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Food miles: time for a re-think? [1]

Abstract

Purpose
The purpose of this paper is to test the efficacy of the concept of food miles which has proved so popular with the public as a means of assessing the sustainability of produce.

Design/methodology/approach
We use data from a UK major food importer and retailer to correlate carbon emissions from transport, and transport-related storage, with food miles by creating farm-specific mode-weighted emission factors.

Findings
The correlation is found to be poor for a wide range of products and locations and it is clear that the mode of transport is as important as the distance, with sourcing from parts of the Mediterranean resulting in emissions greater than those from the Americas.

Practical implications
It is concluded that it is difficult to justify the use of food miles when attempting to influence purchasing behaviour. Because of this result, processes and tools have been developed that relay information on true transport-related carbon emissions to customers and bulk purchasers that allow them to make informed decisions.

Keywords

Food miles; carbon emissions; agro-food sustainability.

Paper classification: Research paper

1. Introduction

Numerous tools have been brought to bear to help study the problems of sustainable agriculture, the chosen method often primarily depending on the way sustainability is viewed and the background of the investigator (Leach, 1976; Cormack and Metcalfe, 2000; Carlsson-Kanyama, 2003; Constanza et al., 1997; Pretty et al., 2002; Rees, 2003; Lewis, 1997; Bailey, 1999). As the environmental impacts of global agro-food systems have been exposed (Conway and Pretty, 1991; Uphoff, 2002), the concepts of ‘local food’ and ‘food miles’ were promoted as powerful polemical tools in policy discourses built around sustainable agriculture and alternative food systems (Lang and Heasman, 2004). Both are appealing to public opinion in their apparent simplicity of application and have demonstrated the fluidity to be used in different contexts as the alternative food debate has progressed and changed. There has been a strong tendency to assume that local food is a solution to the problem of food miles. Local food both pre-dates food miles as a concept and, as a consequence, to some extent, helps to configure the conceptualisation of food miles. Originally the environmental impact of food miles was broadly conceptualised (SAFE Alliance 1994; Raven and Lang 1995; Subak 1999). The reduction of food miles was seen as an aspect of making more explicit the links between particular foods and particular natures, a re-territorialisation or re-spatialisation of food production which begins to reverse the aspatialities which are, or were, an intrinsic part of a globalised food order (Winter 2005). This was based on a growing realization that the properties of food are ‘natural’ and that the heterogeneity of edaphic conditions gives rise to varied natures represented in varied foods and their distinctive provenance. To reduce food miles implied the need for food systems grounded in local ecologies and responsive to consumer demands for quality food (Murdoch et al 2000), hence the growing literature on the benefits of a more localised food supply system (Winter, 2003; Sage, 2003; Morris and Buller, 2003; Cowell and Parkinson, 2003).

More recently however, food miles have been linked much more explicitly, and in some cases solely, to carbon accounting and the climate change debate (Jones, 2001; Pirog, 2001; Smith and Smith, 1997; Lal et al., 2004). In some ways this has served to radically shift the food miles argument away from sustainable agriculture production systems *per se* to food distribution and retailing and, in particular, the use of carbon in transport. In their influential report to Defra on the validity of the concept, AEA Technology (2005) largely focus on CO_2 emissions as the key indicator of sustainability, and operates with a correspondingly narrow conception of environmental sustainability and virtually no sense of social and economic sustainability at all. AEA provides a series of case studies on food miles which focus on energy and carbon emissions, for example comparing tomatoes grown in the UK to those imported from Spain, with no attempt to place this within a wider conceptualisation of sustainability. Defra’s (2006) Food Industry Sustainability Strategy takes a somewhat broader approach but still gives considerable salience to the role of transport in carbon emissions in marked contrast to the breadth of its earlier Farming and Food Strategy (Defra 2002). Alongside the concern at the narrowing of the sustainability agenda brought about by the focus on food miles is an equally important concern at the crude nature of the calculations used to assess carbon emissions in most studies hitherto. AEA’s tomato case study is illustrative. Basically it amounts to a balancing out of the energy used in production (less in Spain, because of the climate, than in Britain) against the extra energy used in the transport to Britain. Such a simplistic approach masks the very real differences between the contrasting production and distribution systems.

