SINGLE-IMPACT FICHE – ORGANIC SYSTEMS

IMPACT: GREENHOUSE GAS EMISSION

Data extracted in October 2021

Note to the reader: This fiche summarises the impact of organic systems on GREENHOUSE GAS EMISSION (reported for CH_4, N_2O and aggregate GHG emissions). It is based on 5 peer-reviewed synthesis research papers[1]. Each synthesis paper includes a number of individual studies, which ranges in this case from 9 to 164.

1. WEIGHT OF THE EVIDENCE

- CONSISTENCY OF THE IMPACT: The effect on GHG emissions of organic farming systems, as compared to conventional systems are reported as:
  - per unit of area:
    - Aggregated GHG-emissions: the only 1 available synthesis paper reported positive effect (i.e. decrease on GHG emissions) for organic mixed farming (i.e. with animal and plant production on the same farm).
    - CH_4 emission: positive effects were reported by one synthesis paper for cropping systems (arable soils under organic management showed higher methane uptake, than under conventional), and by another one for livestock/mixed farming systems (lower methane emissions). Uncertain results were reported in one synthesis paper on rice production from paddy soils.
    - N_2O emission: positive effects were reported by 2 synthesis paper for cropping systems and by one for livestock/mixed farming systems.
  - per unit of product:
    - Aggregated GHG-emissions: no significant effect was reported for cropping systems, livestock/mixed systems, respectively by 3 and 3 (2 of high quality) synthesis papers. One synthesis paper reported positive effects for organic fruits and another one reported negative effect for livestock products (excluding dairy products, which showed no significant effect). Uncertain results were reported in one synthesis paper for crop products and one for livestock products.
    - CH_4 emission: positive effects were reported by one synthesis paper for cropping systems (arable soils under organic management showed higher methane uptake, than under conventional), while no results were available for livestock/mixed systems. Uncertain results were reported in one synthesis paper on rice production from paddy soils.
    - N_2O emission: contrasting results were reported for organic cropping systems, with one synthesis paper reporting negative effects and another one no significant effects. No results were available for livestock/mixed systems.

All syntheses included studies conducted in Europe.

[1] Research synthesis papers include a formal meta-analysis or systematic reviews with some quantitative results

Table 1. Summary of effects. The effect with the higher score is marked in bold and the cell coloured. The numbers between parentheses indicate the number of synthesis papers with a quality score of at least 50%. Details on quality criteria can be found in the next section. Some synthesis papers reported effects for more than type of system.

Impact	Metric	Impacts per unit of agricultural land				Impacts per unit of product			
		Positive	Negative	No effect	Uncertain *	Positive	Negative	No effect	Uncertain *
Organic cropping systems									
Decrease GHG emissions	Aggregated** GHG emissions					1 (1)	0	**3 (2)**	1 (1)
	CH_4 emission	**1 (1)**	0	0	1 (1)	**1 (1)**	0	0	1 (1)
	N_2O emission	**2 (2)**	0	0	1 (1)	0	**1 (1)**	**1 (1)**	1 (1)
Organic livestock systems									
Decrease GHG emissions	Aggregated** GHG emissions	**1 (1)**	0	0	0	0	1 (0)	**3 (2)**	1 (1)
	CH_4 emission	**1 (1)**	0	0	0				
	N_2O emission	**1 (1)**	0	0	0				

* Number of synthesis papers that report relevant results but without statistical test comparison of the intervention and the control.

** Emissions (including contributions of all GHG emissions sources, as CO_2-equivalents) are typically accounted for all 'cradle-to-farm gate' activities, using life cycle analysis (LCA), to assess the performance of organic systems in comparison to conventional systems.

- QUALITY OF THE SYNTHESIS PAPERS: *The quality score summarises 16 criteria assessing the quality of three main aspects of the synthesis papers: 1) the literature search strategy and studies selection; 2) the statistical analysis; 3) the potential bias. Details on quality criteria can be found in this document* →.

As shown in the "Quality score" in **Table 2,** the quality the 7 synthesis papers retrieved ranged from 44% to 69%. The least frequently satisfied quality criteria were: "Search string", "Number of studies of each step", "Individual effect sizes", "Individual studies weighted", "Heterogeneity of results analysed" and "Publication bias analysed".

2. IMPACTS

The main characteristics and results of the 5 synthesis papers are summarized in **Table 2**. The references are ordered chronologically with the most recent publication date first.

Table 2. Main characteristics of the synthesis papers reporting impacts on GHG emissions. All detailed results of each synthesis study are reported in the summary reports →.

