Carbon Labelling and Low Income Country Exports: An Issues Paper

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Abstract

In response to growing concerns over climate change, consumers and firms in developed countries are considering their carbon footprint. Carbon labelling is being explored as a mechanism for greenhouse gas emission reduction primarily by private actors. This paper discusses the carbon accounting activities and carbon labelling schemes that are being developed to address these concerns with a view to their impact on small stakeholders, especially low income countries. This discussion centres on *transportation*, and the common presumption that products produced locally in the country of consumption will have an advantage in terms of carbon emissions, and on *size*. Exports from low income countries typically depend on long distance transportation and are produced by relatively small firms and tiny farms who will find it difficult to participate in complex carbon labelling schemes. However, the popular belief that trade by definition is problematic since it necessitates transportation, which is a major source of emissions, is generally not true. The scientific evidence shows that carbon efficiencies elsewhere in the supply chain may more than offset the emissions associated with transportation. Indeed, the effective inclusion of low income countries in labelling schemes may offer important opportunities for carbon emission reductions due to their favourable climactic conditions and their current use of low energy intensive production techniques. The disadvantages of small size can be reduced by carbon labelling schemes that use innovative solutions to low cost data collection and certification.

1. Introduction

In response to growing anxiety over climate change, policy-makers, firms and consumers are considering ways in which to reduce greenhouse gas emissions. A possible mitigation mechanism undergoing rapid development is carbon[2] labelling. This involves measuring carbon emissions from the production of products or services and conveying that information to consumers and those making sourcing decisions within companies. Well designed schemes will create incentives for production of different parts of the supply chain to move to lower emission locations. Thus, carbon labelling is an instrument that enables consumers to exercise their desire to join the battle against climate change by using their shopping trolley.

Firms are eager to cater to consumers' demands and to reduce their own carbon footprints. Global retail giants, such as, UK Tesco or US Wal-Mart are developing carbon labelling schemes and major manufactures are following suite. Popular outdoor garments manufacturers Patagonia and Timberland, for instance, are seeking to satisfy their nature-friendly consumers by allowing them to see exactly how many emissions are caused by their purchase of a product. But the strong desire to act on carbon labelling has been running ahead of the challenges of measurement and the problems of effective communication through labeling that must be addressed for schemes to be successful. And a growing number of standards are being developed with little effort to coordinate and generally little or no voice given to small players, such as, low income countries.

With regard to policy-makers, the European Parliament, for example, has recently passed a resolution that calls for "the introduction of WTO compatible common standards and labelling schemes regarding the GHG implications of different products, including at the production and transport stages"; "a procedure to assess and label these ecological footprints and to develop software in order to enable businesses to calculate the quantity of GHG emitted from every production process"; and "the development of a scheme based on sound life-cycle data which includes finished goods, such as cars and electronic equipment" (European Parliament 2007).

Fears have been raised that low income countries will face greater difficulties in exporting in a climate constrained world where carbon emissions need to be measured and certification obtained to enable participation in carbon labelled trade. This discussion centers on *transportation*, and the common presumption that products produced locally in the country of consumption will have an advantage in terms of carbon emissions, and on *size*. Exports from low income countries typically depend on long distance transportation and are produced by relatively small firms and tiny farms who will find it difficult to participate in complex carbon labelling schemes. However, the scientific evidence shows that carbon efficiencies elsewhere in the supply chain of a product may more than offset the emissions associated with transportation. The disadvantages of small size can be accommodated in carbon labeling schemes through innovative solutions to low cost data collection and certification.

The impact of carbon labeling schemes on low income countries hinges on the issues of design and implementation. Low income countries generally use technologies and sources of energy that entail relatively low carbon emissions. For example, in agriculture modern inputs, such as, fertilizers, pesticides and fuel are not used intensively. A well-designed carbon labelling scheme would value this production structure since modern inputs are an important source of carbon emissions in agriculture. Mechanisms for implementing carbon labeling schemes must make sure that such advantages are not lost to burdensome data collection and verification requirements.

Box 1. Carbon terminology

The terminology used to discuss carbon labelling is about as complicated as the issue of climate change itself. This box gives an overview:

Carbon	Shorthand for all greenhouse gases. Refers more directly to carbon dioxide which is the most common greenhouse gas.
Carbon emission	Emission of all greenhouse gases
CO_2e	Carbon dioxide equivalent. The greenhouse gas measurement unit that translates the effect of all greenhouse gases into carbon dioxide
Carbon footprint	The carbon emission caused by an activity
Carbon accounting	The measurement of carbon footprints
Carbon labelling	The display of the measurement of carbon footprints on a product. Also used to refer more broadly to the use of carbon accounting information
Carbon efficiency	The ability to have minimum greenhouse gas emission
Carbon tax	A tax on the emission of greenhouse gases
Carbon hotspot	A greenhouse gas-intensive activity in the supply chain
Carbon competitiveness	The ability to compete in terms of low greenhouse gas emissions
Life cycle analysis	The analysis of, in this context, greenhouse gas emissions throughout the various segments of a supply chain from primary production to end use and waste disposal. A comprehensive analysis takes into account emissions related to changes in land use.

The terminology and the effects of greenhouse gases are explained in more depth in section 3.

Carbon labelling is an infant climate mitigation instrument that needs to be based on a sound and well-developed and independent scientific base. At present the available body of scientific evidence is small, but growing. It is too early to make specific predictions of how the exports of low income countries will be affected, but it is timely to identify the major issues. The aim of this paper is to promote discussion of the interests of low income countries in carbon labelling. The paper starts by providing a brief overview of the intersection between carbon labelling and international trade. The paper then proceeds with two empirical sections. Section 3 presents the main conclusions and the key issues raised by studies that have sought to measure carbon emissions or energy used along international supply chains, with a focus on those involving low income countries. Section 4 gives an overview of the emerging carbon labelling initiatives while identifying the key characteristics from a low income country perspective. The following section, section 5 is more analytical and discusses how low income countries' export interests interact with the on-going process of designing carbon labelling schemes and how the schemes that emerge from that process create challenges and opportunities for future trade. Finally, conclusions are offered in section 6.

2. Carbon labelling and trade

The role of carbon labelling is to provide information to consumers and purchasers who are concerned with the impact of their choices on global warming. As with other labelling schemes, carbon labelling is becoming popular within the business and policy-making communities as they seek to respond to the perceived desire of consumers to protect the global environment and the inability of individual consumers to determine themselves the impact of their choices on carbon emissions. Carbon labelling is one instrument in the toolbox of measures available to mitigate climate change that includes other trade measures, such as, carbon taxes and countervailing duties, and specific regulatory requirements. Voluntary labelling schemes may be seen as an attractive approach to dealing with this environmental issue relative to more traditional forms of taxation and regulation. Nevertheless, carbon accounting and labelling may be used to support or complement other environmental instruments. For example, carbon labelling is an integral part of the proposed EU regulation on biofuels, which will be discussed in more detail below. Implementation of carbon taxes is intrinsically linked to carbon labelling through the need for measurement of carbon emissions.

The development of carbon labelling was predated by discussions of 'food miles' which began in the early 1990s (see Box 2 below). While food miles have been discredited as an accurate measure of the impact of food products on climate change, discussions of how carbon labelling can attain the necessary precision to be effective are still ongoing. That is the scientific side of the discussion. The economics of labelling are complex and involve: consideration of how labels may bring down transaction costs in a supply chain by increasing transparency with regard to relevant product attributes (in this case emission efficiency); the costs of providing and verifying the necessary information; and how labelling will change consumer and producer behaviour.

The issue of measurement costs is a critical one for small stakeholders. Low income countries have predominantly small firms and tiny farms, hence any size bias in the carbon labelling schemes, in terms of the costs of measuring emissions and of verifying those measurements, will translate into a heavy burden on the competitiveness of such small players. One of the main features of the last two decades of development in agro-food industries have been the implementation of strict trade standards. One such example is the imposition of the GlobalGAP standard by a group of primarily UK and Dutch retailers. This standard is generally thought to be a major reason behind the marginalisation of small farmers from horticultural export markets because it is more costly to comply with for small than for large farms (Dolan and Humphrey 2000; Gibbon 2003; Graffham et al. 2006; Graffham and MacGregor 2006).

The provision of credible information is essential if a carbon labelling scheme is to meet its objective of serving as a guideline for buyers and consumers in to choosing emission efficient products. Certification is one way to target this problem. Given that costs must be incurred by firms in certifying their emissions, the success of carbon labelling requires that consumers are willing to pay a premium to protect the global environment. Further, by allowing consumers and company purchasers to demonstrate their willingness to pay to reduce their carbon footprints, labelling may initiate a process by which firms in the production chain innovate so to acquire or maintain an existing advantage in terms of carbon emissions.

Box 2. Food Miles

The term "food miles" has entered the world of academia, policy and even common language. It refers to the distance that food travels from production to final consumption. Tim Lang, professor of food policy of City University in London introduced the concept in 1991 when contributing to a television documentary on the geography of food production. In today's globalised food system, food travels more. As an example, a 2005 report from the UK Department for Environment, Food and Rural Affairs (Defra) estimates that between 1978 and 2002, the amount of food trucked on heavy vehicles increased by 23% and the distance travelled increased by more than 50%.

