Agricultural GHG Mitigation: Policies and Prospects

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Introduction
As the COP26 negotiations in Glasgow, Scotland, blunder on it is appropriate to reflect on the core policy issue, namely, to recognize that most of climate change, and certainly the warming part of it, is indeed anthropogenic, and to take actions that adapt and abate as well as is possible. Agriculture is a significant contributor (about one-quarter) to greenhouse gas (GHG) emissions and it is reasonable that it should make corresponding contributions to solutions through effective mitigation. This note explores policies and actions that can assist in mitigation, and in this way is intended to complement an earlier consideration of adaptation efforts (Anderson 2021), as part of policy analysis supporting broad modern agricultural transformation and development.

The note first reviews how agriculture (herein defined to include forests, plantations and aquaculture as well as crops, pastures and livestock) and, by implication, agricultural policy have variously contributed to global GHG pollution. Mitigation possibilities and policies are then briefly reviewed according to selected subsectors; forests, crops and livestock.

Expansion of Crops and Livestock has added to the Mitigation Challenge
Carbon exists in diverse forms but those of particular interest for agricultural policy are: biomass such as woody perennials, including forest trees; crop residues and soil organic carbon (SOC) under crops, pastures and forests; and atmospheric heat-trapping gaseous compounds, including carbon dioxide (CO₂), a product of plant and animal respiration, and methane (CH₄), a contemporary product of anaerobic fermentation by bacteria in rumens and flooded rice fields, as well as from fossilized petroleum deposits. Both these gasses are major contributors to global warming, as also is nitrous oxide (N₂O), product of microbial activity in nitrogen-rich soils, waterways and manure stocks. Elaboration of the chemistry, physics and economics of global warming and the roles of GHGs (including water vapor) is beyond the scope of the present note. Detailed expositions are available in many accessible sources, notably in the reports of the United Nations’ Intergovernmental Panel on Climate Change (IPCC).

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Clearing forests and savannas to make way for crops and pastures directly converts much stored carbon to GHGs, especially CO$_2$, and thus human quests for increased food production have made this aspect of humanity an important contributor to global warming. The environmental damage does not, of course, stop with the clearing process itself. Cropping, including its use of nitrogenous fertilizers, uses energy sources that mostly involve new CO$_2$ emissions, and typically results in reductions of SOC and increases in N$_2$O. Similarly, grasslands and rangelands as typically managed also increase GHG emissions, especially if the grazing animals are ruminants with their seemingly largely inevitable co-production of methane along with their valued products such as meats, hides, fibers and draft power. But all farmed animals, from guinea pigs to equines directly respire CO$_2$ and produce waste that makes further direct GHG contributions unless appropriately processed.

The history of agricultural development is, however, not all negative concerning atmospheric degradation. Through wise agricultural policy driving productive agricultural sciences, the Green Revolution, with its modern cultivars boosting staple cereals production, spared large areas of forest conversion to croplands (Anderson Herdt and Scobie, 1989). More than just cultivar development was involved but it is perhaps useful to be cognizant of the positive roles that agricultural research and development (R&D) can play in pursuit of greener agricultural futures. Of course, not all innovative agricultural enterprises have such favorable environmental outcomes! Reflect, for instance, on the Tropical Oil Crop Revolution (Byerlee, Falcon and Naylor, 2016), with its conversion of peatlands in Indonesia, and savannas in Brazil. Overall, **policy decisions on land use in agriculture are the dominant instruments for mitigation efforts** but other policies can be helpful within the land uses that prevail, to which attention is now turned.

**Mitigation via Forest Practices**

As noted, land-use policy regarding forestry regulation and investment is the major element in many national efforts to mitigate GHG emissions. Particularly where large areas are publically owned, it is relatively easy for governments to declare areas as dedicated parklands and woodlands or to invest in state-owned forests. Governments can also invoke policies to provide incentives for private woodland development, or “conservation set-asides” that can help in mitigation. Public attention for afforestation in many countries such as China has often been focused on lands regarded as too degraded to be useful for productive crop and livestock agriculture where trees can not only mitigate emissions but provide co-benefits of reducing flooding and soil erosion and thus reservoir siltation and degradation.

Ecosystem-specific R&D is a critical element of such mitigation efforts. Productive sequestration will depend on wise cultivar choices (sometimes as mixes) as well as successful propagation, establishment and maintenance practices, including fire management. Considered as mitigation “projects”, implementation spans are typically decades long and beyond the life cycles of the policy makers and implemented involved. Contemporary implementation and monitoring is much facilitated by modern technologies such as satellite-based observational capacity held not only by the national governments concerned but also by external authorities and organizations attentive to the integrity of claimed practice. Resources concerning such forest policy issues are readily and widely available in accessible forms (e.g., [https://redd.unfccc.int/fact-sheets.html](https://redd.unfccc.int/fact-sheets.html)) and for brevity are not elaborated here.
Mitigation via Cropping Practices

