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Where are the best opportunities for reducing greenhouse gas emissions in the food system (including the food chain)? A comment

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ABSTRACT

In a recent paper Garnett (2011) examines the greenhouse gas emissions arising from the global food system. This paper builds on Garnett's contribution by considering how high levels of food waste contribute to the food chain's greenhouse emissions and how they can be reduced, something Garnett generally overlooks. The emissions that arise from food waste represent the emissions embedded in the production of food that is then wasted and the emissions that arise from the process of waste disposal. Food waste can also be split into pre-consumer and consumer waste. These distinctions give rise to four categories of food waste related emissions: pre-consumer embedded, pre-consumer waste disposal, consumer embedded and consumer waste disposal emissions. The levels of food waste in each category differ between economies, as do the causes of wastage. Policies to address food waste and the associated emissions need to promote a mixture of technological and behavioural change and be tailored to the economic, cultural and technological conditions in each country.

Introduction

In a recent paper in Food Policy Garnett (2011)[1] reviewed greenhouse gas (GHG) emissions arising at different stages in the food system and outlined policy options for reducing emissions. While agreeing with Garnett's broad conclusion that the major challenge in reducing food system GHG emissions is changing (richer) consumers' dietary preferences, this comment draws attention to significant potential for reducing food related emissions by reducing food waste, something Garnett largely overlooks.

Despite conflicting data on regional and global levels of food waste (Gustavsson et al., 2011; Godfray et al., 2010; Stuart, 2009; Quested and Johnson, 2009) it is widely acknowledged that food waste is a major problem, with a third or more of global food production lost or wasted (Gustavsson et al., 2011; Godfray et al., 2010). With agriculture responsible for 17–32% of global GHG emissions (Bellarby et al., 2008) reducing food waste should offer substantial opportunities for reducing greenhouse gas emissions (as well as the other negative environmental effects of agriculture and food production). Stuart (2009), for example, estimates that cutting European food waste by half could lead to a saving in total European greenhouse gas emissions of 5%, and Chapagain and James (2011) estimate that avoidable household food waste in the UK is responsible for 20 million tonnes of carbon dioxide-equivalent (CO_2e) each year, 3% of the UK's total emissions.

This comment explores the potential for reducing food waste related emissions by distinguishing between waste arising at two different stages in the food system: pre-consumer waste (from the manufacturing, processing, distribution and retailing of food) and consumer waste (arising in households, after purchase). A distinction is also made between two different types of emission; embedded emissions (generated during the production of food that is wasted) and waste disposal (from the processes of disposing waste food). These distinctions give four categories of food waste emissions: pre-consumer embedded, pre-consumer waste disposal, consumer embedded and consumer waste disposal emissions.

It is argued that Garnett underestimates the potential for savings in each of these emissions categories, and therefore overlooks some important policy options for reducing food system GHG emissions – options that differ between low, middle and high income economies. Embedded and waste disposal emissions from pre-consumer waste are considered first, and then the two emission types from consumer waste. When considering embedded emissions the scale of each type of waste is examined as these emissions are reduced by reducing waste (with given production, processing and transport systems). Waste disposal emissions, however, can also be reduced by adopting lower GHG emission waste disposal systems.

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[1] Hereafter referred to simply as Garnett.

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Pre-consumer waste

Pre-consumer embedded emissions

Levels of per capita pre-consumer waste, from production through to retailing, are relatively similar across the different regions of the world, varying between 150 and 200 kg/year in nearly all regions apart from South and Southeast Asia where they are 110 kg/year (Gustavsson et al., 2011). This outweighs consumer food waste by a factor of 2 in Europe and North America, a factor that is higher in less developed regions, rising to over 25 in Sub-Saharan Africa, where consumer waste is very low (Gustavsson et al., 2011). By largely ignoring pre-consumer waste Garnett ignores the majority of global food wastage, and hence a substantial part of the global food system's GHG emissions.

