The role of corporate social responsibility in reducing greenhouse gas emissions from agriculture and food

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Additional background information

Further details of the evidence used in the research reported here are available from Donal Murphy-Bokern.

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"Companies still thinking about the environment as a social responsibility rather than a business imperative are living in the dark ages"

Carter Roberts, President of the World Wildlife Fund (WWF)

"We start from the core belief that this (sustainability) is pre-competitive space and we will only move to a competitive position if there is a really good argument for doing so."

Mr Barry Parkin, Chief Sustainability Officer, Mars Inc.

September 2013 at the UN Global Compact Leaders' Summit.

CONTENTS

PREFACE

This study was conducted in 2013 and 2014 to examine the effect of corporate social responsibility (CSR) strategies and programmes on greenhouse gas emissions (GHG) from agriculture and food.

Climate protection is subject to a profound market failure and this raises questions about the true commitment that can be made to climate protection in CSR strategies and the real effectiveness of resulting measures. An extensive academic literature on CSR exists, much of it using disciplines such as behavioural economics to examine the evolution, drivers and consequences of CSR. The effect of CSR on the corporate world, on consumer behaviour, on the role of governments, and even on democracy is debated. Our purpose is not to contribute to debate about the principles of CSR. Instead, this study addresses a practical question: are agri-food sector CSR programmes making an impact on greenhouse gas emissions?

Firms' own reports provide our primary evidence base, augmented by academic reports of mitigation approaches and progress. The challenge of reconciling the need to generate profit with the cost of reducing greenhouse gas emissions from food raises a number of practical questions that this study addressed: What type of corporate responsibility strategies are operating in the agriculture and food sector which are relevant to climate protection? How do the resulting measures impact on primary production (farming) where a very large number of suppliers are in competition with each other in commodity markets? How do these strategies impact on direct supply chain carbon dioxide emissions? How do these strategies impact on other GHG emissions, especially nitrous oxide and methane? What effect has CCR on land use change?

In addition to examination of the reports cited, the firms studied were consulted on the early draft of this report. We are very grateful for the time companies took to examine our findings and to provide additional data and comments. The results however remain our considered and completely independent assessment based on our observation of the evidence cited.

Dr Donal Murphy-Bokern and Dr Linda Kleeman

1. EXECUTIVE SUMMARY

The aim of the research reported here is to examine how corporate social responsibility (CSR) strategies in the agri-food sector address the causes of greenhouse emissions from the agri-food sector. We analysed the CSR strategies of a sample of 40 firms and from this we provide an assessment of how CSR addresses GHG emissions. This was achieved in three steps. First, we assessed to what extent CSR activities target relevant emission sources. Second, we analysed their ambition and reach in terms of change envisaged and their contribution to climate protection. Third, we considered the drivers behind the development of CSR to mitigate greenhouse gas emissions, which we term as 'corporate climate responsibility (CCR)', to estimate the longevity and likely future ambition of these activities.

The analyses show that CCR has grown significantly in the agri-food sector in the last decade and that this trend is robust. Our overall conclusion is that considering the commercial constraints and the obligations of firms to shareholders, CCR is contributing to climate protection. These private sector efforts alone are not sufficient to achieve the far reaching change necessary if the agri-food sector is to contribute to climate protection in proportion to its contribution to emissions and the emission reductions required across the economy for climate stabilisation. However, the extent of CSR activities, their very rapid growth, and in particular recent efforts to standardize certification across whole sectors or countries combined with synergies with public sector regulatory activity means that CSR is now an important component of wider climate protection efforts.

The CCR effort extends across the whole agri-food sector. These efforts are still new in many of the firms we sampled, with many firms now reporting just the early phases of efforts to reduce GHG emissions. The development of these strategies and activities continued during the global financial crisis of 2007 to 2010. From this and our examination of firms' strategy documents, we conclude that the drivers behind CCR are central to firms' strategies and not marginal or passing activities. Many current strategies set out plans to extend current activities. This growth is particularly clear in terms of the use of certified produce with targets to reach 100% by 2020 common. Similarly, reductions in energy use in operations of up to 20% by 2020 are also common.

Differences between firms in commitment as indicated by the number of mitigation activities undertaken cannot be attributed to differences in forms of business ownership or to the differences in terms of where firms are head-quartered or registered. Firms that are hardly visible to consumers are as committed as firms with valuable consumer brands. Greater recognition is required of the need to support collaboration across sectors, including with public policy development, can support climate-responsible supply chains and in particular add to disincentives for irresponsible production.

Approach: We have ranged widely in terms of the various forms of corporate social responsibility strategies, related mechanisms and supporting instruments. We took two parallel approaches independent of each other: we qualitatively examined the corporate social responsibility schemes operated by 40 organisations (39 companies and one association) in the food system. Parallel to this, and independently, we examined the financial and other data that we could obtain about these firms. This provided the evidence we used for our analysis. In addition to examining the strategies as presented by firms, we examine the instruments used and how these interact with the processes driving greenhouse gas emissions in the food value chain.

The challenge: We start with a description of corporate social responsibility as it operates in the food sector, together with some historical background and social context. This is followed by an overview of emission processes. The food system is a major source of emissions, comparable with transport. Primary production activities (farming) are dominant in terms of emission sources, with emissions largely independent of energy use and linked to fundamental biological processes in the soil and in animals. Beyond the farm gate, refrigeration is an important source of emissions.

The corporate social responsibility response: The firms we examined ranged from the world's largest food company (Nestle) to a micro-brewery in the Netherlands. The sample covers the supply chain from the supply of planting media through to high-value catering. We identified a total of 166 individual measures operated through the sample. The average number of measures operated at firm level in the sample was 18. Large international food firms commonly operate in excess of 30 measures each. The focus of most of these is primary production through agri-food certification, setting farm practice, and providing training or technical support. The major focus in processing, manufacture and distribution is energy consumption.

In broad terms, corporate climate responsibility (CCR) activities focus on the most important emission sources, particularly primary production. Food manufacturing is also well represented. Significant emission sources which are not the focus of CCR activities include fertiliser manufacture, transport, and food storage and preparation in the home. Many of these apparent gaps are due to the lack of influence firms have in these areas. Where quantifiable, the targets set by firms are generally ambitious and their reports also indicate solid progress against targets over the last five years. There is also a rapid growth in commitment to agri-food certification in major traded commodities such as soy, palmoil, coffee and cocoa.

The level of commitment to CCR was similar across types of company ownership and governance (publicly listed, private or mutual). However we did observe a pattern linked to the country of origin of firms. In our sample, the American- and British-based firms support on average more activities that firms in our sample based in continental Europe.

Significantly, firms such as commodity traders in our sample that are not visible to consumers are just as committed as firms with highly visible consumer brands.

Impacts on emissions: Impacts vary along the value chain. Starting with land use change, the evidence that corporate social responsibility alone is impacting on global land use change emissions is weak. This is not due to a lack of commitment and effort. It is due to the fragmented nature of effects on land-use decisions and 'shunting' within markets for resources. The 'shunting' effect is when commodity rejected by climate responsible firms is purchased by firms not operating climate responsibility schemes. However, there is rapid growth in the demand for certified produce and also the success of associated measures such as the ABIOVE moratorium on soy from recently cleared land. Deforestation is a difficult problem to address. Companies should not be discouraged by a lack of highly visible progress. They are contributing to a wider effort to deal with deforestation and deforestation rates have dropped significantly.

On the farm side, we conclude that measures aimed at reducing farm emissions are having a wide range of diffuse benefits arising from a general improvement in production efficiency benefits of training, awareness and networking of producers. There is little direct emphasis on the major emission processes: nitrous oxide emissions from soils, methane emissions from livestock production, and the loss of carbon from soils. For example, increasing the efficiency of nitrogen use within farming systems is rarely mentioned. However, even if activities are not directly impacting on major emission processes, this technical support is generally beneficial in terms of greenhouse gas emissions. Some measures enable farmers to estimate farm-level greenhouse gas emissions, such as the provision of the Cool Farm Tool. This has the potential to significantly raise farmers' awareness of the effect of their decisions on emissions and to achieve reductions through technical improvement in the longer term. It is significant that private sector interest in corporate social responsibility has stimulated public sector measures such as the Origin Green programme run by the Irish Food Board. This public sector-wide approach to production certification is evidence of far-reaching impact of corporate social responsibility approaches.

The most focused activities can be found in the post-farm side: processing, manufacture and retail where energy use is the major target. A very wide range of energy saving technologies have been adopted and there is also evidence of some investment in system changes, such as transferring freight from road to rail.

We identified no corporate social responsibility activities that explicitly support consumption change for the purpose of climate protection. The lack of attention to consumption even extends to businesses with strong plant-based food brands that could benefit. Similarly, the growth in the market for frozen or chilled ready-made meals and similar food products is not challenged.

The ambition: Overall, the majority of firms in our sample (24 from 40) are focused mostly on incremental product or process improvement. Programmes that support more radical change are confined largely to companies in niche areas, particularly those associated with the organic sector. 14 firms are classified as making significant efforts to improve whole supply chains, 5 firms are focused on radically new products and processes, and 4 firms exhibit features of both these and tend towards changing the business model.

Outlook and recommendations: Our study reveals an agri-food sector in transformation. Almost all of the firms we examined have introduced their corporate climate responsibility strategies and activities in the last decade. We identified four types of responses on the part of firms: cost reduction; brand enhancement; support partnerships; and pioneering investment. Patterns are difficult to identify because corporate climate responsibility is predominantly added on to existing strategies originally focused on social and other environmental goals.

Maintain momentum

Corporate climate responsibility in the food sector is relatively new. It has grown rapidly over the last decade, building largely on existing corporate social responsibility activities aimed at social and wider environmental outcomes. Even though this activity is still in its infancy, there is evidence of a widespread change in business culture operating through supply chains. The proportions of major internationally traded commodities now certified are significant. However, there is still little evidence that they have reached a level that gives clear disincentives to minimum standard production, given the buffering effects of other growing markets. Premia for certified produce remain low. The priority for climate responsible firms must be to grow and consolidate the market for climate-responsible produce. The sector must support measures to identify produce that is not associated with land-use change and generate clear farm-level financial incentives for its responsible production. **We recommend that companies with corporate climate responsibility programmes should redouble efforts to grow the market for responsible produce. Consumers can be confident that responding positively to these activities is beneficial.**

Reduce fragmentation

The agri-food sectors climate responsibility efforts are fragmented. The foundations of pre-competitive collaboration to address this have been laid in various fora such as the Sustainable Agricultural Initiative. **The climate-responsible agri-food sector should work to reduce fragmentation of efforts and to consolidate activities.**

Review and tighten certification standards

Agri-food certification, particularly commodity certification, is controversial. NGOs argue that many standards relevant to greenhouse gas emissions, particularly land use change, are too lax. **Linked to pre-competitive collaboration, the agri-food sector should tighten certification standards to achieve zero land-use change from certified food.**

Use innovative market-based mechanisms

The challenge of sourcing and tracing supplies from responsible producers is one of the barriers to developing corporate climate responsibility. This is particularly challenging in commodity markets where segregation and distinguishing between batches of bulk commodity from different sources is difficult. Trade in certificates rather than in physically segregated material enables food business to rapidly grow demand for certified produce and to transmit premiums to certified growers effectively. This mechanism could be an important component of pre-competitive efforts to create critical mass in the demand and rewards for climate responsible production. **The food industry needs to work collectively to develop the trade in certificates and understanding of the benefits. This may require efforts in explaining the impact of an effective and rewarding certified produce credits to consumers.**

Support more fundamental change to climate-responsible farming

Biological processes on farms are a major source of greenhouse gas emissions. Tackling these requires addressing the emissions at source by reducing the loss of soil carbon, the intensity of the nitrogen cycle, and methane from ruminants and manure. Generally, corporate social responsibility at this level is focused on promoting good general farm practice but there is relatively little effort to impact fundamentally on emission processes at the system level. This would involve investment changing land use in some cases to reverse the decline in soil organic matter levels, efforts to increase nitrogen use efficiency at a range of scales, and efforts to raise the efficiency of ruminant whole herds and flocks. **We recommend that existing programmes of technical support to farmers be examined for their impact on basic emission processes and revised if scope for greater impact is found. In particular, efforts to raise the efficiency of nitrogen and protein use should be supported. Much of this is pre-competitive activity which could be done in conjunction the public research base and with regulation (for example the regulation of fertiliser and manure use.)**

Support fundamental change in the food system

The case for changing 'western' diets to simultaneously improve public health and climate-related outcomes is compelling. With the exception of Barilla and Provamel that are specialised in products with small carbon footprints, and Tesco which is providing carbon footprint data on many of its products, we identified no serious efforts to support dietary change to lower carbon-footprint diets. **We recommend that food industry actors that are serious about corporate climate responsibility work to facilitate dietary change towards lower carbon footprint diets in developed economies in line with relevant public health recommendations.**

Extend efforts to emerging markets

The drivers behind land-use change will remain in place as long as commodity producers associated with land-use change find ready markets. The relevant expanding markets are in Russia and China, and a wide range of developing economies for palm oil. Even if all

markets in developed western economies focused entirely on climate-responsible produce, the trade with these emerging markets can provide adequate outlets for uncertified production. **We recommend that the food sector together works to increase the market for certified produce in these emerging markets. This is a long term effort, but it will send a signal to producers that irresponsible production practices compromise access to global market position in the long term.**

Work with public policy

Governments ultimately bear the responsibility for levelling the competitive playing field, ensuring public welfare, and protecting public goods. Parallel to cross-sector pre-competitive collaboration, the food sector can actively support public policy development and regulation to add to the incentives for climate-responsible supply chains and in particular to add to disincentives for irresponsible production. The success of ABIOVE soy moratorium shows how this can work, and the public sector Origin Green initiative in Ireland is a sector-wide semi-state approach. Working together, the food industry operating at farm level and local regulators can achieve a great deal to create advantage for responsible producers. **Corporate social responsibility strategies should place much greater emphasis in supporting the development and enforcement of regulation and public policy to support climate-responsible production**

1. INTRODUCTION

There has been huge growth in the number and scope of corporate social responsibility strategies and activities operating in the food sector over the last 15 years. Consumers are now frequently presented with the opportunity to purchase products and services that producers, manufacturers and retailers claim are produced with special attention given to minimising negative social and environmental impacts, additional to those required by law. Global brands and household names such as Coca-Cola, McDonald's and Nestle have corporate social responsibility (CSR) strategies that, amongst other objectives, aim to reduce greenhouse gas emissions. The question addressed by the research reported here is how are such corporate social responsibility strategies and measures affecting greenhouse gas emission from the agriculture and food sector? We refer to this aspect of corporate social responsibility (CSR) as 'corporate climate responsibility (CCR)'.

Some background

Food is estimated to be directly and indirectly responsible for 20-30% of global greenhouse gas emissions.[1] [2] In terms of consumers' carbon footprints in developed economies, food ranks as high as other major categories of consumption such as home heating and private transport. The processes behind emissions from food production are more complex than from the energy sector. The effects of consumer choice on agricultural and food greenhouse emissions, along with other impacts of the food system, are widely debated.[3] [4]

Who is responsible for emissions from the food sector? There are two ways of addressing this question. One is to use the approach taken by national emission inventory systems and attribute emissions to economic sectors. For food, this approach implies that responsibility rests with producers, processors and other actors at each stage of the food chain. The second is to allocate the emissions to food products at the point of use and to quantify those product-related emissions using life-cycle assessment (LCA). With LCA,

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[1] IPCC. 2007. Climate Change 2007: Synthesis Report. Intergovernmental Panel on Climate Change, Geneva.

[2] Smith P., M. Bustamante, H. Ahammad, H. Clark, H. Dong, E.A. Elsiddig, H. Haberl, R. Harper, J. House, M. Jafari, O. Masera, C. Mbow, N.H. Ravindranath, C.W. Rice, C. Robledo Abad, A. Romanovskaya, F. Sperling, and F. Tubiello, 2014: Agriculture, Forestry and Other Land Use (AFOLU). In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[3] Streck, M and Draf, S. 2010. Der Preis ist billig, aber das Fleisch ist schwach. Stern 27.05.2010. 32-44.

[4] Garnett, T. 2008. Cooking up a storm. Food, greenhouse gas emissions and our changing climate. The Food and Climate Research Network.

environmental burdens and their impacts are explicitly allocated to the product or service consumed (the so-called 'functional unit'). This helps all involved in the supply chain, including consumers, identify the effects of their decisions and activities. This LCA-based approach can have a profound effect on how consumers think about the causes of environmental problems. Instead of attributing environmental impacts to the processes such as 'farming' or 'industry' that directly give rise to them, LCA focuses thinking on the consumption decisions by linking the decision to use a product or service to environmental impacts arising from its production.

The implication of the use of LCA and other emission calculation techniques in public debate is that consumers can influence environmental outcomes through their decisions. Assuming good and correct consumer information and a significant share of consumers value low-emission food and agricultural products, the cumulative effect of millions of such informed consumption decisions would be an improvement in the relevant environmental conditions brought about by decisions made within the supply chains involved. In these circumstances, a significant share of firms will act to reduce emissions in production and create new environmental friendly products. The development of this industrial ecology approach to consumption decisions, the goal of which is the evolution of the world's industrial activity into a sustainable and environmentally benign system[5], is an important part of the context of the development of corporate climate responsibility.

Definitions and drivers

The term "corporate social responsibility" (CSR) is associated with or at least related to terms such as triple-bottom line, corporate ethics, and creating shared value. The common theme of CSR and related goals is commercial firms' consideration of their impact on wider societal interests, particularly their social and environmental impacts.[6]

The modern understanding of corporate social responsibility stems from the 1800s, although the concept first took widespread hold in the forms we see today in the 1950s.[7] The Civil Rights movement, the Women's Movement, and the Environmental Movement all contributed to the development the concepts that took hold and impacted on the corporate world into the 1990s.[8]

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[5] Socolow, R., Andrews, F., Berkhout, F. and Thomas, V. 1994. Industrial ecology and global change. Cambridge University Press.

[6] Abagail, M. and Donald, S. 2001. Corporate social responsibility: a theory of the firm's perspective. Academy of Management. The Academy of Management Review 26 (1): 117-127

[7] Visser, W. 2010. The Evolution of Corporate Social Responsibility. In: Responsible Business: How to Manage a CSR Strategy Successfully. Eds: Pohl, M. and Tolhurst N., Wiley.

[8] Wokutch, R.E. 1990. Corporate Social Responsibility Japanese Style. The Executive, 4 (2) 56-74

While approaches to CSR vary, there are a number of international guidelines that support a common understanding and approach. These are particularly relevant to large international companies operating in different markets. These include OECD Guidelines for Multinational Enterprises; the ten principles of the United Nations Global Compact; the ISO 26000 Guidance Standard on Social Responsibility; the ILO Tri-partite Declaration of Principles Concerning Multinational Enterprises and Social Policy; and the United Nations Guiding Principles on Business and Human Rights. A number of working definitions and descriptions are used. These tend to reflect the background business and political cultures in the various countries concerned. The definition of CSR is the subject of academic enquiry.[9] In the USA, the Harvard Kennedy School of Government defines CSR as a firm's approach to making profit, rather than just to what they do with profits.[10] This focuses on the internal business processes that lead to profit and emphasises that efforts must go beyond philanthropy (which is a feature of US firms) and compliance with the law. It focuses attention on how companies manage their economic, social, and environmental impacts in the workplace, the marketplace, the supply chain, and the wider the community.

The European Commission defines corporate social responsibility as "the responsibility of enterprises for their impacts on society". To fully meet their social responsibility, enterprises "*should have in place a process to integrate social, environmental, ethical human rights and consumer concerns into their business operations and core strategy in close collaboration with their stakeholders*".[11] In line with the Harvard definition, the German Federal Ministry of Labour and Social Affairs emphasises the efforts beyond legal minima and says that CSR means voluntary commitments that go beyond what is required by law.[12]

There is a long tradition of corporate social responsibility in Japan. Responsibility towards employees is a major underlying driver, particularly with regard to health and safety.[13] Environmental responsibility is also strong in the Japanese approach. Public policy actively supports voluntary environmental protection in business and environmental responsibility is seen as aligned with financial goals with emphasis on resource conservation. In other Asian countries, for example South Korea, CSR has developed as part of the response to financial challenges. There is a focus on financial responsibility and corporate governance.[14]

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[9] Dahlsrud, A. (2008). How corporate social responsibility is defined: an analysis of 37 definitions. Corp. Soc. Responsib. Environ. Mgmt 15: 1-13.

[10] Harvard Kennedy School. The initiative defining Corporate Social Responsibility. http://www.hks.harvard.edu/m-rcbg/CSRI/init_define.html

[11] European Commission 2011. A renewed EU strategy 2011-14 for Corporate Social Responsibility. Communication from the European Commission.

[12] Bundesministerium für Arbeit und Soziales. 2012. CSR Made in Germany.

[13] Wokutch, R.E. 1990. Corporate Social Responsibility Japanese Style. The Executive, 4 (2) 56-74

[14] Wokutch, R.E. 1990. Corporate Social Responsibility Japanese Style. The Executive, 4 (2) 56-74

This study was conducted in a period of rapid growth in CSR activity. According to KPMG, in 2005, 90 percent of Japanese companies, 71 percent of UK companies and 32 percent of US companies participated in CSR reporting. According to KPMG[15] [16], in 2011 CSR reporting had increased to involve 95 percent of the 250 largest companies in the world. Becchetti et al.[17] identify globalisation as an underlying driver of modern corporate social responsibility arguing that as consumption becomes more distanced from production, the quest for assurance that production in distant countries complies with consumers' values increases. They also identify national differences in deep rooted legal traditions as contributing to the differences in emphasis in corporate social responsibility, particularly the difference between legal systems based on civil law in the Anglo-Saxon tradition and the common law traditions of continental Europe. They argue that CSR complements the Anglo-Saxon legal tradition in particular. In effect, it represents private sector efforts prevent a 'race-to-the-bottom' where legal systems give priority to protecting private interests. This has supported a tradition of corporate philanthropy which in turn has seeded interest in CSR in North America and the United Kingdom in particular.

A large literature exists from research about the development and consequences of CSR. Much of it deals with matters outside the scope of this study, for example the range of corporate strategic motives and effects of CSR. For the purposes of this study we can deduce several drivers from the literature. These can be categorised as:

1. company values and personal values of the owners and management;
2. strategy and competitiveness;
3. brand and reputation; and
4. avoiding or shaping regulation.

With respect to climate change, the second driver in the form of cost savings, new business opportunities and consumer preferences were found to be by far the most important.[18] Brand and reputational benefits are also important. Avoiding or influencing

[15] KPMG Global Sustainability Services, 2005, KPMG International Survey of Corporate Responsibility Reporting, downloadable at http://www.kpmg.de/docs/CSR_Reporting_2005.pdf

[16] KPMG, 2011, International Survey of Corporate Responsibility Reporting, downloadable at http://www.kpmg.com/PT/pt/IssuesAndInsights/Documents/corporateresponsibility2011.pdf

[17] Becchetti, L., Ciciretti, R. and Conzo, P. 2013. The legal origins of corporate social responsibility. CEIS Tor Vergata Research Paper Series. Vol. 11 (12), No. 291. October 2013.

[18] Varnäs, A., Vulturius, G., Benzic, M., Carson, M. and Davies, M. Broadening Horizons: Business Engagement with climate change in 2007 and today. 3C/SEI Final report. Stockholm Environment Institute, Sweden

regulation may also be a driver [19] although there are examples of firms encouraging regulation from a CSR standpoint.

Approach

The study is used three strands of investigation: a study of relevant academic and technical or commercial literature; a quantitative analysis of data from 40 agri-food firms that engage in corporate social responsibility activity; and a qualitative assessment of material published by these 40 firms. The quantitative and qualitative assessments of information from firms were done independent of each other.

The research began with an internet search of firms involved in agriculture and food that have CSR strategies or reports. A sample of 40 of these firms was taken and these provided the foundation of the data used in the study.