Some believe that this is a major environmental problem leading to higher carbon dioxide emissions, air pollution, congestion, accidents and noise. It may also have social effects as local communities are affected by the relocation of food production. While food miles is about much more than climate change, the rise of the latter on the priority list of politicians has given the concept new momentum. The Defra 2005 report acknowledged that food transportation has severe implications but found that the simple distance that food travels is not a meaningful indicator of sustainability.

Food miles is a great metaphor for the evolution of the global food industry. But it is difficult to apply. The UK newspaper, the Guardian, sent three journalists to the local supermarket in May 2003 and found that their basket of food had travelled 100,943 miles or four times the Earth's circumference in total. How did they get to that number? They bought 20 items of various quantities and added up the distances from each item's production location to where the journalist stood. One item was US apples. Calculations show that sailing apples from South Africa, another popular off-season origin, causes less than 100 times the amount of carbon dioxide emissions than if they are flown. Yet the food miles concept tells us nothing about whether the apples sailed or flew.

Sources: Defra (2005), Guardian (2003), and Wangler (2006).

In principle, such labelling schemes could play an important role in achieving emission reductions and could be a useful complement to other environment policies. However, as with other eco-labels, there is a concern that such schemes may, in practice, unfairly restrict trade and especially trade with low income countries. This may arise if the labelling criteria reflect local technologies and tend to exclude "acceptable products" produced with different processes in overseas locations, as might occur if the process of developing the labelling scheme is liable to capture by domestic interests.[3] Similarly, there may be discrimination against imported products if the carbon emissions of particular products are indirectly derived using parameters based on data in the importing country and which may overestimate the emissions in the country of production (Deere 1999). Both of these concerns are likely to impact most heavily on low income countries where production processes tend to differ from those in rich countries and for whom parameters derived in rich countries will be most inappropriate. In addition, as noted above the costs of certification are likely to impinge especially heavily on producers in low income countries and if these costs lead to the exclusion of low emission producers from developed country markets, then the labelling scheme would be undermined.

Finally, consumers who are concerned about the environment may also consider other dimensions of the impact of their purchasing decisions, such as ethical and developmental. In some cases of multiple labelling, consumers may be asked to make a trade-off between different concerns, for example, when a product is labelled as having relatively higher carbon emissions and a fair-trade label. However, in low income countries, for a range of products, it may be possible for producers to complement ethical approaches with an advantage in carbon emissions.

3. Carbon emissions throughout an international supply chain

Concern about climate change has stimulated interest in estimating the total amount of carbon emitted during the production, processing and distribution of a product. The final outcome of this exercise is called the product's 'carbon footprint' and the exercise itself is known under the name of 'carbon accounting'. A product's carbon footprint is different from a company's carbon footprint as the former includes the carbon emitted by consumption (and disposal) of the product itself as well as of all inputs necessary to produce the product. It is therefore called an embedded (or embodied) footprint while a company's footprint is usually restricted to the carbon emitted at the site of a factory, for instance.

Methods are already established for measuring, reporting and verifying carbon emitted during production[4]. One scientific method typically applied in environmental analysis is Life Cycle Analysis (LCA) however this method is difficult and costly to apply to carbon accounting.[5] In principle, carbon accounting through LCA should imply adding up all carbon emissions throughout a product's life from the production of inputs to final consumption and disposal of waste. The methodological difficulties of turning this intuitively appealing idea into practice are immense and the lack of standardised methods heavily influences the usefulness and comparability of existing studies.

Nevertheless, a small but rapidly growing literature analyses product level carbon footprints. The scientific literature is dominated by case studies of agricultural supply chains serving Northern Europe and particularly the United Kingdom. Needless to say, carbon accounting is becoming increasingly difficult in today's globalised world where supply chains grow longer and ever more complex with inputs being produced in a large number of countries. There is little doubt that this complexity accounts for the dominance of agricultural supply chains in the literature as many foods are subject to little processing and pass through relatively simple supply chains. Other products that have been subject to carbon measurement studies include transport fuels and forestry products, where again the supply chains are relatively straightforward. Nevertheless, carbon accounting may be also implemented for more complex products like industrial products. However as carbon accounting studies for industrial products are still rare, many of the observations in this paper will be particularly relevant for food trade.

Carbon footprints are expressed in units of CO_2 equivalents (CO_2e). This is because different greenhouse gases (GHG) have different impacts on the atmosphere – so-called radiative forcing[6]. The degree of radiative forcing of a GHG depends on several factors including how long they survive in the atmosphere, their current concentration in the atmosphere and their ability to capture infrared radiation.

There are relatively few complete LCAs or carbon footprints for entire supply chains published in the peer reviewed literature, and those that study a supply chain that includes activities in a developing country are even fewer. Similarly, studies that consider alternative supply chains for the same good, that is a good supplied to the same market place via different supply chains, are very scarce. There is a larger grey literature on carbon footprinting often produced by parties with commercial interests. To make things even more difficult, studies differ in their methodologies, making comparison difficult. Table 1 presents an overview of the main studies. With these caveats in mind, the rest of this section will present the available evidence and distil the lessons for low income country export opportunities.

Carbon emission patterns are highly complex.

The literature illustrates a number of ways in which different carbon emitting activities interact to provide an overall carbon footprint. An important implication of this is that geographical location alone is a poor proxy for overall emissions; favourable production conditions may more than offset a disadvantage in transport.

Williams (2007) estimated the carbon footprint of cut roses supplied to the UK market from a company in Kenya compared with a supplier in the Netherlands and found that even after taking into account the emissions from air transport the roses produced in Kenya generated considerably lower emissions than roses produced in the Netherlands. The emissions from aviation transport from Kenya to the UK were less than the higher emissions in the production stage in the Netherlands. The latter arising from the fact that electricity and heat used in Kenyan greenhouses was derived from geothermal energy, while in the Netherlands heating and electricity were generated by burning fossil fuels.

Fogelberg and Carlsson-Kanyama (2006) point out the trade off between relying on high use of diesel in Swedish broccoli production and accepting carbon emissions from long distance transportation of broccoli from South and Central America where, on the other hand, the agricultural technologies used are less mechanised and primary fossil fuel consumption is much lower. Schlich and Fleissner (2005) explore the trade off between close-to-market but small scale fruit juice production and far away carbon efficient large scale production and find that better use of scale economies outweighs transportation-related emissions.

The exact structure of emissions is likely to be highly specific to the given supply chain under scrutiny and the limited body of existing evidence offers few rules of thumb. Mila i Canals et al. (2007a) find that the balance between carbon emissions from refrigeration of local apples and emissions from transporting apples from the other side of the globe shifts throughout the year. In the European spring and summer, long distance trade is most efficient, but when European apples are in season the balance tips and local apples are most efficient.

Table 1. Life Cycle Analyses relevant to low income country exports

Study	Case	Outcome	Comments
Williams (2007)	Kenyan and Dutch roses consumed in the UK	Air freight-related emissions counteracted by higher energy use by Dutch greenhouses to the extent that it was more 'carbon efficient' to produce cut roses in Kenya	Comparison of one Dutch farm with one Kenyan farm. Comparison may not be typical. Data supplied by farms and not verified independently
Jones (2006)	Kenyan and UK beans consumed in the UK	On-farm energy consumption of Kenyan and European production systems similar. Energy consumption of Kenyan supply chain 12 times higher than UK sourced once due to air freight	No primary data collected in the UK, so basis for comparison is questionable.
Sim et al (2007)	Kenyan, Guatemalan and UK runner beans consumed in the UK	Global warming potential from Kenyan and Guatemalan runner beans 20-26 times higher than UK ones primarily due to airfreight	As no primary data were collected in the UK it is hard to compare overall emissions from UK and overseas supply chains.
Fogelberg and Carlsson-Kanyama (2006)	Frozen South and Central America broccoli compared with fresh Swedish broccoli consumed in Sweden	Transportation-related emissions counteracted by lower use of fossil fuels in South and Central American production systems. In terms of carbon emissions there is no substantive differences between the two origins	Only aggregated data presented in graphs, so it is hard to really understand the data collection and manipulation methods. Attempts were made to normalise the results to account for nutritional differences between fresh and frozen product – which is a non-standard approach.
Fogelberg and Carlsson-Kanyama (2006)	Brazilian and Swedish chicken consumed in Sweden	Analyses trade off between shipping feed from Brazil to produce chicken in Sweden and produce both feed and chicken in Brazil and ship chicken to Sweden. Finds that differences in emissions are small	Only aggregated data presented in graphs, so it is hard to really understand the data collection and manipulation methods.
Blanke & Burdick 2005	German and Southern Hemisphere apples consumed in Germany	Northern grown apples would need to be stored to be available year-round. Energy to store apples almost as great as energy needed to transport apples from overseas	Relies on modelling supply chains rather than primary data collection. Studies one month only. Only studies energy use (correlated with but not identical to carbon emissions)
Mila i Canals et al. 2007a	EU and Southern Hemisphere apples consumed in the EU	Northern grown apples would need to be stored to be available year-round. Southern Hemisphere apples as energy efficient as EU apples during EU Spring and Summer due to energy needed for storage counteracting energy needed for transportation by ship	Considers the whole calendar year. Only studies energy use (correlated with but not identical to carbon emissions). Incorporates variation in energy use in the supply chains and presents a more realistic range of energy use than the normal LCA approach of presenting only one figure per supply chain.

