Commentary II: Conceptual and Practical Aspects of Climate Change Mitigation Through Agriculture: Reducing Greenhouse Gas Emissions and Increasing Soil Carbon Sequestration

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Abstract

Mitigation in agriculture needs to be based on two pillars:

- Technically, nitrogen inputs should be reduced, organic fertilizers should replace synthetic fertilizers and storage losses should be minimized. Integrated systems with closed, efficient nutrient cycles should be the order of the day in the future.
- Socially, food wastage should be minimized and meat consumption reduced.

In general, reducing GHG emissions and increasing sequestration in agriculture is no easy task, either conceptually or in practice. But there are at least five clear exceptions plus one possible exception at the conceptual level.

First, avoiding open burning of biomass reduces emissions. Given that open biomass burning is the third largest contributor of direct GHG emissions from agriculture – accounting for more than 10 per cent – after nitrous oxide emitted from fertilized soils and methane from enteric fermentation in ruminants, there is a considerable and undoubted mitigation potential linked to this (Smith et al., 2007b; Bellarby et al., 2008). In most industrialized countries, open burning of biomass is prohibited, but in developing countries it is still common practice.

Second, reducing the global numbers of ruminants would directly reduce the corresponding methane emissions that account for about 30 per cent of total direct GHG emissions from agriculture (Smith et al., 2007b; Bellarby et al., 2008). This is mainly an issue for industrialized livestock systems, and not for smallholders. Due to carbon sequestration in pastures, pastoral livestock systems can even be carbon-neutral if stocking rates are adequately low.

Third, 30–40 per cent of food is lost globally, mainly as a result of wastage in industrialized countries and by storage losses in developing countries. Avoiding losses and wastage would therefore reduce the output needed and the corresponding GHG emissions (Godfray et al., 2010). Given the magnitude of losses and wastage, reducing them is essential in any effective climate mitigation policy for agriculture.

Fourth, conversion of pastures and/or forests to agricultural land and of forests to pastures needs to be reduced, as this leads to high CO_2 emissions, of roughly the same order as total direct agricultural GHG emissions (Smith et al., 2007b; Bellarby et al., 2008). Insofar as such land-use change is due to animal husbandry and feedstuff production for ruminants, ideally this reduction should be combined with reduced animal numbers.

Finally, the mitigation potential of carbon sequestration in optimally managed agricultural soils should be exploited. This potential is of the same order of magnitude as total agricultural emissions (Smith et al., 2007a; Bellarby et al., 2008). Soil carbon losses can be reduced and sequestration increased by application of organic fertilizers, minimal soil disturbance and planting legume leys in crop rotations.

Conceptually, these five aspects are uncontested, but, regrettably, they are the only ones of such clarity and importance. Addressing the other most relevant emission sources in agriculture (e.g. nitrous oxide emissions from soils, methane from rice production, manure management) is often highly complex. There are indications that actions and strategies relating to each of the sources may reduce emissions, but the high degree of complexity and context dependency of the underlying processes and their interactions with other processes often hinder clear statements. For example, reduced nitrogen input tends to reduce nitrous oxide emissions, but considerations of other characteristics of a location and cropping system, such as temperature, humidity, soil type, crops and fertilizer types, may dominate; or reduced flooding of rice fields cuts methane emissions but tends to increase nitrous oxide emissions. Nevertheless, indications are strong enough to mention reduced nitrogen applications as a sixth realistic option: the right type, place, rate and timing of nitrogen fertilizer applications are important (for more details, see Müller et al., 2011a; Müller and Aubert, 2013).

Regarding emissions from energy use, agriculture plays a minor role: farm machinery accounts for only 3 per cent of direct agricultural GHG emissions, while efficiency improvements in irrigation would contribute somewhat more, as irrigation accounts for about 7 per cent of emissions (Bellarby et al., 2008). However, reduction of energy use along the agricultural value chain has undoubted mitigation potential. There are significant emissions from transport, processing and storage, all of which are attributed by emission inventories to sectors other than agriculture. Thus, increasing efficiency and reducing the amount of road and air transport would considerably reduce emissions from the food system (for more information on supply-chain-related GHG emissions, see comments by Rundgren, Krain, Linne, and Gaebler in this chapter).

Regarding transport, it is worth pointing out that there is significant misreporting of emissions in national GHG inventories, as imports are not accounted for. National boundaries are the basis for emissions accounting, and "grey" embedded emissions in imported production inputs and consumption goods are added to the balance of the countries of origin. This considerably distorts national emissions from the food systems of countries where imports and exports play a crucial role.