The quantitative analysis of information from these firms concentrated on identifying patterns in the quantitative data gathered for the 40 firms from their reports (Table 1). These data relate to the number of activities they supported that are relevant to reducing greenhouse gas emissions, firm size, sector, capital intensity, country of origin and consumer linkages. In particular, we describe and classify certifications used and carbon targets set.

Our quantitative analysis revealed the limitations to assessing corporate social responsibility activities on the basis of firms' data. Complementing it, and independent of the quantitative analysis, CSR documents published by the 40 firms were examined to identify how relevant measures are used and how the firms describe the interaction between these and emission processes.

Based on these three steps we classify corporate social responsibility programmes and activities in relation to their potential impact on greenhouse gas emissions and their potential for inducing larger change processes in the food sector.

[19] Kitzmueller, M., and Shimshack, J. (2012). Economic Perspectives on Corporate Social Responsibility. Journal of Economic Literature, 50(1): 51–84.

Table 1. Sources of information on firms' approaches to CSR used in this report.

Firm	Source documents used (latest available at the time of the research)
Associated British Foods	Measuring our responsibility – corporate responsibility 2010
Archer Daniels Midland	Corporate responsibility overview 2011; Our commitment to sustainable cocoa (2011)
Alfred Ritter GmbH	Verantwortung ist bunt – Nachhaltigkeit bei Ritter Sport (2011)
Arla Foods	Sustainable Agriculture Factsheet (2011), Climate Change Factsheet (2010). General statement on Arla Foods´ position on carbon offsetting.
Barilla	Good for you, sustainable for the planet … in other words our way of doing business 2011
Barry Callebaut	Corporate social responsibility and sustainability 2011/12 (2011)
Cargill	2012 Corporate responsibility report – Our responsibility in a changing world
CocaCola	2011/12 Sustainability report, 2011/12 GRI report
COOP	Group Sustainability Report 2012
Del Monte	Del Monte corporate website 04.03.2013
Danone	Sustainability Report 2012
Ferrero	Sharing values to create value - Corporate Social Responsibility report 2012
General Mills	General Mills Website 22.02.2013
Glanbia	Our journey of growth and sustainability 2012; Website 20.02.2013
Gulpener Bier	Firm website 04.03.2013. European Commission (2003) Responsible entrepreneurship: A collection of good practice cases among small and medium-sized enterprises across Europe.
H. J. Heinz Company	Corporate Social Responsibility Report 2011
Hershey	2013 Corporate social responsibility report
Hipp	Nachhaltigkeitsbericht 2012
John Lewis Partnership	Sustainability Report 2012
Kelloggs	2012 Corporate Responsibility Report and website 04.03.2013
Klasmann Deilmann	Sustainability Report 2013
Kraft Foods	Our progress in 2011 – creating a more delicious world
Marks and Spencer	How we do business report 2012
Mars	Putting our principles into action to make a difference to people and the planet through our performance 2011 (published 2012)
McCain Food	Corporate social responsibility benchmark report 2009 and website 26.02.2013
McDonald's	Corporate social responsibility and sustainability report 2012- 2013
Morrisons	Corporate responsibility review 2011
Nestlé	Creating shared value and meeting our commitments 2012
Peeze Coffee	Website 11.10.2013
PepsiCo	Performance with a purpose 2012, website on 08.04.2013 and 19.03.2013
PHW Group	Website 26.02.2013
Provamel	Website 07.03.2013
Sainsburys	Our 20 commitments to help us all Live Well For Less - Our progress so far 2013
Starbucks	2012 Global Responsibility Report, Café practices, Supplier standards
Stora Enso	Global Responsibility Report 2012
SRA[a]	Website 07.03.2013
Tesco	Corporate Responsibility Review 2012
Tchibo	Sustainability Report 2011 update, Tchibo Nachhaltigkeitsbroschüre (undated)
Unilever	Unilever Sustainable Living Plan, Progress Report 2012. Promoting Sustainable Biofuels (undated); Sustainable Agriculture Code (undated); Sustainable Water (undated)
Walmart	Global Responsibility Report 2012

2. EMISSIONS AND THEIR MITIGATION

To consider the effect of agriculture and food-oriented corporate social responsibility schemes on the greenhouse emissions, we need first to consider the sources and magnitude of relevant emissions and how they might be mitigated. Mitigation is defined by the IPPC as a technological change or substitution which reduces GHG emissions or enhances carbon sinks.[20]

Global estimates identify food as a category of consumption with one of the highest carbon footprints. One global study, which reflects consensus in the scientific community, estimates that food (excluding land-use change) is responsible for 27% of global greenhouse gas emissions compared with 26% for heating, cooling and lighting, and 20% for transport.[21] In the recent Fifth Assessment Report of the Intergovernmental Panel on Climate Change, agriculture, forestry and other land uses is estimated to be directly and indirectly responsible for one quarter of global GHG emissions.[22] Because food is a necessity, the absolute level of emissions is relatively stable in relation to consumers' expenditure.[23] The animal-based component of the food system is a major source of these emissions. A FAO report estimates that emissions from livestock account for 18% of global emissions.[24] Another study estimates that livestock account for about 12% to global anthropogenic GHG emissions.[25]

National and regional studies support these global assessments. The Food Climate Research Network reported that the UK food chain (production, processing and retail, but

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

[21] Hertwich, E. G. and G. P. Peters. (2009). Carbon footprint of nations: a global, trade-linked analysis. Environmental Science & Technology 43(16): 6414-6420.

[22] Smith P., M. Bustamante, H. Ahammad, H. Clark, H. Dong, E.A. Elsiddig, H. Haberl, R. Harper, J. House, M. Jafari, O. Masera, C. Mbow, N.H. Ravindranath, C.W. Rice, C. Robledo Abad, A. Romanovskaya, F. Sperling, and F. Tubiello, 2014: Agriculture, Forestry and Other Land Use (AFOLU). In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[23] UNEP (2010) Assessing the Environmental Impacts of Consumption and Production: Priority Products and Materials, A Report of the Working Group on the Environmental Impacts of Products and Materials to the International Panel for Sustainable Resource Management. Hertwich, E., van der Voet, E., Suh, S., Tukker, A., Huijbregts M., Kazmierczyk, P., Lenzen, M., McNeely, J., Moriguchi, Y.

[24] Steinfeld, H, Gerber, P, Wassenaar, T, Castel, V, Rosales, M and C de Hann. 2006. Livestock's long shadow. Food and Agriculture Organisation of the United Nations (FAO).

[25] Westhoek, H. et al (2011). The Protein Puzzle. Netherland Environmental Assessment Agency

excluding land-use change) accounts for 19% of UK consumption GHG emissions.[26] The UK Cabinet Office[27] reported that 18% of UK greenhouse gas emissions can be attributed directly to food with just under half of this attributed to UK farming and fishing. Another analysis of the UK food system shows that livestock products account for a little less than one third of the dietary energy supply but account for nearly two-thirds of production (farm) emissions.[28] For Western Europe as a whole, the EU Environmental Impact of Products (EIPRO) study[29] identified food as responsible for 20-30% of most categories of environmental burdens, including greenhouse gas emissions. For greenhouse gas emissions, this 20-30% attributable to food comprises 4-12% for meat, 2-4% for dairy products, and about 1% for cereal products.

The estimates cited above cover the whole of the food system comprising five major stages: pre-farm; on-farm (agriculture); post-farm processing, manufacture and retail; and the consumption phase. They generally exclude land use change which, if included, would increase the proportion of emissions attributed to food further. To assess the effectiveness of CCR activities, some insight into the role of these different stages in the supply chain is needed.

There is consensus that pre-farm and on-farm emissions account for half or more of total direct supply chain emissions in developed food economies that have high levels of livestock product consumption. In most of the studies, the production phase (agriculture and fisheries) is responsible for more than half of the life-cycle emissions (excluding land-use change) up to the point of consumption (Figure 1).

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[26] Garnett, T. 2008. *Cooking up a storm. Food, greenhouse gas emissions and our changing climate*. The Food and Climate Research Network.

[27] Cabinet Office. 2008. Food matters. Towards a strategy for the 21st century. The Cabinet Office Strategy Unit, UK.

[28] Audsley, E., Brander, M., Chatterton, J., Murphy-Bokern, D., Webster, C., and Williams, A. (2009). An assessment of greenhouse gas emissions from the UK food system and the scope for reduction by 2050. How low can we go?. WWF-UK and the FCRN. www.murphy-bokern.com

[29] Tukker, A, Huppes, G, Guinée, J, Heijungs, R, de Koning, A, van Oers, L, Suh, S, Geerken, T, Van Holderbeke, M, Jansen, B and P Nielsen. 2006. Environmental Impact of Products (EIPRO). Analysis of the life cycle environmental impacts related to the final consumption of the EU-25. Main report IPTS/ESTO project.

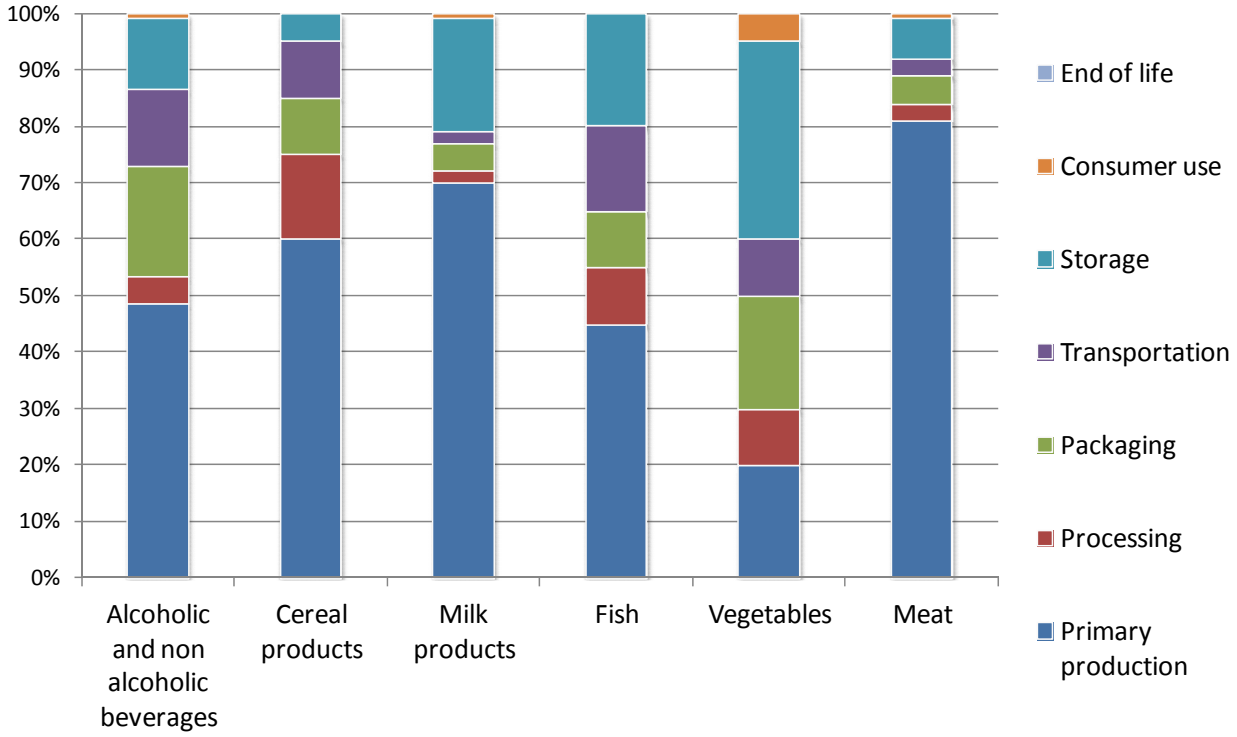

Figure 1. The allocation of life cycle stage global warming impacts for selected food groups to different stages in the production cycle.[30]

Land use change

Agricultural land generally, and cropped land in particular, almost always carries a lower stock of carbon in the soil compared with the same land in its wild state. Therefore, the clearance of land for agriculture is a large source of greenhouse gas emissions, which continue for decades after clearance until a lower soil carbon steady-state level is reached. The same is true when permanent grassland is converted to arable. These emissions are known as land-use change (LUC) emissions.

From 1960 to 2011, agriculture gained almost 500 million ha from other land uses. This growth in the agricultural area was driven largely by increasing demands for food from a growing population.[31] Over the period 1980 to 2000, it is estimated that about 80% of new

[30] Sonigo, P, Bain, J., Tan, A., Johansson, L. Murphy-Bokern, D. Shields, L., Aiking , H., Erb, K., and Kastner, T. (2012). The resource use efficiency of the European food cycle. Report for the European Commission. BIOIS Paris.

[31] Smith, P., D. Martino, Z. Cai, D. Gwary, H. Janzen, P. Kumar, B. McCarl, S. Ogle, F. O'Mara, C. Rice, B. Scholes, O. Sirotenko, 2007: Agriculture. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [B.

land for crops and pastures came from replacing forests, particularly in the tropics.[32] This trend is projected to continue into the future. It is estimated that about 70% of the growth in agricultural output required to 2050 will come from increases in yield on existing agricultural land and the remaining 30% will come from conversion of land to agriculture. About 120 million ha of additional crop land will be used.[33]

The estimate made for the Intergovernmental Panel on Climate Change (IPCC) is that land use and land-use change in total accounted for 17% of global greenhouse gas emissions in 2004.[34] There is a great deal of uncertainty about the size of this emission and estimates range from 8 to 20%.[35] About 75% of deforestation and forest degradation can be attributed to agriculture[36] and 58% of deforestation has been attributed to commercial agriculture connected to international trade.[37] Of relevance to this study is the increasing role of corporate agriculture as a driver.[38]

The causes of land use change can be classified as direct and indirect. The indirect causes are changes that drive a general expansion in agricultural land. For example, the increased demand for rapeseed oil in Europe to produce biodiesel may cause an increase in vegetable oil prices generally. This indirectly drives expansion of palm oil production.

Expansion in commodity production at the place where land-use change is taking place is a direct cause. Analyses of land-use change data and corresponding data on agricultural trade identifies three commodities that are directly associated with a large proportion of land-use change, particularly deforestation: beef, soy and palm oil. There are other

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Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[32] Gibbs HK, Ruesch AS, Achard F, Clayton MK, Holmgren P, et al. 2010. Tropical forests were the primary sources of new agricultural land in the 1980s and 1990s. *Proc. Natl. Acad. Sci. USA* 107:16732–37.

[33] FAO. 2006. World agriculture: towards 2015/30. Rome: Food and Agricultural Organization of the United Nations.

[34] Barker T., I. Bashmakov, L., Bernstein, J. E. Bogner, P. R. Bosch, R. Dave, O. R. Davidson, B. S. Fisher, S. Gupta, K. Halsnæs, G.J. Heij, S. Kahn Ribeiro, S. Kobayashi, M. D. Levine, D. L. Martino, O. Masera, B. Metz, L. A. Meyer, G.-J. Nabuurs, A. Najam, N. Nakicenovic, H. -H. Rogner, J. Roy, Sathaye, R. Schock, P. Shukla, R. E. H. Sims, P. Smith, D. A. Tirpak, D. Urge-Vorsatz, D. Zhou, 2007: Technical Summary. In: *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [B. Metz, O. R. Davidson, P. R. Bosch, R. Dave, L. A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[35] van der Werf GR,MortonDC, DeFries RS, Olivier JGJ, Kasibhatla PS, et al. 2009. CO_2 emissions from forest loss. *Nat. Geosci.* 2:737–38.

[36] Blaser J, Robledo C. 2007. Analysis on the mitigation potential in the forestry sector. *Intercooperation Rep*. for Secr. UN Framew. Conv. Clim. Change, Bern.

[37] Audsley, E., Brander, M., Chatterton, J., Murphy-Bokern, D., Webster, C., and Williams, A. (2009). An assessment of greenhouse gas emissions from the UK food system and the scope for reduction by 2050. How low can we go?. WWF-UK and the FCRN.

[38] DeFries RS, Rudel T, Uriarte M, Hansen M. 2010. Deforestation driven by urban population growth and agricultural trade in the twenty-first century. *Nat. Geosci.* 3:178–81.

commodities directly associated with land use change such as coffee, tropical and citrus fruit, and maize for livestock feed and biofuels.

In policy terms, deforestation (and other types of destruction of natural vegetation such as peatland drainage and use) is attributable to due to the valuable private goods generated by conversion (private land title, timber, and food commodities) compared with the low economic value of the public goods provided by the forest land. The corporate sector can address direct land use change by managing or influencing supply chains, for example through commodity Round Tables and certification. Raising the efficiency with which existing agricultural land is used can contribute to the reduction in the forces driving indirect land use change. The opposite effect can also occur if the application of technology that increases productivity also increases the agricultural value of recently or illegally cleared land close to the remaining forest. The literature indicates that the marginal expansion of production, for example in the Amazon biome or countries such as Indonesia, is heavily dependent on surges in global demand for food and the boom in commodity prices.

Beef and soy

Brazil is the leading country in recent decades in terms of agricultural expansion as global food markets grow. Brazil ranks highest in the world in beef production and export, soy production and export, and in recent decades land-use change (particularly deforestation of tropical forest and savannah). The effects of beef and soy on tropical deforestation are interlinked, particularly in Brazil.[39] The increased international trade in soy for feeding livestock in Europe and Asia has driven conversion of savannah and agricultural grassland to soy production in the Cerrado of Brazil. With the associated changes in land values, this has resulted in cattle production moving northwards into the Amazon, as well a more clearance of land in the Cerrado itself. Clearance rates reached unprecedented levels in 2007 when global food prices were rising rapidly. Chomitz[40] sets out a model of the agricultural frontier which identifies the rent from agricultural land as affected by proximity to food markets as the key driver behind deforestation. Corporate social responsibility will ultimately be a driver of reduced deforestation of it supports differences in produce value or market access and ultimately differences in land values between farm businesses that are not based on recently converted land and those that are. Nepstad et al.[41] present convincing evidence relating to the value of agricultural land. The net present value of Amazon land for cattle is about $500 per hectare throughout much of the Amazon. This

[39] Kaimowitz, D., Mertens, B., Wunder, S. and Pacheco, P. (2004). Hamburger connection fuels Amazon destruction: Cattle ranching and deforestation in Brazil's Amazon. Center For International Forestry Research http://www.cifor.cgiar.org/publications/pdf_files/media/Amazon.pdf

[40] Chomitz, K. (2007). At loggerheads? Agricultural expansion, poverty reduction, and environment in the tropical forests. The World Bank.

[41] Nepstad, D., Almeida, O., Rivero, S., Soares-Filho, B. and Nilo, Jose (2008). Assessment of agriculture and livestock sectors in the Amazon and recommendations for action. Draft Internal WWF Report, 25 January, 2008.

rises to about $1000 per hectare where there is access to export markets. Most of the Amazon is not (yet) suitable for soy production but where it is, net present land values can exceed $10,000 per hectare.

Palmoil

Indonesia, Malaysia, Columbia and Papua New Guinea are central to the international palm oil trade and oil palm is the dominant traded agricultural crop in South-east Asia. Between 2002 and 2012, which is a period when corporate social responsibility developed rapidly world-wide, palm oil production nearly doubled from 26 million tonnes to 50 million tonnes. Indonesia is now the biggest producer with about 24 million tonnes per year followed by Malaysia with about 19 million tonnes (FAOSTAT). Indonesian production in particular has grown rapidly over the last decade when agricultural land grew from 46 million ha to 56 million ha and the forest area declined from 99 million ha to 94 million ha. In Malaysia, the agricultural area remained stable at 8 million ha but the forest area declined from 22 to 20 million ha.

The Indonesian Government plans to expand oil palm plantations to about 10 million ha by 2020, representing a ten-fold increase in 25 years. This is driven by biodiesel production as well as food. The social costs of this plantation expansion are huge.[42] The world price of palm oil reached a peak of about $1,100 per tonne in 2008 equating to about $1 per litre for diesel. A mineral oil price of about $140 dollars per barrel ($0.88/litre) which was reached in mid-2008 suggesting that the price of palm oil is linked to the price of crude oil as suggested by Lewis.[43]

Recent studies try to document land use change in Malaysia and Indonesia.[44] From 1990 to 2010 oil palm plantations in Malaysia, Indonesia and Papua New Guinea increased by approximately 10 Million hectares.[45] On the Malaysian peninsula alone total land use change accounts for 2.7 million hectares from 2006 to 2009.[46]

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[42] Marti, S. 2008. Losing ground. The human impacts of palmoil expansion. FOE.

[43] Lewis, L. (2008). Biofuels and banquets put pressure on stocks of palm oil. The Times, 9 January.

[44] Timothy J. Killeen, T. J. and Goon, J. (2013). Reports from the Technical Panels of the 2nd Greenhouse Gas Working Group of the Roundtable on Sustainable Palm Oil (RSPO). Available online at: http://www.rspo.org/en/reports_from_the_technical_panels_of_rspos_2nd_greenhouse_gas_working_group.

[45] Gunarso, P., Hartoyo, M.E., Agus, F. and Killeen, T.J. (2013). Oil Palm and Land Use Change in Indonesia, Malaysia and Papua New Guinea. In: Reports from the Technical Panels of the 2nd Greenhouse Gas Working Group of the Roundtable on Sustainable Palm Oil (RSPO).

[46] Timothy J. Killeen, T. J. and Goon, J. (2013). Reports from the Technical Panels of the 2nd Greenhouse Gas Working Group of the Roundtable on Sustainable Palm Oil (RSPO). Available online at: http://www.rspo.org/en/reports_from_the_technical_panels_of_rspos_2nd_greenhouse_gas_working_group.

Reducing land use change for beef, soy and palm oil production

The evidence presented by Jaccoud et al[47] suggests that the influence of the final consumer on the production chain can be strong, especially with respect to expansion in the transitional lands. The impact that a moratorium in Brazil on soy from recently deforested areas has had provides useful insight into the potential effects of market measures. In 2006, the Brazilian Soy Producers Association (ABIOVE) and its member companies pledged on July 24 2006 not to trade soy originating from land cleared in the Amazon biome. This was extended for a further year in June 2008, and remained in place in 2013. Recent research using remote sensing concludes that associated with this moratorium, soybeans are no longer playing an important role in the deforestation of the Amazon. The moratorium period saw the lowest deforestation rates in the Legal Amazon in an historic series of 24 years.[48] This 'moratorium' is a valuable first step in collectively addressing the threats to forests but its success in tackling deforestation in Brazil depends of much wider measures, including measures in the beef sector.

Separate from the ABIOVE moratorium, The Round Table on Responsible Soy (RTRS) operates a certification programme that enables food and feed industry purchasers of soy to support soy certified by the RTRS. RTRS certification is controversial and a wide range of environmental NGOs claim that it is ineffective in reducing deforestation.[49] Crucially for the purposes of this report, there is little evidence that farmers complying with RTRS standards are rewarded with higher prices compared with uncertified producers. The premium paid to farmers for certified production is only about 2 to 5 USD.[50] In 2013, the RTRS certified only 1.1 million tonnes or less than 0.5% of global production. Pro Terra, which focuses on certifying non-GM soy for Europe certified 2.9 million tonnes in 2013. According to Garret et al. [51] , the premium paid by Pro Terra to farmers is 4 USD/tonne, (in addition to the premium for non-GM. This compares to their estimate of only 1.5 USD for RTSO soy.

Consumer driven market mechanisms can complement top-down regulation of land use change.[52] Successful negotiation of social and environmental performance criteria and an associated system of certification that enhances returns to agriculture on land that does

[47] Jaccoud, D' A., Lemos de Sa, R., Richardson, S. (2003). Sustainability assessment of export-led growth in soy production in Brazil. WWF.

[48] Rudorff, B.F.T., Adami, M., Aguiar, D.A., Moreira, M.A., Mello, M.P., Fabiani, L., Amaral, D.F., Pires, B.M. The soy moratorium in the Amazon biome monitored by remote sensing images. Remote Sensing, v.3, p.185-202, 2011.

[49] Friends of the Earth 2012. Roundtable on Responsible Soya – the certifying smoke screen.

[50] Information provided to the authors by the RTRS on 17.12.2013.

