Editorial: Achieving enhanced GHG emission reduction levels in sustainable agriculture

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1 Introduction

There is an emerging need for agriculture to adapt to a changing environment. Climate change has been on policy and research agendas while farmers are increasingly being confronted with day-to-day weather changes in many areas of the world. In Australia, during the first decade of the 21st century, crop and animal production suffered from some of the most adverse weather conditions ever recorded. Implications for crop yields and productivity as a whole have been enormous, especially in the Darling-Murray Basin, an area which normally provides the continent with a surplus of wheat. In 2010, almost 14 million people (most farmers) were affected by torrential rains in Pakistan. The disaster was driven by a ‘supercharged jet stream’ that also caused floods in China and a prolonged heat wave in Russia. Changing patterns in weather conditions in Europe have led to worsening drought conditions especially in the south of the continent, but also as far east as the Brandenburg area near Berlin in Germany, and is putting pressure on rainfall dependent crops and animal production practices. In 1980, on average, one-third of the continents' surface was desert. Forecasts are for one half by 2020 (Reeves and Lenoir, 2005).

An additional dimension of changing weather patterns is the increasing impact of extreme events. In a 2002 report on natural disasters, it was shown that resulting global financial and economic impacts are not only enormous but also increasing rapidly (Innovest, 2002). From 1980 through 2004, the worldwide economic costs of weather-related natural disasters totalled US$ 1.4 trillion. Global weather-related losses in recent years have been trending upward much faster than population. For example, damages from US storms grew 60-fold between the 1950s and the 1990s, to reach US $6 billion/year (Mills, 2005). Stopping the threat caused by climatic change to the economy will require significant reductions in greenhouse gas (GHG) emissions. Mitigation of agricultural practices will be one major step that needs to be taken to limit its consequences in the long run.

But agriculture is facing more challenges than climate alone, including a fast-growing global population requiring ever more food, energy and water (Tilman et al., 2002). These demands will add to already increasing competition for natural resources in many places of the globe, and is already threatening world order (Valantin, 2005). 40% of crop production is generated by only 16% of agricultural land, which is irrigated, but water is regionally scarce. Shortages are also reported for other essential inputs (e.g., phosphorus). Consumption of fossil energy is another element that will force changes in the way we produce, process, and consume agricultural products. An average European inhabitant will consume 10 kilos of oil equivalents in energy terms daily (Eurostat, 2007), three quarters of which come from fossil fuels (oil, gas or coal). It is half of the average consumed (20 kg) in North America, and double the consumption (5 kg) in the Middle-East and North Africa (Earthtrends, 2010). Transportation fuels can be partly substituted by biofuels. The rationale for such a replacement, which was discussed by King (2010), includes:

1 the decreasing cost-effectiveness of fossil-based production following the growing scarcity of conventional crude oil resources

2 the growing need for national energy security and geopolitical stability

3 increasing public pressure for environmental sustainability linked to increasing environmental awareness.

Therefore, the adaptation of existing practices in food, feed and energy production will have to reflect a wide array of changes in an environment where limitations (local, regional, international) play an increasing role in production decision making. The implications will be felt by producers, consumers, policy makers and scientists all along the globe. The consequences for farmers may be extraordinarily important, especially when facing the direct impacts of weather change, limitations in water availability or decreasing land production capacity.

Agricultural activities play an important role in both causing as well as mitigating climatic change. They are responsible for a considerable part of the emissions of greenhouse gases (GHG), but can also help to decrease prevailing CO_2-concentrations, either by directly reducing GHG emissions within production processes, or indirectly, by producing biomass that can replace fossil fuel applications in chemistry, heating, electricity production or transportation. Moreover, long term establishment of perennial crops including grasses and trees, can help to store large amounts of carbon in the soil, thus further reducing carbon levels in the atmosphere. This explains why issues of land-use are so sensitive when dealing with agriculture. One key objective is the monitoring of GHG emissions caused by agricultural activities.

2 Monitoring improvement

The direct measurement of GHG emissions is impossible (Le Treut and Jancovici, 2004), because gases come from multiple scattered sources. So, monitoring GHG emissions is performed thanks to indirect assessments. For instance, the analysis of the chemical composition of any combustible provides a fair prediction of how much GHG will be released when burning. It is the same for any other material used during industrial or agricultural processes. Data bases record the chemical compositions. Models deliver how much material is used during standard processes, and how much GHG will be released. At the level of the agricultural product chain, it is relevant to take into account GHG emissions caused by background activities (fertiliser, pesticide, machines and other inputs). The methods used to gather any kind of former data bases, former models, and which pays attention to background processes are called life cycle assessment (LCA) methods. There are different instruments to monitor changes in production practices, but LCA methods are dominant when assessing the environmental impacts caused by product manufacturing (for instance agricultural product, food, feed, biofuel).

The papers presented in this special issue deal with GHG emission reduction. All of them either directly use LCA methods to make a demonstration, or use results provided by LCA methods. Therefore, it is worthwhile to briefly explain what LCA is.