Table 1. Life Cycle Analyses relevant to low income country exports (continued)

Study	Case	Outcome	Comments
Mila i Canals et al. 2007b	UK and Spain lettuce consumed in the UK	Spanish winter production plus road transport is more 'carbon efficient' than UK winter greenhouse production. Refrigerated transport causes high emissions of Spanish lettuce, heating in greenhouses cases high emissions of UK winter lettuce. Fertilisers important source of emissions in all systems	Primary data collected through field surveys on farms. However sample size still too small to claim that the results are statistically representative of lettuce production in Spain and the UK. Highlights the variation between farms in emissions /kg lettuce produced.
Schlich and Fleissner (2005)	German, Brazilian and New Zealand fruit juices and lamb consumed in Germany	Large global companies are better able to exploit opportunities for reducing energy inputs that come from greater scale. Better use of scale economies outweighs transportation-related emissions	
Saunders et al. (2006)	New Zealand and UK lamb consumed in the UK	More extensive farming systems in New Zealand more than outweigh transportation-related emissions so that New Zealand lamb consumed in the UK has lower emissions that domestic UK	Methodologically flawed in many ways. Analyzed seven NZ farms as compared with standard data for one UK farm-type. Did not consider all greenhouse gases. Given the surprising conclusion that the NZ source is four times more 'carbon efficient' than UK production, this study received widespread media coverage as well as NZ political support.
Barrett et al. (2002)	Food consumed in York (UK)	Meat and dairy products have highest carbon emissions, horticultural products have emission 3 to 5 times lower than meat and dairy (per kg basis)	Used Ecological Footprinting as the methodological basis for the analysis. Specifically used Energy Analysis Program (EAP) to model the carbon emissions. Hence details of the analysis are not presented.
Wallén et al. (2004)	Food consumed in Sweden	Cheese, coffee, frozen fish and meat have highest carbon emissions, horticultural products have emission 3 to 12 times lower than meat and dairy (per kg basis)	Data on different food stuffs taken form secondary sources, including suppliers. In the absence of some data a series of assumptions were made
Kramer et al. (1999)	Food consumed in the Netherlands	Meat and dairy products account for 50% of food related carbon emissions, fruit and vegetables account for 15% of emissions	

Emissions from the use of imported inputs that have been transported long distances are important in comparing the carbon footprints of products from different locations. Fogelberg and Carlsson-Kanyama (2006) compare chicken consumed in Sweden from two sources: Sweden and Brazil. Two key differences in production between the two locations are highlighted. First, energy consumed in the production of chicken in Brazil is lower than that in Sweden due to the more conducive climate. Second, the feed used in Sweden is produced partly from imported soy meal (which may come from Brazil). In Brazil, all ingredients in the feed are obtained domestically.

Thus, the complexity of carbon emissions discredits simplistic but intuitively appealing concepts such as food miles and buy local campaigns. Such concepts may be more relevant when particular food qualities are sought by the consumer such as freshness and authenticity but the available stock of evidence lends little support to the notion that these concepts have much to offer in terms of climate change mitigation.

Transportation is one source of carbon emissions among many.
The popular belief is that trade, by definition, is problematic from an environmental perspective since it necessitates transportation, which is a major source of carbon emissions. But this is generally not true; transportation is one source among many. Carbon emissions per tonne-km vary with the different types of transport and generally fall in the order of air freight, road, ships. However, while aviation emissions are widely known to be high there remains some discussion as to what they actually are. Energy use for transporting freight differs between short and long haul flights (23.7 MJ/tonne-km and 8.5 MJ / tonne-km, (Defra 2005) and also between freight carried in the belly of a passenger plane and in a dedicated freight plane. As a result there are a variety of emission factors available for air transport.

Emissions from ocean going ships are considerably lower. Indeed Jones (2006) estimates that if green beans were transported from Kenya to the UK by ship (Mombasa to Southampton) the energy use would be 1.7 MJ / kg of beans. This is 56 MJ/kg less than the air freight transport from Nairobi to London. However, given that the journey by sea would take 11-12 days it would be necessary to chill, or otherwise treat, the beans in order to render them saleable after they reached the UK. In a similar set of calculations Wangler (2006) estimates the emissions from transporting 1 kg of produce from Cape Town to London by air would be 14.9 kg CO_2e. Transporting them by ship from Cape Town to Southampton in the UK would emit between 0.1 – 0.12 kg CO_2e.

Thus, air transport is a carbon hotspot and it is clear that the airfreight of fresh fruit and vegetables is responsible for a substantial, if not the major, proportion of carbon emissions emitted in the supply chains to wholesalers (Sim *et al.* 2007). However, the emissions from transport are perhaps most evident in supply chains providing fresh fruit and vegetables than in other food items. This is because there are so few other inputs into fresh produce. However, the overall emissions from vegetable production are considerably lower than for other products. So by definition transport will be a smaller part of total emissions in the supply chain of a processed and chilled dairy product (such as ice cream or butter) than they are for fruit and vegetables.

Nevertheless, the vast majority of low income country exports and of international trade in general, is transported by ships for longer distance transport and roads for shorter distances. Notably, ship transport has become highly energy efficient (measured on a tonne-km basis) and for most products it is highly unlikely that transportation will be a disproportional source of carbon emissions. This is particularly relevant for processed food and industrial products for which energy consuming processing activities weigh more heavily than for the relatively simple products analysed in LCAs so far.

Low income countries' carbon competitiveness needs to be explored.
The potential of low income countries to participate in global trade in a climate constrained world in which carbon emissions carry a larger cost than today has not been investigated in any detail. The few existing studies suggest that low income countries may remain competitive in sectors where they have traditionally done well. This is the case for Kenyan roses and presumably also the case for many traditional bulk commodities transported by sea.

Some studies, have shown that one particular agricultural production process is extremely energy intensive; protected production. Examples include production under glass or in polytunnels in the case of horticulture. This arises because of the use of energy to heat the greenhouse and to provide light, whereas it is inputs of natural light and heat that are used in non-protected agriculture. In addition, substantial emissions in the cultivation of protected agriculture arise from the production of the materials used to build the glass houses and polytunnels; steel, glass, plastics.[7] Hence, low income countries are likely to have an advantage in terms of carbon emissions in competing with protected production in richer Northern countries. The source of energy is also important. This was highlighted in the case of roses produced using thermal energy in Kenya but energy generated from fossil fuels in the Netherlands[8].

Carbon accounting is a complex and costly activity
Most LCAs done so far have been the result of academic-style research projects. The dedication of time needed to produce the emission estimates is considerable. White (2007) gives a rough indication of the requirements involved:

- A study of four New Zealand commodities required three people working part time for six months. Many data were sourced secondary and about half the data required were readily available.
- In a study of Boots shampoo, eight people spent three months part time to study two products.
- For a study of Cadbury's chocolate bars it took six months to produce LCAs for two products (although the work was part time and not a top priority for the people involved).
- A study for Glaxosmithkline on the carbon footprint of the head office took two to four weeks for a site based study (although the company reports that now with the

> infrastructure set up it would have taken one week). An assessment of seven of the company's products took four to six months. The studies were mainly produced by a full time internship working for four months.

It is vital that, on the one hand, schemes are comprehensive in order to capture the many opportunities for emission savings along a supply chain, including those that involve low income countries. On the other hand, low cost approaches to obtaining data and certification needed to ensure that small players including those in low income countries can afford to participate in such schemes. So far a mere handful of products have been labelled and it is in the step towards general application that this issue will have to be addressed. The next section takes a closer look at existing schemes of carbon labelling, discusses attempts to standardise and simplify measurement methodologies and highlights some emerging innovative solutions to data collection and certification.

4. Emerging carbon labelling initiatives

2007 became a boom year for discussions of carbon labelling with a number of new initiatives emerging, often backed by large commercial players, and in the case of the UK and France, by the government. The UK has been at the centre of carbon labelling discussions, in addition to the source of much activity regarding carbon accounting. However, recently this momentum spread to continental Europe and to the US with concrete initiatives emerging in several countries. Most approaches have been based on the development of voluntary standards for carbon labelling but the EU Commission is also active and has proposed new regulations that specify mandatory requirements for measuring the carbon footprint of biofuels and the French government is encouraging retailers to develop environmental initiatives including carbon footprint measurements, mostly linked to transport . Table 2 presents a non-exhaustive overview of emerging carbon labelling initiatives. This section discusses these initiatives by identifying their key characteristics.

Carbon labelling has great momentum.

The combination of a strong private sector push and public support has propelled carbon labelling initiatives forward in the UK. Tesco is the largest UK supermarket with a market share of 31% and is an increasingly large global actor. Tesco chief executive Terry Leahy announced plans to carbon-label all products on Tesco's shelves (estimated to include 70,000 items[9]). The announcement was made in January 2007 and a trial of about 20 products has been available in Tesco stores since April 2008. The stated objective is to allow consumers to integrate carbon emissions into their purchasing decisions by providing information in the same easily accessible way as for nutritional value or price. So far no more than a handful of products have been carbon labelled, although an interim system has been developed that puts a small airplane symbol on airfreighted products. This has been implemented under the assumption that airfreight is a major source of the carbon emissions in a product's life cycle. The airplane symbols have also been used by Tesco's competitor Marks & Spencer and by the Swiss supermarket Coop.