With these remarks, we hope to have offered some options at the conceptual level. At the practical level, there are some difficulties, but differentiating three phases helps. Practical implementation means offering incentives, and establishing monitoring and enforcement mechanisms.

Providing incentives and enforcement are a challenge in many respects, but monitoring is relatively easy for the five proposals outlined above: avoiding burning, reducing animal numbers, avoiding losses and waste, and preventing deforestation and land conversion. Monitoring soil carbon changes can be more demanding, but it is feasible. Given the necessity of fundamental changes in agricultural production in order to increase its sustainability, these five aspects need to play a central role in any mitigation policy for agriculture. In addition, reducing nitrogen inputs should be a key policy target, and changes in how emissions from imports and exports are accounted for are needed to enable unbiased and more accurate assessments of countries' emissions.

We do not touch on enforcement here, but what follows are some remarks on actions that need to be taken to move towards a more sustainable agricultural system as outlined above.

First, open burning of agricultural waste should be prohibited, as has been implemented successfully by industrialized countries. Information and training, and if necessary, even some financial support should accompany such a ban. This will partly influence weed and pest management and alter some nutrient flows, though some additional investment or labour costs may accrue (e.g. in sugarcane without pre-harvest burning). The biomass not burned is a valuable resource, which can be used as source material for compost or mulch (i.e. as organic fertilizer) or for bioenergy production. Clearly, these alternative uses need to be supported by information and training, and perhaps also by investment support. There may be some options for obtaining financial assistance from the carbon markets (e.g. renewable energy or composting projects under the Clean Development Mechanisms).

Second, reduced animal numbers and land-use change can be addressed on the producers' side through optimal stocking rates, efficient grassland management and pastoralism, forest protection and land-use legislation. An optimal combination of crop farming and animal husbandry produces the most efficient nutrient cycles. However, reducing animal numbers is usually not an issue for smallholders in developing countries, and animal husbandry is essential for their food security. Actions on the producers' side would include making inputs more expensive and, correspondingly, increasing output prices, which to some extent would reduce demand. On the demand side, it is primarily an issue on a global scale, and concerns mainly more wealthy consumers, whose increasing demand for meat and dairy products needs to be discouraged. One possible way to reduce demand would be by imposing a “meat tax” (tied to the emissions from animals). It is, however, questionable whether price increases could be high enough to achieve the necessary reductions; there also needs to be a discussion of consumer behaviour, lifestyles and quality of life, and how these are linked to excessive consumption, and meat consumption in particular.

The third issue, closely related to the issue of food wastage, concerns consumer behaviour and perceptions of quality, freshness and needs, which are decisive in this respect. Making food more expensive (through internalization of all external costs) would help, but aspects of justice need to be kept in mind, as significant price increases affect the freedom of choice of less wealthy people much more than that of wealthy people. Thus, again, sustainable lifestyles need to become a major consideration in policy discussions (for a detailed discussion of these aspects, see the commentary of Reisch in this chapter).

The other aspect of wastage is storage losses in many developing countries. In these countries, investment in storage and processing facilities and information and training would greatly help. This should be of primary importance, as it would reduce the needed level and intensity of actions on the other aspects mentioned here. Each unit loss avoided reduces pressure on production. Thus it is less about additional money needed for these measures, than about a shift in focus on where to channel the money that already flows into agriculture and the food system (see the commentary of Parfitt and Barthel in this chapter).

Fourth, reduced nitrogen inputs can be achieved through regulation, following the example of the successful EU Nitrogen Directive. Taxing inputs is another option: a heavy carbon tax would serve a similar goal, due to the use of fossil fuel for synthetic fertilizer production. However, nitrogen regulation should go further than only input reduction. Closed nutrient cycles and increased use of organic fertilizers should be the final goal, as this would also have highly beneficial effects on soil carbon levels and the corresponding mitigation (see the commentary of Leu later in this chapter).

This is linked to efforts for increasing soil carbon sequestration. To achieve this, the necessary steps include abolishing subsidies for synthetic fertilizers and supporting organic fertilizers, reducing soil disturbance in tillage operations and planting legume leys in crop rotations. Support should consist of both investment support and extension services (e.g. for optimal composting and compost use). Additional benefits from higher soil carbon levels include improved soil structure, soil fertility and soil life, which contribute to water holding and retention capacity with corresponding positive effects on climate change adaptation (i.e. increased resistance to drought and extreme weather events).

Finally, embedded emissions need to be made visible. National GHG inventories should be amended to take into account imports and exports in order to obtain a full and more accurate picture of national emissions, and not overlook the responsibilities of consumers abroad.