GHG Management at the farm level

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Abstract Greenhouse Gas (GHG) emissions from agriculture are a significant contributor climate change. With a growing consumer concern in this issue, food manufacturing companies have become increasingly interested in measuring and reducing the Greenhouse Gas (GHG) impacts of their agricultural supply chains as part of their impact reduction commitments. To do GHG data from the farmers upstream in the supply chain need to be measured in order to be better managed. The Cool Farm Tool is a farmer-focused, on-farm quantitative GHG management tool that aims to do this. The tool is designed to; 1) help farmers to generate and understand more robust primary GHG data; 2) allows exploration of farm management improvement scenarios and; 3) provides users with primary data capture and evidence of farm management and improvement. This paper will describe the tool and early insights and lessons from its use.

1 Introduction

With a growing global population to feed and the drive for fuel diversification through production of biofuel and biomass crop alternatives, the pressures on agricultural productivity have increased [1, 2]. Already, agriculture is a significant contributor to global anthropogenic greenhouse gas (GHG) emissions with estimates ranging from 10 – 12 % [3] or in some estimates up to 15% [4], and through extensification and intensification, this contribution will likely rise. GHG emissions in this sector come from a number of sources including; the production, distribution, storage and use of chemicals such as fertilizers and pesticides; the production and use of farm machinery as well as emissions arising from natural sources like soils and biomass. To this end, some GHG emissions from agriculture are inevitable, however there is significant mitigation potential of emissions as well as sequestration opportunities through changes in management practice at the farm and field level. Smith *et al.*, (2008) [5] estimate the technical potential to be a substantial 5.5 Gt CO_2e yr-1 by 2030. Changes in farm practice that increase energy efficiency; reduce releases of potent GHGs such as nitrogen (N_2O) and methane (CH_4), enhance removals of GHGs, and help to avoid or displace emissions, can all play a role in realizing this GHG reduction. There are of course several constraints, economic and other that limit the mitigation potential of each farming system, but GHG impact reducing changes could be a factor in helping to increase the longevity and sustainability of the system.

Many companies, food companies in particular, rely heavily on agricultural inputs to their products. In recent years consumer awareness and concern for the state of the environment and the impact that companies have on it has heightened there has been increasing interest for these companies to trace and track their environmental impact. GHG emissions are just one of the impacts of interest. As such, many food manufacturing companies have begun setting aggressive and ambitious GHG reduction targets. Unilever have committed to halving their GHG impact and sustainably sourcing 100% of raw agricultural materials by 2020 [6]. Similarly PepsiCo, have launched their '50 in 5' target which seeks to reduce emissions by 50% over 5 years [7], and Marks and Spencer have announced their Plan A which includes targets to ensure all their agricultural produce meet independent environmental standards and demonstrate environmental benefits [8].

To achieve these reduction targets companies first need to measure the baseline impact of their current operations and product portfolio. This includes gathering emissions data from agricultural suppliers and growers upstream in the life cycle, an area previously omitted from corporate GHG inventories [9]. This omission can result in substantial underestimates in the total food product footprint. In 2008 Unilever established their baseline impact by calculating the GHG emissions across the lifecycle for key product groups within 14 countries that account for approximately 70% of Unilever's total volume. This represented over 1,600 individual products. The baseline revealed that over a quarter of Unilever's GHG impact arose upstream in the sourcing of raw materials, 50% of these from agriculture (Figure 1). Much of the data used to calculate this impact came from literature sources, life cycle inventory data sets including Ecoinvent [10] and those contained within GaBi lifecycle assessment (LCA) tool [11]. For Unilever to realize the true impact of their own agricultural supply base and to meet their 100% sustainably sourced target, there was the need for a tool to capture sufficient data from agricultural suppliers to perform a comprehensive GHG calculation for the impact at the farm level. Unilever therefore collaborated with the University of Aberdeen to combine expertise in agronomy and data modelling with industrial knowledge of LCA and supplier engagement to develop a robust and credible farm-scale GHG calculator called the "Cool Farm Tool"

Fig.1: Unilever's 2008 baseline GHG calculation across the lifecycle representing 70% volume across 14 countries [12].