The French supermarket Casino has developed its own labelling scheme addressing issues of climate change and waste management. The part on climate change is mainly an application of the food miles concept rather than proper carbon accounting. Casino's own brand food products will be marked with both a traffic light system indicating environmental friendliness as well as a specific number giving the amount of carbon dioxide emitted during the transport stage of the product's life cycle. Casino's initiative has been endorsed by the French Environment and Energy Management Agency, a public agency. The French government also signed a charter with France's Federation of Distributors and Trade Enterprises in early 2008 which provides objectives for sustainability in the retail sectors. The charter includes an article on carbon footprints and focus on the reduction of the carbon footprint of domestic transportation. The French government is also reported to have asked all French retailers to look into a system similar to Casino's (Casino et al. 2007; Ministère de l'Ecologie, du Développement et de l'Aménagement durables and FCD (2008); Market New Zealand 2008).

The Carbon Trust, a private company in statute set up by the British Government in response to the climate change threat, has developed a pilot methodology to measure the carbon footprint of products as well as a label to display the information on individual products (Carbon Trust 2007a). Walkers cheese and onion crisps, produced by a subsidiary of Pepsico, was the first product to be carbon labelled in July 2007. The Carbon Trust is now working with the British Standards Institution (BSI) and the British Department for Environment, Food and Rural Affairs (Defra) to produce a standardized methodology to measure embodied carbon footprints using as a base the Carbon Trust's own pilot methodology. The initiative runs under the technocratic name of PAS 2050 (BSI 2008). A PAS, or Publically Available Specification, is a type of fast track standard that should not be mistaken for a true British Standard. It may serve as the basis for a future, more authoritative, British Standard. The PAS 2050 has a target publication date in final form of June 2008. The methodology is currently being tested on approximately 75 product ranges from 20 different companies (see box 3 below).

Table 2. Carbon labellling initiatives

Initiative	Aim	Context	Measurement methodology	Display methodology
Tesco (UK)	Long term aim to carbon label all 70,000 products on the shelves	Part of broader company goal to become more environmentally sustainable	Cooperate with the Carbon Trust Preliminary use of air freight as a proxy for climate change impact	Cooperate with the Carbon Trust Preliminary label air freighted products with airplane symbol
Casino (France)	Aim to carbon label 3,000 of own brand food products	Part of broader company goal to become more environmentally sustainable	Developed by the consultancy firm Bio Intelligence Service and endorsed by the French Environment and Energy Management Agency, a public agency	The scheme will use a color code denoting the amount of carbon dioxide emitted in manufacturing a product's packaging, the amount of packaging to be recycled and the amound of CO2 emitted in transporting the product
Migros (Switzerland)	To identify best performers in the product range	Company goal to reduce climate impact	Life Cycle Analysis developed by the Climatop organisation in collaboration with the Ecological Centre	Labels products with least carbon footprints as 'CO2 champions'
Coop (Switzerland)	To reduce airfreight	Company goal to reduce climate impact	Simple indication of whether a product was airfreighted	Airfreighted products labelled with an airplane sticker
Carbon Trust (UK)	To promote carbon labelling as part of a general climate change mitigation strategy	UK government goal to facilitate carbon labelling	Carbon Trust Pilot Methodology	Label products with grams of CO_2e and with a downward pointing arrow indicating commitment to reduce carbon emissions
BSI-Carbon Trust-Defra (UK)	Develop a potential, internationally applicable, measurement standard	UK government goal to facilitate carbon labelling	Develop fast track standard for embodied carbon footprint measurement based on the Carbon Trust pilot methodology	Not part of the measurement methodology
Soil Association (UK)	Include climate change considerations into organic labelling	Desire to broaden the understanding of organic agriculture to include climate change considerations	Use air freight as a proxy for climate change impact	Suggested to deny organic certification to air freighted products

Table 2. Carbon labellling initiatives (continued)

Initiative	Aim	Context	Measurement methodology	Display methodology
Wal-Mart (US)	To develop 'carbon scorecards' (indicators of carbon emissions of suppliers)	Drive towards ethical profile/large carbon footprint reduction goal	Own designed	No plans to display information to consumers. Presumed use of information as performance benchmark of suppliers
Patagonia (US)	To display environmental information on flagship products to the consumer	Part of company strategy to be environmentally sustainable	Own-designed simplified life cycle analysis	Display of information on individual product. Use of website to provide in-depth information
Timberland (US)	Long term aim to display environmental information on all products to the consumer	Part of company strategy to be environmentally sustainable	Own-designed simplified life cycle analysis	Uses ‘green index tags’. Instead of raw data, the tags use a scale of 0 to 10, with the bottom denoting the smallest impact on an expanded range of issues incl. climate change
General Motors	To start a process of awareness about carbon emissions	Major car producer that operates in a market where environmental awareness is on the rise	Unknown	Internal use of information, transfer of knowledge and technology
Carbon Disclosure Project	Set up the Supply Chain Leadership Collaboration to create a standard to measure and manage emissions through the supply chain	A not-for-profit organisation that aims to be the largest repository of corporate carbon emission data in the world and thereby to facilitate dialogue and create transparency about carbon footprints	Own-designed simplified life cycle analysis	Not designed for display but for supply chain management use
Reckitt Benckiser	To measure embodied carbon footprints so as to make reduction goals credible	Part of company commitment to reduce carbon emissions (embodied carbon footprint) by 20% by 2020	Own-designed simplified life cycle analysis. Company states that progress will be measured by independent experts and verified by third parties	Not designed for display but for the recording of embodied carbon emissions savings

Table 2. Carbon labelling initiatives (continued)

Home Depot	To label products with sustainability information including carbon emissions	Part of company strategy to demonstrate environmental awareness	Unknown	Individual product labelling with a range of sustainability indicators including carbon emission data
KRAV	To develop a label that may be used to carbon label both conventional and organic food	Joint industry and KRAV desire to avoid multiple climate labels	Defines climate friendly production practices and labels accordingly rather than measure exact emission level	Not decided
Dell Computers	To commit suppliers to measure carbon emissions and to reduce them	Part of company strategy to demonstrate climate change awareness	Unknown	Not for the labelling of individual products, but individual suppliers have to disclose emission data to the public
EU biofuel regulation	To define what constitutes a biofuel in order to facilitate compliance with forthcoming EU regulation	EU introduced binding requirements for renewable energy use incl. biofuel use. Required definition of what constitutes a biofuel	Based on life cycle analyses taking complex issues like land use changes into account	Not for display but to prove compliance with regulation

The Soil Association which is the major organic standard setter in the UK wants to develop its organic standard to take climate change concerns into account. Initially, it suggested excluding airfreighted products from organic certification on the assumption that airfreighted goods are major emitters of carbon relative to goods transported by other means. This led to a strong reaction from development agencies and from the Kenyan horticultural industry, which is a major source of off-season fresh vegetables and cut flowers. The International Trade Centre commissioned the Danish Institute for International Studies to conduct a study of the economic impacts that would occur if the Soil Association ban on certification or re-certification of organic products imported by air was implemented. The study found that 50 to 60 producer-exporters worldwide would be affected by a ban and that at least 21,500 livelihoods in developing countries would be compromised. Furthermore, the environmental impacts themselves may be ambiguous as organic growers would be tempted to convert to conventional products in order to keep growing for export markets (Gibbon and Bolvig 2007). The Soil Association took the many protests and the evidence of the social consequences into consideration and decided to ‘ensure that organic food is only air freighted to the UK if it delivers genuine benefits for farmers in developing countries’ (Soil Association 2007). In the future, air freighted organic food will have to meet the Soil Association’s own Ethical Trade standards or the Fairtrade Foundation’s standards and licensees will be required to develop plans for reducing any remaining dependence on air freight. The details of the proposal will be open to further consultation during 2008, and will begin to take effect from January 2009 (Soil Association 2008).

The UK debate has to a large extent focused on food, probably due to the fact that the idea of ‘Food Miles’ was born in the UK, and presumably also because the low degree of processing of many foods make the idea of calculating embodied carbon emissions relatively tractable. The development of carbon labelling is, however, far from isolated to the UK. A number of major US retailers and brand name manufacturers are in the process of developing their own schemes. Such initiatives include those of Wal-Mart, the world’s largest retailer, manufacturers of footwear and outdoor products such as Timberland and Patagonia, a car manufacturer, General Motors, and the household goods producer, the Reckitt Benckiser Group.

In September 2007, Wal-Mart initiated a pilot program with 30 suppliers of seven common items, namely DVDs, toothpaste, soap, milk, beer, vacuum cleaners and soda, to measure and reduce the amount of energy used in their production and distribution (New York Times 2007). News Corp.’s Twentieth Century Fox Home Entertainment, which is the Wal-Mart supplier of DVDs, has, for instance, analyzed the carbon emissions caused throughout the production and distribution of its DVDs with participation of more than 20 of its key suppliers. According to Wal-Mart, that analysis led to an industry standard for measuring the carbon impact of DVDs and instructed the use of the methodology for other consumer packaged goods (CRM Buyer 2007).