[51] Garrett, R. D., Rueda, X. and Lambin, E.F. (2013). Globalization's unexpected impact on soybean production in South America: linkages between preferences for non-genetically modified crops, eco-certifications, and land use. Environ. Res. Lett. 8 (2013) 044055 (11pp) doi:10.1088/1748-9326/8/4/04405

[52] Nepstad, D.C., Stickler, C.M. and Almeida, O.I. (2006). Globalisation of the Amazon soy and beef industries: opportunities for conservation. Conservation Biology 20: 1595-1603.

not threaten sensitive habitats is a potentially powerful instrument. Efforts to encourage efficient production in suitable agro-ecological zones could lead to a scenario where greater market access combined with effective and enforceable policies to manage expanded production brings mutual reinforcement of economic, environmental and social benefits.[53]

The driver behind beef-related deforestation is the difference in the value of forest and deforested land used for grassland. The forest is worth more dead than alive even though the resulting grassland is not particularly valuable or productive. Tipping the balance towards retention of the forest might be achieved by awarding an economic return for the ecosystem services, for instance through REDD or the Clean Development Mechanism, provided by the standing forest, by higher prices for selectively harvested (sustainable logged) timber, and/or market discrimination against food commodities delivered from newly or illegally cleared forest. Mechanisms to deliver these are developing and could be applied concurrently to deliver synergistic effects and to avoid unintended consequences associated with the transfer of agriculture to other forest frontiers.

Pre-farm emissions

Fertiliser manufacture

The pre-farm emissions include emissions from the manufacture of fertilisers and pesticides. The major source of pre-farm emissions is fertiliser production, particularly the production of nitrogenous fertiliser. Fertiliser accounts for 37% of all energy expenditure in US agriculture.[54] An analysis of existing LCAs[55] of nitrogen fertilisers showed that the primary energy use in their production ranged from 41 to 49 MJ/kg N with a GWP of 3.0 to 7.4 kg GHGe/kg N in Europe. Some reports suggest that energy use in fertiliser manufacture outside Europe is higher[56] with an average of 65-101 MJ/kg N. The total amount of nitrogen fertiliser manufactured and used as fertiliser is estimated to be 101 million tonnes in 2009.[57] In addition, the total use of phosphorus and potassium is 19 million tonnes and 25 million tonnes respectively. The energy requirement of phosphorus and potassium is estimated to be 15 and 8 MJ/kg respectively.

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[53] Jaccoud, D' A., Lemos de Sa, R., Richardson, S. (2003). Sustainability assessment of export-led growth in soy production in Brazil. WWF.

[54] Lang, T., Barling, D., & Caraher, M. (2009). Food policy: Integrating health, environment & society. Oxford, UK: Oxford University Press. p. 193

[55] Williams, A.G., Audsley, E. and Sandars, D.L. (2006) *Determining the environmental burdens and resource use in the production of agricultural and horticultural commodities.* Main Report. Defra Research Project IS0205. Bedford: Cranfield University and Defra.

[56] Bellarby J, Foereid B, Hastings A, Smith P. 2008. *Cool Farming: Climate Impacts of Agriculture and Mitigation Potential*. Amsterdam, Neth.: Greenpeace Int.

[57] FAOSTAT (website accessed in 12.06.2013).

Based on the emission factors presented by Ballerby et al. and fertiliser production data for 2009 from the FAO, we estimate that the total greenhouse gas emissions from the manufacture and distribution of fertilisers to range from 348 to 704 million tonnes CO_2e. This equates to 0.71 to 1.44% to total global emissions. These are dominated by nitrogen fertilisers which account for 332 to 665 million tonnes GHG equivalent or 0.67 to 1.35 of total emissions.

The emissions from the production of non-nitrogenous fertiliser are due to the energy used in mining, transport and processing. These emissions are mitigated as these processes become more efficient. The situation with nitrogen fertilisers is more complex. The emission arises from energy use in the process (particularly from natural gas use) and from emissions of nitrous oxide as a trace product of the reactions.[58] Nitrogen fertiliser production is the largest source of industrial emissions of N_2O[59] and technical measures can reduce these by up to 90%. Despite the availability of these measures, it is estimated that 80% of the world's nitric acid production is not fitted with this mitigation technology.[60]

Planting media and compost

The production of planting media for protected cropping is a pre-farm activity that accounts for a proportion of the impact of the relevant products, e.g. greenhouse-grown salad crops. It is analogous to fertiliser production for open-field production. The two major raw materials are peat and mineral fibre (e.g. "Rockwool").

The production of peat-based media causes loss of peat reserves. In terms of the emission process, the loss of carbon from degrading peat is the same as any other emission from long-term carbon stores.

For agriculture or peat extraction, peatland must first be drained and this contributes to the land-use change emissions discussed earlier. Globally, the carbon dioxide emissions from drained peatlands (including emissions from peat fires) amount to two gigatonnes per year[61] and represent almost 25 percent of the greenhouse gas emissions from land use, land use change and forestry sector (LULUCF).[62] The proportion of this loss directly attributable to peat extraction is small. Further, the proportion of extracted peat used for

[58] Wood S. and Cowie A. (2004). A review of greenhouse gas emission factors for fertiliser production. IEA Bioenergy Task 38.

[59] United States Environment Protection Agency.

[60] Intergovernmental Panel on Climate Change (IPCC) 2000 Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories: N2O Emissions from Adiphic Acid and Nitric Acid Production. London, U.K.

[61] Joosten, H. 2009. The Global Peatland CO_2 Picture. Peatland status and emissions in all countries of the World. Ede, Wetlands International. 10 pp. (available at: http://tinyurl.com/yaqn5ya)

[62] Canadell, P. 2011. The Global Carbon Budget and the Role of Forests and Peatlands. Presentation Workshop on Tropical Wetland Ecosystems of Indonesia, Bali, April 11–14, 2011. (available at: http://www.forestsclimatechange.org/fileadmin/tropicalworkshop/Overview_Session/1P_CanadellP_GCP.pdf

food production is smaller still. The abstraction of peat for planting media is geographically concentrated and therefore has significant local impacts. In this study, one of the 40 corporate social responsibility strategies examined comes from Klasmann Deilmann, a company specialised in producing peat-based planting media.

For protected cropping food production, stonewool and nutrient film technologies are now much more widely used than compost in modern production systems. Stonewool production is energy intensive. However, in a LCA of tomato production, the difference between using stonewool and other nutrient film technologies was reported to be trivial compared with the other inputs into the tomato production system.[63]

Biocides (pesticides and pharmaceuticals) manufacture
Ever since the publication of *Silent Spring* by Rachel Carson in 1962, the use of pesticides has been the focus of much public, policy and scientific debate. This is reflected in the strong emphasis on crop protection measures in farm and farm produce certification. Compared with fertiliser production, the production of pesticides is a comparatively low GHG emitter estimated to be 30-140 million tonnes CO_2e per year.[64] The quantities of veterinary pharmaceutical products used are lower than pesticides and thus they are also not a large source of greenhouse gas emissions.

Emissions from agricultural production

The IPCC 5th Assessment Report[65] estimates that emissions from agriculture, forestry and other land use (AFOLU) amounts to ca 12 $GtCO_2$e/year in 2010 or 24% of all anthropogenic greenhouse gas emissions (Figure 2). The IPCC 4th Assessment Report[66] estimates that direct emissions from farming activities accounted for an estimated emission of 5.1 to 6.1 $GtCO_2$e/year in 2004 (10-13% of total global anthropogenic emissions of greenhouse gases). The greatest proportion of direct emissions comprise

[63] Williams, A.G., Audsley, E. and Sandars, D.L. (2006) Determining the environmental burdens and resource use in the production of agricultural and horticultural commodities. Main Report. Defra Research Project IS0205. Bedford: Cranfield University and Defra.

[64] Bellarby J, Foereid B, Hastings A, Smith P. 2008. *Cool farming: Climate impacts of agriculture and mitigation potential*. Amsterdam, Neth.: Greenpeace Int.

[65] IPCC, 2014: Summary for Policymakers. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

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

nitrous oxide (N_2O) from nitrogen cycle processes in the soil and methane (CH_4) emitted from the digestive system of cattle and sheep and from manure stores (Figure 3).

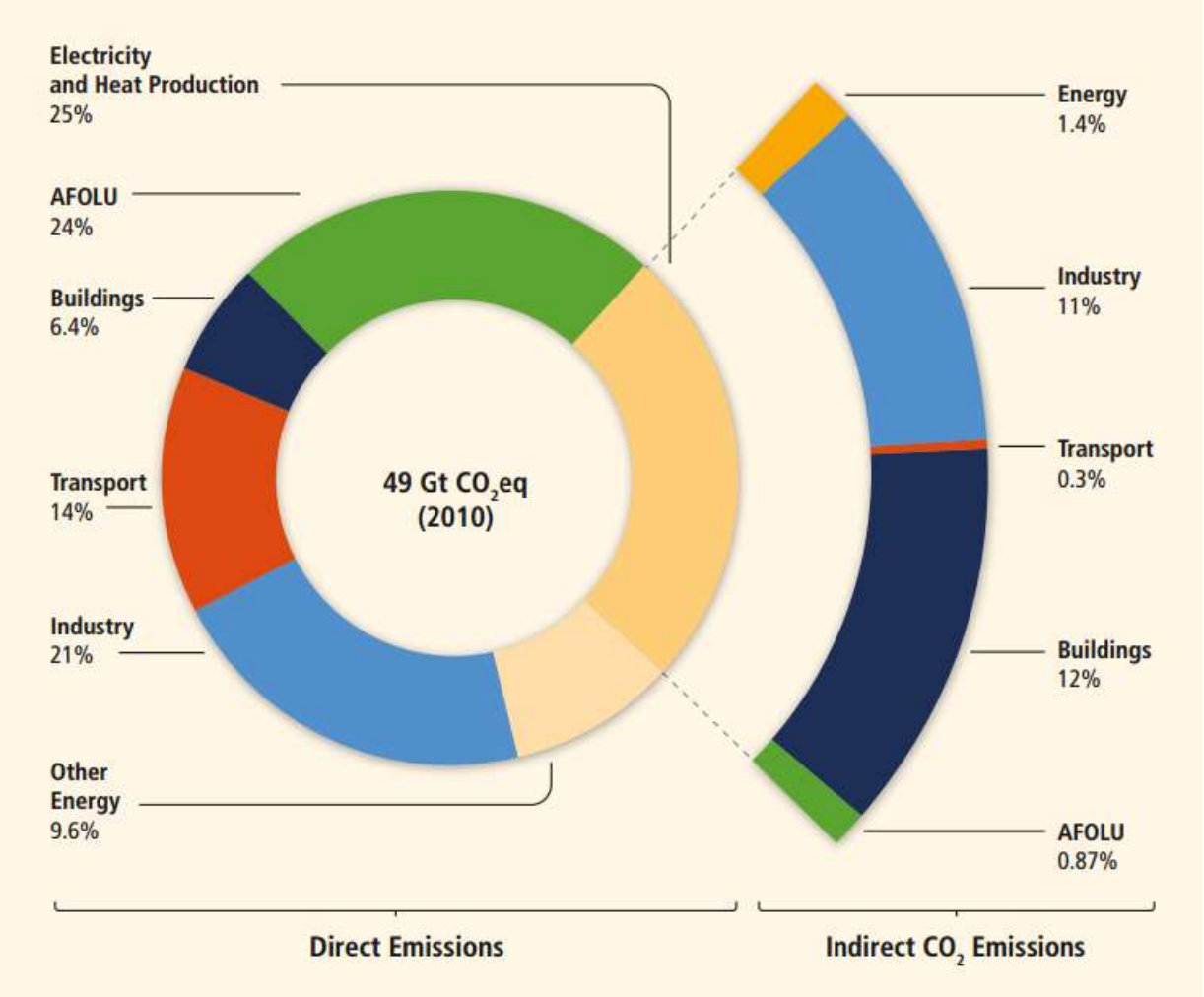

Figure 2. Total anthropogenic GHG emissions (GtCO2eq/yr) by economic sectors. Inner circle shows direct GHG emission shares (in % of total anthropogenic GHG emissions) of five economic sectors in 2010. Source: IPCC [67]

In relation to the total amount of these gases emitted, agriculture accounts for about 60% of N_2O and about 50% of CH_4. These emissions occur independent of fossil fuel use and are intrinsic to the biological processes involved in growing crops and producing animals. The indirect emissions comprise CO_2 from land use and land use change.

[67] IPCC, 2014: Summary for Policymakers. In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

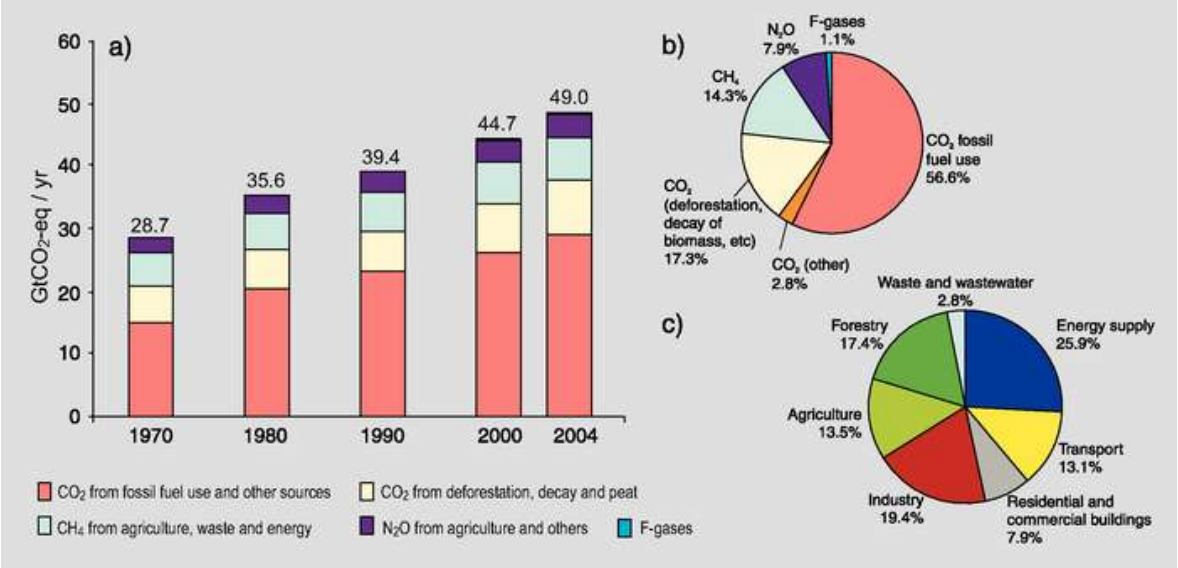

Figure 3. a) Global annual emissions of anthropogenic GHGs from 1970 to 2004. (b) Share of different anthropogenic GHGs in total emissions in 2004 in terms of GHG-eq. (c) Share of different sectors in total anthropogenic GHG emissions in 2004 in terms of CO_2-eq. (Forestry includes deforestation). Source: IPCC.[68]

Nitrogen

Nitrogen is the major 'GHG nutrient'.[69] Nitrous oxide (N_2O), a trace gas and a potent GHG, is a product of the nitrogen cycle. Rockstöm et al.[70] ranked environmental processes in relation to the transgression of limits and concluded that nitrogen pollution ranks at the global scale as one of the top 3 threats to biodiversity.

The intensity of the nitrogen cycle is raised in agro-ecosystems directly or indirectly by the use of synthetic nitrogen fertilisers or by biological fixation in legume crops such as pea and soy. This addition of reactive nitrogen by man has increased ten-fold since 1860 to

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[68] Solomon, S., D. Qin, M. Manning, R.B. Alley, T. Berntsen, N.L. Bindoff, Z. Chen, A. Chidthaisong, J.M. Gregory, G.C. Hegerl, M. Heimann, B. Hewitson, B.J. Hoskins, F. Joos, J. Jouzel, V. Kattsov, U. Lohmann, T. Matsuno, M. Molina, N. Nicholls, J. Overpeck, G. Raga, V. Ramaswamy, J. Ren, M. Rusticucci, R. Somerville, T.F. Stocker, P. Whetton, R.A. Wood and D. Wratt, 2007: Technical Summary. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[69] Williams, A., Audsley, E. and Sandars, D. 2006. Determining the environmental burdens and resource use in the production of agricultural and horticultural commodities. Defra project report IS0205.

[70] Rockström, J., W. Steffen, K. Noone, Å. Persson, F. S. Chapin, III, E. Lambin, T. M. Lenton, M. Scheffer, C. Folke, H. Schellnhuber, B. Nykvist, C. A. De Wit, T. Hughes, S. van der Leeuw, H. Rodhe, S. Sörlin, P. K. Snyder, R. Costanza, U. Svedin, M. Falkenmark, L. Karlberg, R. W. Corell, V. J. Fabry, J. Hansen, B. Walker, D. Liverman, K. Richardson, P. Crutzen, and J. Foley. 2009. Planetary boundaries: exploring the safe operating space for humanity. Ecology and Society 14(2): 32.

more than 150 million tonnes, with two thirds (100 million tonnes) of this due to fertiliser manufacture.[71] [72] [73] About a further 32 million tonnes is added in the cultivation of legumes. This fixation ultimately intensifies nitrogen fluxes in the environment, including the losses of nitrate, ammonia and nitrous oxide (N_20). Consequently, N_2O concentrations in the atmosphere have increased from a pre-industrial level of 270 ppb to a current level of 319 ppb. The losses and impacts of nitrogen cascade through supply chains. Despite some recycling of manures back to the soil, more than 4 kg nitrogen is lost to the environment for each kg nitrogen recovered in the product. Tackling GHG emissions from agriculture involves addressing these losses at each stage of the production cycle.

Methane

Methane (CH_4) is a potent greenhouse gas (GHG), which makes it a significant contributor to climate change, especially in the near term (i.e. 10–15 years). Though methane is emitted into the atmosphere in smaller quantities than CO_2, its global warming potential (i.e., the ability of the gas to trap heat in the atmosphere) is 23 times greater in 100 years after emission. Ruminants account for 29% of all methane emissions which is the largest single source.[74]

The importance of methane is increased when the effect of timescale is considered. Conventionally, the greenhouse gas effect of methane is expressed as that in 100 years – this is the effect of an emission today in 100 years, i.e. 23 times that of CO_2. Methane degrades, and so the greenhouse gas effect of a given emission declines with time. The corresponding effect over 20 years is 72. This means that reducing methane emissions has a large effect and particularly relevant if rapid mitigation is required, which is the case in contemporary climate policy.

Land use emissions

In many situations, the use of agricultural land causes emissions of CO_2 as soil organic matter is broken down. These are land use emissions and usually grouped together with LUC. The extent of these carbon loss processes depends on how close soil organic matter contents are to the steady-state level for the land management practices being used. Soils used for arable crop production that are high in organic matter because of past management practices or recent conversion from grassland and soils on drained peat are usually net emitters of CO_2. These emissions are particularly high where peatland is

[71] Enquete Commission (1994). Protecting our green earth. Enquete Commission of the German Bundestag. Economica Verlag.

[72] Jenssen, T.K. and G. Kongshaug (2003) Energy consumption and greenhouse gas emissions in fertiliser production, Proceedings No. 509, International Fertiliser Society, York, UK, 28 pp.

[73] Braun, E. 2007. Reactive nitrogen in the environment. UNEP.

[74] Global Methane Initiative (undated). Global methane emissions and mitigation opportunities.

drained and used for agriculture. Drained peatland is estimated to emit 1,298 million tonnes of carbon dioxide per year, which equates to about 1% of total emissions.[75]

On-farm energy use

The other major source of farm GHG emissions is on-farm energy use. Estimating this is difficult as the use of diesel fuel in crop production varies hugely. Bellarby et al. provide an estimate of 0.16 GT GHG per year.[76] On-farm fuel use is a relatively minor source of emissions.

Mitigating agricultural emissions

There is consensus that the greatest scope for mitigating agricultural emissions (excluding land use change) lies in soil management. As well as reducing emissions, soils can be managed to be net sinks for carbon.

Smith et al.[77] estimate that agriculture has the technical potential to reduce emissions by 6,000 million t CO_2e/year (Figure 4). The main mechanism is increasing soil carbon: soil carbon sequestration. This represents the greatest mitigation potential in agriculture.[78] Managing agricultural land to increase soil carbon has a mitigation potential of 5,340 million tonnes CO_2e/year. Much of this mitigation effort has an economic cost and they estimated that this technical potential equates to an economic potential of 4,300 million t CO_2e/year at a carbon price of 100 USD t CO_2e. 89% of this mitigation potential lies in soil carbon sequestration, and the remaining 11% arises from reducing emissions of methane (9%) and nitrous oxide (2%). Much relates to the restoration of natural vegetation on crop land. Restoring wetlands and peatland can provide even larger carbon sinks. In total, restoration of land to nature has the potential to mitigate about 4,600 million t CO_2e per year.

[75] Joosten, H. 2009. The Global Peatland CO_2 Picture. Peatland status and emissions in all countries of the World. Ede, Wetlands International. 10 pp.

[76] Bellarby J, Foereid B, Hastings A, Smith P. 2008. Cool farming: Climate impacts of agriculture and mitigation potential. Amsterdam, Neth.: Greenpeace Int.

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

[78] Bellarby J, Foereid B, Hastings A, Smith P. 2008. Cool farming: Climate impacts of agriculture and mitigation potential. Amsterdam, Neth.: Greenpeace Int.

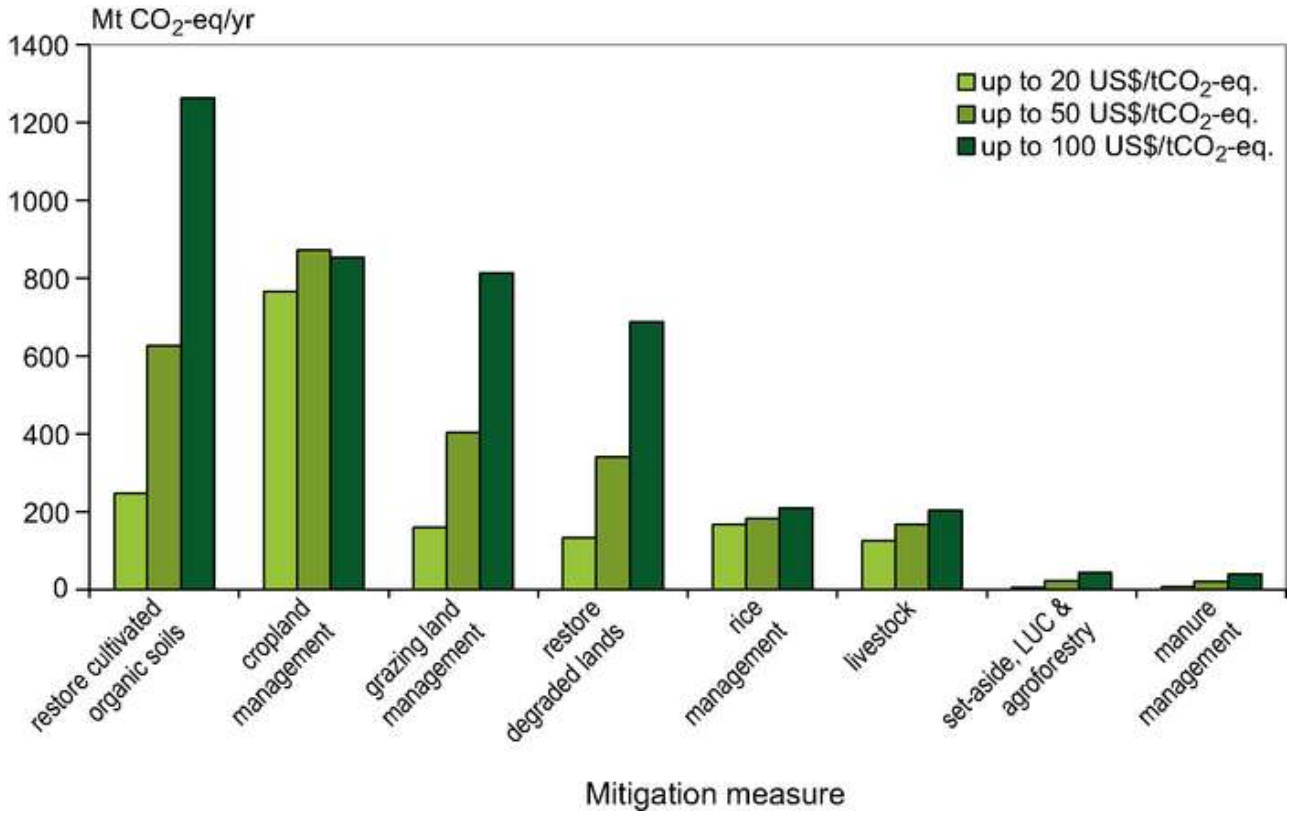

Figure 4. **Greenhouse gas mitigation potentials in agriculture as affected by the carbon price or willingness to pay (IPCC 2007).** [79]

Reduced tillage

Modified tillage, particularly a switch to reduced cultivations, is widely regarded as a means of increasing soil carbon sequestration. However, the consequences of reduced tillage for soil carbon are not straight-forward. Detailed assessment of evidence concluded that conservation tillage "has little effect on soil organic matter, other than altering its distribution in the profile".[80] More recently, Baker et al.[81] concluded that the widespread belief that reduced tillage favours carbon sequestration may simply be an artefact of sampling methodology with reduced tillage resulting in a concentration of soil

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

[80] Powlson, D.S., Jenkinson, D.S., 1981. A comparison of the organic matter, biomass, adenosine triphosphate and mineralizable nitrogen contents of ploughed and direct-drilled soils. J. Agric. Sci. 97: 713–721.