LCA method is more a form of accounting than empirical science. The system under scrutiny is made up of ‘unit processes’. They are the physical life-cycle stages one given product follows from birth to death: including the making of commodities, the manufacturing, transportation, usage and disposal stages. All the flows of materials, water and energy coming into and out of the system are monitored. The flows escaping the system are translated into environmental burdens (for instance into GHG emissions). The decision-maker using the results provided by LCA adopts a kind of social planner’s view on environmental issues (Heiskanen, 2002). Indeed, LCA takes into account not only the environmental burden generated by the company he/she is responsible for, but all the environmental impacts caused anywhere in the supply chain used in the making of the product, or during the use or disposal stages.

LCA methods have gained huge credibility in environmental management and policy. They have become a new institutional logic that influences the way environmental problems are conceptualised (Heiskanen, 2002). As they are accountancy methods (and not the statement of facts) the results are very sensitive to numerous issues. Here are just some of the questions that need to be addressed:

1 What is the function of the product chain (despite each product is multifunctional)?

2 How to allocate the results impacts between several co-products (wheat and straw generated by the same life-cycle)?, and especially

3 Setting the boundaries of the system, to include more or less externalities within the studied system.

As pointed out by Swarr (2009, p.287) "externalities are the zone of conflict, and deciding where to draw the boundary is *the* fundamental question for sustainability".

Indeed, the issue of LCA boundary setting may be one very high stake issue in round table platforms[1] like the round table on sustainable biofuels or the round table on sustainable palm oil. One knows that land-use conversion (e.g., destroying forest to cultivate biofuels) can be the cause of increased GHG emissions. Therefore, we need to appreciate the consequences of such a choice upon calculations: do we take into account or not such a region suffering from land-use changes?

Adaptations in day-to-day agricultural practices may occur at different scale levels (Langeveld et al., 2003; ENCI-LowCarb project, 2011): field or herd, farm, region or production chain. Classical agricultural literature shows a tendency to emphasise field level analysis, although the increasing emphasis on LCA analysis obviously favours chain evaluations. Due to the value that is given to LCA and similar approaches, there is also a shift from mono disciplinary science to broader approaches (multi- or interdisciplinary work).

Six papers presented in this special issue are based on presentations given at one IFSA symposium. Consequently, we would like to say a quick word on IFSA. In fact, the objectives of IFSA are the same as IJSD[2], but applied to farming system issues only. The farming systems approach was, originally based on a family of principles and methods used by an international research and extension community, which focused on alleviating rural poverty in developing countries. The investigations focus on processes leading to innovation, not by seeking a most effective or optimal solution, but by co-constructing transitions and learning processes with stakeholders, aiming at empowering rural actors on local paths to sustainable development (Darnhofer et al., 2011). This explains why the work made within the IFSA community may be of interest to IJSD readers.

3 This issue

In line with IFSA conferences organised around the world, the IFSA community organised a workshop on GHG emission reduction during its 8th European conference held in Clermont-Ferrand (France) in 2008. During this workshop, which was titled 'GHG emission reduction and energy production in agriculture, forestry, aquaculture and mariculture: potentials and impact', the IFSA philosophy (on multidisciplinary and stakeholder-oriented scientific analysis) was applied to investigate GHG reduction potential in relation to agricultural practices. Six papers from this workshop have been selected, and rewritten to be presented in a special issue. One new paper has been added.

Paper	Crop vs. livestock	Level	Continent	Mitigation	Principal method in use
1 Hayashi	Crop, rice	Farm	Asia	Direct	Extension of LCA framework by multi-input, multi-output model
2 Fiorelli et al.	Mixed dairy and crops system	Farm	Europe	Direct	Coupling of two dynamic models to quantify the emissions of different land-uses
3 Benoit and Laignel	Sheep	Farm	Europe	Direct	Computer simulation of results (economic, energy efficiency, GHG…) for three systems
4 Katajajuuri et al.	Livestock	Chain	Europe	Direct	Calculation made by LCA
5 Mikkola and Risku-Norja	Milk	Chain	Europe	Direct	Analysis of food expert focus groups' discussions about GHG information
6 Langeveld et al.	Crop, sugar beet	Chain	Europe	Indirect	Calculation by LCA of net energy and energy efficiency from measured crop yields and inputs.
7 Drouvot et al.	Crop, palm oil	Region	S. America	Indirect	Press and literature review

The five first papers deal with *direct mitigation* of GHG emissions. In all five cases, researchers envisage scenarios to lower the GHG emissions from usual activities, either from farm (Japanese rice, usual European mixed dairy and crops system, mountainous sheep) or from a complete product chain (chicken broilers and milk). The fifth paper specifically addresses the role of consumers in orienting milk production (which led to a drop into dairy farm GHG emissions). The two other papers are tackling the *indirect mitigation* of GHG emissions, through provision of biofuels to replace fossil fuels. The paper 6 deals with the sugar beet chain for ethanol production in The Netherlands, while paper 7 is about a massive biofuel production project based on palm oil in Brazil.