Wal-Mart has stated that the pilot program will eventually be spread to all its 68,000 suppliers. The company has, however, stated that it has not yet decided how it will use the new measurement system once it is put into place. According to Jim Stanway, senior director of Wal-Mart's Global Supply Chain Initiative, "[i]t's too early to tell […] Significant amount of work has to be done before we reach that point where we have to decide carbon reduction standards for each category" (Business Week 2007). One option that has surfaced is a` 'carbon scorecard' for it's suppliers. Such a scorecard could potentially be used to rank and sort suppliers according to their effectiveness in reducing their carbon footprint (Washington Post 2007).

Box 3. Carbon labelled products in the UK

2007 became a year of grand declarations on carbon labelling by both private and public entities in the UK. So far a number of companies has been involved in the labelling of a limited number of products, these include:

Walkers (crisps)	The Co-operative Group (200g and 400g punnet Strawberries)
Boots (shampoo)	Halifax (Halifax Web Saver Account)
innocent (fruit smoothies)	Kimberly-Clark (Andrex Toilet Tissue and Huggies nappies)
Aggregate Industries (hard landscaping products (paving stones, etc)	Marshalls (hard landscpaing products (paving stones, etc.)
Cadbury Schweppes (Cadbury Dairy Milk chocolate bars)	Müller Dairy (UK) Limited (yoghurt)
Coco-Cola (a sparkling and a still beverage)	Scottish & Newcastle (beer and cider)
Tesco (30 individual products falling into five categories of tomatoes, potatoes, orange juice, light bulbs and washing detergent)	British Sugar (granulated white sugar)
Colors (South African fruit)	Continental Clothing Company Ltd (Earth Positive™ apparel)
Coors Brewers Ltd (beer)	Danone Water UK Ltd (Evian and Volvic miniral water)
Mey Selections (shortbread and honey)	Morphy Richards (irons)

While all the above products are in the process of being carbon labelled, only some of them actually carry the label at the time of writing (March 2008). Walkers Cheese and Onion crisps were the first product to be labelled in July 2007.

Sources: Carbon Trust (2007b, 2007c, 2008).

Major outdoor manufacturers have long been at the forefront of environmental activism coupled with the sale of branded garments and other equipment necessary for the modern lover of wide open spaces. Patagonia, for instance, is a major producer with a long time dedication to raising funds for environmental purposes and using low impact production processes as a part of their business strategy. The company has initiated a scheme entitled the 'Footprint Chronicles', where five products are analysed from design to distribution according to environmental criteria including those of distance travelled and carbon emissions. Naturally, the five products analysed are only a small sub-set of the total product line and the ambitions are relatively modest as Patagonia states it will add only a few new products each season. However, the initiative involves a significant public relations investment with all information published prominently on the company's website[10] including a blog actively used to publish and answer critical questions about the company's environmental behaviour.

Timberland is a major shoe company that has pioneered a carbon labelling scheme. In autumn 2006, the company began to include a small tag with its products detailing the energy used in marking the shoes, the portion that is renewable and factory's labour record. The energy is calculated as 'embodied energy' that is inclusive all energy used throughout the supply chain from the cow supplying the leather through to distribution. The information was initially expressed in metric form, for instance as 3.1 kilowatt hours of energy consumed per pair of shoes. In February 2007 Timberland introduced 'green index tags' which use a 0 to 10 scale to express the impact on a range of issues. Climate effects is expressed so that a 0 rating means less than 4.9 kilograms of carbon equivalents were generated, while a 10 indicates that 100 kilograms were emitted. The index also includes information on chemical use and recycling and organic material use. Initially five shoes were tagged, but the goal is to tag all products by 2009.

The initiatives of Wal-Mart, Patagonia and Timberland are being followed by a large number of initiatives from other leading companies (see Table 2). Most often activities to analyse and label the carbon emissions of products take place within the larger context of a declared company goal to reduce carbon footprint and is often coupled with carbon offsetting schemes that companies are using to proclaim an ultimate goal of carbon neutrality. The methodologies used for measurement as well as the degree to which third party verification is applied are often unclear. Some initiatives have also been taken in continental Europe. The Swedish organic standard setter, KRAV (Swedish for 'demand') is in the process of developing a carbon labelling scheme for food (organic as well as conventionally produced). Similar initiatives are being developed by Swiss standards setters specifically for organic food (Gibbon and Bolwig 2007).

The Carbon Disclosure Project (CDP) is a London-based non-profit company that acts as a depository of knowledge on company carbon emission data. It works with a large number of the world's biggest companies. In October 2007, it set up the Supply Chain Leadership Collaboration[11] which aims at collecting supply chain information on carbon emissions and present them in a comparable form. Hewlett Packard, L'Oreal, PepsiCo, Reckitt Benckiser, Wal-Mart, Cadbury Schweppes, Nestlé, Procter & Gamble, Tesco, Imperial Tobacco, Unilever and Dell have partnered with the CDP to produce supply chain emission data. Each company has selected suppliers to work with and is scheduled to respond to an information request by the CDP by March 2008.

Many of the recent initiatives place most emphasis on the public relations element and downplay the practical problems of implementing carbon labelling schemes. The motivation for launching carbon labelling schemes is to give a company a green profile and to target environmentally sensitive market segments. Broader issues of methodological rigour and how to develop cost effective solutions at a scale greater than the individual company are naturally not addressed by those who are concentrating on the interests of their own shareholders. As such, approaches to carbon measurement and labelling have been developed with little coordination and a lack of transparency. The attempts to define common standards in PAS 2050 and by KRAV indicates a concern amongst stakeholders that too many standards may provide few benefits as they will confuse users such as consumers with conflicting messages. There is a real danger of fragmentation. Governments may start to take more interest as the use of carbon labelling expands and the scope for abuse of labels becomes greater.

There has been little effort internationally in exploiting the economies of scale from harmonising the standards. However, at the Bali meeting on climate change in December 2007, a high ranking Swedish trade official called for a multilateral effort to explore using labels and certifications, in collaboration with the WTO, UNFCCC and ISO, pertaining to environmental information about the life cycle impact of products in a way that expands trade and avoids new impediments to international commerce from labelling and certification schemes (Heaps 2007). It is likely that measurement and display standards will soon become more established as business and standard-setters respond. However, as soon as a standard is established it becomes much more difficult to influence its design hence the immediate need to ensure that the process of developing these standards is open and transparent and reflects the interests off all stakeholder both large and small. We discuss the issue of participation of low income countries in carbon labelling schemes in the next section, which concentrates on the challenges of developing effective carbon labelling schemes that are comprehensive in terms of including the many opportunities for reducing carbon emissions along international supply chains but provide for cost effective methods of collecting and certifying the necessary information.

5. Development issues in carbon labelling

The state of the art of carbon labelling is that a number of schemes are emerging in an uncoordinated fashion. These schemes are based partly on political and commercial desires to act on climate change and partly on scientific knowledge about emission patterns. It is fair to say the schemes are still far from being broadly applicable. In their current form, such schemes will be costly to implement and science has not yet produced the data upon which widely applicable schemes can be built. However, many resources are being devoted to the development of carbon labelling schemes and the underlying science and innovative solutions to low cost data collection are emerging so that the situation is likely to change rapidly over the next few years.

We do not have sufficient knowledge to make strong predictions on how exactly low income countries will be affected by carbon labelling. In standard setting the devil is typically found in the detail. But it is possible to identify key issues and to suggest appropriate responses that will push carbon labelling in a development friendly direction. This is the focus of this section. Naturally, carbon labelling is by design an environmental instrument. The development angle to this is to assure that carbon labelling schemes include the capacities of low income countries in mitigating climate change as well as the reality regarding the ability of firms and farms in poor countries to measure and certify their carbon emissions.

Measurement methodology

There are four key elements of the approach to determining the carbon footprint of a product or service, and all can have a critical impact in determining the quality and reliability of the study: the use of primary versus secondary data, the use of emission factors, the setting of the system boundary and treatment of land use change.

In general, it is preferable to use *primary data* (i.e. process-specific data collected from part or all of the supply chain) to *secondary data* (i.e. non-process specific data obtained from sources other than direct measurement of the supply chain being investigated). The Carbon Trust pilot methodology and the draft PAS 2050 both recommend the use of primary data to the extent possible[12]. However, the collection of primary data can be expensive and time consuming. This is particularly the case for supply chains that cross international boundaries. There are very few studies that have collected primary data from low income countries. For this reason, many companies that are actively involved in the debate about carbon footprint methodologies prefer a more standardized approach in which secondary data from well recognized sources are used in conjunction with standard databases of emission factors to estimate carbon footprints of particular supply chains. Such an approach will be relatively resource efficient, easy to implement and will tend to encourage the use of similar methodologies across different supply chains.

However, the available studies question the reliability of using secondary data and the representativeness of data obtained from specific or a limited number of suppliers. For example, using secondary data from producers in rich countries to estimate the carbon emissions of producers in low income countries will not capture the fact that the technologies being applied in rich countries are not available or are not suitable for production in the low income countries. Even within countries, information from one farm may not reflect practices from other farms. A number of studies have shown large differences in the carbon emissions arising from different farms which produce a similar product. Such a pattern may also occur elsewhere in the supply chain. Any method which assumes standard emissions per kg of produce on all farms will fail to capture this variation. While this may not be important to firms such as retailers, it is important to both individual producers, such as farmers, and consumers.