In this paper we question the value of using the concept of food miles as a driving force for changing purchasing behaviour by either the customer or the purchasing department of a retailer. The first part of the analysis makes a comparison between food miles as traditionally applied and a method based on carbon emissions, not just distance. Two ways of influencing behaviour are then demonstrated. One attempts to influence the customer by informing them of the carbon emissions of alternative products in an attempt to make them switch to a more sustainable alternative when making an on-line purchasing decision (e.g. a vegetable box low in imported fruit items against one high in such items). The other influences the actions of bulk purchasers within a retailer by giving them information on the carbon emissions of various alternatives (e.g. tomatoes from France rather than Spain). Given the interest in food miles, organic production, localism and carbon emissions from energy use, the research is highly topical (Coley, Howard and Winter, 2008; Seyfang, 2006; Illbery and Maye, 2005; Wetherell, Tregear and

Allinson, 2003; Hinrichs, 2003; Rigby and Caceres, 2001; Morgan and Murdoch, 2000; Tait and Morris, 2000).

As already indicated, the question of sustainability in food production and distribution is obviously far wider that that of emissions from fossil fuel use, and includes questions of water pollution, rural economics, landscape amenity and a host of others (Bollman and Bryden, 1997), and, as Table 1 shows, the external costs of agriculture are not minor. However, by restricting the analysis it is easier to address in a quantitative manner one of the questions of most interest to the public, and one in which, through their purchasing decisions, they have the ability to effect change.

Table 1. The negative externalities of UK agriculture (year 2000). For comparison the UK's GDP in 2005 was around £1.2 T. (Adapted from Pretty, 2005.)

Source of adverse effects	**Actual costs from current agriculture (£ M yr^{-1})**
Pesticides in water	143.2
Nitrate, phosphate, soil and *Cryptosporidium* in water	112.1
Eutrophication of surface water	79.1
Monitoring of water systems and advice	13.1
Methane, nitrous oxide, ammonia emissions to atmosphere	421.1
Direct and indirect carbon dioxide emissions to atmosphere	102.7
OV-site soils erosion and organic matter losses from soils	59.0
Losses of biodiversity and landscape values	150.3
Adverse effects to human health from pesticides	1.2
Adverse effects to human health from micro-organisms and BSE	432.6
Total	£1514.4

2. Background

The advent of mobile refrigeration allows the easy global transport of fresh produce without spoiling and so makes a broader selection of items available: from fresh Kenyan beans to New Zealand apples stored and shipped when the local season has ended. As shown in a recent Defra study on the public understanding of sustainable food, seasonality is now a concept lost on many consumers who have come to expect all produce to be available at any time of year regardless of the UK's climate (Owen and Prince, 2007).

Inevitably there is an environmental cost associated with the long distance sourcing of these items. Transport and refrigeration rely on fossil fuels to power them, resulting in the emission of various gasses which have a detrimental effect on the environment (Figure 1). Received (public) wisdom states that this impact varies approximately in direct proportion with the distance from source to consumer. The work discussed here shows that although this might be true for single mode transport of a product, this is rarely the case in the real world where many different modes are used in the supply chain.

