 19 shows that (footnotes 7 and 8) many more times of water and energy are required for animal-based foods. 62% of land use is for animals… using a feed conversion ratio of about 12 (between 5 and 20), this 62% of land produces about 5% of calories and 10% of protein than the same amount of land used for plant-based food.