[81] Baker, J.M., Ochsner, T.E., Venterea, R.T., and Griffis, T.J. 2007. Tillage and soil carbon sequestration – what do we really know. Agriculture, Ecosystems and Environment 118: 1-5.

organic matter in the upper soil layer rather than a net increase through the soil. This is relevant to some corporate social responsibility measures.

Increasing the return of organic matter

Switching from an agri-ecosystem that supports a low soil carbon content to one that supports high levels of soil carbon, for example a switch from intensive arable cropping to perennial agro-forestry or permanent grassland will deliver net carbon sequestration in depleted soils until a new steady state is achieved – a process which can last several decades and even centuries. It can be assumed that sequestration will be greatest in the soils most depleted compared to their natural ecosystem state. The means for achieving this include avoiding bare fallow and growing crops such as 'catch' crops for incorporation into the soil.

Natural grassland can also be managed to increase the carbon stock and this is estimated to have a potential of 1,350 million tonnes CO_2e/year. This involves improved management to reduce erosion and reducing the incidence of fire.[82]

Restoring natural vegetation and wetlands

If changing land use from natural vegetation to agriculture is a major source of emissions, then the opposite process is potentially an important mitigation measure. This measure has a high mitigation potential. The re-wetting of drained wetlands is analogous to restoring native grassland or forest. This has a mitigation potential of 2,000 million tonnes CO_2e.

Reducing nitrogen emissions

Due to the role of nitrous oxides in agricultural emissions, reducing man's intervention in the nitrogen cycle through raising the efficiency of nitrogen use in agriculture is central to the mitigation of greenhouse gas emissions from farming. Increasing the efficiency of nitrogen use by the growing high yielding crops is the first step in the mitigation of direct emissions.

The efficiency of nitrogen use has improved in Europe. According to the European Environment Agency[83] and the OECD, the surplus of nitrogen fertiliser applied over the quantity removed in produce has dropped significantly in Europe. In 2000 the gross nitrogen balance ranged from 37 kg ha^{-1} (Italy) to 226 kg ha^{-1} (the Netherlands). Most national gross nitrogen balances show a decline in estimates of the gross nitrogen balance between 1990 and 2000. The general decline in nitrogen surpluses is due to a small decrease in nitrogen input (-1.0%) and a significant increase in nitrogen output (10%). Nitrogen use efficiency has increased through increased output.

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[82] Bellarby J, Foereid B, Hastings A, Smith P. 2008. Cool farming: Climate impacts of agriculture and mitigation potential. Amsterdam, Neth.: Greenpeace Int.

[83] EPA, 2011. Agriculture: nitrogen balance

The largest nitrogen loses in agriculture occur from animal wastes. About half of the nitrogen entering the pig production system (and even more in other systems) is lost from manures or the soil during or after manure application. Making the most efficient use of the N in organic manures is essential. Technologies such as slurry injection, manure treatment, and accurate rate and timing of manure application are all important. Losses of up to 80% of mineral nitrogen in slurry through ammonia emissions when broadcasting slurry are common damaging sensitive ecosystem downwind of application. Reducing these emissions conserves nitrogen within the soil/plant system and offers the opportunity of establishing a virtuous circle of ammonia reductions, nitrogen conservation, and reduced fertiliser inputs.

Anaerobic digestion (AD) for biogas is worthy of mention here. The by-product of AD is 'digestate', a liquid in which the nitrogen and phosphorus from the feedstock (e.g. manure, crop material and food waste) is conserved in a plant available form. The use of anaerobic digestion within integrated crop/animal systems has the potential to improve the nitrogen efficiency of the whole system if the feedstock is based on manure or food wastes and the digestate is used to effectively replace synthetic fertiliser nitrogen.

Using technology to reduce nitrous oxide and methane emissions directly from the food chain has an important role to play with a total potential of about 20% of food chain emissions. Inhibitors of the conversion of ammonium to nitrate in soil (nitrification inhibitors) were developed several decades ago but adoption has been hindered by their cost compared with the direct yield benefits. However, there is now renewed interest in their use to obtain the associated reductions in nitrous oxide emissions. Substantial reductions (in the region of 50%) in nitrous oxide emissions from agricultural soils have been recorded. Audsley et al.[84] estimate their use would reduce emissions from primary production by 11%. This approach to conserving reactive nitrogen in the soil/plant system is highly complementary with increasing production efficiency.

Reducing methane emissions

Developing and applying technical measures to reduce methane emissions is challenging. Most of the emissions come from microbes in the rumen. Antibiotic-based approaches were commercialised in the 1980s and raised animal performance by altering rumen microbes to produce less methane. Regulations now ban the use of these antibiotics in this way in many countries.

Anaerobic digestion technology (biogas) can be used to generate and capture methane from manure and slurry. Its use to capture the majority of emissions of methane from manure would require very significant capital investment. In the UK only about a quarter of

[84] Audsley, E., Brander, M., Chatterton, J., Murphy-Bokern, D., Webster, C., and Williams, A. (2009). An assessment of greenhouse gas emissions from the UK food system and the scope for reduction by 2050. How low can we go?. WWF-UK and the FCRN.

the theoretical UK potential is technically available.[85] Like other measures, the anaerobic digestion is highly compatible with production efficiency measures if the by-product (digestate) is used as an effective fertiliser to reduce losses from the nitrogen cycle. Biogas fuelled by bioenergy crops, (e.g. maize), which is common in Germany, increases agricultural greenhouse gas emissions directly and indirectly and is not considered further here because it is not part of the food system.

Increasing efficiency in livestock production also reduces methane emissions principally by reducing the number of animals required to produce a given level of output. Some very significant reductions have been claimed. Garnsworthy reported that restoring the fertility of dairy cows to 1995 levels combined with further increases in milk yield per cow would reduce methane emissions from milk production by 24% by reducing the number of young female animals raised to replace the dairy herd and the number of lactating cows in the herd.[86] In considering the effect of efficiency increases, care is needed in considering all the outputs of complex interconnected systems, for example meat and milk from the cattle herd. Using sophisticated modelling approaches, Del Predo and Scholefield[87] estimate that measures to increase the fertility of dairy cows would reduce methane emissions by 3%. Gerber et al.[88] show that at the level of national average yields, the mitigating effect of increases in milk yield level off at about 3,000 litres per year. At a global level, Havlik et al. draw attention to the potential to reduce emissions from livestock production by improving feeding in extensive traditional systems.[89] They assess the effects of improved production efficiency that facilitates land-sparing effects and thus reduced deforestation.

Farming system changes

Much of the effort to improve the nitrogen use efficiency in whole agricultural systems relies on the re-coupling of crop and livestock production and the efficient use of the nutrients emitted by animals in crop production. Public policy can have profound effects. For example, the reduction of transport subsidies for Canadian wheat stimulated the use of wheat for animal feed on the prairies re-coupling crop and animal production with environmental benefits.[90]

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[85] Defra. 2006. *Assessment of methane management and recovery options for livestock and slurries*. Defra research project AC0402.

[86] Garnsworthy, PC. 2004. The environmental impact of fertility in dairy cows: A modelling approach to predict methane and ammonia emissions. *Animal Feed Science and Technology*, 112, 211–223.

[87] Defra. 2008. *New integrated dairy production systems: specification, practical feasibility and ways of implementation*. Defra project report IS0214.

[88] Gerber, P.J., Vellinga, T., Opio, C. & Steinfeld, H. 2011. Productivity gains and greenhouse gas intensity in dairy systems. Livestock Science, 139: 100–108

[89] Havlík, P., Valin, H., Herrero, M., Obersteiner, M., Schmid, E., Rufino, M.C., Mosnier, A., Thornton P., Boettcher, H., Conant R.T., Frank, S., Fritz, S., Fuss, S., Kraxner, F., Notenbaert, A. (2014). Climate change mitigation through livestock system transitions. *Proceedings of the National Academy of Sciences.*

[90] Doan, D. and Paddock, B. (2003). Grain Transportation Policy and Transformation in Western Canadian Agriculture. Agriculture and Agri-food Canada

One of the system change options that is directly relevant to corporate social responsibility and consumer-based action is organic farming. Consumers who purchase organic produce supporting the effects of organic farming, which may include greenhouse gas mitigation. One of the first applications of life-cycle assessment techniques to agriculture[91] showed that there are no consistent difference between conventional and organic production in terms of energy use and direct greenhouse gas emissions. This conclusion was confirmed in 2006 in a much more detailed study[92] which reported only small differences between organic and conventional production in the UK in terms of commodity life-cycle emissions. A recent meta-analysis supports this conclusion.[93]

Post-farm processing, manufacture and retail

When indirect land use and land-use change emissions are factored in, post-farm activities are estimated to account for 10 – 17% of total global food system emissions.[94] The two major sources are energy use and loss of refrigerants as follows (Mt CO_2e): refrigeration, 490; storage, packaging and transport, 396; retail activities, 224; primary and secondary processing, 192; food preparation, 160; and waste disposal, 72. There are however great uncertainties in these global data.

In an examination of the UK food system, Audsley et al.[95] estimated that the post-farm part of the food chain accounted for 26% of emissions when emissions for land-use change were accounted for. At the country level, the emissions from food processing, manufacture and retailing are greatly affected by the carbon intensity of electricity in particular. Therefore, studies of the Swedish food system and products for example show lower levels of electricity-related emissions due to the high use of nuclear and hydro-electricity.

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[91] Murphy, D.P.L., Roever, M. and Heinemeyer, O. (Editors) (1998). Bewertung der Verfahren der ökologischen und konventionellen landwirtschaftlichen Produktion im Hinblick auf den Energieeinsatz und bestimmte Schadgasemissionen. Evaluation of the conventional and organic agricultural production in terms of primary energy consumption and pollution gas emissions. Landbauforschung Völkenrode ISBN 3-933140-33-1(Refereed monograph, 206pp).

[92] Williams, A., Audsley, E. and Sandars, D. 2006. Determining the environmental burdens and resource use in the production of agricultural and horticultural commodities. Defra project report IS0205.

[93] Tuomisto, H., Hodge, I.D., Riordan, P., and Macdonald, D.W. (2012). Does organic farming reduce environmental impacts – a meta-analysis. Of European research. Journal of Environmental Management. 112: 309-320.

[94] Vermeulen, S., Cambell, B.M., and Ingram, J.S.I. 2012. Climate change and food systems. Annual Review of Environmental Resources 37:195-222.

[95] Audsley, E., Brander, M., Chatterton, J., Murphy-Bokern, D., Webster, C., and Williams, A. (2009). An assessment of greenhouse gas emissions from the UK food system and the scope for reduction by 2050. How low can we go?. WWF-UK and the FCRN.

Sonigo et al.[96] provide an overview of the results of a meta-analysis of relevant evidence identifying the differences in the role of various stages in the supply chain for a range of product types (Figure 5). If the total GWP impacts of the respective food groups are weighted by the proportions of these in consumption, an estimation of proportion of total GWP impact of food supply in Europe per lifecycle stage, is as follows (excluding land-use change): agriculture 55%; processing 4%; packaging 7%; transportation 5%; distribution 11%; consumer use 1%; end of life 1%. A number of post-farm processes and activities that are widely acknowledged as important causes of greenhouse gas emissions were identified. The two most notable are refrigeration and transport.

Refrigeration can be regarded as a 'hot-spot' of emissions. Refrigeration creates greenhouse gases both because of the energy used to operate the equipment and because of the global warming potential (GWP) of the refrigerant gases. Garnett estimated that food refrigeration accounts directly for 2.4% of UK greenhouse gas emissions.[97] Audsley et al.[98] estimated that refrigerants alone account for the equivalent of 5.9 million tonnes of CO_2 equivalent in the UK (or nearly 4% of direct emissions from the food system). In addition, energy used in refrigeration was estimated to account for 13 million tonnes of CO_2 (or about 9% of food emissions). Garnett[99] estimates that the cool chain as a whole is responsible for 15% of food chain emissions. This large role of refrigeration has implications for the design and prioritisation of corporate social climate responsibility measures.

In the UK, food-related transport accounts for 1.8% of total UK emissions with 87% of this emission occurring up to the retail outlet.[100] While this shows that transport is a substantial source of emissions, the option of replacing imported food with home-produced food is not a straight-forward solution. The disadvantages of long-distance transport can be outweighed by the effects of lower emissions from food imported from places where production is efficient, for example because the production is in-season.[101] In addition, long distance transport by sea or rail is energy efficient.

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[96] Sonigo, P, Bain, J., Tan, A., Johansson, L. Murphy-Bokern, D. Shields, L., Aiking , H., Erb, K., and Kastner, T. (2012). The resource use efficiency of the European food cycle. Report for the European Commission. BIOIS Paris.

[97] Garnett, T. (2007) Food refrigeration: What is the contribution to greenhouse gas emissions and how might emissions be reduced? A working paper produced as part of the Food Climate Research Network.

[98] Audsley, E., Brander, M., Chatterton, J., Murphy-Bokern, D., Webster, C., and Williams, A. (2009). An assessment of greenhouse gas emissions from the UK food system and the scope for reduction by 2050. How low can we go?. WWF-UK and the FCRN.

[99] Garnett, T. (2007) Food refrigeration: What is the contribution to greenhouse gas emissions and how might emissions be reduced? A working paper produced as part of the Food Climate Research Network.

[100] AEA Technology (2005). The validity of food miles as an indicator of sustainable development: Final report to Defra.

[101] Williams, AG, Pell E, Webb J, Tribe E, Evans D, Moorhouse E., Watkiss P. (2008) Comparative life cycle assessment of food commodities procured for UK consumption through a diversity of supply chains. Final Report for Defra Project FO0103.

All the post-farm CO_2 emissions arise from the use of energy and the full range of energy efficiency and conservation measures are relevant to corporate social responsibility strategies addressing greenhouse gas emissions. Many of these are under the direct control of the firms operating in the food system and are therefore relatively easy to address. Some important factors are outside the control of firms. In particular, the emission intensity of processes is strongly influenced by the electricity mix in the country concerned. Transport infrastructure is also an important factor, as is local policy on energy conservation generally.

Consumption phase

A significant proportion of the refrigeration energy referred to above is used in the home. Two other consumer-related activities have significant impacts: cooking and transport. Audsley et al. (2009) [102] estimate that cooking accounts for about 10% of direct emissions from the UK food system but other sources indicate the role of food preparation in supply chain emissions is a good deal lower.[103] The role of consumers' shopping-related travel is significant. It accounts for half of all food-related vehicle movements in the UK and emissions equal to that from air-freighting of food and from long-distance shipping.

As referred to earlier, Audsley et al (2009). reported that in the UK livestock products account for one third of food calorie intake and nearly two-thirds of food-related emissions. The IMPRO study[104] proposed alternative diets with positive health impacts with low intake of livestock products (dairy and meat). In Europe, the GGELS[105] project provided detailed product-based estimates of emissions from the livestock sector in the EU-27 according to animal species, animal products and livestock systems following a food chain approach. It concluded that 29% of GHG emissions are from beef production (approx. 6% by weight), 29% from bovine milk production (approx. 70% by weight) and 25% from pork production (approx. 13% by weight), while all other animal products together do not account for more than 17% of total emission (approx. 11% by weight). Importantly, it showed that low emissions in Austria (14.2 kg GHG-eq. per kg of beef) could be attributed to a high self-sufficiency in feed production and a high share of grass in the diet, whereas emissions from production in the Netherlands (17.4 kg GHG-eq. per kg of beef) is also relatively low due to efficient and industrialised production structure with strict environmental regulations.

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[102] Audsley, E., Brander, M., Chatterton, J., Murphy-Bokern, D., Webster, C., and Williams, A. (2009). An assessment of greenhouse gas emissions from the UK food system and the scope for reduction by 2050. How low can we go?. WWF-UK and the FCRN.

[103] Munoz, I., Mila i Canals, L., Fernandez-Alba, A. (2010). Life cycle assessment of the average Spanish diet including human excretions. Int. J. Life Cycle Assessment 15:794-805.

[104] JRC-IPTS (2008), IMPRO Environmental Improvement potential of meat and dairy products

[105] Leip A., et al (2010). Evaluation of the livestock sector's contribution to the EU greenhouse gas emissions (GGELS) -final report, European Commission, Joint Research Centre

At the product level, there are large variations between LCA results for a given commodity reflecting differences in the approach of studies and also differences between production systems. Figure 5 shows data for global warming potential (GHG emissions) from a review of LCA results conducted for the European Commission.[106] These variations between production systems have implications for corporate social responsibility programmes in that they show that a given commodity can vary greatly in its carbon footprint depending on its origin and production and this provides a basis for exercising preference to reduce emissions from supply chains.

To date, few guidelines combine health and environmental perspectives and those that exist vary greatly in terms of reporting method, choice of indicators and scope. In a report from the Health Council of the Netherlands[107] 'win-win' guidelines were identified, which, apart from health benefits, deliver environmental benefits in terms of land use and GHG emissions. These centre on reducing meat and dairy consumption compensated for by increased whole-grain products and pulses, fruit and vegetables and a reduction in energy intake in cases of over-weight. A study on the link between consumption and the nitrogen cycle in Europe showed that a reduction in the consumption of livestock products in line with current public health guidelines would have a major effect on the nitrogen cycle reducing all related emissions, the use of arable land, and the need for imported soy.[108] A 50% reduction in livestock product consumption would reduce the need for soy by 75%. This has very significant direct and indirect consequences for the global demand for cropland.

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[106] Sonigo, P, Bain, J., Tan, A., Johansson, L. Murphy-Bokern, D., Shields, L., Aiking, H., Erb, K., and Kastner, T. (2012). The resource use efficiency of the European food cycle. Report for the European Commission Report for the European Commission
(http://ec.europa.eu/environment/eussd/pdf/foodcycle_Final%20report_Dec%202012.pdf)

[107] Health Council of the Netherlands. Guidelines for a healthy diet: the ecological perspective. The Hague: Health Council of the Netherlands, 2011; publication no. 2011/08E.

[108] Westhoek, H., Lesschen, J., Rood, T., Wagner, S., De Marco, A., Murphy-Bokern, D., Leip, A., van Grinsven, H., Sutton, M., Oenema, O. (2014). Food choices, health and environment: effects of cutting Europe's meat and dairy intake. Global Environmental Change 26: 196-205.

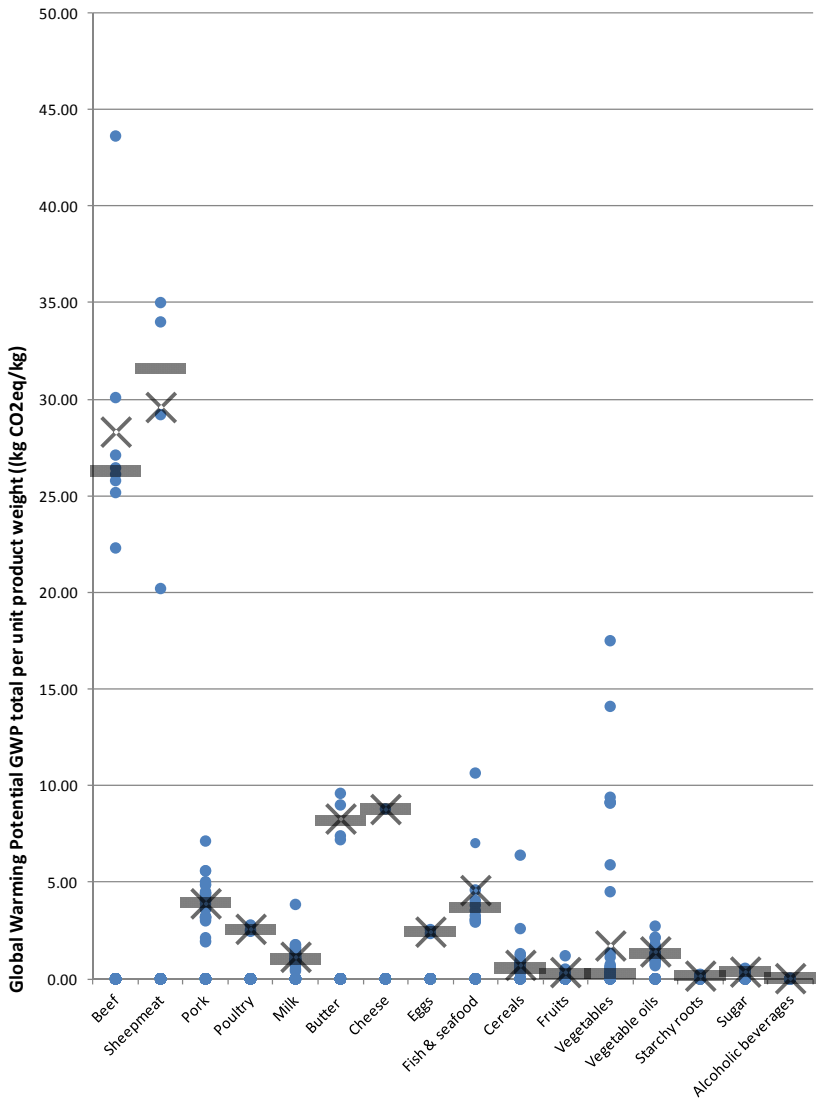

Figure 5. The global warming potential of greenhouse gas emissions arising from the production of various food commodities (kg GHG eq. per kg product weight). The blue dots are individual results, average values of these are indicated with an 'X' and median values are indicated with a '—' (Source: BIOIS Paris[109]).

[109] Pierre Sonigo, P, Bain, J., Tan, A., Johansson, L. Murphy-Bokern, D., Shields, L., Aiking , H., Erb, K., and Kastner, T. (2012). The resource use efficiency of the European food cycle. Report for the European Commission. BIOIS Paris.
(http://ec.europa.eu/environment/eussd/pdf/foodcycle_Final%20report_Dec%202012.pdf)

3. CORPORATE SOCIAL RESPONSIBILITY STRATEGIES

Defining and managing corporate social responsibility in conventional industrial sectors is relatively easy. Materials are usually traceable and their production is in the hands of a relatively small number of large commodity suppliers or manufacturers whose activities can be monitored. In the case of agriculture and food, the primary resources are land and water, and the suppliers are almost always millions of farmers competing in open commodity markets. Because of this, corporate social responsibility in farming and food extends well beyond the activities of the operating firms to include their suppliers. The measures used include semi-private and private certification schemes and associated standards covering large numbers of farmers and/or commodities. Corporate social responsibility strategies can encompass large parts of the complex relationships shown in **Error! Reference source not found.** or cover a small portion such as land use or specific parts of processing.

