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Green Food Project Bread Subgroup Report

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1. Introduction and Summary

In the Natural Environment White Paper (June 2011)[1] Defra committed to 'bring together Government, industry and environmental partners to reconcile how we will achieve our goals of improving the environment and increasing food production.' The Green Food Project is taking this work forward.

The Bread Subgroup is one of five set up within the Green Food Project to develop case studies to explore the opportunities and tensions around increasing food production and enhancing the environment. The Subgroup has set itself the objective of using a popular national end-product – bread - as a vehicle for teasing out the tensions, trade-offs and win-wins around combining increased food production with an improved environmental impact. It has then identified and recommended priority areas for action.

Bread was chosen for a number of reasons. Specifically –

- It is a household staple widely consumed within the UK; consumption is expected to increase and the main ingredient, wheat, is largely UK-grown;
- Warburtons, one of the larger industrial bakers in the UK, has volunteered to be a partner providing evidence and insight into the industry;
- It provides an opportunity to consider different ingredient scenarios (e.g. wholemeal, multigrain) with a potential link to the health agenda;
- It provides an opportunity to consider food waste as bread is a common contributor to household waste; and
- It provides an opportunity to read across to another Subgroup looking at wheat.

The Subgroup has focused its analysis on a standard white loaf of bread within the context of other bread products, specifically brown and wholemeal breads, breads 'with bits' and speciality breads (e.g. breads of the world). Morning goods and other bakery snacks (e.g. croissants, crumpets, etc.) fall outside the scope of this report.

This report is built around the questions posed by the Synthesis Subgroup (Section 2). The Bread Subgroup has prioritised the Synthesis Subgroup's questions based on their degree of relevance to the end product category. Only those questions that have most relevance to bread have been addressed fully and have been listed at Annex 1. Whilst focussed on the end-product the Subgroup adopted a whole chain approach (i.e. looking all stages of production pre and post farm gate) to its analysis.

The Synthesis Subgroup identified three price scenarios for consideration by the Subgroups in answering the questions. Those scenarios provide possible contrasting

[1] The Natural Choice: securing the value of nature, June 2011 http://www.official-documents.gov.uk/document/cm80/8082/8082.pdf

futures of how the world might look in 2050. The Bread Subgroup has chosen not to provide a set of answers for each scenario, but rather to combine answers whilst highlighting, as and when appropriate, actions or consequences that each scenario may favour.

The analysis that is provided in this report is underpinned by the evidence gathered by the Subgroup which is summarised at Annex 2. This outlines facts, opportunities, risks, barriers, tensions and trends in the bread supply chain.

On the basis of the analysis conducted, the Subgroup has concluded (Section 3) that the primary production end of the supply chain should be targeted, since this is where the largest environmental impacts occur and there are opportunities for making productivity and environmental gains. Post-farm gate, environmental and economic savings can be made by focusing on energy efficiency, transport and packaging impacts, and influencing consumer behaviour. Both manufacturers and retailers can play a major role in this regard by influencing both farming and consumers. The Subgroup recommends that initiatives to boost innovation, R&D, knowledge transfer and better understanding of consumer behaviour should be pursued for the industry to improve its productivity, efficiency, and responsiveness to changing prices, and to sustainably increase production.

This document is written and owned by members of the bread sub group. The content does not necessarily reflect the views of Green Food Project Steering Group members.

2. The Synthesis Subgroup Key Questions and Scenarios

Environmental impacts and potential for improvement

Raw materials

UK farming provides approximately 80% of bread-making wheat for manufacture[2], and it has been estimated that wheat yields could increase by about 50% by 2050[3]. However, commercial yields are not increasing in line with trial yields and so realising that potential will be challenging, particularly while addressing environmental impacts of farming.

The largest environmental impacts from bread are associated with the primary production end of the supply chain[4]. Almost 40% of GHG emissions associated with bread supply come from wheat production[5]. Data exists on a wide range of environmental impacts of wheat production in the UK (water use, emissions to air and water, impact on biodiversity)[6]. Issues relating to reducing impacts and production losses are being considered separately in the report of the Wheat Subgroup, however industry choice and specifications for raw materials also have a role to play.