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This paper will describe the Cool Farm Tool (CFT) and some of the considerations made throughout its development. It will discuss the challenges associated with engaging with agricultural suppliers, data capture and assessment of diverse and variable agricultural systems and the challenges in measuring and managing GHG emissions at the farm level. In particular, this paper will discuss differentiation of the CFT compared to other tools in the sustainable agriculture and GHG accounting space and the potential of the tool going forwards. Despite it being very early in the life time of the Cool Farm tool, some initial insights and learning points from the tool will be described through case study examples.

2 Measurement at the farm level

GHG measurement and management is generally not an integral part of agri-food supply chains at present. As such, many farmers are not familiar with provision of detailed activity data concerning the GHG impact of their system and practices to other members of the supply chain. However, it is not unusual for farmers to monitor and hold detailed records of the input and output activity data as it is important for managing the whole-farm nutrient balance and maximizing system productivity as well as being an important exercise for fiscal management. In other cases, farmers may be required to provide a certain level of information to meet farm assurance criteria, but with these assurance schemes focusing mainly on quality management, the quantification of environmental and GHG impacts are usually not requested. Companies wishing to meet emissions reductions targets from agricultural produce will only be able to do so through the engagement and establishing of joint and farm-specific solutions with farmers. One important challenge is therefore achieving the buy in and long-term commitment of the farmers and translating large company targets into specific measurable targets and practicable solutions on an individual basis. This challenge is amplified when the target farmers include both large and smallholder farms and are distributed throughout a global value chain.

A second challenge, is the lack of a defined and consistent methodology to enable global comparability and equitable accounting from very different farm systems. Accounting for land use change (LUC) is one area in particular that requires further development, particularly regarding its abatement potential. Omission of this important source of emissions, in many instances, can lead to serious underestimations of farm and subsequently product GHG footprints [13]. Many current means to calculate agricultural emissions also fail to take into account the differences in farming practices and the effect of innovative new processes or the impact of wider reaching policies. There is a need for use of an agreed methodology and data capture tool that provides rigour and uses robust science to facilitate intelligent farming decisions and provide quantitative data for users on different levels, i.e. farmers, buyers, policy makers.

Albeit the lack of one agreed farm measurement methodology, studies have begun to quantify the relative contribution of different farming management practices as part of the larger carbon footprint of different crop types [3] [14], IPCC emission factors and inventories guide users to produce more accurate estimates but the most significant issue is farm specific data. As such detailed agricultural GHG inventories are still some way behind other sectors. However, a number of tools have now been developed that aim to narrow this farm level GHG data gap. Models such as DNDC [15] and DAYCENT [16] [17] require a strong grasp of agri-ecosystem processes for effective use whereas others like CALM [18] and the CFF carbon calculator [19] adapt national inventory data into tools for farm use in the UK.

The Cool Farm Tool combines measurement at the farm-level with an assessment of management practice to encourage GHG saving changes.

3 The Cool Farm Tool

3.1 Background

The Cool Farm Tool was developed primarily by Jon Hillier at the University of Aberdeen and experts at Unilever and the sustainable food lab and it is available for free download and use under a creative commons license available from: http://www.unilever.com/aboutus/supplier/sustainablesourcing/tools.

It is a Microsoft excel spreadsheet based tool designed to incorporate robust available science to help reverse engineer empirical data from global GHG calculation methods and data sets into a farm or field level GHG balance. The tool is farmer focused and captures on-farm activity data familiar to the farmer or that can easily be ascertained whilst in the field. IPCC GHG inventory methods [20] [21] are characterized into three distinct tiers; tier 1 methodology is simplest, using fixed emission factors and designed to use globally available data sources for national accounting, hence it will provide coarse impact estimates and is not appropriate for farm level assertions. Tier 3, in contrast requires, a deeper understanding of agricultural system modeling and comprehensive activity data beyond the capability of non-experts and therefore most farmers. Moreover the data inputs required at this level would render the tool unsuitable for farmer use. The Cool Farm Tool was therefore designed to reside in between these two extremes, providing tailored emissions estimates without need for a data beyond farmer common knowledge and a deeper understanding of the interactions between land use, biophysical processes and management operations [22]. Data inputs are used to calculate a context specific GHG footprint at the farm or field level to facilitate intelligent planning and identification of mitigation opportunities. Farmers are able to model their own farming system and are provided with instant results consisting of a single GHG figure and accompanying graphs to provide a ‘hotspot’ analysis of their farm inputs and outputs and management activity. Farmers are able to manipulate the tool for scenario analysis where they can begin to ask ‘what if’ questions and gain insight into the potential emissions reductions that can result from management practice changes. It can therefore provide decision support for farmers with regards to specific site characteristics and external market conditions as farmers can consider the wider implications and feasibility of input changes and machinery investments [22].