Position and operation of strategies within the food system

Here we describe corporate social responsibility strategies and measures which impact or potentially impact on the greenhouse gas emissions from the food system. In the context of position in supply chains and related market drivers relevant to CSR, we have identified three categories of firms:

1. Firms interacting with consumers in relation to specific products and supply chains, typically food product manufacturers that are known to consumers through their brands such as Heinz or Alfred Ritter.

2. Firms interacting with consumers over a wide range of products and supply chains, such as retailers.

3. Firms not interacting directly with consumers, typically commodity traders and commodity processors.

This categorisation helps examine underlying economic and market drivers relevant to corporate social responsibility, particularly brand protection, and influencing consumer preferences and responses.

Firms interacting with consumers in relation to specific products and supply chains
These firms with branded products generally have a relatively high degree of control of their supply chains. These brands, which often relate to specific supply chains (e.g. Flora, Heinz, Walls Ice-cream, Mars) are valuable. This means additional costs arising from investment in corporate social responsibility measures can be offset by an indirect economic return through the strengthening of the brand. When operated down to the level of farmer suppliers, there may be further internal benefits arising from security and

scheduling of supplies. In some sectors, ownership (or at least control) of the supply chain may extend down to primary production and even pre-farm activities, for example feed manufacture and the development of advanced strains of livestock. This occurs for example in the pig and poultry sectors (e.g. the PHW Group in Germany which owns the 'Wiesenhof' brand of poultry products).

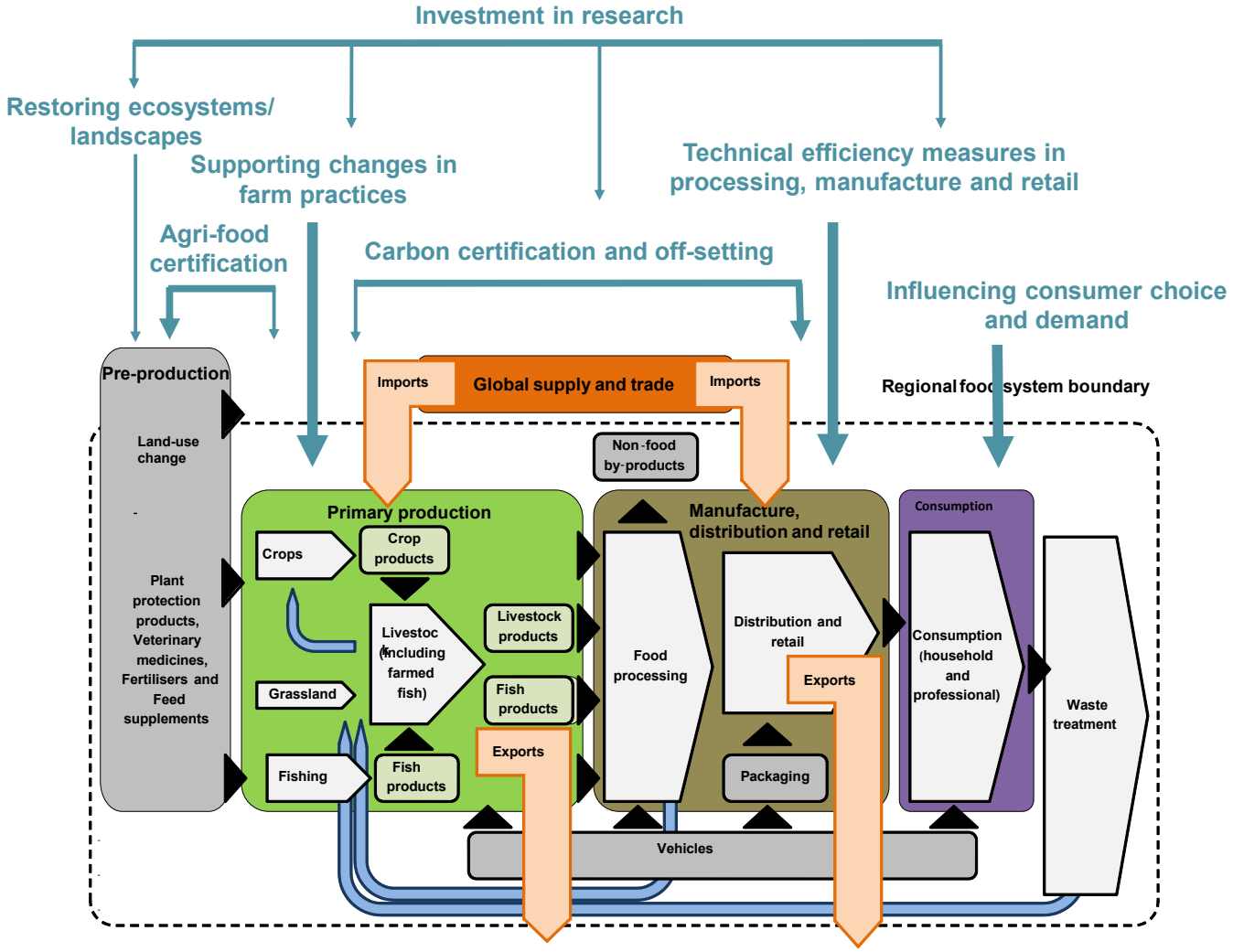

Figure 6. Corporate social responsibility activities and their greenhouse gas mitigation impact pathways (in blue) in relation to the components and resources flows of a regional (e.g. European) food system. The width of the blue impact arrows indicate the relative potential for corporate social responsibility according to this study.

Firms interacting with consumers over a wide range of products and supply chains

Large retailers and catering firms draw on a wide range of supply chains, some with their own branded products. This trend is particularly marked in the United Kingdom where 4

multiple retailers control 75% of the grocery market[110] and where 'own-brand' accounts for nearly half of food sales.[111] From a corporate social responsibility perspective, it is similar to classical product-based approaches, but ownership is with the retailer/restaurant chain and extends across a wide range of food products. Therefore the scope for supporting change at the food system level is greater. Retailers' brands are prominent, valuable and vulnerable to reputational damage. As for product-based strategies, enhancing the reputation of the brand provides the rationale for bearing the additional costs they may entail.

Firms not interacting directly with consumers – commodity traders and processors
A number of firms influence and even control key parts of supply chains but are largely invisible to consumers. These firms are active in commodity processing and trading. Typically, they interact intensively with farmers or local commodity traders, process and store commodity, and then transport commodities over long distances. Some of these commodities such as soy are inputs into other supply chains, so the link to consumer markets is particularly weak.

These firms operate in a particularly competitive commodity trading environment, where the scope for branding and product differentiation is limited. There is little or no opportunity for distinguishing commodity in terms of user or process quality, except through segregation.

Corporate social responsibility measures

Regardless of the type of corporate social responsibility strategy, its owners, and its profile with consumers, the impact of corporate climate on greenhouse gas emissions depends on the effects of the **measures** used on the supply-chain activities and processes that cause greenhouse gas emissions. An overview of the measures and the way they are used by types of corporate social responsibility strategies is provided in Table 2.

[110] Kantar Worldpanel 2013. Over half the UK now shops in a discounter (17.12.2013). http://www.kantarworldpanel.com/Global/News/Over-half-UK-now-shops-in-a-discounter
[111] Gibbons, L. 2012. Own-label food to continue gains over branded: Kantar. http://www.foodmanufacture.co.uk/Business-News/Own-label-foods-to-continue-gains-over-branded-Kantar

Table 2. Overview of corporate social responsibility measures relevant to greenhouse gas mitigation in agriculture and food

Measures	**Use in corporate social responsibility programmes**
Farm certification	Used as a foundation of some wider certification schemes.
Supply-chain certification	Assured farm produce (e.g. Red Tractor) and organic produce certification are typical examples. There are also firm standards for own-brand products.
Commodity certification	Widely used for imported commodities such as palm oil, soy, cocoa, coffee, sugar and tea.
Carbon certification	This is a third party process which enables the use of a carbon label. It is used for products, production processes or on firm level. Sub-classifications are carbon rating, carbon intensity, carbon reduction and carbon neutral certification.
Carbon offsetting	Offsetting of carbon emissions is often used in transport and manufacturing, sometimes as part of a carbon certification.
Farm management and agricultural practices (in addition to certification schemes)	Food manufacturers, retailers and commodity traders commonly support technical change on farms, particularly for fresh produce. The overall effect is increases in yield or quality for a give level of inputs such as fertiliser.
Technical efficiency measures in processing, manufacture, and retail	These form the foundation of many corporate social responsibility strategies. They are focused on raising internal resource use efficiency in processing, manufacturing, transport and retailing.
Sectoral cooperation, partnerships, platforms and roundtables	Many of these are closely related to product certification. It is possible for firms to support these without committing to the purchase of associated certified produce. Such membership has awareness-raising effects and there are benefits from shared insights and information.
Restoring ecosystems	In the context of climate change mitigation, this is largely about restoring soil carbon stocks through for example re-wilding of farmed land, restoring forests or grassland, or rewetting drained peatland.
Investment in research	The agri-food sector has a record of investing in research and development to improve overall system performance, particularly farming. Much of this research has a pre-competitive character.
Influencing consumer choice and demand	Such measures would actively support consumers who want to reduce the carbon footprint of their diets.

Agri-food certification

Voluntary certification of food and agricultural products have increased in number and importance in recent years. In 2010, the EU found more than 400 different certification systems in the agri-food sector.[112]

Certification of agricultural production may focus on the whole-farm business, a supply-chain certification over several commodities, or certification of specific commodity supply chains. There are combinations of these approaches and some certification schemes incorporate several. The following categorisation of approaches to agri-food certification is not precise. It is provided to help appreciate the range of approaches used.

Farm certification focuses on primary production on a whole-farm basis. The farm unit is the subject of the certificate. The certification schemes themselves, particularly those specialised in farm certification, are sometimes owned and run mutually by farmers. The recently developed Origin Green scheme in Ireland is owned and operated by a semi-state body (Bord Bia) and aims to provide coverage of all dairy farms in the Irish Republic. With farm certification generally, the production processes operating in each farm business are externally monitored and the farm as a whole is certified as reaching varying levels of environmental and social performance (incl. animal welfare). The required production standards range from rigorous adherence to the law (e.g. LEAF) through to organic farming standards that are distinctly different from 'conventional' production and defined as such in international law. The relevant farm certification schemes include LEAF (UK), Global G.A.P., Conservation Grade farming, UTZ, Origin Green (Ireland), Rainforest Alliance, and the organic farming certification schemes. Rainforest Alliance and UTZ aim to link land-use practices, business practices and consumer behaviour in the production of tropical crops, including coffee, bananas, cocoa, oranges, cut flowers, ferns, tea and palmoil.

Supply chain certification is closely related to farm certification and there is overlap between these (e.g. Rainforest Alliance, UTZ, Origin Green). Terms such as 'assured farm produce', or 'certified produce' are sometimes used to describe supply chain certification. The distinction between supply chain certification and farm certification is the certification applies to a specific product, generally up to the point of retail sale, rather than just the farm. At the farm level, this form of certification covers the relevant commodity or produce and does not necessarily require certification of other parts of the farm business, for example on a mixed dairy and arable farm, to operate to analogous standards.

Assured Food Standards is one of the most widely used supply-chain certification schemes in the UK, and the driver for its development came largely from the farm sector.

[112] European Commission (2010): Commission Communication — EU best practice guidelines for voluntary certification schemes for agricultural products and foodstuffs. Official Journal of the European Union. 16.12.2010

Food products meeting the standard are entitled to carry the Red Tractor logo. There is evidence in the literature that supply-chain assurance schemes are particularly strong in the UK where for example assured produce accounted for 60-90% of UK production by about 2005.[113]

Organic certification is also a form of supply chain certification that uses a strong component of farm certification. Most certified organic produce comes from farm businesses that are themselves certified as entirely organic.

Some of the best-known international certification bodies such as UTZ and Fairtrade are mainly certifiers of supply chains. Fairtrade is particularly focused on the social performance of supply chains and so addresses conditions in processing and trading businesses as well as on farms.

Commodity certification operates within specific commodity-based sectors and addresses the particular challenges of supporting certified production through large bulk-traded commodity supply chains. The context is the very open and large-scale commodity production systems and markets operating for example in soybeans and palmoil.

These schemes are based the identification of commodity produced to higher environmental, resource protection or social standards than that of commodity produced to the minimum local regulations. Food traders, manufacturers and retailers supporting this higher standard can claim to be using 'sustainable' sources. The certification itself may be based on assessments made at the individual farm level as it is in the case of soy, or at the level of the first processor, for example a palm oil mill linked directly to specific plantations.

A feature of commodity certification is their ownership and management by Roundtables. These bring stakeholders related to a specific commodity supply chain together. These include environmental NGOs who often play a leading role, retailers, food processors, and commodity traders and shippers. Membership of these roundtables is a feature of many relevant corporate social responsibility strategies. This membership may or may not come with a commitment to support certified production.

The Round Table on Responsible Soy (RTRS) is a multi-stakeholder initiative that certifies soy produced in compliance with defined social and environmental standards. The standards include adherence to good agricultural and soil management practices, standards of employee and community welfare, and avoidance of land recently converted from native forest. Soy is traded in large bulk lots within long supply chains. Keeping soy from certified production segregated is technically challenging and so the RTRS offers the

[113] Garcia, M. 2007. Economic analysis of food quality assurance schemes. The Red Tractor Scheme. European Commission.

opportunity to support certified production on a mass-balance basis or by purchasing credits. With mass balance, the RTRS undertakes to ensure that an equivalent quantity of certified soy has been produced for the soy actually purchased. In the case of credits, the purchaser buys credits with the soy which are passed on to certified producers. In this way the certified production is rewarded without the complexity of commodity segregation.

The principal objective of the Roundtable for Sustainable Palmoil is "to promote the growth and use of sustainable palm oil through co-operation within the supply chain and open dialogue between its stakeholders".[114] It was the first Roundtable to be established (in 2001) with a leading role played by Unilever and the WWF. The instruments used are similar to those used by the RTRS, including for example the opportunity to purchase Green Palm certificates.

Carbon certification

Carbon labels offer companies the possibility of communicating their performance in terms of GHG emissions to the customer. Their use is increasing with the development of more sophisticated carbon measurement systems.

Carbon certification is based on an estimate of emissions applied to products, processes or firms. Some certification schemes concentrate on estimates only. This is the case for carbon intensity and rating labels. Others require firms to take action to reduce emissions by reducing actual emissions or buying carbon credits (carbon offsetting). This is the case for low carbon and carbon reduction labels.

[114] RSPO 2013. How to be RSPO certified. http://www.rspo.org/en/how_to_be_rspo_certified accessed on 5 December, 2013.

Carbon off-setting

Carbon neutral labels additionally require carbon off-setting or compensation schemes (Table 3). Offsetting can be done through voluntary or compulsory schemes. Compulsory schemes are the clean development mechanism (CDM), or the EU emission trade and joint implementation scheme (UNFCCC). Voluntary schemes include amongst others the Gold, CarbonFix and VER plus Standards.

Table 3. Categorisation of carbon labels (from Walter und Schmidt)[115]

Carbon Intensity Label	Indicates the amount of carbon emitted in a product's supply chain.
Carbon Rating Label	Used by products within certain product categories. These products give rise to low emissions through in their value chains.
Low Carbon Label	Indicates companies that implement measures to reduce greenhouse gas emissions or products with small carbon footprints.
Carbon Reduction Label	Indicates the reduction of carbon emissions within a value chain.
Carbon Neutral Label	Used by products whose value-chain emissions are off-set by purchasing carbon credits derived from climate protection projects.

[115] Walter, S. und Schmidt., M. (2008): Carbon Footprints und Carbon Label – eine echte Hilfe bei der Kaufentscheidung? UWF Umweltwirtschaftsforum Vol. 16(3): 175-181. DOI: 10.1007/s00550-008-0082-3.

Table 4. List of available carbon standards (April 2013)

Standard **type**	**Labels**	**Certification body**	**What it does**	**Focus in food sector**
Carbon Intensity	Carbon Label	Carbon Trust	Analysis	Product
Carbon Neutral	Atmosfair	Stiftung Zukunftsfähigkeit	Analysis and compensation	Transport
Carbon Neutral	TÜV NORD CERT	TÜV NORD CERT	Analysis, reduction and compensation	Supply chain
Carbon Neutral	CarbonFree Certified	Carbonfund.org Foundation	Analysis, reduction and compensation	Product
Carbon Neutral	Carbon*Free*® Partner programme/events	Carbonfund.org Foundation	Analysis and CO_2-compensation	Product
Carbon Neutral	Carbon Neutral	The CarbonNeutral Company	Analysis, reduction and compensation	Whole supply chain
Carbon Neutral	Climate Neutral	myclimate (Swiss foundation)	Analysis and CO_2-compensation	Whole supply chain
Carbon Neutral	Climate performance	myclimate (Swiss foundation)	Analysis, reduction and compensation	Firm
Carbon Neutral	CO_2 neutral production process	Provamel	Analysis, reduction and compensation	
Carbon Neutral	CO_2OL	Forest Finance Group	Analysis, reduction and compensation	Product
Carbon Neutral	Green Index rating		Analysis, reduction and compensation	
Carbon Neutral	KlimaINVEST	Investment company KlimaINVEST	Analysis, reduction and compensation	Whole supply chain
Carbon Neutral	National Carbon Offset Standard	Low Carbon Australia	Analysis, reduction and compensation	Firmfirm
Carbon Neutral	No CO_2 Certification Program	Carbon Reduction Institute	Analysis, reduction and compensation	Whole supply chain
Carbon Neutral	Stop Climate Change	AGRA-TEG Agrar- und Umwelttechnik	Analysis, reduction and compensation	Firm
Carbon Neutral	SwissClimate "CO_2 Neutral"	Swiss Climate AG	Analysis, reduction and compensation	Firm
Carbon Neutral	Certification "Carbon negative"	Green Tick Certification Limited	Analysis, reduction and compensation	Firm
Carbon Neutral	Certification "Carbon neutral"	Green Tick Certification Limited	Analysis, reduction and compensation	Firm
Carbon Rating	Climatop	Climatop Association	Analysis	Firm
Carbon Reduction	Carbon Reduction Label	Carbon Trust	Analysis and reduction	Product
Carbon Reduction	Carbon Trust Standard	Carbon Trust	Analysis and reduction	Firm
Carbon Reduction	Climate certification for the food chain	KRAV Swedish Seal/Svenskt Sigill	Reduction	Product
Carbon Reduction	ABCERT Standard	ABCERT AG	Analysis and reduction	Whole supply chain
Carbon Reduction	Soil & More	Soil & More International	Analysis and reduction	Whole supply chain
Carbon Reduction	SwissClimate "CO_2 optimized"	Swiss Climate AG	Analysis and reduction	Firm
Low Carbon Label	Corporate Carbon Footprint	TÜV NORD CERT	Analysis	Whole supply chain
Low Carbon Label	SwissClimate " CO_2 footprint"	Swiss Climate AG	Analysis	Firm

Farm management and agricultural practices (in addition to certification schemes)
Many agri-food firms support on-farm measures outside agri-food certification schemes that could affect greenhouse gas emissions or pressurise or support their suppliers to do so. These include measures such as supporting conservation tillage, planting improved varieties, integrated pest management, precision irrigation, and innovation in feeding practice. It also includes awards and financial incentives for meeting certain environmental criteria, promoting the sharing of best practices among suppliers, supporting suppliers in implementing their own carbon assessment schemes, and raising awareness among suppliers of environmental issues. Some corporate social responsibility strategies include investment in farmer training directly and such actions are particularly relevant to strategies operated by food manufacturers who have tight links with farm suppliers, especially in sourcing fresh produce such as milk and vegetables. This is in addition to certification requirements on training.

Companies may also provide knowledge-based aids and tools. For example, the Cool Farm Tool is a farm-level greenhouse gas calculator for estimating net GHG emissions from agriculture that was developed by the University of Aberdeen with support from Unilever. It can be used as an incentive scheme because it allows simulating emission changes resulting from changes in agricultural practices on farm-level.

Technical efficiency in processing, manufacture and retail
Most corporate social responsibility strategies include technical measures to reduce the consumption of energy and other resources within the post-farm supply chain. These include energy conservation measures, use of renewable energy, reducing and optimising transport, reducing packaging, reducing and reusing waste. These efficiency measures have obvious internal benefits and give rise to cost reductions for the firms involved.

Sectoral cooperation, partnerships, platforms, and roundtables
In addition to managing commodity certification, many roundtables, fora, platforms and partnerships bring together people from several industries involved in the same food area. Depending on the type of institution and the level of individual engagement, activities range from contributing to exchange platforms and lobbying partnerships to establishing commitments among their members. Many are initiated by NGOs. The WWF and a number of leading food brand owners (e.g. Unilever, Nestle, Danone and Mars) have played a leading role in these.

Restoration of ecosystems
In the context of climate change mitigation, this is largely about restoring soil carbon stocks through for example re-wilding of farmed land, restoring forests or grassland, or rewetting drained peatland. These activities may be embedded in farm or commodity certification or may be incentivised indirectly through carbon off-setting. The overall effect in terms of greenhouse gas emissions is analogous to the reversal of changing land-use to agriculture

Investment in research

A number of large firms invest in research relevant to the goals of their CSR strategies. This includes research to improve agricultural production, including research in pre-farm activities such as plant breeding. There is also a wide range of research activities around carbon foot-printing and assessment at various levels.

Some research activities go beyond the direct interests of firms and extend to wider public interest topics such as climate change in general, diet and health, and general agricultural improvement.

Influencing consumer choice and demand

The carbon footprint at the consumer level is largely determined by diet, particularly the quantity and type of protein as determined by the intake of livestock products. Relevant measures could include marketing activities directed at supporting consumers in reducing the intake of carbon-intensive foods and low-impact local or seasonal food.

4. THE IMPLEMENTATION OF GREENHOUSE GAS MITIGATION ACTIVITIES

Chapter 2 of this report examines the sources of agri-food greenhouse gas emissions and options for their mitigation. Chapter 3 describes activities supported in corporate climate responsibility strategies relevant to reducing greenhouse gas emissions from the food system. This chapter examines the use of these corporate social responsibility activities using a sample of firms operating in agriculture and food. This provides the basis of an integrated assessment of the impact of corporate social responsibility in Chapter 5.

Selection of corporate social responsibility strategies for study

This study uses a purposive sample of firms with corporate social responsibility strategies and supporting instruments that potentially affect greenhouse gas emissions. Only firms in the agricultural and food sector in a wider sense, including processing (e.g. Arla) and catering (e.g. McDonald's) were sampled. The sampling strategy was based on a structured search process. Short interviews with industry experts were conducted to help identify firms that are involved in corporate social responsibility activities relevant to reducing greenhouse gas emissions. Reports by international governmental and nongovernmental agencies were also examined with the same aim. We then drew up a list of candidate firms and used size, type of firm and country of origin as criteria for inclusion in the sample. 40 firms were identified and included in the study (Table 4). This sample includes several of the major players such as Unilever, but also medium-sized firms such as Arla. The large players have significant market power and are thus particularly relevant for the global scale. Among the smaller companies we included companies from all stages of the supply chain. The information we used was obtained from these firms' corporate sustainability and corporate social responsibility reports and any related information from the company websites.

Table 5. The country of origin or base, the category of firm according to its position in supply chains, the number of greenhouse gas mitigation measures undertaken, and the type of ownership (publicly traded, private and mutually owned). Category 1 is firms with specific branded consumer products (e.g. Heinz). Category 2 covers firms that interact with consumers over a wide range of products in the retail and food services sector. Category 3 is commodity processors and traders. The ownership models are publicly traded private, and mutually owned. [a] The SRA (Sustainable Restaurant Association) represents a group of restaurants and does not easily fit into the categorisation.