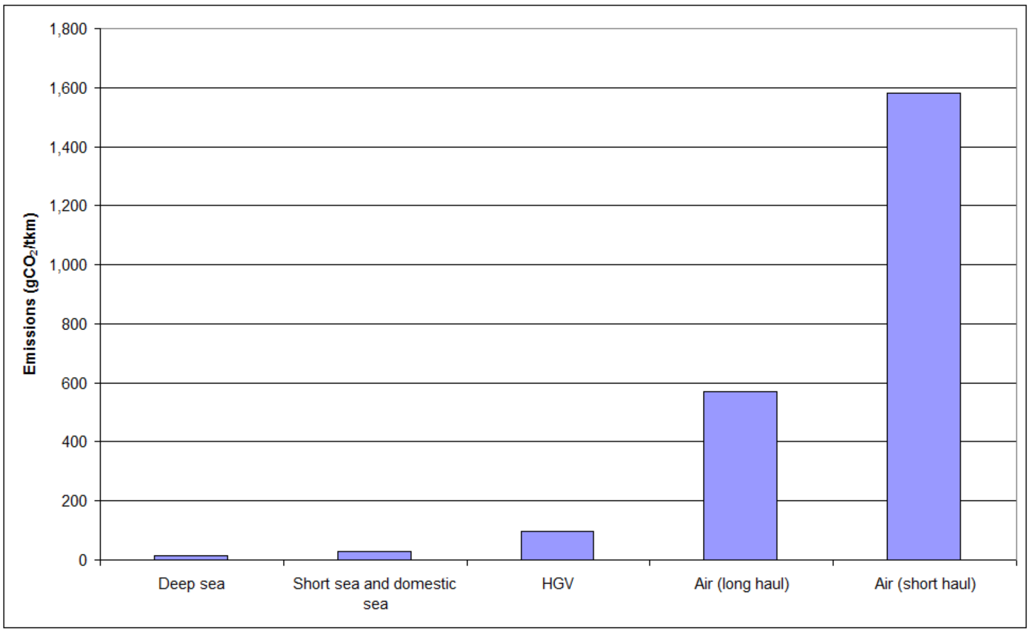

Figure 1. CO_2 emissions generated by different modes of freight transport. (AEA Technology, 2005).

Our work focuses solely on contributions to climate change measured in terms of the most important anthropogenic greenhouse gas—carbon dioxide (CO_2). It uses the database of purchases of the UK's largest vegetable box supplier to estimate the correlation between distance travelled by product to total carbon emissions from farm gate to box-packing warehouse.

Of the 18.9 million tonnes of CO_2 emissions generated as a result of food transport for the UK in 2006 (Defra, 2007) 47% were due to international transport of produce to the UK (see Figure 2). Clearly the CO_2 emissions associated with the international sourcing of produce are significant and therefore any sourcing policy should be based on sound principles, rather than *long distance bad, short distance good*, unless this can be proved to sensibly capture the essence of the problem and a reasonable correlation can be found between emissions and total transport from farm gate to consumer. In the following we measure this correlation for a large number of items and source countries using real data from a major supplier including the location of farms and accounting for transport and storage emissions in the county where the produce is grown.

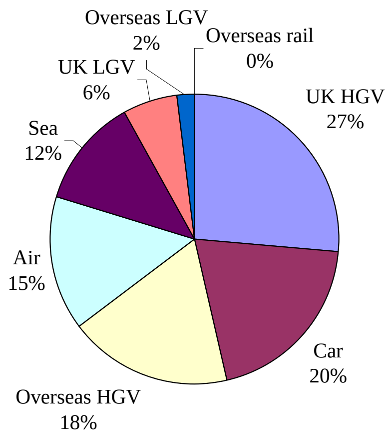

Figure 2. Mode and location for UK food transport [Defra, 2007].

Previous work has questioned the concept of 'food miles' (AEAT, 2005; Coley, Howard and Winter, 2008). The results of our work show similarly that, for mixed mode international transport, this questioning is valid for a wide range of produce and locations.

3. Method

There are essentially three variables that drive CO_2 emissions from freight, these are the distance travelled, the mass transported and the mode used. Emission factors derived as part of Defra funded research have been used in this study, they are given as gCO_2 emitted per tonne-kilometre for a given mode. A tonne-kilometre being a measure of both mass of produce, and the distance the food has been transported. Details of the derivation of these factors can be found in AEAT, 2005, but in essence we have:

$$E_{\text{source}} = \sum_{\text{mode}} EF_{\text{mode}} X_{\text{mode}} \qquad (1)$$

where EF_{mode} signifies the CO_2 emissions factor (in gCO_2/tkm) for a given mode of transport, X_{mode} signifies the distance travelled by the individual mode of transport and E_{source} signifies the CO_2 source and transport mode weighted emissions for the particular source (or farm) in question in terms of gCO_2/kg produce. Typically Equation (1) can be written as:

$$\begin{aligned} E_{\text{source}} &= \left(EF_{\text{deepsea}} \times X_{\text{deepsea}}\right) + \left(EF_{\text{shortsea}} \times X_{\text{shortsea}}\right) + \\ &\left(EF_{\text{HGV}} \times X_{\text{HGV}}\right) + \left(EF_{\text{air}} \times X_{\text{air}}\right) + \left(EF_{\text{LGV}} \times X_{\text{LGV}}\right) \end{aligned}. \qquad (2)$$

The great difference (a factor of 40-100) between the emission factors for air transport and shipping (Figure 1) has led many to sensibly conclude that air transport should be avoided. What has been given less public exposure is that shipping has a much lower emission factor than HGV-based transport (by a factor of 6.4 for deep sea and 1.9 for short sea). This leads to the possibility that sourcing from more distant locations that allow the use of water-borne transport might result in lower carbon emissions than sourcing from farms more closely located to the retailer.