A key merit was that the Cool Farm Tool be applicable to a wide and diverse range of farms that are typically part of a global food supply chain. To this end the tool was constrained in part by the need to provide a simple yet holistic quantification of GHGs whilst remaining generic across crops, livestock and regions. The tool is not designed for detailed comparisons between farms or supplier discrimination, although a top level comparison of emission ranges and hotspots is possible. Furthermore its data capture is detailed enough to provide an overall farm GHG assessment and account for some variation e.g. between conventional and organic farming ideologies, however it is beyond the remit of the tool to account for more complex variations and delve into the impacts arising from soil compaction, timing of fertilizer applications and other areas where there is also a large degree of uncertainty.

3.2 Tool components

The tool inputs required include to calculate the GHG footprint are: crop management data; livestock and manure management; field energy use; primary processing energy use. Additional tabs contain the supporting data, default factors and present the results of the analysis.

3.3 Implementation

In 2010 a number of companies, academic institutions and NGO’s committed to use the Cool Farm Tool as part of the Global Agriculture Climate Assessment, now called the ‘Cool Farming Options Initiative’ being coordinated by the Sustainable Food Lab [23]. The project has eighteen sponsoring partners including Unilever, PepsiCo, Marks and Spencer, CostCo and Heinz among others, each assessing different farming systems across a number of locations globally. Assessments cover both large scale production of crops including apples, tomatoes, potatoes, dairy, pulses, sugar and wheat along with a suite of small scale production suppliers of tea, coffee, beans and cotton. To ensure successful implementation into the diverse range of supply chains, the tool is accompanied by guidance documentation help text that has been integrated into the user interface. Online webinar sessions and training materials have also been administered to provide an opportunity for wider discussion and questioning [24]. Industry partners are responsible for engaging with their supply chain, providing detailed training and support to farmers through their own working partnerships. Many sponsoring companies have embedded the tool into their sustainable agriculture strategy and as a means to help meet corporate targets and drive a wide uptake. Furthermore several companies have endeavored to make minor adaptations in order to optimize the tool to be ‘fit for purpose’ for their target supply chain, where relevant. Being open source in this way adds to the transparency and credibility of the tool and allows critical appraisal from both the scientific and industrial communities, helping further the development and evolution of the tool. Each sponsor collects their own data to be analyzed and then shared with the project partners and documented, with anonymity maintained if requested. Currently, participating organizations are at different stages of engagement and use of the tool and have their own agenda for implementation ranging from extensive training on farm with the farmers, in the case of PepsiCo, or through higher supply chain partners as Unilever are doing.