Consequently, the Group recognises that effort needs to be prioritised in addressing impacts pre-farm gate (including losses of fertilizer to the environment, water use, land use pressures)[7] supported by R&D and innovation to develop solutions to improve productivity with reduced environmental impact (e.g. precision farming, genetic improvement, increased crop resilience, technologies for improving crop nutrient management).

What post production actions (including waste and transport) could lead to higher value, less environmentally damaging food reaching the consumer?

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[2] The Federation of Bakers, Factsheet No.7, How Bread Is Made (October 2011)

[3] Defra project IS0210 - YIELDS OF UK CROPS AND LIVESTOCK: physiological and technological constraints, and expectations of progress to 2050.

[4] Grocery & Home Improvement Product hot spots, October 2011- BFF report for the Product Research Forum.

[5] Grocery & Home Improvement Product hotspots (October 2001)

[6] Defra project IS0205 - Determining the environmental burdens and resource use in the production of agricultural and horticultural commodities.

[7] How low can we go? An assessment of greenhouse gas emissions from the UK food system and the scope for reduction by 2050. WWF/FCRN, 2010. Audsley et al 2010.
Food, land and greenhouse gases: The effect of changes in UK food consumption on land requirements and greenhouse gas emissions. A report prepared for the United Kingdom's Government's Committee on Climate Change; Macdiarmid et al 2011.

Manufacturing

There is scope for improvements in environmental performance post-farm gate at the manufacturing, processing and retail stages (including transport) but these are relatively incremental. Resource use efficiency (primarily energy use) provides the main opportunity for improvement in bread manufacture; if there was opportunity to decarbonise the food chain energy supply, the associated GHG emissions would be substantially mitigated, but there would still be a case to reduce energy use.

For example, Figure 1 shows that the carbon footprint of manufacturing is estimated to contribute by approximately 15% to the total carbon footprint associated with the life cycle of bread. About half of the emissions in bread manufacture are associated with baking, proving and cooling operations, where there are opportunities to reduce impacts, with the oven accounting for up to 45% of total site carbon emissions[8]. Water use contributes to <10% of impacts in processing. There is no evidence that bread waste is significant in manufacturing.

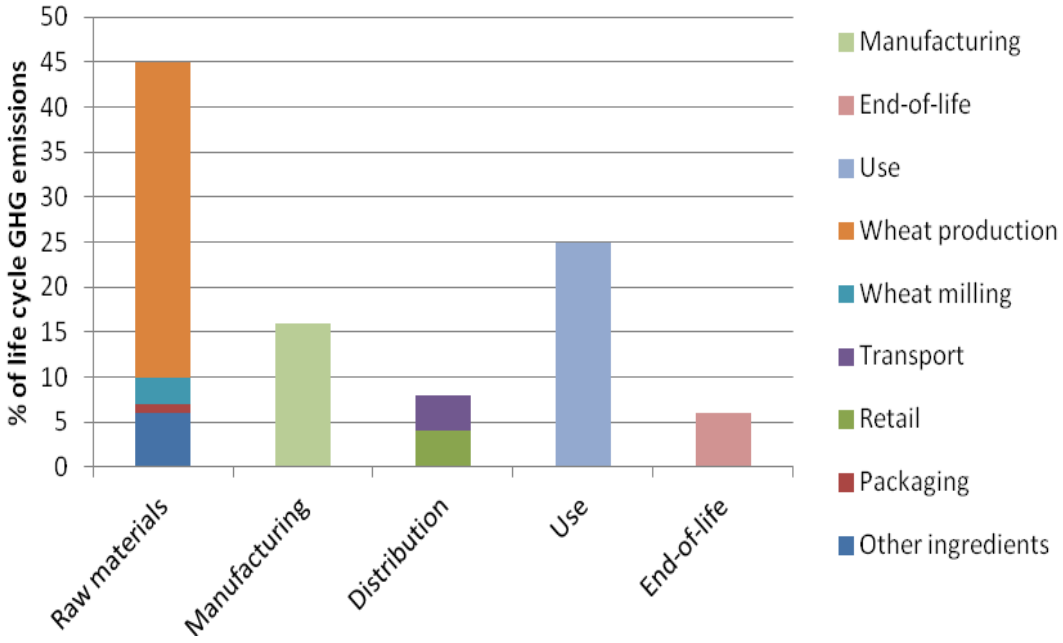

Figure 1: Contribution of life cycle stages to total carbon footprint of bread; Data source: Grocery & Home Improvement Product hot spots, October 2011