The retailer's database of purchases for (2006) was used to estimate the carbon emissions from the regular sourcing of items from 56 locations in 26 different countries. Routes were mapped from the farm gate to the whole-seller, then to the packing house in the UK and broken down into distance travelled by each transport mode and Equations (1) and (2) applied. From this, CO_2 emissions generated by importing a kg of fruits or vegetables by that route were calculated. The results are presented in Figure 3.

For sea transport, emission factors were based on the Defra Guidelines for Company Reporting on Greenhouse Gas Emissions (Defra 2001), supplemented by other sources. The Defra guidelines were specifically aimed at companies wishing to assess their CO_2 emissions and give an estimate of CO_2 emissions per tonne of freight for several different ship types: small and large ro-ro, liquid bulk and dry bulk. However, container ships, which were not included in the Defra guidelines, also carry a high proportion of food freight. AEAT derived emission factors for these container ships based on the average of a ro-ro and a bulk transport ship (AEAT, 2005) and then made assumptions (see below) for the percentage of food freight carried by each type of ship, for both short sea and deep sea transport, and used these to derive weighted emission factors for short sea and deep sea freight.

The mix of ship types was derived from an analysis on what fractions of imported and exported foodstuff is dry bulk (i.e. cereals, oil seeds, animal feed and waste) both in Europe and the rest of the world (based on HM Customs and Excise statistics). It was assumed by AEAT that all dry bulk was carried by dry bulk ships. For short sea transport they assumed that one third travelled in large dry bulk ships and two thirds in small ships. For deep sea transport they assumed 75% in large and 25% in small ships. Of the remainder, it was assumed that for short sea transport, 75% travelled by ro-ro and 25% by container, with half in large ships and half in small ships.

A summary of the emission factors used is given in Table 2.

The following additional assumptions were made.

- Transport emissions are based on pre-determined routes of import combining HGV and shipping
- Distances include the distance from farm or collective to shipping point and from the point of arrival in the UK to the retailer's distribution and packing centre.
- Road distances are taken from Microsoft mapping software Live Local
- Shipping distances are taken from www.shippingdistances.com

Table 2. Emission factors used in the study.

Transport mode	**Emission factor (gCO_2/tkm)**
Deep sea	0.015335
Short sea	0.029381
HGV	98.15