4 Results

4.1 Initial feedback

The large body of organizations that have committed to use the Cool Farm Tool is an initial indication of the positive reaction towards it and its potential to gather and build a vast farm GHG databank over the long-term. The data being requested is new for many supply chains and farmers but effective communication and training of users has helped to overcome initial resistance to the information request. Moreover, farmers have quite quickly realized that they already know much of the information being sought and that they can get instant results to baseline their impact and identify where simple changes can help them reduce their impact and save money. The ‘tier 2’ approach of the tool has meant the accuracy of results and feasibility of use are suitable at the farm level and translate into meaningful management scenarios for farmers as well as important impact data for companies. As a significant intervention in data capture from supply chains, it is compatible with other projects as it’s underlying LCA methodology and datasets are consistent and complementary to PAS 2050, GHG Protocol and ISO standards. Additionally, several other bodies including the Carbon Disclosure Project (CDP), Fair-trade, Rainforest Alliance and Leaf certification in the UK, are pointing towards the Cool Farm Tool as the recommended means for farm GHG footprinting. A key factor of the tools success is the scenario analysis capability. An example of this presented by the sustainable food lab demonstrating the emissions mitigation potential of a typical navy bean producing farm in Canada. The baseline of 530.91kg CO_2e/acre is compared to two management change scenarios. Scenario 1 is reduced tillage and addition of cover crops once every four years resulting in a footprint of 231.07kg CO_2e/acre, and scenario 2 describes the same situation but with the use of hog manure in place of a fertilizer alternative, this results in -941.46kg CO_2e/acre [25]. These results therefore demonstrate not only the savings possible through management changes but also the sequestration potential arising through reduced soil disturbance, soil carbon sequestration from increased inputs and less use of emission heavy fertilizers.

Participating organizations have expressed enthusiasm towards the tool as a means to drive meaningful change and emissions reductions through their supply chains as well as a mechanism to align company targets, educate consumers, raise food industry standards and advocate policy changes in agriculture at a higher level, through the project as a neutral platform. It is still very early to draw conclusions and results from the implementation of the tool due to the time involved in engaging suppliers and the subsequent gathering and synthesis of data. There are however some early examples of Cool Farm Tool use that are indicative of its capability as an enabler of change

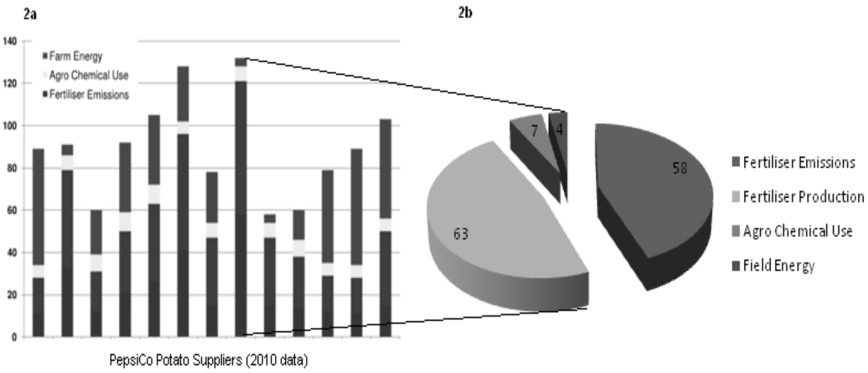
4.2 Early adopter case studies

The following describes some case study examples of companies at various stages of use and with differing levels of results from the Cool Farm Tool. Each addresses a different aspect of the tool.

4.2.1 Multi farm, single crop analysis

PepsiCo have been one of the most active early adopters of the tool and have rolled it out with a number of potato farmers in the UK in 2010. They have realised the significant effort required to assist farmers in measuring their impact on a crop specific basis, and how the Cool Farm Tool can provide good quality data consistent with other LCA methodologies, in a simple to use manner. The Cool Farm Tool generated an average figure of 110kg CO_2e/t potato crops across 22 data sets. This was comparable with PE International and their Gabi LCA tool that utilised 2 UK farm data sets to generate a figure of 111kg CO_2e/t and with the Carbon Trust calculation of 142kg CO_2e/t utilising just one data set in a 2008 study [26]. In a detailed assessment of 12 farms PepsiCo calculated a mean of 95kg CO_2e/t potato with a range from 58 up to 132kg CO_2e/t (Figure 2a). On closer inspection of the higher impact farm, PepsiCo were able to see where the emission hotspots were and thus prioritise areas for action and also where further support might be required for data entry (figure 2b).

Fig.2: a) Cool Farm Tool Carbon impact of PepsiCo potato suppliers (kg CO2e / t) (b) Emissions break down of a higher impact supplier (Image adapted from [26]).