Firm	Base	Category	Activities	Ownership
Associated British Food	UK	1	28	Publicly traded
Archer Daniels Midland	USA	3	25	Publicly traded
Alfred Ritter GmbH	Germany	1	5	Private
Arla Foods	Denmark	1	22	Mutual
Barilla	Italy	1	17	Private
Barry Callebaut	Switzerland	3	15	Publicly traded
Cargill	USA	3	75	Private
CocaCola	USA	1	22	Publicly traded
COOP	Switzerland	2	22	Mutual
Danone	France	1	8	Publicly traded
Del Monte	USA	1	12	Private
Ferrero	Italy	1	18	Private
General Mills	USA	3	18	Publicly traded
Glanbia	Ireland	3	13	Publicly traded
Gulpener Bier	Netherlands	1	3	Private
H. J. Heinz Company	USA	1	16	Private
Hershey	USA	1	9	Publicly traded
Hipp	Germany	1	13	Private
John Lewis Partnership	UK	2	34	Mutual
Kelloggs	USA	1	19	Publicly traded
Klasmann Deilmann	Germany	3	2	Private
Kraft Foods	USA	1	20	Publicly traded
Marks and Spencer	UK	2	33	Publicly traded
Mars	USA/UK	1	14	Private
McCain Foods	Canada	1	26	Private
McDonald's	USA	2	25	Publicly traded
Morrisons	UK	2	25	Publicly traded
Nestlé	Switzerland	1	35	Publicly traded
Peeze Coffee	Netherlands	1	5	Private
PepsiCo	USA	1	48	Publicly traded
PHW Group	Germany	1	7	Private
Provamel	Netherlands	1	11	Private
Sainsburys	UK	1	26	Publicly traded
Starbucks	USA	2	20	Publicly traded
Stora Enso	Finland	3	6	Publicly traded
SRA[a]	UK	NA	6	NA
Tesco	UK	2	12	Publicly traded
Tchibo	Germany	2	25	Private
Unilever	UK/Netherlands	2	32	Publicly traded
Walmart	USA	2	22	Publicly traded

We took two approaches to our analysis: qualitative and quantitative. These were conducted independent of each other. The qualitative examination of corporate social responsibility reports and related documents was done to examine commitment and effectiveness of corporate social responsibility activities in reducing greenhouse gas emissions. The activities identified are provided in Annex 1.

The quantitative assessment examined firms' published financial and other business data for relationships between firms' characteristics and their use of activities relevant to reducing greenhouse gas emissions. We recorded the number of GHG-related corporate social responsibility activities per firm and examined other criteria such as firm size and turnover in order to find out if certain characteristics of firms are correlated with corporate social responsibility efforts to reduce greenhouse gas emissions from the food system.

A quantitative and qualitative overview of mitigation-related measures

The 40 firms are supporting a total of 166 individual measures. The number of activities per firm is presented in Table 5. There are two caveats with this table. The activities of large firms may be under-represented because local activities operated by branches of the company may be overlooked in corporate reporting. Counter to this, large firms may have more sophisticated overall corporate social responsibility reporting and report more than smaller firms. We nevertheless believe that the data presented give a reliable general overview of engagement of firms in corporate climate responsibility.

Fourteen types of activities were identified. The number times the activities in these categories was recorded as used by the 40 sample firms was computed. The result is shown in Figure 7.

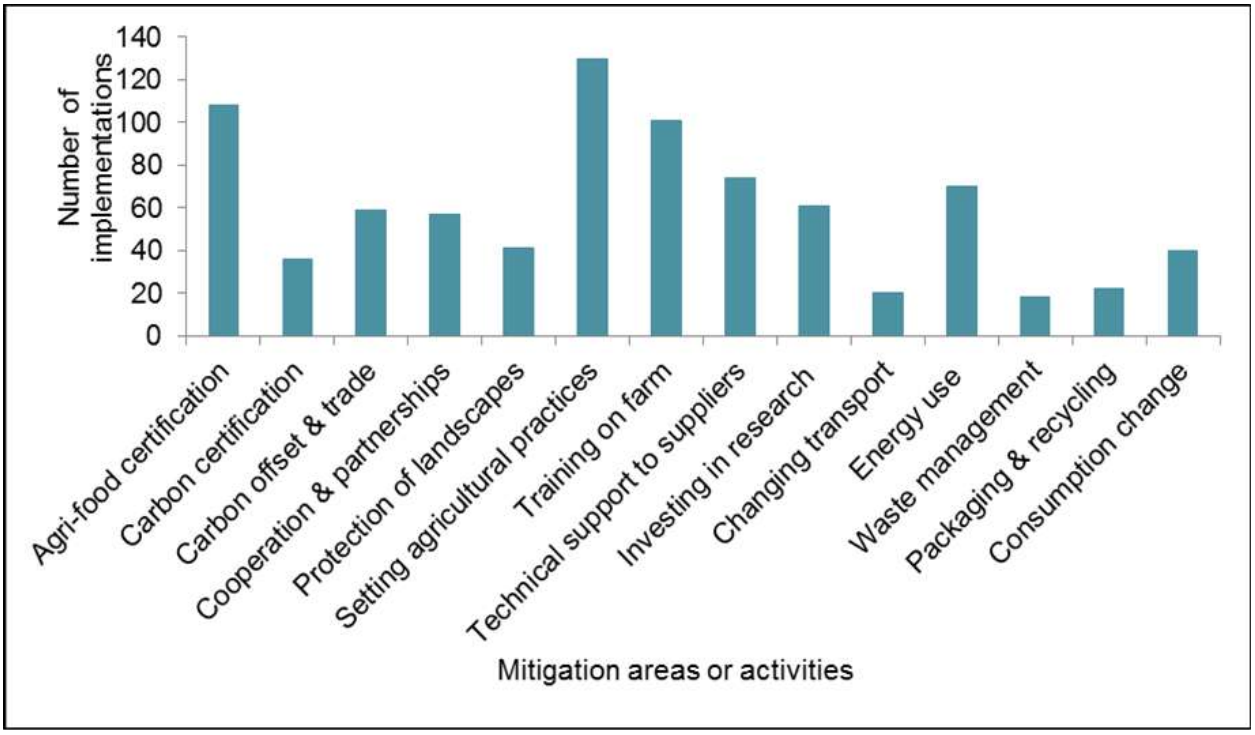

Figure 7. The number of cases of the implementation of greenhouse gas mitigation activities by the 40 firms in relation to mitigation areas or activities. The use of each of the 166 activities (Annex 1) identified is allocated to one of 14 mitigation areas or mitigation activities.

Agri-food certification

The use certified produce or commodities is common in our sample of firms, with firms supporting three certification-type activities on average. These include purchasing produce directly from certified farms; using organic or Fairtrade ingredients; purchasing certified commodities; and purchasing credits for certified production. The most widely used commodity certification is that for palm oil from the Roundtable on Sustainable Palm Oil with 23 of the 40 firms using it. Fairtrade is used by 19 of the 40 firms and is the most widely used commodity certification used. Certification by Rainforest Alliance is also widely used, as are a range of other certification schemes such as UTZ.

Carbon certification, carbon offsetting and trading

A wide variety of carbon certification schemes are used by 22 of the 40 firms. The Carbon Trust standard is the most popular with 5 firms reporting using it. Measuring the firm's own carbon footprint is common with 32 of the 40 firms engaging in it, either for single products or for the business as a whole. All of these firms also have a carbon reduction aim. 20 firms purchase carbon offsets or invest in carbon offsetting projects.

Cooperation and partnerships

We identified 57 examples of the use of cooperation, partnership and networking across the sample of 40 firms. A cooperation or partnership is defined here as an explicit arrangement with another firm or NGO for a specific purpose. They are often 'Round

Tables' and trust-based voluntary peer groups. NGOs such as the WWF and a number of leading food brand owners (e.g. Unilever, Nestle, Danone and Mars) have played a leading role in these. Activities range from knowledge exchange to establishing commitments among their members. These round table initiatives are also used for pre-competitive collaboration to address strategic goals. Membership has awareness-raising effects and there are benefits from shared insights and information. Round table organisations also operate certification programmes. It is possible to purchase or otherwise support certified produce without being a member of the relevant round table, and vice versa.

Protection of ecosystems

In the context of climate change mitigation, restoring ecosystems is largely about restoring soil carbon stocks through, for example, re-wilding of land, restoring forests or grassland, or rewetting drained peatland.[116] A few firms are involved in several activities and the majority involved in none at all. Those involved include large companies such as Nestlé and companies directly linked to forest ecosystems such as Del Monte and Stora Enso.

[116] Smith P., M. Bustamante, H. Ahammad, H. Clark, H. Dong, E.A. Elsiddig, H. Haberl, R. Harper, J. House, M. Jafari, O. Masera, C. Mbow, N.H. Ravindranath, C.W. Rice, C. Robledo Abad, A. Romanovskaya, F. Sperling, and F. Tubiello, 2014: Agriculture, Forestry and Other Land Use (AFOLU). In: Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Edenhofer, O., R. Pichs-Madruga, Y. Sokona, E. Farahani, S. Kadner, K. Seyboth, A. Adler, I. Baum, S. Brunner, P. Eickemeier, B. Kriemann, J. Savolainen, S. Schlömer, C. von Stechow, T. Zwickel and J.C. Minx (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Table 6. List of available carbon standards (April 2013)

Label type	Labels	Certification body	What it does	Focus
Carbon Intensity	Carbon Label	Carbon Trust	Analysis	Product
Carbon Neutral	Atmosfair	Stiftung Zukunftsfähigkeit	Analysis and compensation	Transport
Carbon Neutral	TÜV NORD CERT	TÜV NORD CERT	Analysis, reduction and compensation	Supply chain
Carbon Neutral	CarbonFree Certified	Carbonfund.org Foundation	Analysis, reduction and compensation	Product
Carbon Neutral	Carbon*Free*® Partner programme/events	Carbonfund.org Foundation	Analysis and CO_2-compensation	Product
Carbon Neutral	Carbon Neutral	The CarbonNeutral Company	Analysis, reduction and compensation	Whole supply chain
Carbon Neutral	Climate Neutral	myclimate (Swiss foundation)	Analysis and CO_2-compensation	Whole supply chain
Carbon Neutral	Climate performance	myclimate (Swiss foundation)	Analysis, reduction and compensation	Firm
Carbon Neutral	CO_2 neutral production process	Provamel	Analysis, reduction and compensation	
Carbon Neutral	CO_2OL	Forest Finance Group	Analysis, reduction and compensation	Product
Carbon Neutral	Green Index rating		Analysis, reduction and compensation	
Carbon Neutral	KlimaINVEST	Investment company KlimaINVEST	Analysis, reduction and compensation	Whole supply chain
Carbon Neutral Label	National Carbon Offset Standard	Low Carbon Australia	Analysis, reduction and compensation	Firmfirm
Carbon Neutral Label	No CO_2 Certification Program	Carbon Reduction Institute	Analysis, reduction and compensation	Whole supply chain
Carbon Neutral Label	Stop Climate Change	AGRA-TEG Agrar- und Umwelttechnik	Analysis, reduction and compensation	Firm
Carbon Neutral Label	SwissClimate "CO_2 Neutral"	Swiss Climate AG	Analysis, reduction and compensation	Firm
Carbon Neutral Label	Certification "Carbon negative"	Green Tick Certification Limited	Analysis, reduction and compensation	Firm
Carbon Neutral Label	Certification "Carbon neutral"	Green Tick Certification Limited	Analysis, reduction and compensation	Firm
Carbon Rating	Climatop	Climatop Association	Analysis	Firm
Carbon Reduction Label	Carbon Reduction Label	Carbon Trust	Analysis and reduction	Product
Carbon Reduction Label	Carbon Trust Standard	Carbon Trust	Analysis and reduction	Firm
Carbon Reduction Label	Climate certification for the food chain	KRAV Swedish Seal/Svenskt Sigill	Reduction	Product
Carbon Reduction Label	ABCERT Standard	ABCERT AG	Analysis and reduction	Whole supply chain
Carbon Reduction Label	Soil & More	Soil & More International	Analysis and reduction	Whole supply chain
Carbon Reduction Label	SwissClimate "CO_2 optimized"	Swiss Climate AG	Analysis and reduction	Firm
Low Carbon Label	Corporate Carbon Footprint	TÜV NORD CERT	Analysis	Whole supply chain
Low Carbon Label	SwissClimate "CO_2 footprint"	Swiss Climate AG	Analysis	Firm

Influencing farm practices

This is effort to support or require technical change on farms through the provision of training, technical support or the setting of practice guidelines that supplier farms have to follow, and even direct implementation of on-farm technical improvements. These activities of seek to improve technical efficiency with measures such as supporting conservation tillage, the adoption of new varieties, integrated pest management, precision irrigation, and innovations in feeding practice. Firms may require that their suppliers change specific practices or they may create awards and financial incentives for meeting certain environmental criteria. They may promote the sharing of best practices among farmers, support suppliers in implementing their own carbon assessment schemes, and in general raise awareness among suppliers of environmental issues.

The setting or implementation of standards or definition of key environmental performance indicators for suppliers; issuing supplier guides or best practice charta, toolboxes and the carbon assessment of suppliers/farmers are common. There are cases of the public sector stepping in to provide publicly-owned certification schemes which would support all relevant food industry players, for example Origin Green developed by the Irish Food Board which is a state-sponsored body in Ireland. Supporting the gathering of environmental data and promoting the sharing of best practices between suppliers are also mentioned frequently, whereas direct financial incentives and rewards for desired activities are not common.

There is a high correlation (0.75) between the use of different measures to influence agricultural practice and the use of training. These are also both positively correlated with certification, signifying that support of certification and training are often linked.

Investing in research

We recorded 61 cases of firms investing in research. Most support carbon assessment and foot-printing methodologies and improved agricultural practices. Generally, research activities are directly related to or support other measures. The research supported is often pre-competitive. One such example is the Cool Farm Tool from the University of Aberdeen which is used to estimate emission changes resulting from changes in agricultural practices on farm-level. Several firms have plant breeding programmes (e.g. Heinz and Del Monte) which may also involve pre-competitive research activity. Some research activities extend to wider public interest topics such as climate change in general, diet and health, and general agricultural improvement.

Technical supply chain measures: transport, energy use, waste management, packaging and recycling

Technical supply chain efficiency measures are focused on raising resource (in particular energy) use efficiency in processing, manufacturing, transport and retailing and optimising transport, reducing packaging, reducing and reusing waste.

All firms in the sample reported efforts to reduce energy use but many did not specify in detail how they achieve this. Own energy generation, mostly from waste, is mentioned by 21 firms. Other examples include installing solar panels (4 cases), improving cooling, heating or processing systems (5 cases).

15% of firms mention the use of recycled or environmental friendly materials and 20 % mention converting by-products or waste into feed. The use of FSC certified packaging material is by far the most common activity accounting for 59% of all cases. The relative infrequent mentioning of waste management, packaging and recycling may be to some extent due to the role of regulations in determining practices.

We recorded only 20 instances of measures focused on transport, implemented mainly by the large processors and retailers. This may be partly due to companies not reporting transport changes as part of CSR. Of the measures reported, reducing transport distance and moving from road to rail or ship dominated.

Consumption change
Measures influencing consumer choice and demand raises awareness among consumers or actively supports consumers in reducing the intake of foods that give rise to high GHG emissions in production. Firms may also engage in consumer education about waste reduction and prevention.

19 firms were identified as involved in activity related to consumption including promoting seasonal, organic**,** vegetarian food and educational activities around climate change, waste and food storage and environment in general. In our sample, this type of mitigation activity is supported mainly by retailers, caterers and firms with strong consumer brands.

Alignment of activities and climate protection challenges

We now turn to the question of the alignment of the corporate climate responsibility activities identified in these 40 firms and the sources of emissions in the food system (set out in Chapter 2). By assessing activities in relation to their relevance to the various stages in the supply chain, we can consider how well corporate climate responsibility activities are focused on the most important sources of emissions. For this we take the results of the study from Garnett of sizes and sources of emissions from the UK food system the UK[117] reported in Chapter 2 (these do not include an estimate for land use change). From our insight into the literature, we are confident that the results of this assessment of the UK food system are reasonably representative of food systems in developed economies. We allocated each use of a measure for each firm to one of the

[117] Garnett, T. 2008. Cooking up a storm. Food, greenhouse gas emissions and our changing climate. The Food and Climate Research Network.

nine supply chain areas and summed these for the whole sample. The allocation of these to each supply chain stage as a percentage of the total is shown in Figure 1 in relation to the percentage of supply-chain emissions from each stage according to Garnett. This shows that generally the emphasis of corporate climate responsibility efforts match the importance of emission sources, with a strong emphasis on primary production (farming). This however is a rough estimate since the allocation of activities to sources of emissions is not straightforward, and there are some exceptions to this conclusion. We found no examples of firms addressing food-related emissions from activities in the home, for example refrigeration and cooking. In addition some activities such as supporting certification may address several sources. Fertiliser manufacture, which is the largest source of pre-farm supply chain emissions, is not addressed directly by any firm in our sample.

In addition to the above analysis of alignment of measures to sources of emissions, the data set we assembled enabled us to examine stated targets and progress against them for most of the firms. The results of this are shown in Table 7.

It is important to note that these data are not suitable for comparing firms because the basis for the measurement of emissions as well as their scope varies widely. It is not a league table. Some firms account only for emissions from a certain product or production stage, or only from energy use. Others account for emissions from specific plants or factories. Some firms go as far as taking their complete emissions including indirect emissions, e.g. from land use change, into account for their emission reduction aims.

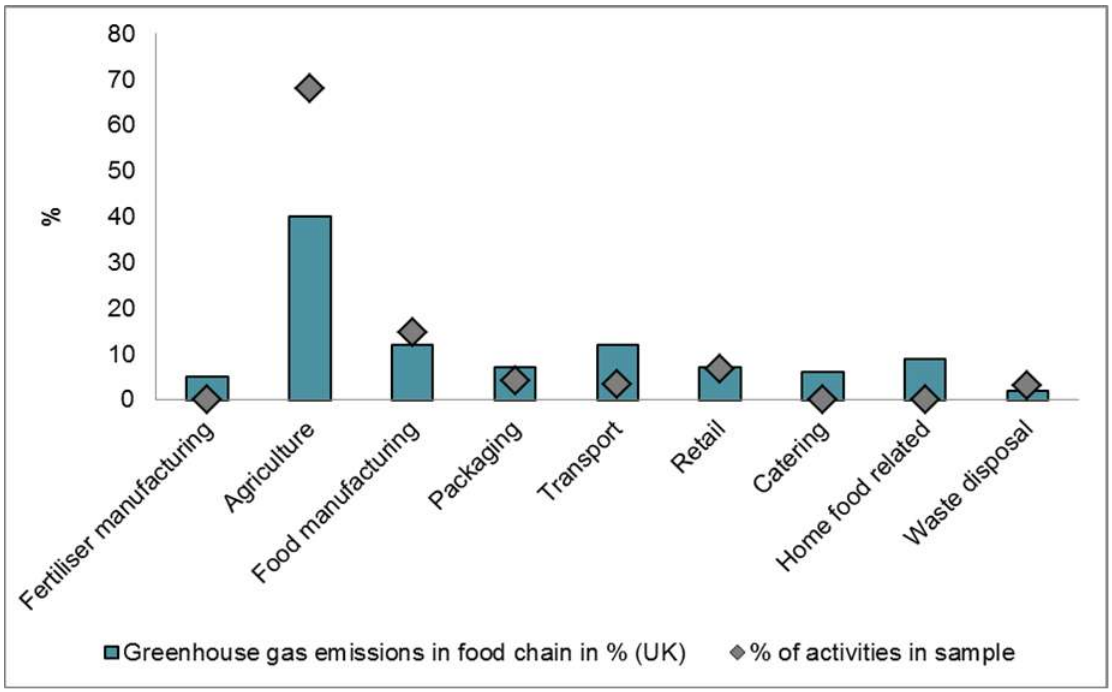

Figure 8. The proportion (%) of food-related greenhouse gas emissions from successive stages of the food chain (excluding land-use change – from Garnett 2008[118]) and the corresponding proportion (%) measures' targets in the firm sample.

[118] Garnett, T. 2008. Cooking up a storm. Food, greenhouse gas emissions and our changing climate. The Food and Climate Research Network.

Table 7. Summary of direct GHG emission aims and achievements as reported by the firms in the study sample (only firms for which aims were recorded in the database).

Firm	Emission reduction aim	Period	Achievements (where reported)	Basis of measurement and scope of emissions
ABF			22% carbon emission reduction 2009/10	varies with sub-firm
ADM	15%	2010 - 2020	2010-2012: 2.6% reduction in emissions; 4.3% reduction in energy use.	Operating energy use and emissions on per unit of production
Alfred Ritter GmbH & Co. KG			6,800 t CO_2 reductions yearly since 2002 through own energy production	
Arla Foods	25%	2005 - 2020		Operating emissions per unit milk
Barilla	55%; 30% for plants and main offices	2014 for plants and main offices	20% or 21% compared with 2008-2011, 19% in 2009-2011	Greenhouse gas emissions per t of finished product (for the 21%achievement), unclear for the target
Barry Callebaut	20%	2008/9-2013/4	19% carbon emission reductions 2008-2011	Operating emissions per unit of production
Cargill	5%	2010-2015	4.9% reduction to 2012	Operating emissions (firm)
Coca-Cola	Zero growth in emissions with output increasing	2004-2015	3% increase in 2011 compared to 2004	Operating emissions for the company (detailed analysis on transport, etc. level)
COOP	Carbon neutral by 2023	2008-2023	15% reduction from 2008-2012	Direct and indirect operations emissions
Danone	30%	2008-2012	35% reduction achieved	Company operating emissions
Del Monte	Processing 10%, transport 7%, packaging 11%	2007 - 2016 (2007 - 2011 packaging)	11% reduction in processing (2007-2011)	Company operating emissions
Ferrero	40%	2007 - 2020	12% reduction in per unit product emissions in 2010-2012	Company operating emissions
General Mills	20%	2005 - 2015	9% reduction in emissions per unit product	Company operating emissions
Glanbia	25%	-2020		Dairy supply chain
H.J. Heinz Company	20%	2005 - 2015	13.2% per unit of production	Direct emissions from operations
Hershey	13%	2009 – 2015	22% reduction 2009-2013, new target 15% (2013-2017), offset emissions for corporate and sales fleet in 2014	Company operating emissions
Hipp	Carbon neutrality		21% energy saving 1999-2011. Carbon neutrality achieved in Germany and Switzerland	
John Lewis Partnership (Waitrose)	15%	2010-2020	On target in 2012.	Company operating emissions
Marks and Spencer	35%	2006/7 - 2012/15	All stores, offices and warehouses in the UK and Ireland were carbon neutral by 2012. Gross CO2e emissions down by 22% by	Company operating emissions

			2012.	
Mars	25% overall. Eliminate GHG emissions from factories & offices (2040)	2007-2015, 2040	5% between 2007 and 2011	Company operating emissions
McDonald's	"aspirational" goal 20% increase in energy efficiency	2013-2020		Energy from company operations and company-owned restaurants in top nine markets.
Morrisons	30%	2005 - 2020	15% reduction in operational emissions 2005 – 2011	Company operating emissions
Nestlé	35%	2005-2015	Emissions declined 24% during 2002 – 2012	Operating emissions per tonne of product
PepsiCo	Stable emissions with business growth			Total operating emissions
PHW group	50%	by 2020		Product life-cycle emissions
Provamel			Production process is carbon neutral since 2010	
Sainsbury's	30 % absolute 65 % relative 50 % in food carbon footprints	2005 - 2020	3.7 % absolute reduction from direct and indirect sources from 2010/11 to 2011/12; 48,000 tonnes of carbon since 2007 through Farmer Development Groups.	Operational carbon emissions – absolute and relative to output; own brand products
Stora Enso	35%	2006-2025	Direct and indirect fossil CO_2 emissions from pulp paper and board production facilities reduced 26% from 2008-2012	Fossil CO_2 emissions per saleable tonne of pulp, paper and board
Tchibo	30%	by 2012	2006 to 2011: 30 % (transport, direct)	Transport emissions adjusted for sales and tonnage
Tesco	50% reduction in buildings' emissions by 2020. Zero carbon for internal emissions by 2050	2006-2020	Generally on or ahead of energy and emission targets	Operational emissions
Unilever	Energy emissions in manufacturing: at or below 2008 levels Manufacturing: reduction of 40% per tonne of production.	2008-2020	32% reduction in 2008-2013 in manufacturing sites (manufacturing accounts for 5% of value chain emissions). the total GHG impacts including consumer use, has increased by 5% since 2010.	Energy in manufacturing, manufacturing Revision of strategy ongoing
Walmart	20%	2005-2012	13% absolute reduction in GHG emissions in 2005.	Applies to a subset of facilities.