Although pre-consumer wastage levels are broadly similar in different parts of the world, the causes of wastage differ greatly. In developing economies pre-consumer wastage occurs principally as a result of losses in transport and storage. This wastage can be reduced by investment in institutions and infrastructure to improve storage, transportation, processing and marketing (Gustavsson et al., 2011; Godfray et al., 2010). Investment in improving market institutions and infrastructure is likely to provide quicker and cheaper reductions in wastage than investment in other more costly infrastructure, such as improving the transport system. For instance programmes that use new communication technology such as mobile phones, the internet and radios to provide producers with up to date market information allow them to get better prices for their goods and reduce wastage at the same time (Overa, 2006). Jensen (2007) reports a complete elimination of wastage in a South Indian sardine market following the introduction of mobile phone networks to the area.

In high income economies, however, much of the wastage occurs as a result of cultural, social or economic choices made by producers and consumers. A lot of on farm wastage occurs when farmers dispose of food that does not meet buyers' stringent aesthetic requirements or over produce as an insurance against a poor harvest that might lead to under-supplying strict supply contracts, (Stuart, 2009). Manufacturing processes also require standardised sizes and weights, leading to trimmings which are often cheaper to dispose of than re-use. A reliance on overly cautious "sell by" dates also leads to large wastage by retailers (Gustavsson et al., 2011; Stuart, 2009). Policy therefore needs to encourage consumers and producers to engage with 'abnormal' fruit and veg, more innovative marketing that allows flexibility in supply and creates markets for 'waste' food, and a shift away from over cautious sell-by dates (Gustavsson et al., 2011; Stuart, 2009). This would not only reduce wastage but result in economic savings for manufacturers and retailers.

Pre-consumer waste disposal emissions

Waste disposal emissions are greatest when food waste goes into landfill (where it decomposes anaerobically, releasing methane (CH_4), a GHG 25 times stronger than CO_2 (Forster et al., 2007)), and are smallest where waste is used for animal feed or in the production of biofuels (replacing other feedstocks and their emissions). Pre-consumer waste disposal emissions are relatively low in high income economies as retailers and manufacturers, compared with consumers, are better at avoiding landfilling food waste. A number of major UK supermarkets have announced that none of their food waste is landfilled (Lee and Willis, 2010) and 2.2 million tonnes of UK food waste from manufacturing is used as animal feed. However more can still be done to improve this, for example by changing EU regulations which restrict the use of catering food waste for animal feed (Garnett, 2011), by encouraging charities who redistribute retailer food waste to needy consumers (such as Fareshare in the UK) or promoting anaerobic digestion. Waste disposal emissions are also likely to be low in poor economies, where waste tends to be intensively recycled. As economies grow then improving food chain systems and infrastructure lead to falling pre-consumer waste but at the same time richer and high and narrowly defined produce standards lead to rising pre-consumer waste. It then becomes important for policies, such as landfill taxes, to discourage this waste and its disposal in landfill and to encourage its efficient and low-cost use as animal and biofuel feedstocks.

Consumer waste

Consumer embedded emissions

Garnett focuses on consumer embedded emissions in her discussion of food waste. As discussed earlier, wastage of food by consumers is a problem generally restricted to developed economies, but even in these countries is about half pre-consumer wastage (Gustavsson et al., 2011): in the UK consumers waste 8.3 million tonnes of food a year (22% of the total bought), two thirds of which is avoidable waste (Quested and Johnson, 2009) while in the US consumers are reported to waste as much as 40% of consumers' food supplies (Hall et al., 2009). Consumer wastage is much lower in low income countries, as low as 4% in Sub-Saharan Africa (Gustavsson et al., 2011).