If an individual farmer is able to produce goods that have lower carbon emissions per unit than the average farmer, then that individual farmer may expect to be rewarded for supplying the good demanded by consumers (and society). Rewarding the carbon efficient producer serves to simultaneously encourage innovation in the food chain, and to bring about reduced atmospheric pollution. The development of a carbon label is potentially an excellent way to communicate the relative efficiencies of different supply chains, including farmers, to the consumer. If presented with a range of similar goods, each of which has different carbon footprints, then the concerned consumer may preferentially purchase the item with lowest footprint. This would then be a practical way to reward individual farmers for their low carbon footprints. However in order to achieve this it would be necessary to calculate the carbon footprint of each individual farm (and maybe each supply chain in which their produce is involved). Further, consumers could only really respond to carbon labels in this way for relatively unprocessed goods such as fruit, vegetables, primary cuts of meat and some dairy produce (e.g. liquid milk). Here the carbon label would be able to reflect the management practices on individual farms. However for goods which utilize produce from more than one farmer this becomes much more difficult to present.

Another critical data issue concerns the choice of baseline year(s) for data collection, which will tend to have an impact on the outcome, particularly if that year was not typical of long term conditions. Consider for example the variation in both inputs to crops between years (e.g. more fungicides on wheat in wet years) and also differences in crop yields due to annual variation in weather).

As we have discussed before, the key challenge for carbon labelling schemes is to balance the need for simplicity with the need for comprehensiveness. One solution, for instance, discussed at a joint Carbon Trust and Tesco sponsored seminar in May 2007, would be to focus on key stages of the supply chain only rather than attempting to take into account the full supply chain (White et al. 2007). Low income countries therefore need greater knowledge about the carbon intensity of the activities that they contribute to international supply chains to ensure that where they have relative carbon efficiency these stages are included in the scheme.

The amount of carbon emitted during particular parts of the manufacture and/or use of products are termed *emission factors*. These are usually expressed in terms of kg of CO2-equivalents. If the emission factors for the manufacture, transport and use are known for a certain amount of product, and the amount of that product in a given process is also known, then the total carbon emission arising from the use of that product in the that process can be estimated. This is achieved by a simple multiplication of the amount of product used by the relevant emission factors. If this process is repeated for all products relevant to that process, then the total carbon emissions for the entire process can be calculated. For example, consider a simple cropping system which involves use of machinery, fertilizer and pesticides. The carbon emissions from fertilizer use in this system can be obtained by multiplying the amount of fertilizer used by the relevant emission factors for the production, transport and on-farm use of those fertilizers. A similar procedure is possible for machinery and pesticides, and the addition of carbon emitted for each of the three inputs provides an estimate of the total carbon emitted by the simple cropping process.

However, some of these emission factors are location specific. For example if a country were to generate a large proportion of its electricity from renewable sources, such as hydroelectric or solar, then the emission factor for electricity in that country would be significantly less than for electricity production in a country with a large dependence on power generation technologies which emit large amount of greenhouse gases, such as coal powered electricity generation. These differences in emission factors for electricity can then have knock-on effects on the carbon footprint (ie the embodied greenhouse gas emissions) from products. So nitrogen fertilizer generated in an economy largely dependent on renewable energy should have a lower emission factor than the same fertilizer produced in a more coal dependent country. This level of detail currently remains relatively underdeveloped in carbon footprinting methodology.

Further, emissions of carbon to and from soils represent one of the major fluxes in the global carbon cycle, and through the biological and chemical processes that occur within them, agricultural soils are responsible for releasing significant amounts of carbon into the atmosphere whilst also acting as a sink for greenhouse gases. The net release of carbon from agricultural soils is a delicate balance of gains and losses across an entire growing season. For this reason accurate estimates of carbon emissions from food production systems require measurements to be made over long time periods (ideally a full calendar year) on a continuous, or very regular, basis (e.g. hourly). This intensity of measurement poses severe practical challenges and is rarely undertaken. The IPCC approach to this problem was to undertake a meta-analysis[13] of all the available experimental data and to produce standard emission factors, which describe, for example, the proportion of nitrogen fertiliser that is emitted as N2O from crop production (Bouwman & Taylor, 1996). This emission factor approach is based on a limited number of data points and is applied worldwide for agricultural soils regardless of variations in soil characteristics, land management or climate (Roelandt et al., 2005). This is obviously a crude approach that can have little relevance to local conditions (Smith et al., 2002). To address this issue researchers have developed mathematical modelling approaches that attempt to simulate net carbon emissions from soil at a range of temporal (days to decades) and spatial scales (field to continental level) (Vuichard et al., 2007). The relevance of these models to specific local conditions remains largely untested.

The absence of up-to-date and locally specific emission factors introduces a degree of uncertainty into the magnitude of the estimated carbon emissions for a product or process. Hence, when standardized emission factors are used it would be appropriate to present the variation in published emission factors to derive upper and lower bounds for any carbon footprint. But this further complicates the task of presenting information to consumers in a clear and simple way.

The *system boundary* defines the extent of processes that are included in the assessment of greenhouse gas emissions and estimates of the carbon footprint of a system will depend on where the system boundary is drawn. In the absence of an agreed framework for calculating a carbon footprint, there is the potential to draw the system boundary in different ways[14]. Systems boundaries may be defined so that they include only certain elements of the supply chain. For example, when considering agricultural activities the system boundary should include emissions arising from the manufacture and distribution of farm inputs, the transport of these inputs to the farm, as well as any impacts related to their direct use on-farm (such as emissions related to production of fertiliser and its transport as well as direct use of fuel and energy on-farm). However, the boundary could be extended to include emissions from soils related to fertiliser use and manure management and further to consider the flow of greenhouse gases into and out of soils and plants in the productive and non-productive areas of the farm, e.g. woodlands.

Decisions have to be made on whether to include, amongst many others factors, manufacture of capital goods, such as tractors, buildings, and transport equipment, routine maintenance of machinery, transport of employees, transport of consumers to retail stores and transport of the produce to the consumers' homes. Such decisions will have important implications for the outcomes of carbon footprinting. For example, the methodology being proposed by the Carbon Trust excludes emissions from the production of capital equipment, which will tend to favour capital intensive production techniques over labour intensive processes and hence will be to the disadvantage of low income countries. The same methodology also excludes emissions from worker transportation. Low income country workers generally either walk or take public transport to work while richer countries' workers commute in cars.

The difficult issue of *land use change* is an example of the complexity that must be addressed when discussing carbon labelling. All growing plants sequester atmospheric CO2 in photosynthesis. Some of this is returned to the soil when roots die and in cropping systems some returns to the soil at the end of the season in crop residues left behind in the fields. Both of these are important in replenishing soil organic carbon stores. Because of the constant addition of plant material to soils, they have come to represent a major stock of carbon. Soils can also store significant quantities of the two other main GHGs relevant for food production namely N2O and CH4. Through the action of bacterial and chemical activity soils can also be emitters of GHG, and emissions of CO2 from soils represent one of the major fluxes in the global carbon cycle. Gaseous emissions from soil are difficult to incorporate in LCAs but approaches, albeit with many approximations, are being developed . The issue is not only how to measure the emissions from land use changes but also a decision has to be made on how many years this 'one-off' increase in emissions should be spread over. The labelling scheme must also decide how these emissions should be represented: equally across all units of the product concerned or entirely to units that come from the converted land?

Consider for example a locality currently producing a horticultural crop as well as dairy and meat. Assume horticultural production increases because carbon labelling informs consumers that it is a more carbon efficient location for horticulture. Some of the previous grazing land for livestock will be displaced and the total effect on GHG emission will consist of the production and trading related changes in emissions, as captured by carbon labelling, plus the land use-related changes. The overall impact of this land use change on greenhouse gas emissions is unclear. We can imagine that there is an environmental equivalent of absolute advantage, and there must be some places that are able to produce some sorts of crops with lower GHG emissions than other places. A challenge for future land use planning is to identify these advantages and enable the market to exploit them.

Low income countries' carbon efficiencies

The choice of data sources, emission factors and system boundaries will influence low income country trade, but at the current state of knowledge it is not possible to foresee the direction of this influence. We simply do not know enough about the carbon efficiency of low income country production systems. We have much better knowledge about the transportation segment, and although air freight will often be a critical element, transportation in general does not look like a big problem.

Where transport-related emissions are significant, processing may relocate to the benefit of raw material producing countries There is a general issue of the location of processing activities and how this affects the overall carbon footprint of a product. In the case of the consumption of chicken in Sweden reviewed in section 3 above, it may be more efficient from a carbon perspective to process the chicken close to the origin of the feed and then ship to the final consumer rather than ship the feed and process the chicken closer to the consumer. Traditionally, the location of the point of processing in agro-food supply chains has been based on a range of criteria, one of which being energy costs. With climate change considerations on the rise, energy use will become more costly and it may be that the location of processing might change to low income countries in some instances. Local processing will save on transport related emissions as the final product will contain much less waste and, in the case of meats, only a fraction of the feed is converted into meat.

