

Challenges of Scale and Specificity in Greenhouse Gas Calculators

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ABSTRACT

LCA tools to certify products and guide farm management have proliferated but a detailed comparison is needed to show whether different tools are consistent. In this work, three widely used tools for cradle-to-gate emissions of greenhouse gases (GHGs) have been investigated - one general tool (Cool Farm Tool) and two crop-specific tools (Bonsucro for cane sugar and PalmGHG for palm oil). Large discrepancies are found even when the same input data are used; they result from detailed model differences so that no individual tool can be identified as “best” or “preferred”. The results raise questions over the extent to which comparability can be expected between tools, particularly when they differ in their specificity to particular geographical areas and crops, and whether farm-level calculations can “add up” to provide estimates for GHG emissions at landscape or national level. Furthermore, generic tools may not be sufficiently representative to guide farm management for specific crops. Agreement is needed on how to reconcile results between different tools and levels.

Keywords: Greenhouse gas calculators, carbon in supply chains, farm management, standardization, comparability

1. Introduction

LCA is a scientifically-based analysis, but differs from conventional scientific models in not being amenable to empirical testing. In this respect, LCA has much in common with economic models. The inherent uncertainty in LCA models has led some to assert that even consequential LCA “cannot produce definitive quantitative estimates of actual environmental outcomes” (Plevin et al. 2014) and is therefore of limited value for policy support, even though similarly uncertain economic models are widely used for these purposes. Where LCA is used for certification or comparative claims, standardisation of approaches is therefore essential, even for the kind of attributional analysis which is used for product labelling (Clift et al. 2009).

Greenhouse gas (GHG) emissions from agriculture and forestry are responsible for nearly 30% of global anthropogenic emissions (IPCC 2007). Therefore emissions from agricultural production have attracted political, media, academic, and public attention at both ‘macro’ (i.e. global and national) level and ‘micro’ level (i.e. focusing on the individual farm), where the terms ‘macro’ and ‘micro’ are used here in their conventional economic senses. Variability and resultant uncertainty are problems for both LCA and economic models of agricultural systems, particularly in comparison to industrial processes whose performance is more uniform and predictable. In recent years there has been a proliferation of both consumer-facing agri-food certification schemes intended to encourage GHG management and measurement of crop production (Keller et al. 2013) and, at the ‘micro’ scale, of GHG calculators intended to report performance and aid management at the level of specific crops and individual farms (Colomb et al. 2013). However, there has been little attempt to compare and standardise calculators, which can yield different results even given the same input values for the same agricultural system (Colomb et al. 2013; Whittaker et al. 2013). This variability hinders creation of benchmark GHG figures or target ranges to guide producers and may limit their value in guiding on-farm management.

This paper compares three GHG calculators in detail: one general farm-focused calculator, the Cool Farm Tool (CFT) developed by the University of Aberdeen, Unilever and the Sustainable Food Lab (Hillier et al. 2011), and two crop-specific tools used by commodity roundtables, namely Bonsucro’s GHG calculator for cane sugar developed at Louisiana State University (Macedo et al. 2008; Wang et al. 2008) and PalmGHG for palm oil developed by the Roundtable on Sustainable Palm Oil (RSPO) (Bessou et al. 2012 & 2014) (Chase et al. 2012). Both crop-specific tools have become central to the certification process (RSPO 2013; Bonsucro 2013). All three tools combine IPCC tier 1 national inventory data (IPCC 2006) with more regionalised tier 2 data, together with farm-specific activity data. Results are reported and compared here on a per land area basis (i.e. as kg CO₂e per ha cultivated) to avoid including the additional variability due to the dependence of yield on very local conditions; for a specific farm, the impact per unit of crop is calculated using the actual site-specific yield. The results do not include the effects of specific management practices such as rotational cropping or tillage, nor the impacts of land use change. More detailed results and comparisons, including the effects of land use change, are given by Keller

(2014).

2. Methods

The three calculators have been applied to assess GHG emissions up to the farm gate, including agricultural production and associated inputs (e.g. fertilizer and pesticide production). Processing of the raw products is not included, nor are emissions embedded in infrastructure or equipment. The systems considered are sugar cane production in Brazil (Bonsucro and CFT) and palm oil cultivation in Indonesia (PalmGHG and CFT). Input data were provided by the relevant commodity round-tables (see Keller 2014) specifically for the purpose of comparing calculators; they are representative of common practice at the micro-level in the two cases but must not be interpreted as representing the sectors at the macro- or meso- levels (see Section 4). The tools differ in their data requirements and formats; e.g. only Cool Farm Tool requires information on soil properties. Minor adaptations to the calculators were made to enable them to use input data which were as near identical as possible but without modifying the underlying data or algorithms. Thus the results show the comparison between the tools in their generally available forms but with a few “bugs”, identified in the course of this work, rectified in collaboration with the tool producers.