Garnett recognises that reductions in consumer waste in higher income economies are possible, but argues that they will have a limited effect on consumers' GHG emissions, as expenditure savings from reducing consumer food wastage could lead to a 'rebound effect' where; "if people waste less food they will save money which they might use to upgrade to more expensive food products (perhaps air freighted foods, or more meat), or to buy other products or services such as clothes, electronic equipment or holidays, all of which have an environmental impact" (Garnett, pS28). This is possible, but questionable, and no supporting evidence is provided. It may, however, be intuitively unlikely in higher income countries where consumer food waste is highest. In the UK, for example, households spend 11% of their weekly income on food (Office for National Statistics, 2010), but food makes up approximately 20% of consumers' GHG emissions (Chapagain and James, 2011; Garnett, 2008), suggesting a high GHG intensity (CO_2 equivalents per $ expenditure). As the incomes of UK consumers rise, recreation and travel, with high income elasticities of demand, make up a greater proportion of spending (PricewaterhouseCoopers, 2008). Among expenditure types with high income elasticities of demand (see Regmi et al., 2001), only extra expenditures on cheap air travel are likely to have a higher GHG intensity than food. The scale of the rebound effect is therefore a matter for further empirical study, but it cannot be assumed that average GHG intensity from extra items and services purchased from waste food expenditure savings is likely to be higher than the GHG intensity of the waste food saved (where GHG intensity includes both embedded and waste disposal emissions).[2]

There may therefore be opportunities for substantial emissions reductions from polices that reduce consumer waste in high

[2] This point is important for Garnett's wider argument – that changes in (richer) consumers' dietary choices are needed for substantial changes in food system emissions. This is undermined unless (a) the rebound effect from waste savings does not apply to savings from the lower cost of lower emissions diets, (b) the rebound effect is less important than she argues, or (c) changes in dietary choices are accompanied by emissions reducing changes in other lifestyle choices and/or in energy and transport systems. (a) is inherently unlikely, while (b) and (c) should apply with both consumer diet changes and waste reductions.

income countries (but little scope in low income countries). Such policies need to focus on changing consumer attitudes and behaviour. Educating consumers to become less reliant on sell by dates as a judge of when food becomes inedible, promoting recipes that use left over food, encouraging consumption of less perishable foods that are not reliant on refrigeration are all examples of ways to help to reduce consumer food waste and embedded emissions. Technological change also has an important role in reducing wastage, for instance Time and Temperature Indicator Labels (TTi) monitor how long food has been stored and at which temperature giving consumers a more accurate idea of when food perishes. Packaging that absorbs ethylene (a hormone that speeds fruit ripening) can also help extend shelf lives.

Consumer waste disposal emissions

Garnett's focus on "the emissions generated during the course of producing and distributing that [wasted] food" ignores the emissions that are released from the process of disposing of food waste. As noted earlier, waste food disposed of in landfill decomposes anaerobically, releasing CH_4 and CO_2. The waste sector contributed 2.5% of the UK national GHG emissions in 2004 (DEFRA, 2006), and 3.5 million tonnes CO_2e are emitted from the landfilling of food waste in the UK annually (Audsley et al., 2009). The majority of food waste entering landfill is as a result of consumer waste, 70% of household food waste in the UK is collected by local authorities, and with only 31% of local authorities collecting food waste separately the majority of this will end up in landfill (Quested and Johnson, 2009).

The quantities of CH_4 and CO_2 released by landfilling food depends on the carbon content of the food, the management of the waste site (particularly landfill gas recovery) and the percentage of the available carbon that decomposes (Bogner and Matthews, 2003). Using the model and data provided by IPCC (2006) 1 tonne of landfilled food waste in the UK is estimated to produce 12 kg of CH_4, and 281 kg of CO_2, while 16 kg of carbon is stored in the landfill site (assuming food waste is made up 10.3% carbon (Han and Shin, 2004), 75% of landfill gas is recovered (DEFRA, 2006), 0.1% of the CH_4 produced is oxidised in the soil cap (IPCC, 2006) and 84% of the carbon in food waste decomposes (EPA, 2006)). This gives overall GHG emissions of 606 kg CO_2e per tonne of landfilled food waste (this total ignores embedded emissions and those that arise from transporting waste and the running and maintenance of landfill sites).