Reference	Population	Geographical scale	Num. papers	Intervention	Comparator	Metric	Conclusion	Quality score
Clark, M; Tilman, D. 2017	LCA studies assessing the performance of organic systems in comparison to conventional systems. Emissions are accounted for all 'cradle-to-farm gate' activities.	Global *	164	Organic Cereals, Organic pulses and oil crops, Organic fruits, Organic Vegetables, Organic meats, Organic dairy products and eggs	Conventional beef, dairy products and eggs	Greenhouse gas emissions (GHGs) per unit of product are reported in carbon dioxide equivalents, and include the greenhouse gas emissions from carbon dioxide, methane, and nitrous oxide. Emissions are accounted for all 'cradle-to-farm gate' activities.	Organic systems (all systems. as average) show comparable GHG emissions per unit of product than conventional systems (no significant change). As compared to conventional products, organic cereals, pulses, oil crops and vegetables, resulted in no significant change for GHG emissions per unit product; organic fruits resulted in significantly lower GHG emissions per unit product; organic meats, dairy products and eggs resulted in no significant change for GHG emissions per unit product.	62%
Lee K.S., Choe Y.C., Park S.H. 2015	Farm-level studies assessing the performance of organic systems in comparison to conventional systems.	Global	19	Organic livestock and dairy products	Conventional livestock and dairy products	Greenhouse gas emissions (overall) per unit of product (large majority) and per unit of area (few). **	Organic livestock products, as compared to conventional, showed significantly higher GHG emissions. Dairy products, fruits, vegetables and crops showed non-significant differences.	44%
Skinner, C; Gattinger, A; Muller, A; Mader, P; Fliessbach, A; Stolze, M; Ruser, R; Niggli, U. 2014	Field studies assessing the performance of organic systems in comparison to conventional systems. In study organic systems organic practices were applied for at least three consecutive years prior to sampling.	Global	13	Organic systems (Arable crops, Grassland, Paddy rice fields***)	Conventional systems	N_2O emission per unit of area and product; CH_4 emission per unit of area and product	There is scientific evidence for lower nitrous oxide emissions from organically managed soils when scaled to the area of cultivated land but higher emissions when crop yield-scaled. This discrepancy is due to the observed 26% lower crop yield under organic management. All arable soils showed an average methane uptake, which was slightly higher (both area-scaled and yield-scaled) under organic than under non-organic management.	50%

Tuomisto HL; Hodge ID; Riordana P; Macdonald DW 2012	Field studies, modelling studies and Life Cycle Assessment studies assessing the performance of organic systems in comparison to conventional systems in Europe.	Europe	71	Organic production of milk, beef, pork, olives, cereals	Conventional production of milk, beef, pork	GHG emissions (LCA approach) per unit of product	N_2O emission per unit of area result significantly lower for all organic production systems, while non significantly different per unit of product. Aggregated greenhouse gas emissions per unit of product were not significantly different for organic (all production systems) vs conventional systems. For single categories of products, olives, organic milk, beef and pork, results were ~~rated~~ labelled as uncertain, due to the lack of statistical analysis and few data available.	69%
Mondelaers, K; Aertsens, J; Van Huylenbroeck, G. 2009	Studies assessing the performance of organic systems (crops + livestock) in comparison to conventional systems.	Global	9	Organic mixed farming: with animal and plant production on the same farm.	Conventional mixed farming	GHG emissions (total, N_2O, CH_4)	Organic mixed farming (crops + livestock) scores equal (per unit product no general direction is noticeable) or better (per unit of agricultural area) than conventional farming.	50%

*In Clark and Tilman (2017), the majority of LCA publications included are from agricultural systems in Europe, North America, and Australia and New Zealand (86% of systems are from these regions). Systems from China (2%), Japan (2%), the rest of Asia (5%), south America (4%), and Africa (.4%) are much less common. The results presented here are therefore indicative of highly industrialized systems and should be interpreted with this in mind.

** Greenhouse emission studies more often used output-based outcome measures with LCA as the measurement method. EAM (Energy Analysis Method). In this analysis, the Energy Analysis Method (EAM), Life Cycle Assessment (LCA), Emergy, and other methods, including Life Cycle Climate Impact (LCCI), are compared.

***In Skinner et al. (2014), only one comparative study on rice paddies is considered and therefore results are set as uncertain. All 19 retrieved studies were conducted in the northern hemisphere under temperate climate.

3. KNOWLEDGE GAPS

Skinner, C. 2014	Only one comparative study on rice paddies has been published up to date. All 19 retrieved studies were conducted in the Northern hemisphere under temperate climate.

4. SYSTEMATIC REVIEW SEARCH STRATEGY

Keywords *	TOPIC: ("organic farm*" OR "organic agriculture" OR "organic system*" OR "organic product*") AND TOPIC: ("meta-analy*" OR "systematic* review*" OR "evidence map" OR "global synthesis" OR "evidence synthesis" OR "research synthesis") TOPIC: ((organic near/4 farm*) OR (organic near/4 agric*) OR (organic near/4 produc*) OR (organic near/3 livestock) OR (organic near/3 animal)) AND TOPIC: ("animal*" OR "livestock" OR "ruminant*" OR "small ruminant*" OR "cattle" OR "dairy cattle" OR "dairy" OR "beef cattle" OR

	"sheep" OR "ewe*" OR "lamb*" OR "swine" OR "pig*" OR "porcine*" OR "goat*" OR "rabbit*" OR "poultry" OR "chicken*" OR "broiler*" OR "turkey*" OR "hen*" OR "horse*" OR "mule*" OR "milk" OR "egg" OR "beef" OR "cheese" OR "meat" OR (animal near/2 protein*) OR "yogurt" OR "bacon" OR "pork") AND TOPIC: ("meta-analy*" OR "systematic* review*" OR "evidence map" OR "global synthesis" OR "evidence synthesis" OR "research synthesis")
Search dates	No time restrictions
Databases	Web of Science and Scopus, run for the first time in July 2020 and updated in September 2021 and October 2021.
Selection criteria	Four main criteria led to the exclusion of a synthesis paper: (1) the paper does not deal with organic systems; (2) the paper does not assess the impacts of organic systems in comparison to another cropping system; (3) the paper report results on the effect of specific farming practices (e.g. organic fertilisation, green manure, alternative pest control techniques, etc.) which are part of organic systems, instead of the effect of the whole farming system; (4) the paper is neither a meta-analysis nor a systematic review including quantitative results. Synthesis papers that passed the relevance criteria were subject to critical appraisal carried out on paper-by-paper basis. From the 220 potentially relevant synthesis papers, 140 were excluded after reading the title and abstract, and 50 after reading the full text according to the above-mentioned criteria. Finally, 30 synthesis papers were selected for organic farming systems, from which 5 were relevant for this impact.

* search queries reported here using the syntax of Web of Science