3. Results

The nature and extent of discrepancies between the general calculator and the relevant crop-specific tool are shown for sugar cane in Figure 1 and for palm oil in Figure 2. These Figures also reveal the GHG “hot spots” in the two systems: agrochemical inputs (including all soil or crop enhancers) and energy use (mainly diesel fuel for farm equipment and transport). Land use change is, of course, also highly significant but is not included in the comparisons presented here.

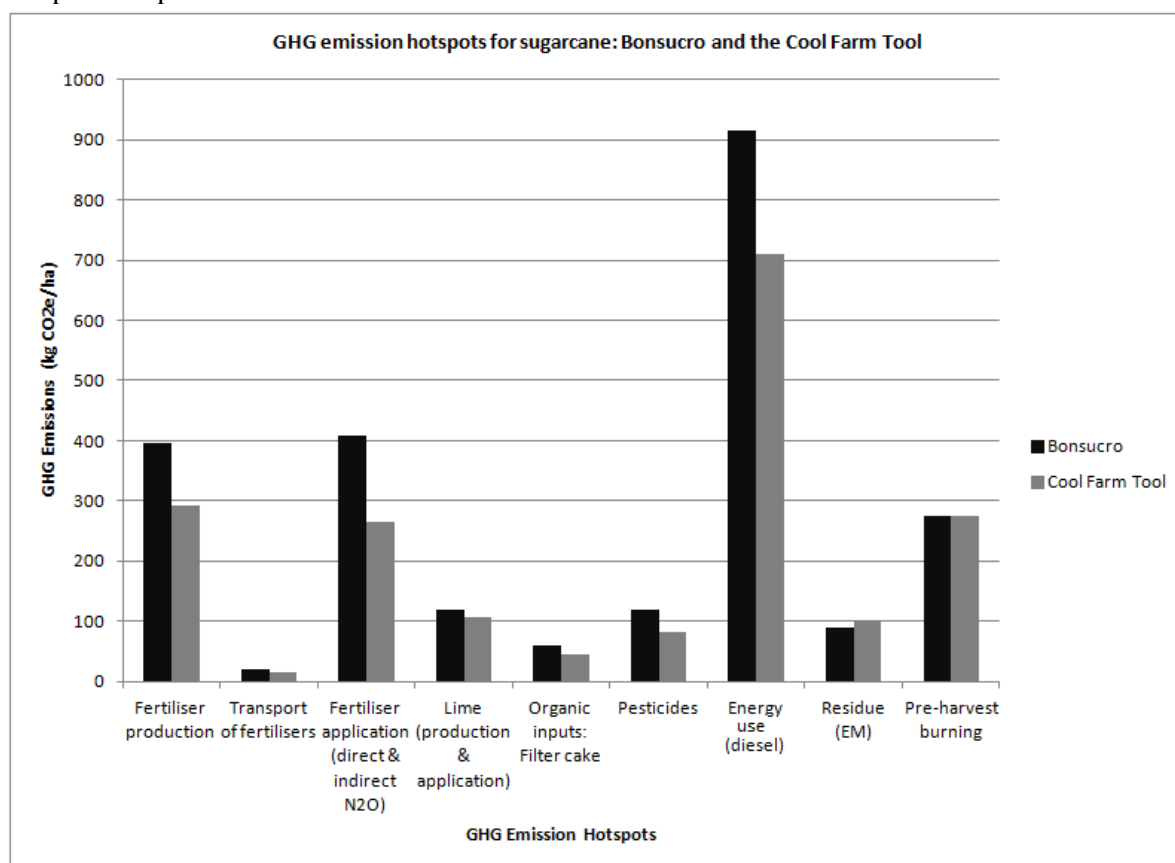


Figure 1. GHG emissions from sugarcane cultivation: Bonsucro and the Cool Farm Tool.