The main thrust here is for policy makers to identify and determine how best to support crop farming practices that virtuously and effectively reduce emissions. Leaving adaptation per se aside for the purpose of the present note, the main ideas for mitigation via cropping practices are swept up in the concept of Climate-smart Agriculture (CSA), coined by FAO at a 2010 Conference and since then actively curated and supported by FAO and other development agencies such as World Bank and IFAD (FAO 2013; Lipper et al. 2018). It is an “integrated approach to managing landscapes” — croplands, livestock, forests and fisheries — that addresses the interlinked challenges of food security and accelerating climate change. Clearly, CSA deals with all the subsectors addressed herein, but CSA is focused upon here in this discussion of crops in particular. An “official” view of CSA (e.g., https://www.worldbank.org/en/topic/climate-smart-agriculture) is that it aims simultaneously to achieve three outcomes:

1. **Increased productivity**: Produce more and better food to improve nutrition security and boost incomes, especially of 75 percent of the world’s poor who live in rural areas and mainly rely on agriculture for their livelihoods.

2. **Enhanced resilience**: Reduce vulnerability to drought, pests, diseases and other climate-related risks and shocks; and improve capacity to adapt and grow in the face of longer-term stresses such as shortened growing seasons and erratic weather patterns.

3. **Reduced emissions**: Pursue lower emissions for each calorie or kilo of food produced, avoid deforestation originating from expansion of cropped and grazed areas and identify ways to remove carbon from the atmosphere.

Clearly CSA encompasses many aspirational “good” things, but development practitioners must ask, especially as variously “implemented” around the world, is it smart enough, and is the name appropriate? No is a plausible answer!

One of the most commonly adopted techniques in the CSA basket is conservation agriculture (CA), which encompasses “zero- or no-till” and “minimum” tillage, and usually crop stubble retention (incorporation or surface mulching as opposed to burning or complete removal, perhaps as animal feed). The key idea is minimal disturbance of the soil by use of tillage practices that otherwise would reduce SOC, and the associated benefits of enhanced soil moisture retention and beneficial microbial activity. As a mitigation strategy per se, the “problem” is that CA is that, at least for much broadacre “industrial” agriculture, it *seldom really very additional in terms of increased sequestration*, with so many farmers adopting it because it is a more profitable approach than the traditional/conventional (especially in reduced energy costs of field operations), even if it involves purchase of specialized equipment and expenditures on herbicides, which, of course, have their own challenging-to-calculate (e.g., Brookes, Taheripour and Tyner 2017) but likely quite modest carbon footprint. To the extent that CA has not been adopted, policies to change that could be beneficial for climate change mitigation (CCM). However, in many situations it seems the increases in SOC are so small, that even if it was additional (and hopefully somewhat permanent), it’s not a great priority from the perspective of CCM.
Avoiding excessive N₂O emissions through reducing nitrogenous fertilizer applications suffers a similar issue of non-additionality. Many farmers (especially in China), often encouraged by highly dubious subsidies, have been routinely using rates of application far higher than for both crop “requirements” and optimal economic returns (especially risk-adjusted, Morris et al., 2007, pp. 55-6). So, farmers should better use fertilizer amendments more in accord with need, a practice made easier with variable-rate technology increasingly available through precision farming methods, and increasing availability of slow-release fertilizer formulations. But if smarter fertilizer use can be encouraged under the banner of CSA (perhaps through extension or regulation), this is a worthy element of mitigation effort in spite of limited genuine additionality, and it can come at low cost to farmers, given the “flat payoff functions” invariably involved (Anderson 1975; Pannell 2006).

Cover crops are often advocated in CSA implementation on grounds that they keep soils cooler and reduce rates of loss of SOC, and, if they are legumes, may bring the benefit of fixed atmospheric nitrogen with associated reduced purchases of commercially manufactured nitrogenous fertilizers, which have a high carbon footprint. However, if they are grazed by ruminants it is likely that any mitigation benefits will be significantly reduced by the increased methane emissions.

Similarly, retention of crop residues can boost SOC accumulation (as it generally does for profits) and perhaps also reduce soil temperature, with consequent reduced emissions. Stubble management of this type is facilitated by special-purpose field equipment. As for the case of specialized no-till planters, public subsidies for private farmers to purchase or hire such CA machines has often encouraged adoption of such modern farm practices, and they can be portrayed as “green” or environment-friendly payments rather than as direct support to producers.

Sequestered soil carbon is a fragile asset. A build-up of SOC can be quickly lost or reversed by conventional tillage operations or even just through a “normal” drought event, such as may become more frequent under climate change in many places. Soil carbon sequestration has been a controversial topic since the early days of climate policy articulations such as The Clean Development Mechanism (CDM), which is a United Nations-run carbon offset scheme allowing countries to fund GHG emissions-reducing projects in other countries and claim the saved emissions as part of their own efforts to meet international emissions targets. It is one of the three Flexible Mechanisms defined in the Kyoto Protocol. Needless to say, not all natural environments allow practicable carbon sequestration. As COP26 nears, it seems “soil carbon farming” as an effective mitigation option is dying if not dead (Popkin, 2021). At least in the specific case of commercial farming in Western Australia, where as elsewhere costs of monitoring are high, it is already a “dead duck”, my term, not used in Dave Pannell’s (2021) insightful and persuasive series that has confirmed my emerging opinion about this option.

