COMMENT

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Comment

FiBL identifies methodological flaws in a study by Julius McGee that criticizes the climate change mitigation potential of Organic Farming, which was published in the journal Agriculture and Human Values in June 2015

A recent study[1] by McGee from the University of Oregon has led to discussions in international media and on the web. This study addresses an interesting question and applies advanced statistics for its analysis. However, we identify several methodological flaws that invalidate the results. Most important are 1) that the conclusions cannot be derived from the hypotheses that were tested and 2) that the data used are not adequate for the analysis that was undertaken.

(Frick, August 11, 2015) This response to the article by McGee (2015) and to the related media coverage in the Guardian, Mail Online, the University of Oregon page and others complements the response by IFOAM from August 4, 2015, in which a wealth of evidence, that has not been acknowledged in McGee (2015), is provided for the GHG mitigation effects of organic agriculture. This evidence is based on scientific literature reporting measured field and farm level data. Here, we focus on further flaws in the formulation of the hypotheses, the data used for the analysis, and the conclusions drawn in McGee (2015).

The paper by McGee addresses an interesting question and applies advanced statistics for its analysis. However, we identify several methodological flaws that invalidate the results. Most important are:

1. that McGee (2015) tests a hypothesis that does not correspond to his main question, and which does not allow McGee to derive the conclusions that are drawn in his paper and reported in the media coverage;
2. that the data used are not adequate for the analysis because:

[1] McGee, J (2015) Does certified organic farming reduce greenhouse gas emissions from agricultural production? Agriculture and Human Values 32(2): 255-263

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2.1. the dependent variable does not reflect the climate change characteristics of organic agriculture (e.g. different emission factors),
2.2. the explanatory variables neglect the livestock sector,
2.3. trade aspects are missing.

The following considerations develop this criticism in further detail.

1. The hypotheses tested are not those that McGee should test when trying to answer his questions. Hypothesis 1 reads as follows: "A one-unit increase in certified organic farmland is correlated positively with agricultural greenhouse gas emissions when controlling for all factors driving agricultural greenhouse gas emissions." However, the hypothesis to be tested should rather be: "A one-unit increase in certified organic farmland is correlated *more strongly and with a higher correlation coefficient* with agricultural greenhouse gas emissions *than a one-unit increase of conventional farmland* when controlling for all factors driving agricultural greenhouse gas emissions."

   Imagine a situation, where conventional areas remain constant and organic areas increase. In this situation, increasing GHG emissions from agriculture are clearly linked to increasing organic areas and the coefficient of conventional areas is insignificant. This would however not tell us anything about by how much more (or less) GHG emissions would have increased if all area increases had been under conventional instead of organic agriculture.

   Here the displacement paradox becomes important. The question behind this is largely the following: Does an increase of organic area replace a corresponding increase in conventionally farmed area that would have taken place in the case that the organic area had not increased? Or is an increase in organic area rather driven by a demand additional to the demand for conventional produce; thus not replacing conventional production? The question is thus whether organic production rather complements or substitutes conventional production. This is an interesting and legitimate question, but to test it, other hypotheses than those of McGee (2015) would need to be formulated and other data would need to be available. In particular, the displacement paradox has to be addressed on the level of areas or product quantities and changes thereof and not on the level of GHG emissions. The issue of GHG emissions (or impacts of organic agriculture in general) would have to be assessed only subsequently and as a consequence of the effects of the displacement paradox being present. Thus, the hypothesis tested does not allow light to be shed on the displacement paradox, which is one key interest of the paper.

   We did not put much thought into how to best test this, but even when following York (2012)[2], who is cited in McGee (2015) as an inspiration for the methods used, the regression would rather be the following: conventional areas (or conventional production) would be the

[2] York, R. 2012. Do alternative energy sources displace fossil fuels? Nature Climate Change 2(6): 441–443.

dependent variable and the explanatory variables would be organic area (or organic production) plus the control variables McGee (2015) used. We propose that more effort should be made to identify the most adequate statistical methods for analyzing the displacement paradox with regard to organic and conventional food. This may or may not result in the method used by York (2012), but we have reservations, because the considerable econometric literature devoted to analyzing complements and substitutes in consumption usually estimates demand systems with several equations simultaneously and not only one equation.

Furthermore, in our opinion, (staple) food is a product that is usually not consumed with large variations per person, but at a certain level for a good life (or survival). Food sourced from different production systems thus substitute rather than complement each other. If a person eats a kg of conventional potatoes per week and organic potatoes then become available, it is likely that this person will not eat two kg's of potatoes afterwards (one conventional and one organic), but only one; namely organic if the person has a preference for organic food. This may be different for coffee and tea and maybe some fruits and vegetables, but not for staple crops. We would thus expect that organic products substitute rather than complement conventional production. These previous sentences are not a scientific argument but merely an opinionated illustration of our conviction that the displacement paradox may not occur in the food production context. It would nevertheless be interesting to statistically test this hypothesis but, as said, another approach would have to be chosen for this.

Finally, we point out that McGee (2015) also refers to a potential weakening of organic practices in US regulations: He states "The USDA national standard for organic agricultural production has had two major effects on the organically produced foods in the US. (1) It has allowed organic practices to continually be weakened. (2) It has allowed for larger corporate involvement in organic markets, which has in turn led to the subsequent centralization of the market. These effects have specific implications regarding organic farming's ability to reduce the emission of greenhouse gases." To pursue this line of argument, McGee would have to show that GHG emissions from US organic production are higher than those from organic systems that have not been weakened. In consequence, his statement should then rather be that organic production under weakened regulation leads to higher emissions than organic production under strict regulation. This is however something very different from the statement that organic agriculture (without further specification) leads to higher emissions.