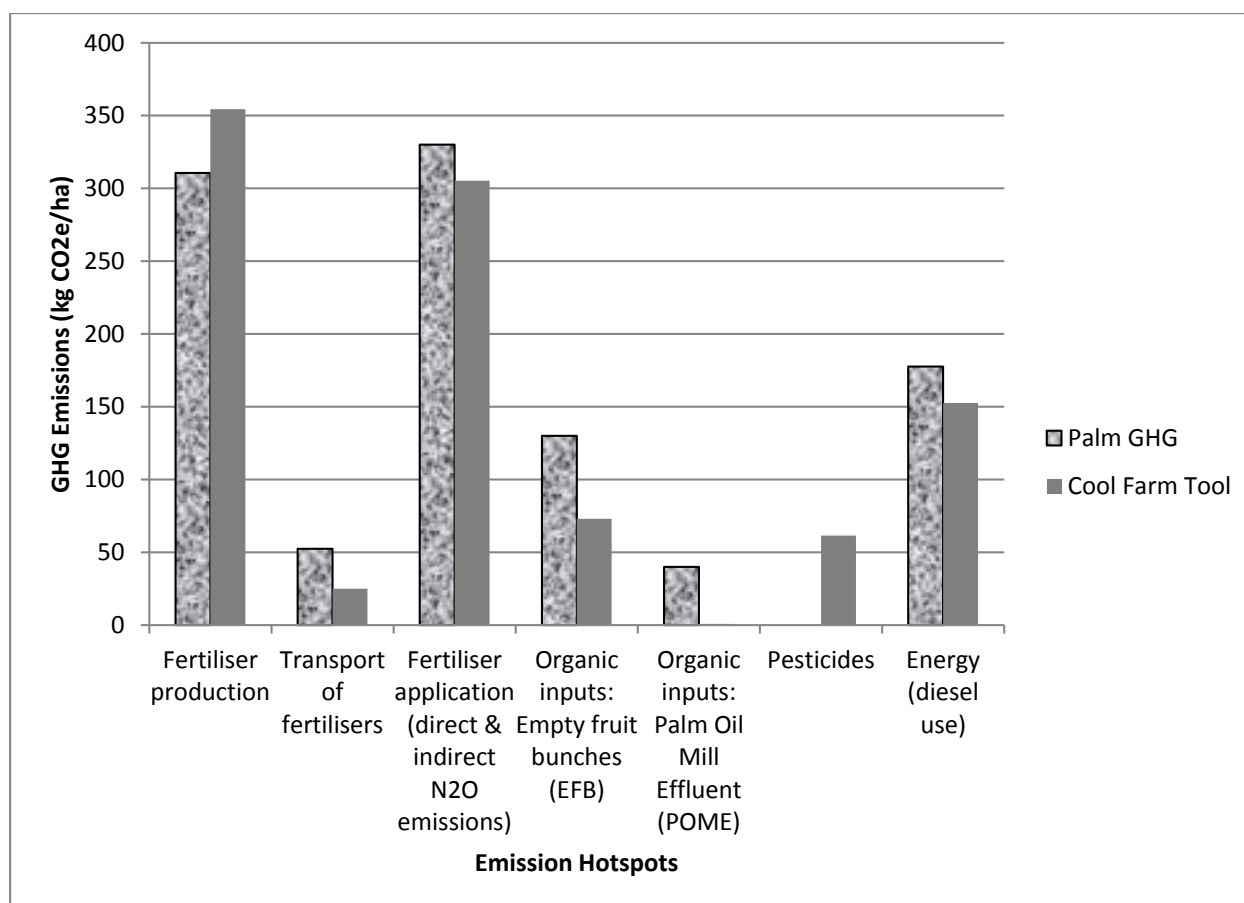


Figure 2. GHG emissions from palm oil production: Palm GHG and the Cool Farm Tool.

For almost all activities, CFT Gives lower estimates than the crop-specific tools. For energy use, the differences result from the emission factors assumed. The differences between the figures from fertilizer use are particularly marked for sugar - as high as 42% for emissions associated with mineral fertilizer. This also results from differences in the background estimates, in this case for emissions from production of nitrogen fertilizer: Bonsucro is based on data from the GREET model (Macedo et al. 2008; Wang et al. 2008) whereas CFT uses data for European fertilizer production that is generally more efficient. These differences illustrate a general problem in comparing calculators: even when they use the same input data and methodology, differences can arise from different background data and models; these aspects are explored by Keller (2014). Moreover, while Bonsucro and PalmGHG enable modeling of different inputs specified by the user, CFT as a multi-crop tool has more in-built flexibility and can model different practices such as reduced tilling and cover cropping. Thus CFT can be used to investigate improvements in management practices, a capability which is missing from Bonsucro and PalmGHG. Figure 3b compares results from Bonsucro with a range of different modes of fertilizer application calculated using CFT. Although the CFT results span a significant range, the range still lies consistently below the value calculated from Bonsucro. However, CFT estimates for different soil types (Figure 3a) span a wider range and do encompass the single estimate from the Bonsucro calculator. GHG emissions from fertilizer production for palm oil is the one component where CFT gives a higher estimate than the crop-specific tool but the range over different soil types is as wide as in Figure 3a so that the difference between PalmGHG and the baseline CFT estimates depends strongly on the soil type adopted as the default in CFT.