For PepsiCo, this initial exercise has instilled confidence in the ability of the tool to produce robust emissions data and scenario analysis. Additionally the tool has demonstrated good usability for farmers of varying capability and farmers have been very receptive to it consequently. PepsiCo plan to expand their use of the tool and engage all of their 350 potato growers in both the UK and across Europe in 2011 to build up a bank of quality data over time.

4.2.2 Small-holder farm compared to certification

GIZ sponsored the Cool Farming Options Project to use, develop and tailor the tool for coffee producers, and thus far they have undergone some initial carbon footprinting activities with over 40 smallholder farms within the Baragwi Co-operative of farms in Kenya. GIZ were able to use the Cool Farm Tool to assess the conventional Baragwi farming impacts with those of a similar farm that has been achieved Rainforest Alliance certification through adoption of the Rainforest Alliance’s good agricultural practices. The certified farm had a much lower carbon footprint than the mean of the 40 uncertified farms assessed [27]. These results may be indicative of the GHG benefits of management practices deployed by Rainforest Alliance's good agricultural practices.

4.2.3 Ongoing studies

StonyField organic are using the Cool Farm Tool to compare two key agricultural models in the organic sugar production; a large plantation in Brazil and a smallholder in Paraguay. They are interested in learning about the different farm management practices employed in the different models and consequent carbon footprint. Stonyfield hope that these results will help to identify improvement opportunities and where good management practices in one model might be transferrable to others to advance the entire supply chain in GHG emissions management.

Unilever are intending to use the tool as part of the GHG metric reporting requirements of their Sustainable Agriculture Code [28]. The fruit and vegetable portfolio of suppliers from across the globe and a smaller group of dairy farmers are the target supply chains. Cool Farm will be embedded within a supplier audit software programme that Unilever are rolling out as part of their wider aims to drive improvement, document impact and understand the relationship of sustainable sourcing vs. GHGs. The first round of data collection is expected by the end of 2011 and will form an important part of evidencing Unilever's commitment of GHG emissions reduction targets. It is however very early in this journey.

5 Discussion and conclusion

Despite being in its early days, the Cool Farm tool as a farmer focused, management relevant GHG calculator, has received wide uptake and demonstrated significant potential to help close the missing farm emissions data gap. Its ability to produce rapid results, generate context-specific management scenario options in a relatively simple way, sets it apart from other tools in the area. Its use by several companies to help them reach and evidence their ambitious emissions reduction targets is also encouraging but whether it can really help to deliver the changes needed and, from the science are known to be possible, is yet to be seen. Indeed, there is likely to be lag time between implementing the tool that encourages changes in management and detecting measurable emissions savings but thus far it has shown significant potential both on an individual farm level and in the broader agricultural emissions agenda. Further data collection, analysis and farm system comparison are the important next steps for the tool before it can begin to be rolled out sector wide and potentially linked to other carbon market mechanisms. A key challenge here is therefore maintaining and increasing the momentum so far experienced to demonstrate how the tool can be used effectively for farmer engagement, emissions measurement and thus improved management at the farm-level.

6 References

[1] Turner, B. L. II, Hanham, R. Q. & Portararo, A. V., Population pressure and agricultural intensity. *Annuals of the Association of American Geographies*, 67, 3, 1977, 384-396.

[2] Fargione, J., Hill, J., Tilman, D., Polasky, S. & Hawthorne, P., Land clearing and the biofuel carbon debt. *Science*, 319, 2008, 1235-1238.

[3] Smith, P., D. Martino, Z. Cai, D. Gwary, H. Janzen, P. Kumar, B. McCarl, S. Ogle, F. O'Mara, C. Rice, B. Scholes, O. Sirotenko. *Agriculture. In Climate Change 2007: Mitigation*. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 2007.

[4] EPA, *2004 EPA, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2002*, EPA 430-R-04-003, U.S. Environmental Protection Agency, Washington, DC, 2004.

[5] Smith, P., Martino, D., Cai, Z., Gwary, D., Janzen, H., Kumar, P., McCarl, B., Ogle, S., O'Mara, F., Rice, C., Scholes, B., Sirotenko, O., Howden, M., McAllister, T., Pan, G., Romanenkov, V., Schneider, U., Towprayoon, S., Wattenbach, M. & Smith, J. Greenhouse gas mitigation in agriculture. *Philosophical Transactions of the Royal Society Biology*, 363, 1492, 2008, 789-813.