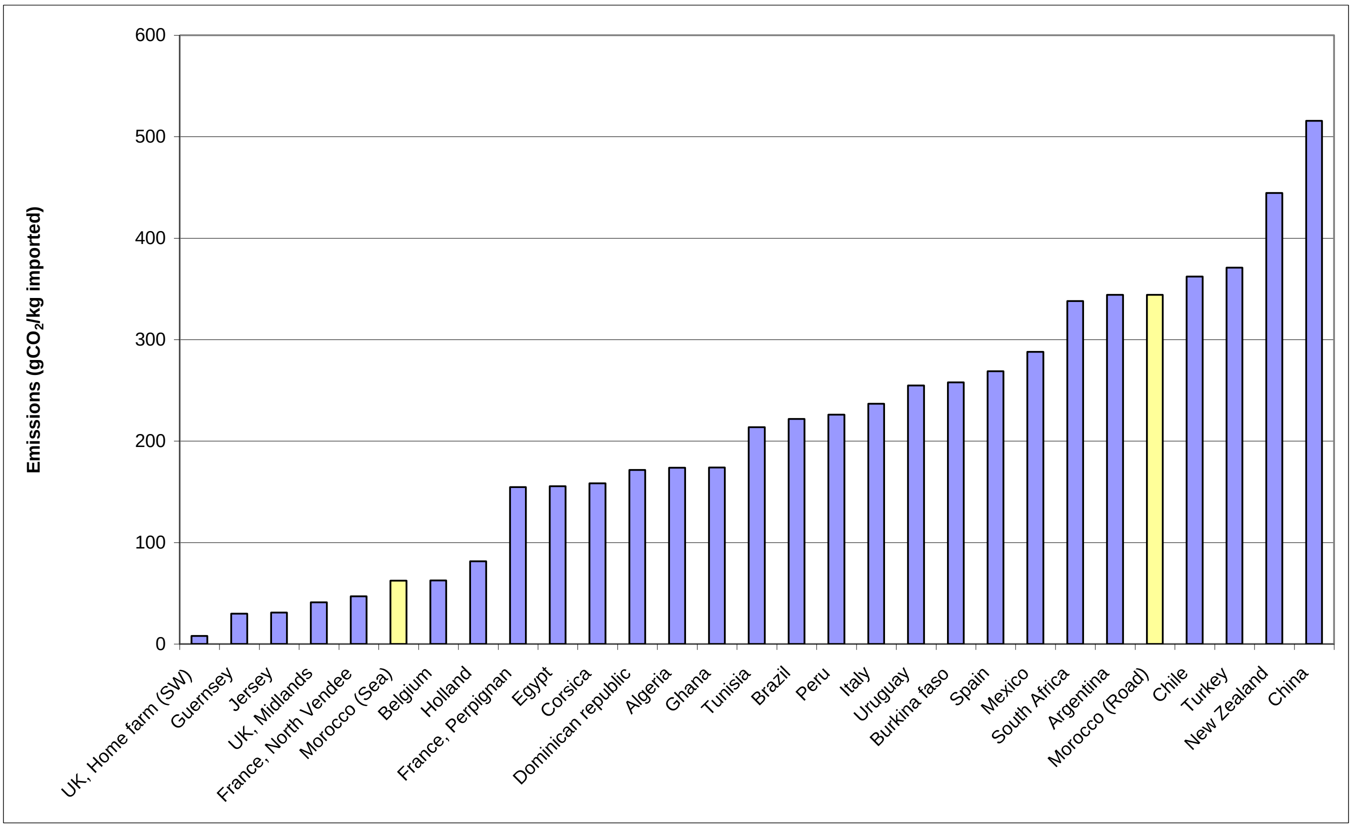

Figure 3. A selection (for clarity) of source and mode-weighted emissions (gCO_2/kg imported) estimated for a single farm in each of the twenty-six countries studied. (Note although the locations are identified by country, they are specific to the farm and supplier used by the retailer in each country and they should not necessarily be seen as representative of the whole country.)

Interesting results are seen for some countries such as Morocco (highlighted in Figure 3) which can appear at the higher end of the scale despite being relatively close to the UK if the produce is mainly shipped over land (through Spain), or at the lower end if shipped by sea. In general, because of the higher CO_2 intensity of road freight in comparison to sea, it was found that sourcing from regions closest to shipping ports (thus minimising road transport) would result in the lowest emissions.

4. Regression Analysis

Scatter plots of the emissions resultant form sourcing items from the individual farms were plotted against the distance the produce travelled and linear regression applied (Figure 4). The results might be considered surprising. As Figure 4 shows, there is little correlation between the distance the produce travels and the resultant emissions and this is confirmed by estimation of the correlation coefficient (R^2 = 0.3). Clearly there are two relatively independent, well-correlated, populations within the data and, as Figure 5 shows, these correspond to situations where the majority of the distance travelled is by sea, or by road. (The retail company considered does not import via air.)