Firms' characteristics and their use of greenhouse gas mitigation measures

To identify patterns in the sample, we examined correlations between the firms' characteristics and their use of GHG mitigation measures. Relevant characteristics include the country or region in which firms are based or head-quartered, firm age, sector, ownership type, turnover, number of employees, or turnover per employee. The clearest observation is that firms with high turnover per employee tend to have fewer activities.

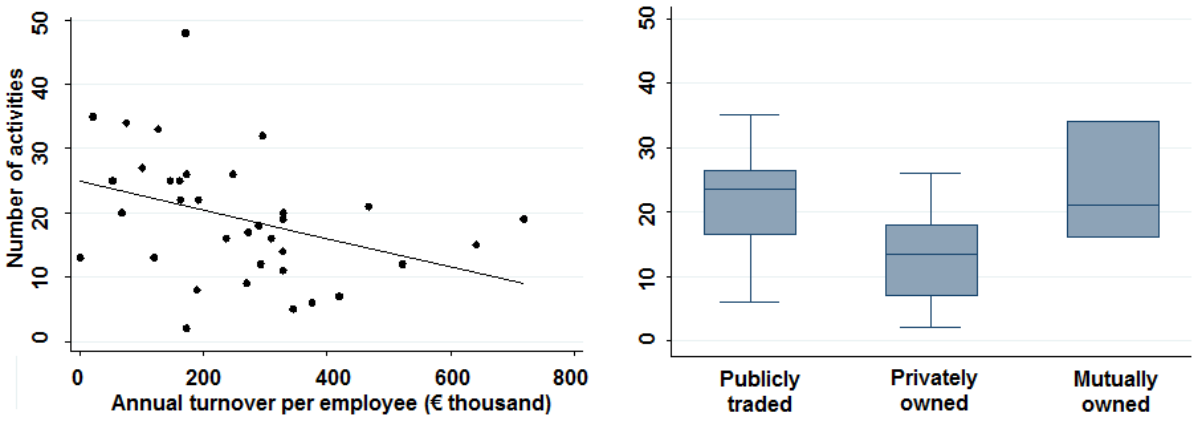

Figure 9. Number of firm CCR activities plotted against annual turnover per employee (left); number of activities in relation to the type of ownership (right). The line shows median, boxes represent 50% of data, whiskers represent 95%.

Labour intensity is typically high in the retail and food services sectors. These firms such as Walmart and McDonald's that address a wide range of supply chains interact intensively with consumers, and have valuable brands. As CSR is relevant to brand protection[119] there is a clear rationale for investment.

Differences in commitment to activities cannot be attributed to ownership models or to the differences in climate protection policy in the countries where firms were founded or are based. There is no statistically significant difference in our sample between different types of ownership in terms of number of activities (Figure 9, right). It might be expected that mutually-owned firms or publicly traded companies would be more active because they are under stronger public scrutiny, but our data for this sample do not support this supposition.

Firms' region of origin or base appears to play a slightly stronger role. Within our sample, UK-based companies engaged in a particularly high number of activities (Figure 10). In contrast, the firms based in France and Germany are characterised by engagement in

[119] Kitzmueller, M., and Shimshack, J. (2012). Economic Perspectives on Corporate Social Responsibility. Journal of Economic Literature, 50(1): 51–84.

relatively few activities and this means that the average number of activities of companies registered in continental Europe is lower than those registered in the UK and Ireland and this difference is significant (p-value 0.04).

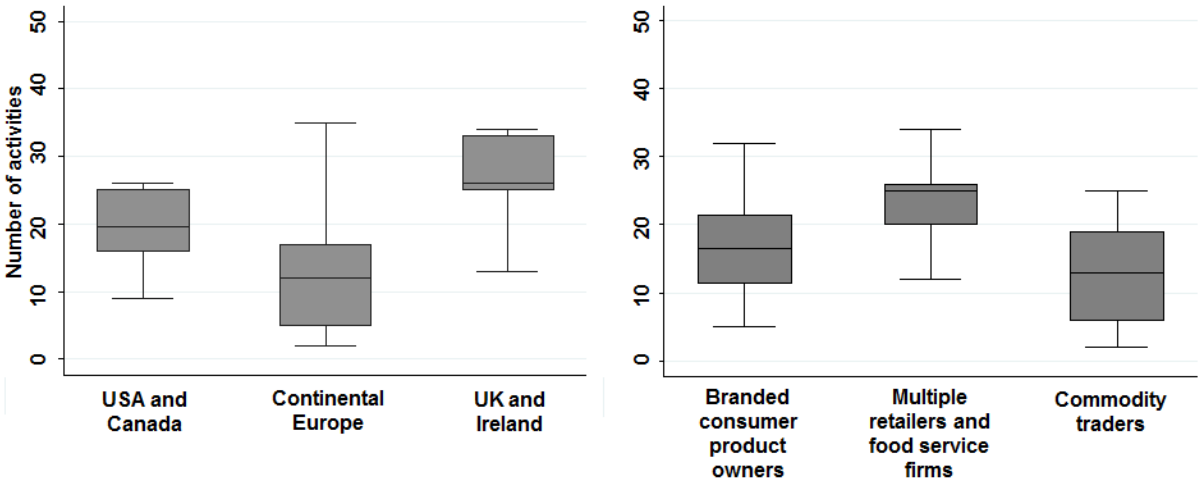

Figure 10. Number of CCR activities in relation to firms' country of origin or base (left) and their type of ownership (right). Line shows median, boxes 50% of data, whiskers 95%.

We also looked at the number of activities as affected by the relationship companies have with final consumers (Figure 10). This showed that the companies in Category 2 (Table 1) with direct contact to consumers over a wide range of products (in particular retailers and food service firms) engage in the largest number of activities. However, the difference between the categories of firms is not significant, and it is notable that Category 3 companies (commodity traders such as Cargill that are not visibly present in consumer markets) also support many CSR activities.

5. IMPACTS OF CORPORATE SOCIAL RESPONSIBILITY ON GREENHOUSE GAS EMISSIONS

Food and climate change: a challenge for markets and food systems

The UK government's Review on the Economics of Climate Change (The Stern Review) identifies climate change as the greatest and widest-ranging market failure ever seen.[120] Stern's assessment sums up the fundamental challenge facing those seeking to reduce greenhouse gas emissions through corporate responsibility. A stable climate is a global public good impacted on by emissions that have the same global impact regardless of origin or cause. With such profound market failure, it is difficult to justify private investment in mitigation, particularly for in agriculture where many emissions are not directly related to internal costs such as energy use. This lack of a link to internal energy-related processes (compared with other parts of the economy) is a particular feature of emissions from food production due to the dominance of emissions from carbon dioxide from land use change, and nitrous oxide and methane from the underlying biological processes.

A feature of the challenge of climate responsibility in the food sector is the complex nature of the causes of greenhouse gas emissions in the food system, compared with for example the steel industry. There are complex interactions between biological processes, land use and consumption choices. Sonigo et al.[121] present a model of the impact of measures to improve the resource use efficiency of food systems as affected by time and the hierarchy of levels of change – product and process improvement, technology change, and system change. They make the point that the greatest improvements require system change over long time periods (Figure 12).

[120] Stern, N. (2006). Stern Review on The Economics of Climate Change. HM Treasury, London.

[121] Sonigo, P, Bain, J., Tan, A., Johansson, L. Murphy-Bokern, D. Shields, L., Aiking , H., Erb, K., and Kastner, T. (2012). The resource use efficiency of the European food cycle. Report for the European Commission Report for the European Commission.

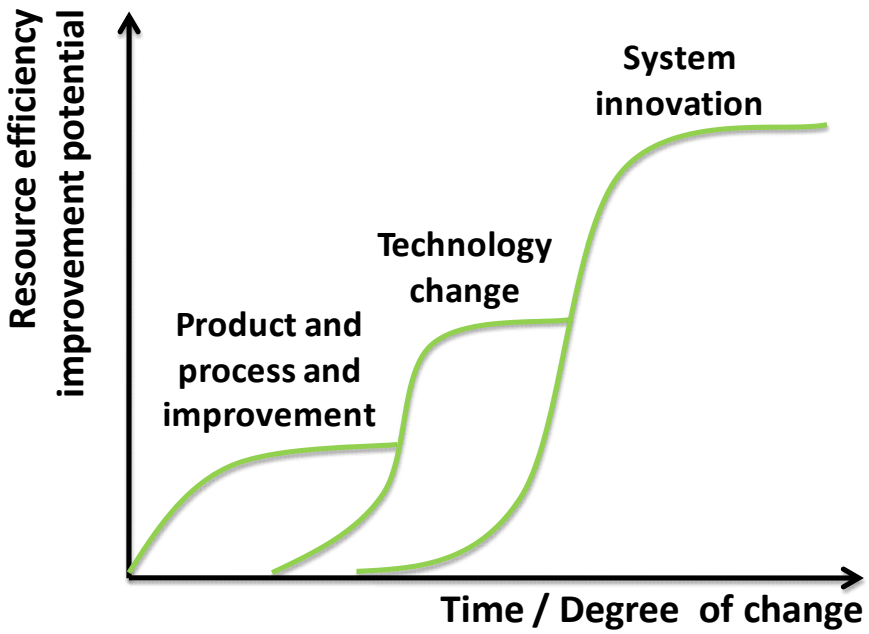

Figure 12. Resource efficiency improvement potential at different levels of system change over time.

This chapter provides an integrated and largely qualitative assessment of how corporate social responsibility in the agri-food sector addresses these challenges. First we summarise effects on each stage of the food system. Then we examine the ambition and reach of the corporate social responsibility strategies. Lastly, we provide an assessment of how the balance of investment in public and private goods and the financial strength of firms.

Impacts of corporate social responsibility on the major sources of greenhouse gas emissions in the food system

Here we make an integrated assessment of the effect of corporate social responsibility on the major sources of emissions on a life-cycle basis: land use change; pre-farm; agricultural production; post-farm processing, manufacture and retail; and consumption.

Land use change

This is a large source of emissions, comparable with the total direct emissions from the growing of crops and the production of livestock. There is interaction between the direct and indirect forces driving land use change. The critical question is what effects have corporate social responsibility activities had on the underlying forces causing land use change, particularly at the frontier between farmland and the forest. CSR addresses the drivers behind land use change through four major measures:

1. the purchase of segregated produce such as soybean and meal, and palmoil from 'sustainable' production;
2. encouragement of sustainable production through purchasing 'sustainable' commodity on a mass balance basis;
3. supporting sustainable production through purchasing credits; and
4. promoting good agricultural practice to increase productivity thereby reducing pressure on agricultural expansion.

The first three depend on commodity, produce and farm certification. The overall effect at farm level is the provision of higher or more stable economic returns to 'responsible' producers than is provided by the open uncertified commodity market. The acid test of this can be summarised in three questions:

- do corporate social responsibility activities result in a disincentive to 'irresponsible' production, for instance a disincentive to produce on recently or illegally cleared land?
- is there a significant premium for the certified produce of 'responsible' producers compare with produce from those not certified as responsible?
- is the demand for certified commodity and produce large enough to support significant change in land use?

The evidence that these questions can be answered positively is, in general, weak. For soy, certified production remains a small proportion of the total soy output (about 2%). The situation with palm oil is somewhat better in terms of market share with RSPO certification accounting for 18% of global production[122] and a steadily rising commitment on the part of the food industry to certified production. However the palmoil certification effort is criticised for weak standards in relation to land use change.[123]

Unlike soy, which has concentrated markets for international trade in China and Europe, the market for palmoil is dispersed and influenced by demand in developing economies such as in Africa and India. Furthermore, while Europe (which is responsible for about 16% of the palmoil market) leads in terms of supporting certification, it is particularly important that certification impacts on markets in developing economies. The efforts of members of the Roundtable on Sustainable Palmoil such as Cargill to influence Chinese customers is particularly significant in this context to overcome commodity swapping that can undermine the effect of certification on land use change in particular.

For both soy and palmoil, there is little evidence of significant premia being paid for sustainable produce so the direct incentive for producers to join certification schemes and

[122] Sustainable Palm Oil Platform (http://www.sustainablepalmoil.org/) accessed in June 2015.

[123] How the Palm Oil Industry is Cooking the Climate" (2007).greenpeace.org. Greenpeace International.

meet their standards is low.[124] However, these commodity certification schemes provide technical support to producers raising yields, reducing costs, and improving conditions for workers. In addition, small-scale certified producers are networked and this provides mutual support in improving their production practices. These less tangible benefits have two effects on greenhouse gas emissions: they are indirect rewards for producers who avoid the most damaging land-use change and they increase productivity reducing land use change pressures in the longer-term. UTZ, which certifies coffee, tea and cocoa, emphasises these benefits.

In assessing impacts on land use change, commodity and produce certification should not be considered in isolation from other measures. Recent developments in Brazil indicate that a quasi-regulatory approach in the form of the ABIOVE moratorium on soy from land which has been illegally cleared in the Amazon biome[125] has had a significant impact on deforestation. Instead of certifying 'responsible' produce, this moratorium approach blocks access to markets. Since the moratorium was introduced in 2006, deforestation in the relevant regions has declined significantly. It is noteworthy that the moratorium included two important flanking measures: the collaboration with public authorities in supporting the acceptance and enforcement of the Brazilian Forest Code, and technical support of producers. In considering this it must be remembered that some of the moratorium partners have key positions in these remote parts of the supply chains and unlike in most other supply chains, they can deny producers access to transport and processing infrastructure and thus all markets. There is some empirical evidence emerging that the combination of controls on deforestation, certification in CSR and improvements in farm practice are associated with very significant reductions in deforestation in Brazil, which is the major source of soy for Europe.[126]

Reducing emissions from pre-farm activities

Pre-farm activities account for 1-2% of total greenhouse gas emissions, and these emissions are dominated by the manufacture of nitrogen fertiliser. There are differences in efficiencies in production with the low emissions per unit nitrogen output recorded in Europe. This study has not identified any examples of direct efforts to reduce pre-farm emissions. All measures that increase farm efficiency have this effect indirectly, particularly those aimed at increasing nitrogen use efficiency. Even here, CSR measures on nitrogen use efficiency and reducing the impact of agriculture on the nitrogen cycle are

[124] Garrett, R. D., Rueda, X. and Lambin, E.F. (2013). Globalization's unexpected impact on soybean production in South America: linkages between preferences for non-genetically modified crops, eco-certifications, and land use. Environ. Res. Lett. 8.

[125] Cargill (undated). Responsible soy production. Ensuring responsible soy production in the Amazon.

[126] Macedo, M. N., de Fries, R., Morton, D.C. Stickler, C.M., Galford, G.L. and Shimabukuro, Y.E. (2012). Decoupling of deforestation and soy production in the southern Amazon during the late 2000s. PNAS 109 (4) 1341-1346

rare. The Irish farm assurance system Origin Green gives attention to nitrogen use efficiency but it is noteworthy that this is an industry-wide public sector initiative.

Emissions from agriculture

Emissions from agriculture are dominated by loss of carbon from soils in cultivation, nitrous oxide from agricultural soils elevated by nitrogen fertilisation and by methane from ruminants and livestock manures. The size of these emissions in a food system as a whole is strongly related to the reliance of the system on animal-based products.

Our analysis shows that corporate social responsibility strategies focus on on-farm activities. They are the primary focus of the full range of certification schemes and also of direct interaction with farmers. The requirement to use practices that optimise responses to inputs used within the legal framework (especially plant protection products) and the provision of technical support is a major component of almost all these activities. These seek to increase production efficiency and reduce local environmental impacts. Corporate measures that target underlying emission processes directly: the loss of soil organic matter; the efficiency of the nitrogen cycle; animal feeding, and system changes that reduce emissions over and above legal requirements are rare. As with the effect of certification on land-use change, the improvement in the technical performance of farms has indirect effects on greenhouse gas emissions by raising resource use efficiency and yield. Even if activities are not directly impacting on major emission processes, some of this technical support includes technology to enable farmers estimate farm-level greenhouse gas emissions, such as the provision of the Cool Farm Tool. This type of support has the potential to significantly raise farmers' awareness of the effect of their decisions on emissions and to achieve reductions through technical improvement in the longer term.

Emissions from processing, food manufacturing and retail

This covers emissions that arise directly from the operations of the firms we studied. So the firms have direct influence over these emissions. They typically account for 30 to 50% of food system emissions (excluding land use change).

Energy use is by far the greatest source of these emissions and so mitigation is directly coupled to potential cost reductions. Reducing these emissions through improving energy efficiency and installing renewable energy technology into systems and buildings is part of all corporate social responsibility strategies we have examined. Targets to reduce emissions by 10 – 20% over 5 – 10 years are typical (Table 9). Above these targets relating to internal technical change, some companies also use carbon certification to off-set emissions further.

Our study indicates that corporate social responsibility is associated with significant reductions in energy use across the companies we have looked at. A very wide range of energy saving technologies have been adopted and there is also evidence of some

investment in system changes, such as transferring freight from road to rail. Energy efficiency has been factored into long-term investments such as the LEED green building certification.[127] The emphasis on energy efficiency is common to all types of companies we examined regardless of size and where they are registered. However, it is notable that companies based in Germany and Switzerland that have relatively ambitious energy policies and tend to report more progress in reducing energy-related emissions.

Product life-cycle assessment (LCA) is now widely used by companies to monitor performance and communicate this to consumers. In the context of corporate social responsibility in the food system, this is most widely seen in the carbon foot-printing of food products. There is a risk that some reports of emission reductions arise merely from methodology, particularly assumptions on the allocation of emissions to co-products and system boundaries. The PHW Group uses LCA to monitor the progress of its corporate social responsibility strategy and aims to reduce the life-cycle emissions from poultry production by 50% by 2020. They already report low levels of emissions per unit of poultry meat, compared to the academic literature. This is due in part to the assumption that a switch to electricity procured over the public network under green tariffs eliminates electricity-related emissions from processing. It is also assumed that the plant nutrients in the manure from the growing poultry offset manufactured fertiliser nutrients. Regardless of the discussion about these allocations, the use of life-cycle assessment over a supply chain in this way is an example of a valuable strategic and systems-level approach.

Some of the strategies we have examined incorporate quite far-reaching measures to reduce these emissions, most notably large retailers in Europe. The British retailers John Lewis, Marks and Spencer, Morrison and Tesco all have ambitious programmes to reduce emissions from their operations with investment in energy saving technologies, more efficient refrigeration, more efficient transport, and renewal of the building stock. The Marks and Spencer Plan A Programme (which incorporates the whole supply chain) is one of the more far reaching of these and it is now reported to delivering financial benefits to the business.[128] Because of the high visibility of these businesses to consumers, these activities may have impact outside their own supply networks and extend to raising awareness of climate protection generally.

However, even the companies with the ambitious efforts rarely go beyond technical change to existing supply systems. We found no example of efforts to change the food systems fundamentally. For example, the chilled and frozen food supply and consumption system is resource, energy and greenhouse gas intensive.[129] There are no efforts to

[127] US Green Building Council.

[128] Marks and Spencer, 2013. Your M&S Plan A Report.

[129] Garnett, T. 2007. Food refrigeration: what is the contribution to greenhouse gas emissions and how might emissions be reduced? A working paper produced as part of the Food Climate Research Network. April 2007.

dampen the expansion of this sector in favour of fresh food or food preserved in other ways.

Consumption

A large body of evidence has emerged over the last decade that shows how changes in consumption are a robust approach to reducing global greenhouse gas emissions from the food system.[130] The two main components of such consumption change would be a switch to a more plant-based diet and reduced use of refrigeration.

Our study identified no corporate social responsibility activities that would support such change. This extends to businesses that have little or no stake in particular types of consumption, for example retailers who sell all types of food. Some retailers emphasise their support for locally supplied food, and this may be interpreted as a potential contribution to mitigation. However, there is consensus that reducing 'food miles' is not an effective mitigation measure. In the case of British retailers such as John Lewis, promotion of local food means promoting the consumption of British meat and dairy products.

The lack of attention to consumption even extends to businesses with strong plant-based food brands. Similarly, the growth in the market for frozen or chilled ready-made meals and similar food products is not challenged in any way by corporate social responsibility.

The ambition of corporate social responsibility strategies

The system-nature of the challenge in the food system is due to many interacting processes and many potential points of intervention where emissions of greenhouse gases can be addressed. There are "win-wins" for investment in mitigation in many cases and measures leading to these are more likely to be adopted in corporate social responsibility schemes compared with measures that bring only external benefits.

Strategic ambition and reach within the food system

We classified the corporate social responsibility strategies according to two dimensions to assess their ambition to reduce emissions. The first is the potential of the activities to drive fundamental change. Here we assess how far schemes aim at radically redesigning production processes, developing new products, and encouraging consumption change compared with incremental improvement of existing processes or products. The second dimension is the scope of activities. Here we ask whether the sample firms' corporate social responsibility strategies cover single products or processes or whether they are inclined to address whole firm activities and value chains, including their suppliers and

[130] Scarborough, P., Allender, S., Clarke, D., Wickramasinghe, K. and Rayner, M. 2012. Modelling the health impact of environmentally sustainable dietary scenarios in the UK. European Journal of Clinical Nutrition. 66:710-715.

customers. We assessed each firm's approach in a qualitative way based on publicly available information on firms' websites and in their corporate social responsibility reporting. We placed each firm in relation to the two scales described above to identify the location of each firm in relation to four spaces (Figure 10). Only clear commitments were taken into account.

The position along the X axis reflects the efforts made to change agri-food systems in a fundamental way. We can use three examples from outside the food sector to describe cases of companies moving to the right. Some energy companies are moving from the mere delivery of fuels to the provision of energy services which opens up opportunities to invest in radical energy saving approaches. The second example is the clothing company Patagonia which has a "natural growth" programme which advocates buying less. The third example is from Marks & Spencer which has a clothing re-use programme called Shwopping.

Box schemes in which suppliers deliver fresh produce directly to consumers is radical business model in that it re-orientates consumers onto what is available with the producer leading on choice. Parts of the organic sector represent a radical re-shaping of the food system in the exclusion of most external inputs and the reorienting of resource flows.

This classification results in four types of corporate climate responsibility programmes illustrated in Figure 11. It must be emphasised that Figure 11 should not be regarded in any competitive sense. Comparisons between firms on the basis of position in this matrix should be avoided. The message that can be drawn is that overall in our judgement the majority of firms in our sample are focused mostly on incremental product or process improvement. Corporate climate responsibility programmes that have the potential to initiate radical change are confined largely to companies in niche areas, for example those associated with the organic sector. Because of the niche character of these firms and because they are driven by other aspirations (e.g. expansion of organic food) which are not necessarily well aligned to reducing greenhouse gas emissions, the potential impact of these more radical programmes on greenhouse emissions is generally low.