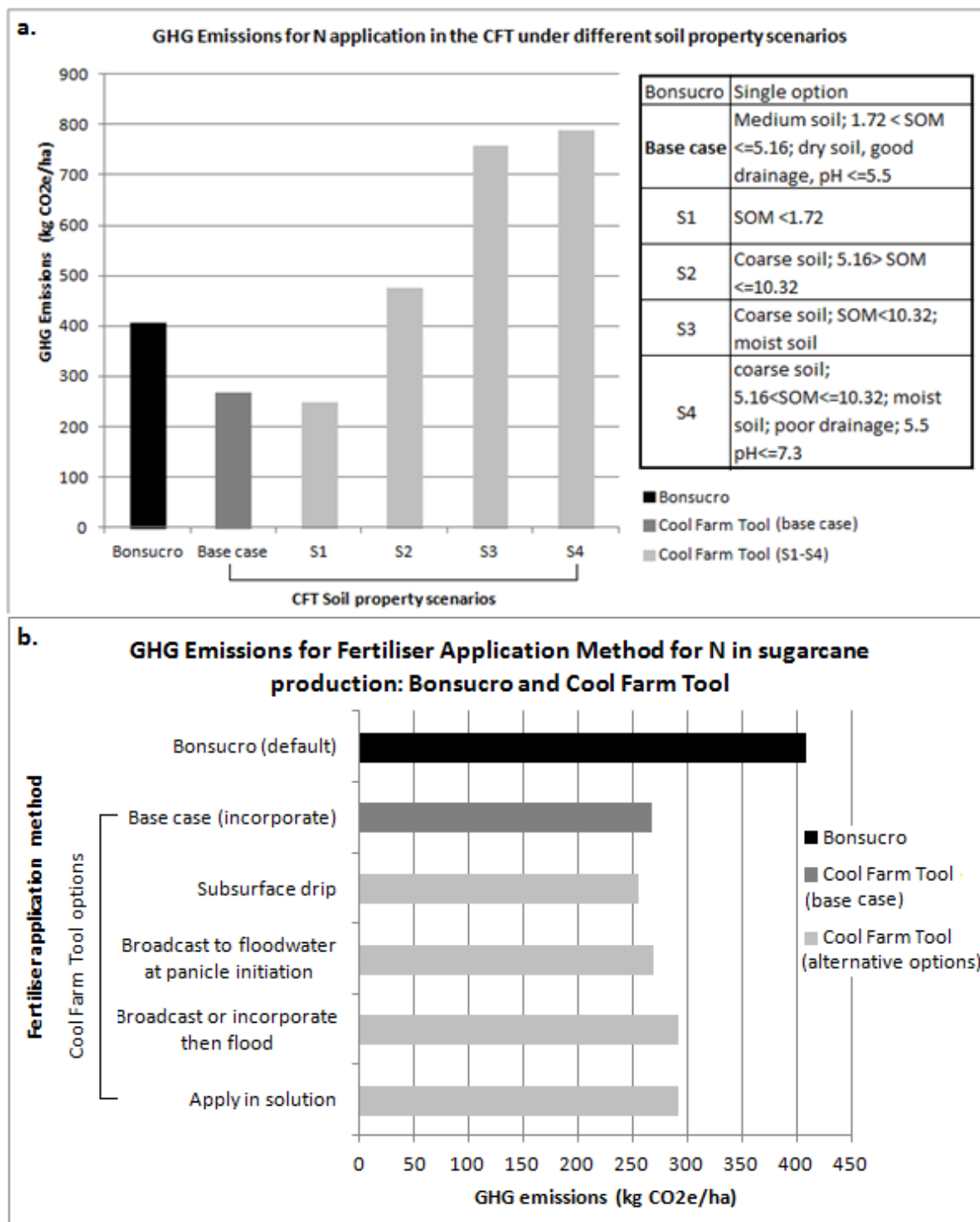


Figure 3. GHG emissions from fertilizer use in sugarcane cultivation: Bonsucro compared with a range of Cool Farm Tool scenarios for soil type and mode of application of fertilizer.