2. The statistical methods used are not *per se* flawed for the analysis undertaken. It is in particular important to emphasize that the analysis is not only a correlation study (albeit the wording in the paper may suggest such, as "correlation" is used frequently; also in the formulation of the hypotheses), but a fixed-effects panel regression, which can in principle be adequate if the data truly fulfills the assumptions that are needed to apply this (McGee does not test this but only refers to similar analyses). Some further thoughts could also be

given to the inclusion of lagged variables, as they are often important in time-series analysis (i.e. the values of GDP, etc. - and even of the dependent variable “GHG emissions” - in preceding periods; there are standard tests to decide on the need for that).

Nevertheless, we identify some flaws in the statistical analysis, which cast further question on the validity of the results:

2.1. The dependent variable does *not* include organic agriculture and its area increase. In GHG inventories, and the data used basically are sourced from these, the total agricultural GHG emission are calculated via area/animal numbers and *conventional* emission factors, so an increase in organic area with different emission factors is thus not reflected in a GHG inventory. An increase in organic or conventional agricultural area is reflected in the total agricultural GHG emissions with the *same* amount of GHG emissions. Even a hypothetical production system with zero emissions would be reflected in the inventory with the classical emission factors. Thus, the indicator used is not reflective of the development McGee wants to shed light on and the choice of the dependent variable is incorrect for the hypotheses McGee wants to test.

    To improve on that, McGee would need to compile the existing knowledge from the organic/conventional comparisons to produce emission factors that specifically apply to organic production. In particular, soil carbon sequestration should be included in the inventory. Furthermore, to fully reflect the differences between the farming systems, a broader life-cycle perspective should be adopted and production emission from inputs should also be included for all farming systems. The literature review of McGee presents some comparison studies that could serve to derive emission factors for organic systems, but it lacks important and recent work such as Gattinger et al. (2012) on soil carbon sequestration; Skinner et al. (2014) on soil-born GHG fluxes; and Aguilera et al. (2015a,b) on LCA emissions of cropping systems, to name just a few.[3] These studies report lower emissions and higher soil carbon sequestration for organic systems and it should then be discussed how this may relate to the results of McGee.

    The total agricultural emissions would then have to be recalculated with those revised and amended emission factors for organic systems and the proportions of organic area. These revised total agricultural emissions would then have to be used as the dependent variable.

[3] Aguilera, E., G. Guzmán and A. Alonso (2015). "Greenhouse gas emissions from conventional and organic cropping systems in Spain. I. Herbaceous crops." Agronomy for Sustainable Development 35(2): 713-724.
Aguilera, E., G. Guzmán and A. Alonso (2015). "Greenhouse gas emissions from conventional and organic cropping systems in Spain. II. Fruit tree orchards." Agronomy for Sustainable Development 35(2): 725-737.
Gattinger, A., A. Muller, M. Haeni, C. Skinner, A. Fliessbach, N. Buchmann, P. Mäder, M. Stolze, P. Smith, N. E.-H. Scialabba and U. Niggli (2012). "Enhanced top soil carbon stocks under organic farming." Proceedings of the National Academy of Sciences 109(44): 18226-18231.
Skinner, C., A. Gattinger, A. Muller, P. Mäder, A. Flieβbach, M. Stolze, R. Ruser and U. Niggli (2014). "Greenhouse gas fluxes from agricultural soils under organic and non-organic management — A global meta-analysis." Science of The Total Environment 468–469: 553-563.

2.2. Animal numbers are missing as explanatory variables although it is acknowledged that, apart from area-born emissions from fertilization, enteric fermentation and manure management are the most important sources of GHG. McGee writes “The three major types include soil management (the most influential factor), which consists of fertilizer application and tillage practices, emissions from livestock production, and manure management”. McGee would therefore also need to include the organic and total numbers of ruminants and monogastrics as explanatory variables to account for methane from enteric fermentation and for methane and N2O from manure. The animal part is otherwise not accounted for, with unknown effects on the estimated parameters. This makes the second model, which adopts a per area basis, even more questionable, as reference of all agricultural GHG emissions to land areas is made, thus further neglecting/blurring the role of the livestock sector.

2.3. A third problem is the fact that trade is missing. The state-level analysis is blind to the relationships between agricultural production (captured via areas) and consumption (captured via population/GDP) at state level. There is much import and export trade between states because some states are mainly cereal producers while others mainly produce livestock, or vegetables, etc. This may bias estimates of the coefficients that determine the contribution of state level production or areas and state-level consumption (i.e. in particular population, but also GDP) to production emissions. The analysis should thus have been complemented with a nation-level analysis, in which national production (i.e. area) and consumption levels (i.e. the proxy “population” and “GDP”) are considered. Even then, import/export effects would still be missing; but the geographic level would better fit the available data.

We emphasize again that even when improving on those named points, the statistical analysis would still only regress total agricultural GHG emissions on organic area plus control variables. The analysis thus would still not capture the *differences* in GHG emissions between conventional and organic production and it would thus still not allow for conclusions as to whether organic or conventional production lead to more or less emissions. Furthermore, even this improved analysis would not allow a researcher to address the displacement paradox hypothesis.

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