[6] <http://www.sustainable-living.unilever.com/wp-content/uploads/2010/10/UnileverSustainabilityPlan2.pdf> (Accessed 10.03.2011).

[7] < http://www.pepsico.co.uk/purpose/environment/reports-and-updates/2010-environment-report/passionate-about-growing/50-in-5> (Accessed 10.03.2011).

[8] < http://plana.marksandspencer.com/about/the-plan/sustainable-raw-materials> (Accessed 10.03.2011).

[9] Russell, S. *Corporate Greenhouse Gas Inventories for the Agricultural Sector: Proposed Accounting and Reporting Steps*. World Resources Institute (WRI) working paper, 2011, Washington, DC, US.

[10] < www.ecoinvent.ch> (Accessed 10.03.2011).

[11] < www.gabi-software.com> (Accessed 10.03.2011).

[12] < http://www.sustainable-living.unilever.com/wp-content/uploads/2010/10/UnileverSustainabilityPlan2.pdf> (Accessed 03.04.2011).

[13] Cederberg, C., Persson, U. M., Neouvius, K., Molander, S. & Clift, R. Including carbon emissions from deforestation in the carbon footprint of Brazilian beef. *Environmental Science and Technology*, 45, 5, 2011, 1773-1779.

[14] Hillier, J., Hawes, C., Squire, G., Hilton, A., Wale, S. & Smith, P. The carbon footprints of food crop production. *International Journal of Agricultural Sustainability*, 7, 2, 2009, 107-118.

[15] Li, C., Frolking, S. & Harriss, R. Modeling carbon biogeochemistry in agricultural soils. *Global Biogechemical Cycles*, 8, 3, (1994), 237-354.

[16] Parton, W. J., Hartman, M. D., Oijma, D. S. & Schimel, D.S. DAYCENT: Its land surface submodel: description and testing. *Global Planet Change*, 19, 1998, 35-48.

[17] Del Grosso, S.J., Mosier, A.R., Parton, W.J., Ojima, D.S., 2005. DAYCENT model analysis of past and contemporary soil N2O and net greenhouse gas flux for major crops in the USA. Soil Tillage and Research 83, 9-24,

[18] < http://www.calm.cla.org.uk/> (Accessed 06.04.2011).

[19] < http://www.cffcarboncalculator.org.uk/calculator-introduction> (Accessed 06.04.2011).

[20] IPCC, IPCC 1996 Revised good practice guidelines for greenhouse gas inventories. Intergovernmental Panel on Climate Change (IPCC), Institute for Global Environmental Strategies, 1997, Tokyo, Japan.

[21] IPCC, IPCC 20066 Revised good practice guidelines for greenhouse gas inventories. Intergovernmental Panel on Climate Change (IPCC), Institute for Global Environmental Strategies, 2006, Tokyo, Japan.

[22] Hillier, J.,Walter, C., Malin, D., Garcia-Suarez, T., Mila-i-Canals, L. & Smith, P. A farm-focused calculator for emissions from crop and livestock production. *Environmental Modelling & Software* (Accepted for publication), 2011.

[23] < http://www.sustainablefoodlab.org/projects/climate> [Accessed 06.04.2011)

[24] <http://www.sustainablefood.org/index.php?option=com_content&view=article&id=20:climate-assessment-launch&catid=6> (Accessed: 06.04.2011).

[25] <http://sustainablefoodlab.org/index.php?option=com_content&view=article&id=117:gaca-home&catid=18&Itemid=53> (Accessed 10.04.2011).

[26] < http://www.slideshare.net/FarmingFutures/precmarkpettigrew-pepsi-co?from=ss_embed> (Accessed 03.04.2011).

[27] Rikxoort, M. van, Carbon footprinting as part of the add-on climate module. GIZ, (2010).

[28] <http://www.growingforthefuture.com/cms/pages/documents/UL%20SAC%20v1%20March%202010.pdf> (Accessed 01.04.2011).