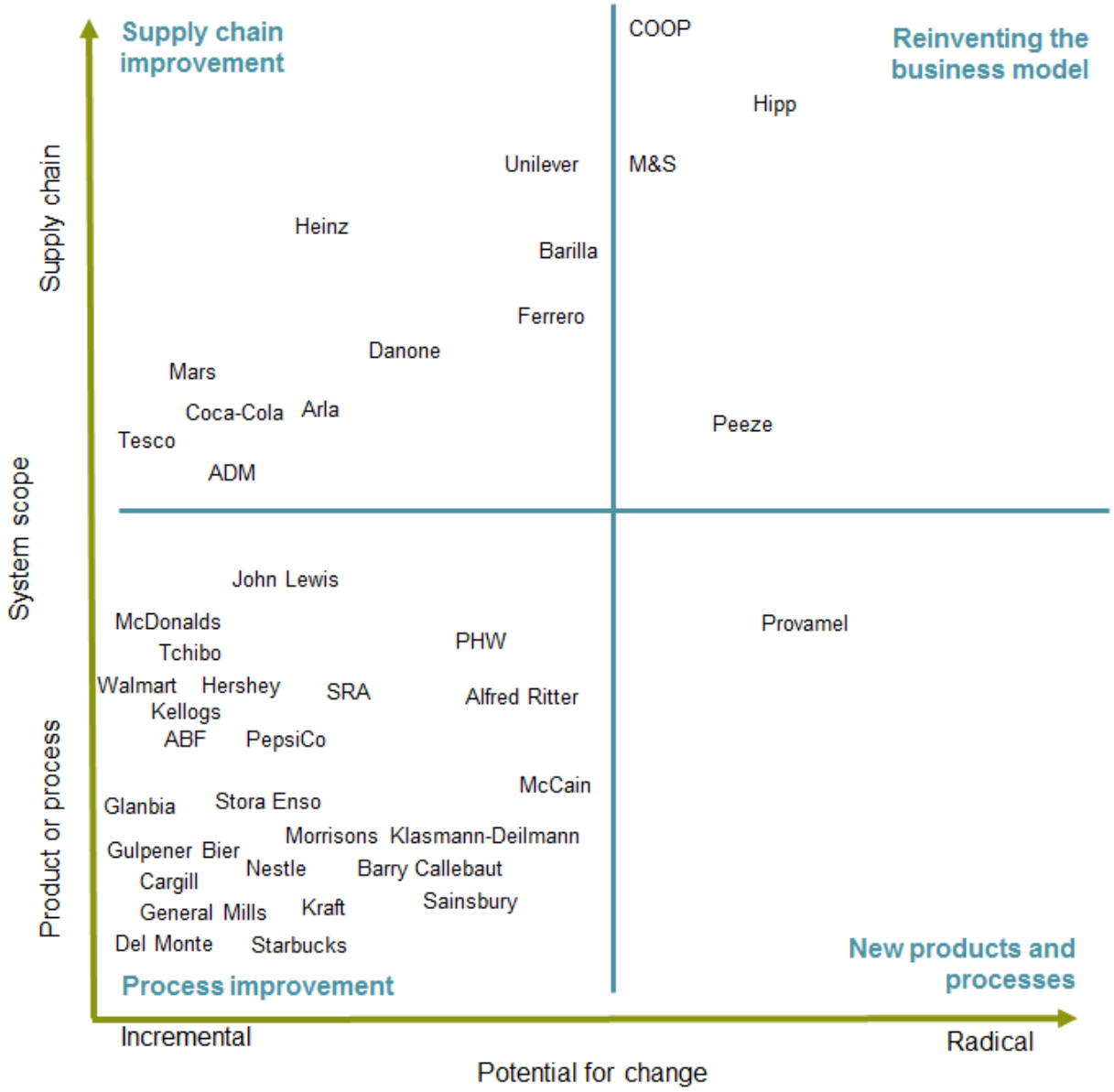

Figure 11. Classification of corporate climate responsibility programmes in relation to the potential for change their scope over the firms and their supply chains.

6. OUTLOOK AND RECOMMENDATIONS

Farming and food: a sector in transformation

With respect to corporate social responsibility, our study reveals a global agri-food sector in transformation. Almost all of the firms we examined have introduced corporate climate responsibility strategies and activities in the last decade. These efforts are still new, with many firms now reporting just the early phases of efforts to reduce greenhouse gas emissions. Here we examine the prospects for sustaining these developments and provide thoughts on bringing corporate climate responsibility forward.

What are the drivers and will these be sustained?
It is remarkable that the development of these strategies and activities continued during the global financial crisis of 2007 to 2010. From this and our examination of firms' strategy documents, we conclude that the drivers behind corporate social responsibility are central to firms' strategies and not marginal or passing activities. Many current strategies set out plans to extend current activities. This growth is particularly clear in terms of the use of certified produce with targets to reach 100% by 2020 common. Similarly, reductions in energy use in operations of up to 20% by 2020 are also common.

Our analysis reveals few patterns. Differences in firms' commitment to activities cannot be attributed to ownership models or to the differences in the political consensus in the countries where firms are strongest or registered. Our observations confirm the view of that corporate social responsibility relevant to greenhouse gas emissions is strongly rooted in Anglo-American business culture.[131] The British-based companies in our sample are particularly committed and this may be related to some measures that have emerged in the UK such as the Assured Farm Produce certification scheme that accounts for 70% of British farm produce consumed in Britain. It is also associated with the sector-wide efforts in sustainable development that emerged after the BSE crisis of the 1990s.[132] [133] The British government's response to past crises included a substantial role for partnerships in the private sector. British-based companies such as Unilever and Mark & Spencer have strong corporate social responsibility programmes. US-based companies with a strong presence in the UK such as Mars are also characterised by engagement in a wide range of activities.

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[131] Becchetti, L., Ciciretti, R. and Conzo, P. 2013. The legal origins of corporate social responsibility. CEIS Tor Vergata Research Paper Series. Vol. 11 (12), No. 291. October 2013.
[132] The Policy Commission on the future of farming and food. (The Curry Report). 2002. The future of farming and food.
[133] Defra 2002. Strategy for stainable farming and food.

While there are some marked differences between companies, we can identify two main drivers behind food-based corporate responsibility: internal cost reduction and brand enhancement. Efforts are also driven by moral codes which seek peace of mind. By 'peace of mind' we mean efforts which go beyond explicit management of specific risks to include a more general and positive engagement with best or better practice with immediate wide ranging benefits in supply chains. The relations between these are set out schematically in **Error! Reference source not found.**.

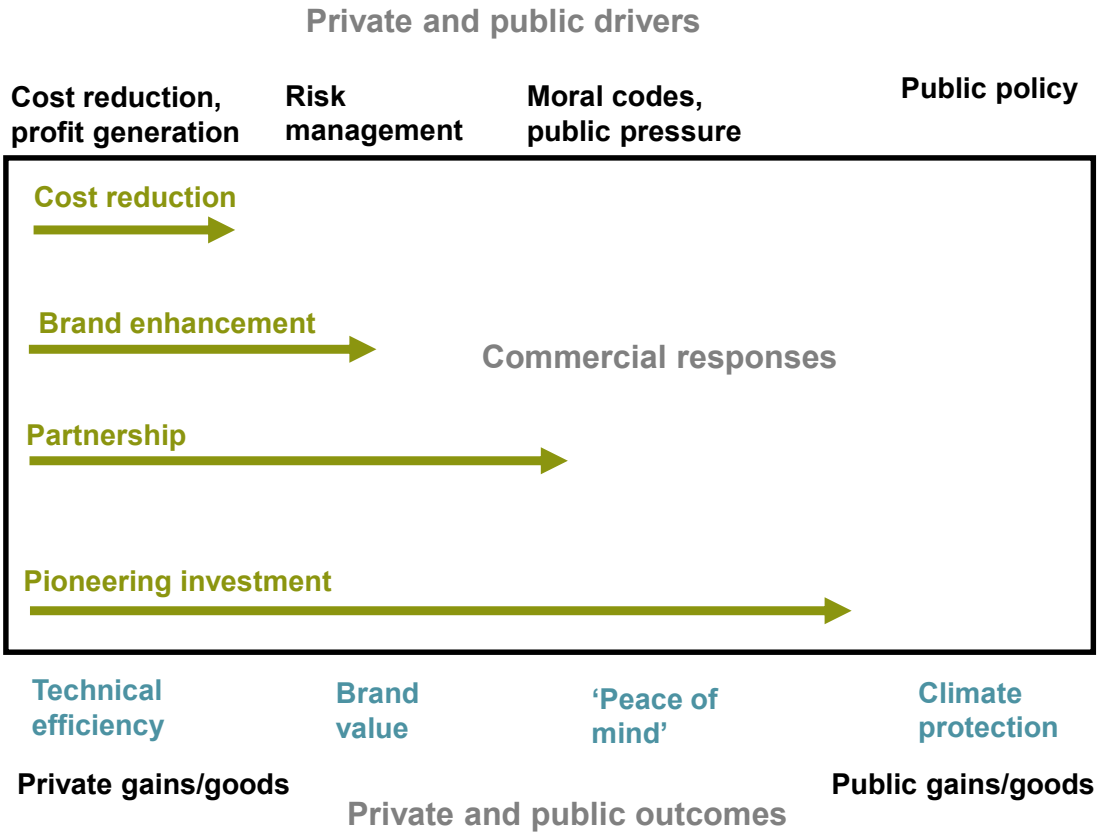

Figure 12. A schematic of external drivers, firms' drivers and outcomes governing the development and delivery of corporate social responsibility strategies relevant to greenhouse gas emissions.

We have identified four types of responses on the part of firms: cost reduction; brand enhancement; support of mutuality and partnerships; and pioneering investment. There is no way of categorising firms clearly in relation to the four levels of response. Patterns in the support of climate-related corporate social responsibility are also difficult to identify because corporate climate responsibility is predominantly added on to existing strategies originally focused on social and other environmental goals. However, we can try to identify some patterns in a qualitative way.

Cost reduction. All the firms in our sample pursue corporate climate responsibility to the level justified by cost controlling. We observe that this is particularly common in Germany where firms have brigaded and framed their economically rational responses to local regulation and their responses to subsidised renewable energy in terms of corporate climate responsibility. The PHW Group factors the production of subsidised electricity from photovoltaic panels mounted on the farm buildings it uses into its corporate social responsibility position. Similarly it highlights its use of biodiesel derived from the poultry fat arising in its processes. PHW also uses life-cycle assessment (using specific assumptions) to quantify and communicate the effects of these resource management practices and assumptions to stakeholders. It identifies nitrogen use as a key component of emissions providing the foundations of the further development of supply chains. Similarly for Klasmann Deilmann regulations governing the exploitation of peatland has influenced their corporate climate responsibility efforts, supported by investment in energy efficiency. They too pioneered the use of life-cycle assessment in their sector. Alfred Ritter GmbH is heavily focused on the use of renewable energy and energy conservation to the extent that the company is prepared to invest up to a point that involves 15% higher overall energy costs at current prices.

Brand enhancement. Corporate climate responsibility efforts that go beyond internal efficiencies can be largely justified by brand protection and brand enhancement. This includes the management of reputational risks. Brands are therefore the primary economic driver. While this driver is felt directly by those firms with highly visible and therefore valuable and vulnerable consumer brands, our study indicates that this is passed effectively along the supply chain to commodity traders such as ADM, Cargill and Barry Callebaut. The result is that retailers (who all now have strong own-brand food products), manufacturing firms with branded products, and firms that are not known by consumers are active to a similar degree in corporate climate responsibility.

Commodity certification and the sourcing traceable supplies are closely connected with each other. Security of supply of high quality produce is therefore a second driver behind supply-chain management activities closely associated with certification. The major food manufacturers such as Nestle, Unilever, Kraft and Heinz all engage in supply chain management activities that are closely related to certification. These are partly and increasingly driven by long-term quality and security of supply considerations. These link informed self-interest, brand enhancement and mutuality and partnership as interconnected drivers.

Partnership. A wide range of firms claim to strive for mutual benefits. Partnerships address pre-competitive targets that are central to ambitious corporate climate responsibility. The framework for mutual cooperation to address pre-competitive targets is developing in the food sector. Much of this is based on commodity Roundtables which also manage certification schemes. Here we must distinguish between supporting certified production by purchasing certified produce or certificates from membership of the

associated roundtables. It is possible to purchase certified produce without being a member of the relevant round table, and vice versa.

These fora and partnership activities are developing with different degrees of ambition with the Roundtable for Sustainable Palm oil now reaching a position where its members could collectively influence land use in the major exporting countries. The Sustainable Agriculture Initiative complements the Roundtables providing a platform for 50 global food companies with a focus on arable and vegetables crops, beef, coffee, fruit, and water in agriculture. So far, the Initiative is focused on cooperation to promote good farm practices. The Initiative is strongest in the dairy sector where its members claim to be involved in 85% of global commercial milk production.

Pioneering investment. Pioneering investments have a pre-competitive character in the sense that they have a potential for long-term impact on emissions but bring no immediate benefit for the individual firm. A combination of firms' internal moral codes and external public pressure has supported the pioneering work of companies that have a long tradition in corporate social responsibility. We found many individual examples of pioneering pre-competitive activity but it is difficult to identify these pioneering firms as a distinct group. Companies such as Mars support mutual development ('shared value') within the business and along their supply chains. This has helped place Mars at the forefront of developing sector-wide pre-competitive activities to advance public agendas. Cargill, operating in competitive commodity markets might not be expected to be a leader in climate-relevant corporate responsibility. However, Cargill too has actively participated in pre-competitive activity through for example the ABIOVE moratorium on soy associated with deforestation in Brazil. Barilla has supported pre-competitive research and communication on healthy eating that could indirectly reduce food-related greenhouse gas emissions. A range of food companies are also involved in plant breeding which is generally an activity that is subject to significant market failure. Marks & Spencer is a pioneer in its sector in launching Plan A which was regarded as pioneering at that time of launch. Marks and Spencer now report that implementing Plan A is now cost neutral and economically beneficial to the company in the long term.

In an interview to the Guardian newspaper given while attending the UN Global Compact Leaders' Summit in 2013, Mr Barry Parkin of Mars provided a vision of the way forward in corporate social responsibility for sustainable development.[134] He sets out the Mars position which he argues should be a position adopted across the food industry. The starting point for Mars is the core belief that this is a pre-competitive space and that Mars would only move to a competitive position if there is a really good argument for doing so.

[134] Parkin, B. (2013). Interview with Jo Confino. Mars CSO: sustainability should be a pre-competitive issue - video http://www.theguardian.com/sustainable-business/video/sustainability-a-pre-competitive-issue

He argues that the current situation with numerous initiatives and many operating in a competitive context is highly inefficient because many parts of the industry are still fixed to the business model that firms must compete on everything. A new model with sustainability at the core built around different competitive principles is needed. He points out that the challenges are global and the science is the same across the industry so the logic for pre-competitive collaboration is extremely strong. There have been 120 initiatives in cocoa over the last 15 years alone and the result is many millions of dollars spent in fragmented efforts. Barry Parkin: *"The net effect is no significant change. So we are making no difference. Pre-competitive collaboration will lead to cross-sector credibility and the scale of the impact will be greater. In moving to a sustainable economy, we (the agri-food sector) are still in the adolescence phase."*

Pre-competitive activity and public policy are closely related. Our analysis of the position of the firms in our sample indicate that while there is a lot being done by individual firms, few companies have worked with public policy to support regulation that would advance the climate protection in a fundamental way. The ABIOVE moratorium on unsustainable soy is a good example of a successful quasi-regulatory approach and this underscores the need for cooperation with public policy. Another example that is not relevant to climate change is recent calls in Germany for public policy to support minimum wages across Europe in the meat sector. Our assessment revealed few examples of firms supporting sector-wide regulation and for the most part, regulators and industry leaders operate in separate spaces with regard to climate protection.

Recommendations

Maintain momentum

Corporate climate responsibility in the food sector is relatively new. It has grown rapidly over the last decade, building largely on existing corporate social responsibility activities aimed at social and wider environmental outcomes. Even though this activity is still in its infancy, there is clear evidence of a widespread change in business culture operating through supply chains. The proportions of major internationally traded commodities now certified are significant. However, there is still little evidence that they have reached a level that gives clear disincentives to minimum standard production, given the buffering effects of other growing markets. Premia for certified produce remain low. The priority for climate responsible firms must be to grow and consolidate the market for climate-responsible produce. The sector must support measures to identify produce that is not associated with land-use change and generate clear farm-level financial incentives for its responsible production. **We recommend that companies with corporate climate responsibility programmes should redouble efforts to grow the market for responsible produce. Consumers can be confident that responding positively to corporate social responsibility activities is beneficial.**

Reduce fragmentation

The agri-food sectors climate responsibility efforts are fragmented. The foundations of pre-competitive collaboration to address this have been laid in various fora such as the Sustainable Agricultural Initiative. **The climate-responsible agri-food sector should work to reduce fragmentation of efforts and to consolidate activities.**

Review and tighten certification standards

Agri-food certification, particularly commodity certification, is controversial. NGOs argue that many standards relevant to greenhouse gas emissions, particularly land use change, are too lax. **Linked to pre-competitive collaboration, the agri-food sector should tighten certification standards to achieve zero land-use change from certified food.**

Use innovative market-based mechanisms

The challenge of sourcing and tracing supplies from responsible producers is one of the barriers to developing corporate climate responsibility. This is particularly challenging in commodity markets where distinguishing between batches of bulk commodity from different sources is difficult. Trade in certificates rather than in physically segregated material enables food business to rapidly grow demand for certified produce and to transmit premiums to certified growers effectively. This mechanism could be an important component of pre-competitive efforts to create critical mass in the demand and rewards for climate responsible production. **The food industry needs to work collectively to develop the trade in certificates and understanding of the benefits. This may require efforts in explaining the impact of an effective and rewarding certified produce credits to consumers.**

Support more fundamental change to climate-responsible farming

Biological processes on farms are a major source of greenhouse gas emissions. Tackling these requires addressing the emissions at source by reducing the loss of soil carbon, the intensity of the nitrogen cycle, and methane from ruminants and manure. Generally, corporate social responsibility at this level is focused on promoting good general farm practice but there is relatively little effort to impact fundamentally on emission processes at the system level. This would involve investment changing land use in some cases to reverse the decline in soil organic matter levels, efforts to increase nitrogen use efficiency at a range of scales, and efforts to raise the efficiency of ruminant whole herds and flocks.

We recommend that existing programmes of technical support to farmers be examined for their impact on basic emission processes and revised if scope for greater impact is found. In particular, efforts to raise the efficiency of nitrogen and protein use should be supported. Much of this is pre-competitive activity which could be done in conjunction the public research base and with regulation (for example the regulation of fertiliser and manure use.)

Support fundamental change in the food system

The case for changing 'western' diets to simultaneously improve public health and climate-related outcomes is compelling. With the exception of Barilla and Provamel that are specialised in products with small carbon footprints, and Tesco which is providing carbon footprint data on many of its products, we identified no serious efforts to support dietary change to lower carbon-footprint diets. **We recommend that food industry actors that are serious about corporate climate responsibility work to facilitate dietary change towards lower carbon footprint diets in developed economies in line with relevant public health recommendations.**

Extend efforts to emerging markets

The drivers behind land-use change will remain in place as long as commodity producers associated with land-use change find ready markets. The relevant expanding markets are in Russia and China, and a wide range of developing economies for palm oil. Even if all markets in developed western economies focused entirely on climate-responsible produce, the trade with these emerging markets can provide adequate outlets for uncertified production.

We recommend that the food sector together works to increase the market for certified produce in these emerging markets. This is a long term effort, but it will send a signal to producers that irresponsible production practices compromise access to global market position in the long term.

Work with public policy

Governments ultimately bear the responsibility for levelling the competitive playing field and ensuring public welfare, and protecting public goods Parallel to cross-sector pre-competitive collaboration, the food sector can actively support public policy development and regulation to add to the incentives for climate-responsible supply chains and in particular to add to disincentives for irresponsible production. The success of ABIOVE soy moratorium shows how this can work, and the public sector Origin Green initiative in Ireland is a sector wide semi-state approach. Working together, the food industry operating at farm level and local regulators can achieve a great deal to create advantage for responsible producers.

Corporate social responsibility strategies should place much greater emphasis in supporting the development and enforcement of regulation and public policy to support climate-responsible production.

ANNEX 1. CORPORATE CLIMATE RESPONSIBILITY ACTIVITIES

Agri-food certification
BOPP
Better Cotton Initiative
Certified Green Palm Oil
Conservation Grade
Cotton Made in Africa
Ethical Tea Partnership
Fairtrade
GlobalGAP
LEAF
Organic
Origin Green
PEFC
Rainforest Alliance
Round Table for Sustainable Beef
Round Table on Sustainable Palmoil
Round Table of Responsible Soy
SAN
Sustainable Rice Platform
UTZ

Measuring carbon emissions, carbon offset and trade
Planning to buy carbon offsets
Bought carbon offsets in the past
Purchase of carbon offsets/ Invest in carbon offset projects
Specification of carbon reduction aim
Trading carbon offsets
Calculating carbon footprint of company or products

Carbon Certification
Certified Emission Reductions (CERs)
VER
Gold Standard
Plan Vivo
Swiss Charter Certificates
Varified Carbon Standard
The Climate, Community and Biodiversity Standards
UK Government Code of Best Practice
Renewable Energy Certificate System
Moorfuture
Carbon Reduction Label (Carbon Trust)
Carbon Label (Carbon Trust)
Carbon Trust Standard
Klimafreundlich (KlimaINVEST)
CarbonNeutral (The Carbon Neutral Company)
Climate Partner
EPD (Environmental Product Declaration)
By Air
CO_2 neutraler Produktionsprozess (Provamel)
International Sustainability and Carbon Certification (ISCC)

Cooperation, partnerships and roundtables
African Cocoa Initiative
Certification Capacity Enhancement (CCE)
Consumer Goods Forum?
Cool Farm Institute
4C Association
LEAF
SAI Platform
Source Trust
Sustainable Food Laboratory
Sustainable Tree Crops Programme
World Cocoa Foundation
Others

Regeneration and protection of landscapes
Supporting forest protection (not specified how)
Planting trees
Promoting forest certification
Combating illegal logging
Restoring native vegetation /deforested land
Preserving natural environment
Building soil terraces
Supporting windbreak projects
Advocating against the use of crops for fuel rather than food

Promoting agricultural practices
Supporting/promoting sustainable farming
New feeding technologies or feed additives
Innovative composting
Organic fertiliser & pesticides
Tillage management
Crop rotation
Advanced fertilisers and pesticides
Improved breeding technologies
Improvement of local supply chain
Direct seeding
Integrated pest management
Encourage investment in energy efficient machinery
Financial support for sustainable practices
Promoting advanced technologies for land use efficiency
Efficient varieties
Supporting naturally or local grown varieties
Improving soil and water quality
Rainwater harvesting and storage
Supporting improved irrigation and water use
Renewal of irrigation systems (drip- , pivot-type)
Funding of irrigation systems
Improving farm irrigation
Implementing laser levelling

Introducing water saving technologies
Landscaping with drought-resistant species

Training on farm
Sustainable agricultural practices
Certification standards
Animal feeding
Pesticides
Fertilizer, crop nutrients
Pasture management
Integrated pest management
Tillage farming
Composting
Biodiversity
Crop rotation
Shade trees
Forest protection
Soil/natural habitat restoration
Soil fertility
Water management incl. Irrigation
Energy use
Forest carbon markets
Train the trainer

Technical requirements to suppliers
Award environmentally friendly and sustainable practices
Financial incentives to meet specific farming criteria
Share best practices between suppliers
Produce grower programme
Supplier guides, best practice charta or toolboxes
Define key performance indicators for suppliers
Assess and audit standards
Carbon assessment, collate emission data of supplier
Support the measuring of key indicators

Research
Animal Feed
Crop & animal breeding
Energy use
Carbon sequestration
Soil fertility
Biodiversity
Crop rotation
Fertilizer, pesticides
Footprinting models, carbon assessment on farm/for supplier
Agricultural practices, development of improved methods
New varieties & plants
Assessing agricultural practices
Climate change in general
(Sustainable) agriculture in general
Consumer behaviour

Transport
Reduce transport distance
Centralize or localize storage or manfacturing facilities
Train/ship instead of truck
Evaluate ship performance
Support extension of railways

Energy use related to food production
Produce energy from waste or by-products
Improve cooling, heating or roasting systems
Install solar-reflective roofs
Reduce energy use (not specified)

Waste use and reduction
Convert by-products or waste into feed
Produce fertilizer by anaerobic digestion of food waste
Provide waste for compost or fertilizing
Use bruised food and vegetables in restaurants

Packaging and recycling
FSC certified material
PFEC certified material
Sustainable Forest Initiative certified material
Environmental-friendly/recycled/-able materials

Consumer related activities
Environmental education
Education on food production
Help in waste management
Education on best food storage
Education on climate change
Remove "best before" label
Promoting recycling or smaller packages
Promoting local food
Promoting seasonal food
Promoting "ugly" food
Promoting vegetarian alimentation
Organic assortment
Collecting ideas from customers
Introducing sustainability labels