Specific opportunities to reduce environmental impacts in processing include:

- More efficient use/re-use of energy in baking systems coupled with the introduction of energy management systems[9];
- Improvement in energy efficiency in flexible bread plants to meet consumer demand for freshness, greater product choice, premium products, quality and convenience (e.g. smaller loaf and pack size options to meet forecasted upward trend in one-

[8] Carbon Trust 2010
[9] Carbon Trust. Industrial Energy Efficiency Accelerator. 2008; Carbon Trust. Energy Performance Enhancement Toolkit For Industrial Bakeries. Dec 2005.

person households and an ageing population; greater range of speciality breads and non-standard shapes)[10]; reducing waste through the use of smart packaging (e.g. use of re-sealable packaging to maintain freshness) and extended ambient shelf life of bread;

- Product development through food technology and novel use of ingredients. The benefits of these are likely to be delivered through coordination between different parts of the supply chain (i.e. breeders, farmers, millers, bakers), and will need to be underpinned by collaborative R&D and technical innovation. For example, wheat used for bread-making has a lower yield per unit of nitrogen fertiliser applied, mainly because the baking process requires wheat with a higher amount of protein, which has lower yields and higher nitrogen requirements than other types of wheat. Technical advance in baking, such as the use of novel enzymes, could lead to reduced demands for protein in wheat[11] and hence lower nitrogen requirement and reduced environmental impact at farm level.

- By the same token innovation at the plant breeding stage could also deliver benefits (for example enhanced protein functionality or starch quality, even at higher yields). These would be best exploited in combination with bakers to ensure that there were no adverse impacts on product quality or tradeoffs over the bread lifecycle.

- Encouraging investment in capital equipment through technological innovation and R&D to support a step-change towards flexible, low carbon bread production which takes account of technological innovation in production e.g. breeding, novel technologies including GM and impacts of climate change;

- Creating an environment (including regulatory and improved consumer awareness) which is supportive to the best available science and technology (including novel technologies such as GM) to optimise resource efficient production across the bread supply chain;

- Provision of clear information to consumers (e.g. transparent labelling, provenance, in-home use, storage and freezing guidance), building on previous work to raise awareness of environmental impacts and drive improvements in behaviour to reduce waste.

Distribution

Transport accounts for less than 5% of GHG emissions of bread over its life cycle[12]. Nevertheless, there are further opportunities to further optimise transport by shifting towards the least polluting and most energy efficient modes of transport (acknowledging the impact of congestion on pollution even with more energy efficient modes), reducing

[10] ONS Household Projections to 2031 Report (March 2009).
[11] Project LK09129 - Exploiting novel genes to improve resource use efficiency in wheat. Defra Report AC0221 (http://randd.defra.gov.uk/Document.aspx?Document=AC0221_9496_FRP.pdf) showed that development of low Nitrogen bread technology would potentially reduce Nitrogen use by 15kt, which would equate to 242 kt CO2e.
[12] Grocery & Home Improvement Product hot spots, October 2011

distance travelled to complement progress already made in using reusable and recyclable transport packaging[13] which allows greater stackability while minimising damage.

Capital investment is also relevant in terms of renewal of a transport fleet to be more efficient - this may require incentives particularly if suggested outside of the planned investment cycle.

Use

Consumer behaviour plays a very significant role, with bread use in the home contributing to a quarter of the total impacts from energy use through toasting, freezing, refrigeration etc[14] (Figure 1). Defra household food waste data (2010) indicated that bread is one of the most wasted foods in the home[15]. These activities out-weigh incremental impacts during processing by some margin.