Relocation of processing to low income countries is more likely when less carbon emitting sources of energy are utilized to process the product. The evidence of Fogelberg and Carlsson-Kanyama (2006) further calls into question ‘buy local’ campaign’s claims that local sourcing is carbon efficient. In today’s globalized world, so-called local products rely on transported intermediary inputs, for instance, oil. There is no reason to expect, a priori, that the carbon emissions caused by local production plus transport of inputs is lower than foreign production plus transport of the end product. The final outcome of carbon accounting for processed agro-foods is likely to be supply chain specific.

The information we have on the domestic segment of the supply chain is piecemeal. However it may be useful to speculate on the potential implications of the knowledge we do have presently. The agricultural capacities and technologies of low income countries are likely to give rise to new opportunities for export to rich countries if carbon emission considerations and effective labelling schemes render the use of carbon intensive inputs such as like agro-chemicals and fertilizer by producers in rich countries a constraint upon competitiveness, compounded by fossil fuel dependency.

Fertilizers tend to be used much less intensively in countries with lower incomes (see Figure 1). Similarly, production in low income countries is less mechanized with much lower use of tractors and other equipment that uses fossil fuels. In low wage countries production is typically labour intensive and energy using capital equipment, which also embodies energy expended in its production, is used much less intensively than in higher wage countries (see Figure 2). Livestock rather than machines are often used for a number of agricultural tasks.

Figure 1: Rich countries tend to use fertilisers more intensively than poor countries

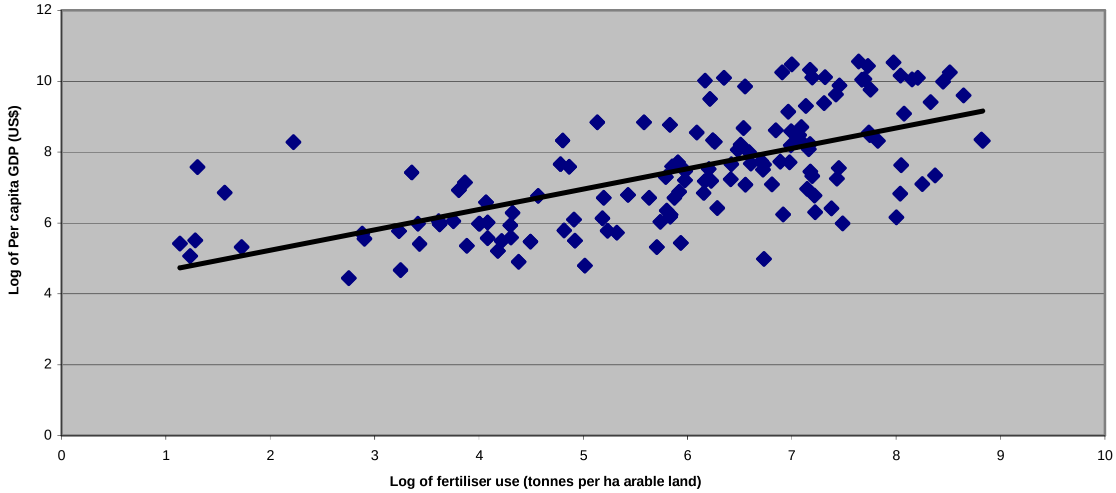
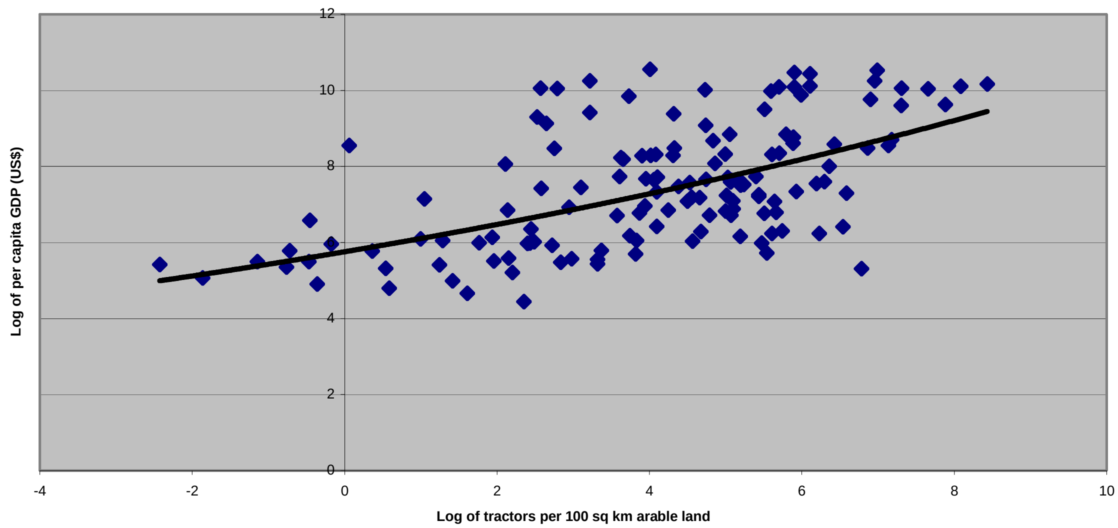


Figure 2: Intensity of tractor use tends to rise with per capita GDP



Source: FAO[15]

Low income country representation

The strong desire to act on carbon labelling has been running ahead of consideration of the methodological difficulties of measurement and the problems of effective communication through labelling. A growing number of standards are being developed with little effort to coordinate and generally little or no voice given to small stakeholders and to low income country concerns with large players dominating discussions. Low income countries have been very poorly represented in the standard setting processes so far even for standards developed in an open structured manner with broad invitations to provide comments going out to stakeholders. The technical capacity and the resources needed to participate in standard development are considerable and may be the main cause for the lack of involvement so far.[16]

The development of appropriate standards for environmental and social purposes is difficult due to the many opposed interests involved. Box 4 presents the Code of Good Practice developed by the ISEAL Alliance which has become the 'gold standard' for how such standards should be set. To develop an effective standard, in terms of meeting the objective that has been set and of achieving the acceptance of the companies and consumers supposed to use the standard, requires a healthy mix of stakeholder consultation and use of good science. Most carbon labelling standards are currently being developed in a way far from ISEAL-type requirements. Some are being developed in an open structured manner, notably the publicly or semi-publically developed standards such as the Carbon Trust pilot methodology, BSI's PAS 2050, the standards of the Soil Association and KRAV. On the other hand, many emerging standards are private requirements where most of the details about their development is unavailable.

Impact assessment

Another issue of concern is the lack of impact assessment of the evolving standards. The costs of compliance remain unknown and therefore there are no efforts to identify ways in which these may be lowered by adopting appropriate strategies of compliance or by modifying the standards themselves. The debate surrounding the potential exclusion of air freighted products from the organic certification of the Soil Association is the only example of an attempt to consider the consequences of implementing carbon labelling standards. The debate remains locked at a technical level centred on setting the standards that on paper would yield an impact of carbon emissions but fails to consider how they would function in a real world of implementation costs and costs of compliance. It is important to emphasise that cost effective standards is not just a purely economic consideration but will in the end determine their environmental effectiveness in mitigating climate change as cost considerations will be a key driver behind their adoption by market players.

Emerging solutions to the challenges facing carbon labelling.

So, it is clear that carbon labelling involves complex technical issues and faces a number of challenges if it is to be a useful tool for reducing carbon emissions in a way that does not exclude small players, especially those in low income countries. There is a need to support an emerging body of independent scientific evidence and thought to ensure that standards are soundly based whilst allowing for all stakeholders to effectively participate in the standard setting process. There are a number of recent initiatives dealing with environmental and sustainability issues that have addressed some of the critical issues that face carbon labelling, in terms of design and process, and which can provide important insights for the development and practical implementation of carbon labelling schemes.

Box 4. ISEAL Code of Good Practice for Social and Environmental Standards

Setting standards is not easy. Many interested parties exist often with conflicting interests. So standards for setting standards have been developed. Most product-related standards are addressed by the WTO TBT Agreement Annex 3 *Code of good practice for the preparation, adoption and application of standards* and ISO/IEC Guide 59 *Code of good practice for standardization*, but these documents do not cover social and environmental standards well. The ISEAL Alliance is an organisation that has developed a Code of Practice of developing such standards that has become recognized as the 'gold standard' in this field.

The ISEAL Alliance is an open membership association for international social and environmental standard-setting and conformity assessment organisations that seek to meet objective criteria for credible operating practices. The ISEAL Code of Good Practice stipulates, among other things, that standards be developed according to documented procedures including published work programmes, with enquiry points to which comments may be submitted, and with well published periods for commenting and a procedure for taking into account submitted comments. Furthermore, the standard-setting process must strive for consensus among a balance of interested parties, standards must be published and must be subject to periodical review. The whole aim of following such codes of good practice is to assure that a final standard meets the intended objective and will be acceptable to its targeted end users among companies and consumers rather than ending up being a tailor-made instrument for the use of vested interests.

The ISEAL Code of Good Practice has an impact on carbon labelling as the Carbon Trust has begun a collaboration with the ISEAL Alliance.

Sources: www.isealalliance.org

While most activity on carbon labelling has been undertaken in the context of voluntary standards, the EC Commission has recently proposed a new regulation that includes mandatory requirements for measuring the carbon footprints of biofuels (Commission of the European Communities 2008). Biofuel is shorthand for any substance of plant or animal original that may be burned to produce energy. Biofuels mainly come from two origins, either from the growing of sugar crops which are used to produce ethanol through fermentation or from the growing of plants and the extraction of plant oil that may be burned directly. Biofuels have been viewed as an alternative to fossil fuels with huge potentials in savings of carbon emissions. However, biofuels have been subject to controversy as claims have been made that biofuels grown under certain conditions may actually lead to more carbon emissions than they save.