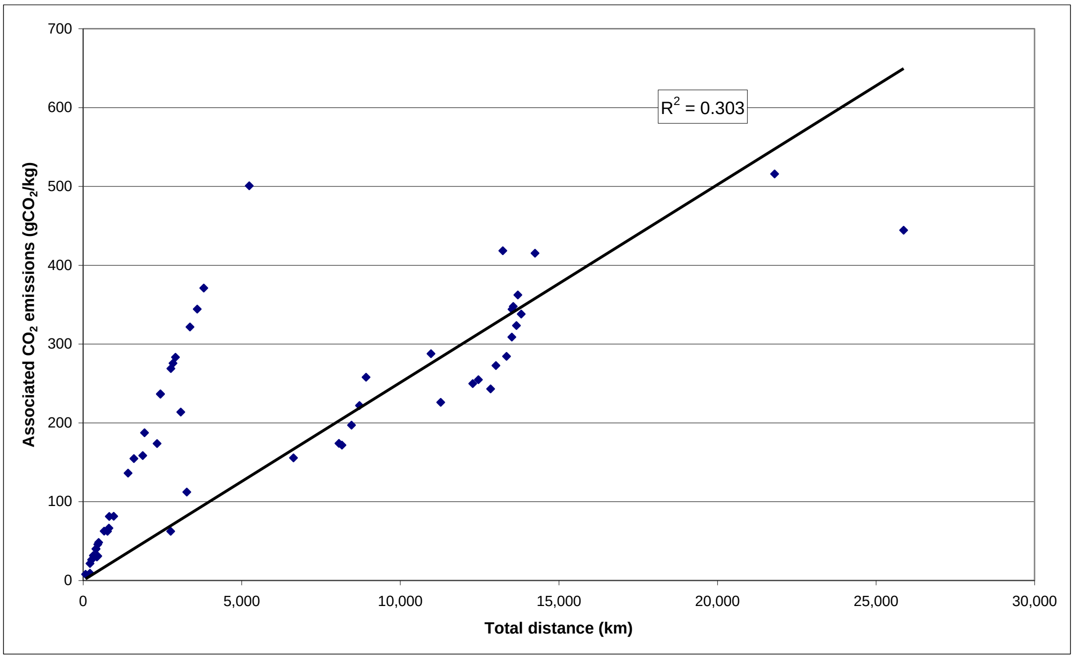

Figure 4. Scatter plot of distance vs. CO_2 emissions for international sourcing routes (and all 55 farms in the study), note the low R^2 value, indicating a poor correlation.

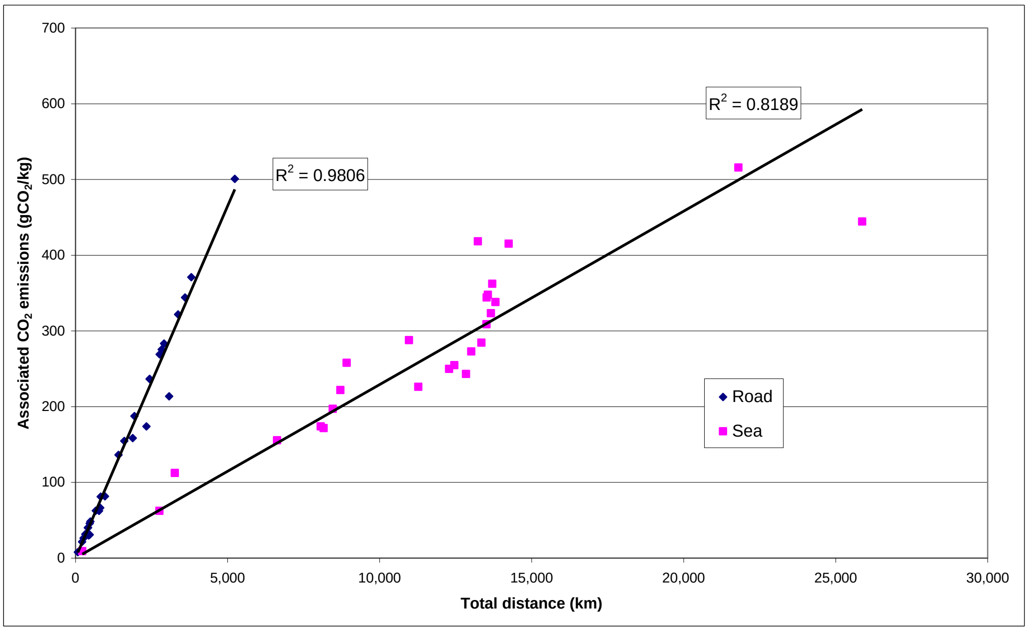

Figure 5. Scatter plot of distance vs. CO_2 separated into routes relying predominantly on road transport and those relying predominantly on sea.

5. Influencing Purchasing Decisions

Having shown that: (a) the concept of food miles is a poorer than expected environmental metric for this sector, and that (b) calculating carbon emissions over the mixed mode cycle with account being made for differences in tonnage transported by the ships and trucks involved was achievable within the database systems of a large retailer, two attempts were made to influence purchasing behaviour, one at the level of the customer, the other at the moment of bulk purchase by the retailer.