In developing countries basic waste management such as small open rubbish sites and burning result in the release of more CO_2 and less CH_4 (Bogner and Matthews, 2003). However in many urban areas where there are larger volumes of waste there is a move towards landfilling. In Kenya and India the majority of municipal solid waste is disposed of in open landfill sites (Narayana, 2009; Henry et al., 2006). These sites, with no soil cap or landfill gas recovery, produce 46 kg of CH_4 and 190 kg of CO_2 with total GHG emissions of 1343 kg CO_2e, per tonne of food waste, over double that in the UK.

To reduce consumer waste disposal emissions in the developed world, as well as aiming to reduce the levels of food waste, it is important to encourage separate collection of food waste allowing for centralised composting or anaerobic digestion and to encourage home composting (though this is not feasible for many city and apartment dwellers). In developing and urbanising economies where waste disposal infrastructure is relatively undeveloped there is the opportunity to build low carbon technology into infrastructure right from the start: anaerobic digestion, landfill gas recovery, composting and incineration can all be used as low carbon, sanitary waste disposal methods that also produce useful byproducts (Barton et al., 2008).

Conclusions

This comment has only brushed the surface of the numerous issues surrounding food waste around the world. However, with over 30% of food around the world wasted and large quantities of CH_4 given off by landfill sites, food waste is an important contributor to the global food chain's GHG emissions. Food waste is also a problem that without proper policy interventions is likely to get worse as countries around the world develop. There is very little data on historical food wastage. However, Hall et al., 2009 estimate that increasing availability of cheap food led to the per capita food wastage in the USA increasing by almost 50% in the 30 years running up to 2005 and data from Gustavsson et al., 2011 shows that food wastage, particularly consumer waste, increases with higher levels of economic development.

There is a wide range of policy options to reduce food waste and its emissions. These include investment in transportation and marketing infrastructure, better integration and communication in food chains, improved waste management, and promotion of behavioural change through consumer education, regulations, subsidies or taxes. Policies must, however, differentiate between and properly target the different types of emissions that arise from food waste and the different problems that cause food waste in different stages of the food chain in different economies.

There is very little data on the cost-effectiveness of different measures to reduce food waste and how they compare to other measures aimed at reducing the carbon footprint of the food system. However as so little attention has been paid to food waste until now there are still many low hanging fruit to be plucked, especially regarding consumer behaviour in developed economies e.g. simplifying the use of 'consume by', 'best before' and 'display until' dates on packaging will have next to no cost yet consumer confusion over the use of different terms is a major reason behind consumer wastage (Lee and Willis, 2010). While agreeing with Garnett that dietary change in richer countries is an important step in reducing GHG emissions, behavioural change surrounding food waste may be easier to sell to consumers, especially considering the £480 a year the average UK household could save by eliminating wastage (Quested and Johnson, 2009). Reducing wastage in developing economies and reducing waste disposal emissions will, in many cases, require significant infrastructure development, which can be slow and expensive, however investment in these areas often produces secondary benefits, e.g. livelihood opportunities from improved roads and gas or electricity from anaerobic digesters.

While this comment has focused on emissions problems from food waste it is of course also important to consider other issues. By creating unnecessary demand in the food system, food waste contributes to more intensive and greater use of resources for food production, and hence promotes biodiversity loss, increasing levels of conflict over land and water, higher food prices, and hence reduced food access for poorer people. Significant reductions in levels of global food waste are a vital component of the more healthy and productive global food system needed to feed the growing world population (Foresight, 2011). In the end, the most shocking aspect of food waste is that one 7th of the world's people live in hunger (FAO, 2009), and their food needs could in principle be met with less than half of the 30% of food that the world wastes.

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