The EC Commission has designed a scheme to ensure that use of biofuels does have climate change benefits. This is part of a regulatory requirement to increase the use of renewable energy. The EU plans to promote the use of renewable energy by setting binding targets. By 2020, the EC Commission proposes that 20% of overall energy consumption should come from renewable energy while 10% of fuels used for transport should come from biofuels. Biofuels used for compliance with the regulatory requirements (and that are entitled to benefit from national support systems), will be required to fulfil criteria for environmental sustainability. These requirements essentially say that: (i) biofuels must lead to at least 35% carbon savings; (ii) biofuels must not be produced on land with high carbon stock; and (iii) biofuels must not be produced on land with high biodiversity value. The two requirements on land have been introduced to address concerns about emissions from changed land use patterns and fears that relying on biofuels may harm other social objectives notably biodiversity.

The EU biofuels scheme bears many resemblances to carbon labelling schemes although the purpose is slightly different since compliance with the EU scheme is mandatory while the carbon labelling schemes are voluntary. The EU scheme is more advanced as it has already defined a methodology to measure the carbon footprint of biofuels as well as a way to use the measurements. This includes attempts to keep down the administrative costs. The proposed EU legal text allows for the use of default values laid down for common biofuel production pathways on the basis of typical values derived from independent scientific analysis.[17] These default values vary by region. Producers of biofuels are entitled to claim the level of carbon savings established by these default values. However, if a producer feels that they are more efficient than implied by the relevant default value, they may use actual values if they use the LCA method defined in the regulation.

A number of other approaches to environmental issues provide examples of how developing countries can be effectively included. For example, the Roundtable of Sustainable Palm Oil, which has sought to deal with the issue of land use changes although carbon emissions are not covered, has considerable developing country participation and is addressing the concerns of small developing country producers, for example, through the establishment of a smallholder task force.

6. Conclusions looking forward

While the carbon labelling scene appears to be buzzing with new initiatives, the non-exhaustive list discussed above has primarily been announced during the year 2007. To date there is more talk than action. Only a tiny fraction of products sold carry any form of carbon labelling. Nevertheless, there is clearly a momentum behind the idea of carbon labelling from consumers, producers and increasingly policy makers. What is uncertain is precisely where this momentum will lead.

What is clear is that simple, cost effective methodologies for measuring carbon emissions will be required for carbon labelling to be broadly applied. But carbon labelling schemes must also be designed so as to capture the complexity of carbon emissions and the many opportunities for reducing carbon emissions that exist along international supply chains. Emissions from transport can be more than offset by efficiencies in other stages of production and distribution. Hence, intuitively appealing concepts such as food miles and buy local campaigns cannot address the complexity of carbon emissions, will distort trade and may even increase emissions. These concepts have nothing to offer in terms of climate change mitigation.

Given their favourable climate and the use of technologies that are typically less carbon intensive than elsewhere, the interests of low income countries must be properly reflected in the design and implementation of carbon labelling schemes. However, the potential for low income countries to exploit the relative emission efficiencies that they possess depends on their ability to measure and verify emissions in a cost effective way.

The development community can play a positive role on three fronts. First, with regard to knowledge, through support for the expansion of the scientific base and dialogue upon which the standards are being built. Second, on the advocacy front, the development community needs to ensure that the interests of low income countries are properly represented in the debate and design of carbon labelling standards. Finally, on the operational front, the development community should assess the capacity of low income countries to participate in carbon labelled trade and help ensure that new opportunities for exports are exploited. Effective participation in carbon labelled trade will require the infrastructure and institutions that provide the necessary measurement and certification mechanisms that are often lacking in low income countries.

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[2] Throughout this paper we follow common usage and use carbon to refer to all greenhouse gases. See box 1 for terminology.

[3] Here we can make an analogy to the rules of origin that industrial countries have applied to determine eligibility for trade preferences. These rules specify the production processes or product transformation that must take place in the preference requesting country for a product to qualify for preferential treatment. In the past, discussion concerning the specification of these rules has been far from transparent, excluded key stakeholders and was strongly influenced by domestic industry. This resulted in overly restrictive rules that limited the value of the preference schemes and constrained the degree of new competition faced by domestic producers.

[4] Such methods have been defined in the World Business Council for Sustainable Development (WBCSD)/World Resource Institute (WRI) GHG Protocol and ISO 14064 on GHG quantification and reporting.

[5] LCA is defined in ISO 14040-44 standards and associated guidelines. It is stated that the methodology defined in the standards should not be used for regulatory purposes

[6] The most important GHGs in agriculture are carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4). Other GHGs that also contribute to climate change through radiative forcing, such as halocarbons, ozone and carbon monoxide are not typically considered in carbon footprints of agricultural produce. Currently it is estimated that 1 kg of CH_4 is equivalent to 25 kg of CO_2, and 1 kg of N_2O equivalent to 298 kg CO_2 over a 100 year time horizon (IPCC 2007). However, as scientific knowledge on global warming has progressed so these conversion factors have been amended over time. Previously the Intergovernmental Panel on Climate Change (IPCC) had suggested that 1 kg of CH_4 was equivalent to 23 kg of CO_2, and 1 kg of N_2O was equivalent to 296 kg CO_2 (IPCC 2001), while before that IPCC (1995) had suggested GWP conversion factors of 21 for CH_4 and 310 kg for N_2O. This is not a problem from a scientific point of view, however some legislation and treaties may have adopted earlier IPCC conversion factors, and care should be taken to ensure equivalence in any calculations.

[7] See the studies of protected lettuce and strawberries presented in Lillywhite et al (2007).

[8] The use of energy generated by nuclear power raises interesting issues. Whilst such energy does not lead to global warming potential, it is likely that a label that signified that a product had been produced with energy from nuclear sources would influence the purchasing decisions of some consumers. An interesting

recent example is that of Eurostar the high speed train service from London to Paris and Brussels that travels in the channel tunnel. Eurostar has recently been marketed as being 'carbon neutral' with vocal support from a number of environmental groups. Subsequently it has came to light that 85% of the electricity that drives the train across England comes from nuclear energy. In France, 80% and in Belgium 50% of the electricity for the train comes from nuclear sources.

[9] The definition of what would actually be an 'item' from a carbon labelling perspective is unclear. It is likely that the 70,000 items is an underestimate. Fresh produce like lettuce or apples, for instance, vary significantly in carbon footprint according to season, so the item 'apple' may have radically different carbon footprints at different times of the year. Seasonality may also be an issue for many other products, including manufactures. Electricity may be provided by hydropower in the rainy season in tropical countries, for instance, while relying on fossil fuels in the dry season. Two manufactured products may therefore have different carbon footprints depending on the timing of production despite being undistinguishable in appearance. This raises the issue of the time period over which emissions should measured and whether emission information should be consignment specific or averaged over a number of batches.

[10] See www.patagonia.com/web/us/footprint/index.jsp

[11] See http://www.cdproject.net/sclc_home.asp.

[12] The Carbon Trust methodology "allows for use of secondary data (i.e. from secondary sources) where collection of primary data (i.e. actual data collected from supply chain) is not feasible" (Carbon Trust 2007, p. 7) The draft PAS 2050 states that "[p]rimary data sources are preferable to secondary data sources as the data will reflect the specific nature/efficiency of the process, and the GHG emissions associated with the process (BSI 2008, p. 4).

[13] Meta-analysis provides a means of assessing and combining empirical results from different studies. The approach takes as individual observations the point estimates of relevant parameters from different studies. This set of observations is then used to derive an overall estimate of the variable of concern.

[14] One has to be aware that the discussion of system boundaries are only relevant for process based lifecycle analysis and hybrid lifecycle analysis. Input-output based lifecycle analysis avoids this problem as it relies on a complete description of the whole economic system (Minx et al. 2007, Hendrickson et al. 1998; Leontief and Ford 1970)..

[15] Fertilizer products cover nitrogenous, potash, and phosphate fertilizers (including ground rock phosphate). Traditional nutrients--animal and plant manures--are not included.

[16] The Kenyan fresh produce and flower industry has participated in the discussion in the UK over carbon and organic labelling. The National Taskforce on Horticulture of Kenya made a formal submission to the Soil Association pointing to the industry's renewable energy use and the importance of export horticulture for the country. The industry also commissioned the life cycle analysis of Kenyan and Dutch produced flowers discussed earlier. The industry has also created its own campaign entitled 'Grown under the sun' that seeks to inform the consumer of the Kenyan industry and the role in plays in climate change and in poverty eradication efforts in the country. However, the Kenyan example is the exception and most carbon labelling initiatives are currently being developed with little input from low income countries.

[17] The proposed directive does incorporate results for pathways of relevance to developing countries: sugar cane and palm oil. With regard to the potential carbon efficiencies of developing countries it is interesting to note that sugar cane ethanol is identified as the best-performing technology in terms of carbon reductions. This supports the notion that a comprehensive approach to LCA in carbon labelling schemes is likely to identify developing countries as a low emissions source of agricultural products.