The matter of the stability and reliability of SOC is a good candidate for further R&D to clarify both the options and the problems. Investment in agricultural R&D has historically been highly provident and will surely continue to be so, in spite of the extreme underinvestment in so much of the world. The most significant agricultural policy issue for GHG mitigation (as it is also for adaptation) is underinvestment in R&D, as argued by many analysts (e.g., Burney, Davis and Lobell, 2010; Pingali 2012; Lobell, Baldos and Hertel, 2013; Cai, Golub and Hertel, 2017; Baldos, Fuglie, and Hertel, 2020; and Anderson 2021)
R&D can produce more productive cultivars of both plants and animals and improved management practices that can reduce the emissions per unit of the outputs that humanity needs going forward, hopefully in a sustainably intensified agriculture. The policy challenge is to make such R&D investment happen.

**Mitigation via Livestock Practices**

All livestock inevitably contribute to atmospheric pollution, as do their human counterparts. Humans and other animals breathe oxygen and exhale CO₂. Some of this CO₂ goes into sinks of various life spans, such as SOC, which may be quite short-lived, or oceans that may (depending on global temperatures) be long-lived. As noted above, some livestock, particularly ruminants, are additionally problematic because they emit a product of their enteric fermentation, methane, which is shorter-lived in the atmosphere (about 10 years) but, while it lasts, much more heat-trapping than CO₂. This reality poses great mitigation challenges for countries that have large numbers of ruminants in their agricultural sectors, such as Australia, Ethiopia, India, Mongolia, New Zealand, South Africa and Uruguay, to mention a few. Not to be forgotten, nearly everything is “big” in China, including ruminant numbers, and rangeland degradation.

R&D to identify ways to reduce enteric pollution is clearly of potentially great importance, but it is challenging and has been slow to yield results that can help significantly. Various fabricated chemicals and some natural products such as some seaweed species have shown potential, but pathways to successful commercialization have yet to be identified. Further research, hopefully sooner than later, will likely produce innovations that meet the challenges in various ways.

Absent such abatement technologies, livestock-based mitigation interventions must necessarily be based on reducing numbers of polluting animals. Such reduction is surely an unwelcome option for the many herders who depend on herds and flocks for their livelihoods. Ethiopia and Mongolia are examples of this challenging situation. Reducing commercial animal numbers is seldom easy as a policy ambition; witness the difficulty of implementing and enforcing a Livestock Head Tax in Mongolia, for instance. To the extent that such reduction in animal numbers is effective, such a policy effectively amounts to reducing the human population dependent on herding the animals, and is thus an element of broader agricultural and rural transformation. Thus, as human resources move from farming activities to work in other sectors, they may assist in mitigation efforts in the agricultural sector but naturally likely add to the mitigation challenge in their new sector.

“Downstream” from the animals themselves, so to speak, also presents challenges that seem likely unresolvable in the case of extensively grazed livestock. In relatively intensive production systems where collection of manure is cheap, there are opportunities for processing manures to contribute less directly to emissions, such as through biogas production, and recycling as crop fertilizer. Policy makers naturally have a range of options of taxing, subsidizing and regulating to encourage such mitigation, and perhaps include in their offerings and claims of “nationally determined contribution”. Not mentioned in earlier sections for brevity, there are analogous downstream residue emissions management possibilities for forests and crops.
Conclusion
For brevity, this short review of mitigation policy and practice in agriculture has focused on forest, crops and terrestrial livestock. For other livestock such as fish in aquaculture, the issues are similar (e.g., FAO, 2013, Module 10); R&D-based new information and technology can often reduce emissions per unit of harvested product. Mitigation opportunities abound in parts of the agri-food system not discussed herein, such as the “water” sector (FAO, 2013, Module 3), and in the value chains beyond primary production (FAO, 2013, Module 11), where the main recommended mitigation thrust is avoidance of “waste” and greater use of low-carbon energy.

R&D effort must surely be a high-priority policy in CCM and it is somewhat reassuring that the CGIAR has reaffirmed its commitment to such work in its new strategy. However, given the perceived difficulties, it seems to this observer unlikely that agriculture will really be able to deliver on its full share of the mitigation agenda variously set in the 2015 Paris Agreement on Climate Change and likely to be expanded at COP26 in Glasgow. It is to be hoped that Glasgow delegates can bring to the agenda new bold but feasible policy options for successful mitigation. Meantime, agriculture must get on more vigorously with the challenging agenda of adaptation as transformation moves forward.

References


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Pannell, David (2021), *Soil carbon is a highly flawed climate policy, Parts 1, 2 and 3* [https://www.pannelldiscussions.net/2021/04/346-soil-carbon-1/](https://www.pannelldiscussions.net/2021/04/346-soil-carbon-1/) [https://www.pannelldiscussions.net/2021/05/347-soil-carbon-2/](https://www.pannelldiscussions.net/2021/05/347-soil-carbon-2/) [https://www.pannelldiscussions.net/2021/05/348-soil-carbon-3/](https://www.pannelldiscussions.net/2021/05/348-soil-carbon-3/)