a. effect of soil properties

b. effect of fertilizer application method

4. Discussion

The results above show that, while these tools are in broad agreement, they give results which can differ by considerable margins. Short of detailed forensic examination of the underlying model data and algorithms, it is unrealistic to expect closer agreement. More critically, provided the tools are formulated correctly, there is no basis for prescribing any individual tool as the standard beyond ensuring that the most relevant background data are used. The differences between the results from different calculators are of comparable magnitude to the differences between individual producers; therefore comparative assessments must be based on results from a single calculator. This is particularly relevant to certification schemes (e.g. RSPO 2013) which require quantification of GHG emissions but permit the use of a specific tool (PalmGHG in this case) or an “equivalent” calculator but without guidance on what might be considered equivalent. However, we have not identified any respects in which the tools are contradictory in the sense of giving contradictory indications on ways to improve environmental performance at the farm level.

The discrepancies between these specific calculators raise the question of whether it will ever be possible to devise a single calculator for GHG emissions applicable to all crops and all purposes. In addition to the problems of describing different crops, production systems and farm or plantation management, there is an overarching question of the purpose for which the results are needed (Keller 2014). Going beyond the micro-/macro- distinction, it is useful to distinguish three different scales and applications:

Micro: products from a specific farm;

Meso: crops from similar agricultural systems;

Macro: global or national: relevant to a large area of land or landscape, with a number of different land uses and products.

Even within each level, there is a need for discussion aimed at agreement on appropriate methodology and data. GHG calculations at the micro-level are needed to guide farm management, and sometimes as the basis for certification or payments for responsible farm management; therefore they should be based as much as possible on primary farm-specific data with tier 2 or 3 data used for the background. Meso-level figures may be used, for example, to compare alternative food sources or the sustainability of different diets or as components of personal carbon calculators. Even within a single food supply or retail company, calculations at the two levels are used for different purposes: given the variability between different producers, micro-level calculations may be used to select individual suppliers and to help suppliers to improve their own performance, whereas meso-level calculations can guide what general products to promote and to select the regions from which they should be sourced. Macro-level figures are necessary for national GHG reporting, to support policy development and to support programs such as UN-REDD and REDD+. Tier 1 data are sufficient for this purpose and it could be appropriate to use environmentally-extended input/output calculations.

As usual with process-based LCA, calculations at the micro- and meso-levels do not necessarily add up to give the macro-level figures, for much the same reasons as LCA results for all a company’s products may not add up to describe the whole of the company’s impacts: the larger scale calculations include shared or background activities which need not be included if the purpose is to improve the environmental performance of a single farm, product or supply chain. Non-additivity should not be a concern provided that the three levels of calculator do not give perverse or contradictory results.

Some certification schemes are beginning to show attention to the landscape level, rather than focusing on individual crops. Rainforest Alliance, Fairtrade, UTZ along with other institutions and certification bodies have recently become members of the Committee On Sustainable Agriculture (COSA) seeking to analyze the impacts of agriculture at a larger scale, particularly associated with the implementation of sustainability initiatives (COSA, 2013). Bringing together and integrating performance information from certification schemes and other supply chain initiatives that may involve GHG calculators with domestic policies and larger programs including REDD

could and should enable impacts to be assessed at the landscape scale (Nepstad et al. 2013) and ultimately scaled up to understand the global impact.

5. Conclusion

Even superficially similar “carbon calculator” tools can give considerably different results for identical cases and input data. At least for the tools compared here – Cool Farm Tool (CFT) vs. Bonsucro for sugar and vs. PalmGHG for palm oil – the differences are not attributable to the fact that CFT is a general tool whereas the others are crop-specific; rather, they derive from differences in the underlying models and, most importantly, in the background data which can only be revealed by very detailed forensic examination. It must therefore be anticipated that discrepancies between different calculators will persist. To achieve consistent and comparable results requires the application of consistent and comparable methods. Thus for comparative assessments for a single crop or level, it is essential to use one tool; comparative assessments or claims should be ignored unless they compare results obtained with the same tool.

Micro-, meso- and macro-scale assessments require different approaches. There is a need for discussion aimed at agreement on appropriate methodology and data for the different scales, although this will not remove the differences between different tools. Comparison across different sectors and scales is likely to remain problematic, dependent on understanding in depth of what lies beneath each calculator.

6. References

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