To achieve this, three tools and representations were developed. The first was purely pedagogical—a map of the world coloured to reflect the mixed-mode emission factor for each location that the retailer uses (Figure 6) and used to ensure bulk buyers and customers understood the issue. In essence, this contains the same information as Figures 3 and 4, but presented in a more usable way: one can clearly see that distance is not the sole driver in the resultant emissions. For example, note the lower emission factor for parts of the USA than the Eastern Mediterranean.

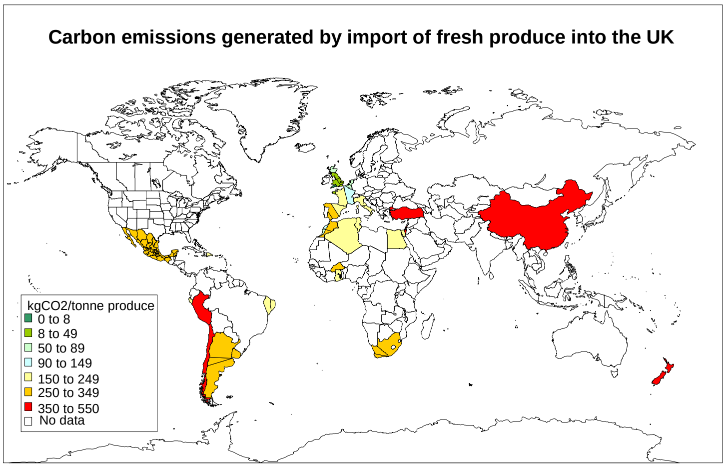

Figure 6. Visual representation of the CO_2 emissions associated with the import of fresh produce into the UK, some source countries have been separated into regions to represent different locations within the country itself.

In addition to the representation shown in Figure 6, a spreadsheet was developed that applied the farm-specific mode-weighted emission factors to the contents of each week's eight vegetable box types (the retailer distributes 1.5 million boxes per annum) and presented the results to bulk purchasers within the retail company. This allowed them to examine the impact of alternative sourcing on the carbon footprint of the different vegetable box types assembled each week. Purchasers could then make sourcing decisions based on keeping the footprint of certain boxes below certain limits. This could be done by either choosing to source the same product from a location with lower resultant emissions, or to make a substitution for a different product.

The final step was to allow customers access to the estimated carbon footprint of each box each week before purchase. They could then elect to receive whichever of the eight boxes most closely matched their desire for specific contents and level of carbon emissions.

6. Conclusions

Data from a large UK vegetable box supplier has been used to estimate the correlation between food miles and carbon emissions resulting from the international sourcing of produce. The correlation was found to be very poor and it is clear that the mode of transport is as important as the distance, with sourcing from parts of the Mediterranean resulting in emissions greater than those from the Americas. This result led to the development of tools based on farm-specific mode-weighted emission factors that take account of the mass of product carried by each mode and the fuel efficiency of each mode. These tools have since been used in an ongoing attempt to influence purchasing behaviour.

We commenced this paper with the suggestion that the agro-food sustainability debate has been narrowed and limited by the recent public and policy focus on food miles and carbon emissions. And yet the empirical material included in this paper is devoted mainly to an examination of food miles and carbon emissions. Our justification for this is simple; we have sought to engage with the debate on its own terms and in so doing have highlighted the weakness of relying on a single simplistic emblem of sustainability – food miles. We do not, of course, suggest that carbon emissions are anything other than a vital factor in the sustainability debate but we would argue that a wider approach to sustainability is, perhaps paradoxically, more likely to give rise to coherent thinking around carbon emissions than the reduction of the issue to the totemic one of food miles. In particular, the inclusion of economic and social dynamicas in any promotion of sustainability is vital, such as the engagement of consumers in thinking through the consequences of their purchasing decisions. We would argue that food miles, and indeed a number of other beguilingly simple ideas for climate change mitigation such as carbon offsetting, have two major drawbacks. First, as shown empirically in this paper, they can be misleading in terms of real world processes. Secondly, they can divert attention from the far more fundamental and deep rooted social, economic and environmental changes that are required to tackle the sustainability challenge.

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Endnotes

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