The seven papers all strive to provide sound methodologies which can be applied elsewhere as well. Up scaling is therefore possible. Even if the authors are focusing on very specific elements of production (like Benoit focusing on livestock production in the Massif Central in the southern part of France), their approach is described in such a way that the results can be applied in other contexts (crops, animal species, regions).

4 Findings

What are the main findings discussed within this special issue? The first three papers deal with GHG emissions *at the level of the whole farm*. They focus on the conditions that favour strong mitigation of GHG emissions. Thanks to his multi-input multi-output farm model with multiple paired comparisons applied to rice farms in Japan, Hayashi demonstrates that it is possible to find *win-win relationships* between agronomic and environmental performances. The model can include many different inputs and outputs, and so delivers a practical way of finding a balance between ecological and economic purposes. It is a step by step process, because the objective is to strike a balance for each pair of input/output. In the complex context of crop/livestock farms, Fiorelli et al. explore *with success a large range of mitigation options* (based on extensification and feed self-sufficiency) starting from farming actual conditions. They highlight the need to assess the potential mitigation options for their impacts upon all the GHG, and even taking into account interactions with other gases. For sheep farming in mountains, Benoit and Laignel show that maximal use of forages improves the energy efficiency of the farms. When it is combined with a high level of numerical productivity, the *GHG emissions per kilogram of carcass can be greatly reduced*.

Papers 4, 5 and 6 adopt a *chain approach* to tackle reduction of GHG emissions. Crop (feed) production for broiler chickens is clearly the part of the production network causing most environmental impacts, from Katajajuuri et al. works. *Different ways of reducing GHG emissions from the whole chain* are discussed (using industrially produced feeds instead of cereals cultivated in broiler farms, managing the manure spreading and moreover industrially treating the manure). They recommend improving the litter quality and demonstrate that heat recovery strongly decreases GHG emissions. Mikkola and Risku-Norja inquire into the *transformation of the food system* aimed at a higher reduction of GHG emissions. The example is the move from dairy milk to plant-based milk product consumption, which is motivated by the considerably lower GHG emissions of the latter. The results display three different cultural ways to relay to dilemmatic GHG information. They offer outlines for policies, in order to facilitate such a change. Langeveld et al. remind us that the *energy efficiency ratios of first generation bioethanol crops* vary between 1.5 (maize in USA) and 2 (wheat) in northern hemisphere, while sugarcane in Brazil achieves 8. So, the first experiments performed on sugar beet in the Netherlands, did not provide satisfactory results (ratio 1.3), but may be improved. Selecting the most efficient conversion technique (which consumes 85% to 90% of all energy inputs) is of the utmost importance. This would drastically reduce GHG emissions per kilogram of biofuel. Using crop residues in a fermentor to generate additional energy can help too.

The last paper is in line with the latter, because it tackles *biofuel issues, but at the regional level* and mainly from a social perspective. It debates the Brazilian case, because of the pre-eminent position of Brazil in the race towards substitutes for transport fuels. Drouvot et al. report that the project of sustainable production of palm oil in Amazonia *could save more than 68,000 tons of CO_2 emissions* (for a surface area of 3,100 hectares and a 25-year life span). One important condition is involving smallholders, despite all the risks of failure the authors discuss. Empowerment is a solution, but representatives of smallholders are not included in the discussion arena to date.

5 Conclusions

Global warming has to be considered at the level of the farm, of the production chain and the regional level. If one level is left out, the solution will suffer. There is no dominant level. No drastic changes are required but an integrated approach defining little steps. Each of the seven papers mentioned above focuses on one of the three levels: farm, chain or region. The resulting picture is a cross section of different scale levels.

This special issue deals with the major ongoing changes in day-to-day decision making in the production and conversion of food, feed and biofuels. It covers different regions and climatic zones. Changes in crops (for food and biofuels) and livestock practices are addressed as well. It offers a multitude of approaches focusing on mitigation of GHG emissions from agriculture. Competition for limited resource (like land use) is addressed. Despite the diversity, it is not story-telling only. The focus is upon methodology development and testing, reporting on the results in such a way that the outcomes have a value that go beyond the application area.

By bringing together an array of analytical methodologies, all contributing to assessment of ecological performance of agricultural activities, the scope is widened. We therefore hope this special issue will provide a large overview of some practical solutions for GHG mitigation.

This short review highlights that strong direct and indirect reduction of GHG emissions from agriculture are feasible here and now. The overall conclusion is that efficient technical solutions are at hand, but that the bottlenecks are related to the involvement and behaviour of people (farmers, consumers…). We invite readers to acquaint themselves with the *IJSD*'s other papers. They offer a wider perspective than agriculture, and they often cleverly tackle tricky issues of involvement and behaviour.

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Notes

1 The Roundtable platform is an organisation gathering stakeholders from one sector, and attempting to monitor the environmental or social impacts of the sector, and to moralise production.

2 "The objectives of IJSD are to establish an effective channel of communication between policy-makers, government agencies, academics and research institutions, and professionals working in the field, and to provide a forum for them to disseminate information and to learn from each other's work. The international dimension is emphasised in order to overcome cultural and national barriers and to meet the needs of accelerating technological change and changes in the global economy."