Around three million tonnes of bakery products were bought in 2010 by consumers[16]. Bread remains a staple item in the UK diet. Overall, bread provides around 11% of daily total energy intake, of which white bread contributes about 6 to 7% in adults[17].

The UK bakery market is one of the largest markets in the food industry and was worth £3.4 billion in 2010, of which £2.1 billion equates to total bread sales[18]. White bread continues to account for the largest sub-sector of bread volume sales, with a 67% value share of wrapped bread in 2010[19]. Volume sales of white and brown bread have declined by 13% and 11% respectively between 2008 and 2010[20]. Conversely, wholemeal, continental, and speciality bread products (e.g. breads of the world) have increased in volume sales between 2008 and 2010[21]. The bread and baked goods market value in 2011 is estimated at £3.5bn of which pre-packed bread accounted for a 64% share of the market, followed by morning goods 16%, speciality bread 12% and rolls 8%[22]. Value is expected to rise to £4,25 billion in 2016 – although volume will not increase by the same margin[23]. The markets for premium quality loaves, healthy, continental and ethnic (e.g. breads of the world) bread products are forecasted to grow reflecting an increasing demand for products offering health, premium or convenience benefits and an increased substitution of white products by products with a higher value[24]. This is driven by a growing focus on physical health (e.g. chronic health conditions, food allergies and intolerances are

[13] Packing contributes <10% GHG emissions, Espinosa-irias, n et al, 2011.
[14] Espinoza-Orias, N et al, 2011
[15] Household Food and Drink Waste linked to Food and Drink Purchases, Defra, 27 July 2010
[16] Food and Drink Federation estimate 2011
[17] The total bread figure combines the figures for 'white bread', 'wholemeal bread', 'brown, granary and wheatgerm bread' and 'other bread'. These figures are taken from National Diet and Nutrition Survey (July 2011): Headline results from Years 1 and 2 (combined) of the rolling programme http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsStatistics/DH_128166 (tables 5.1, 5.2 and 5.5).
[18] The Federation of Bakers, Factsheet No.3, The British Bakery Market (June 2010)
[19] The Federation of Bakers, Factsheet No.3, The British Bakery Market (June 2010)
[20] UK Bread and Baked Goods, Mintel Report 2011
[21] UK Bread and Baked Goods, Mintel Report 2011
[22] UK Bread and Baked Goods, Mintel Report 2012
[23] UK Bread and Baked Goods, Mintel Report 2012
[24] UK Bread and Baked Goods, Mintel Report 2011

becoming more prevalent), growing preoccupation with the physical environment (e.g. climate change, resource scarcity) and the broader context of corporate responsibility, or the need for convenience options, nutritious and convenient solutions that suit trends in lifestyles[25]. For instance, consumers are spending a greater percentage of their time on the move and require nutritious on the go solutions to refuel throughout the day[26]. Those factors are increasingly influencing consumer decision making and, coupled with a rising population and a projected increase in one person households are expected to lead to a change in the overall demand for bread.

Freshness represents the most important purchase consideration for consumers when buying bread[27] and has a significant impact on household waste. Consumers choose whether to eat bread based on its freshness and tend to buy more than they need to meet this need[28]. A 2010 Defra report found that bread was one of the most regularly wasted household items, with around a third of the bread bought (that could have been eaten) being thrown away[29]. Minimising bread waste is therefore paramount and consumers have a number of tools to do this. Those include planning shopping and meals in advance, making better use of bread (e.g. use of stale/ dry bread for toasting, grating, cooking (e.g. croutons), eating or using crusts, toasting from frozen), freezing excess bread and storing bread correctly to retain freshness.

Consumer behaviour can also influence changes at the production end of the supply chain. Consumer acceptance of new technologies, such as GMOs or nanotechnology will influence the range of options available to improve the sustainability of agricultural production. For example, the ability to use lower protein wheat in bread production, product reformulation using novel and natural ingredients (e.g. additives, enzymes for supporting quality low protein bread) and the use of recyclable packaging will incentivise resource efficiency, and more environmentally beneficial practices in the production process. Consumer demand can also support a step-change towards production of low energy appliances such as toasters reflecting the drive for convenience (toasting is the top consumer bread snack preparation method)[30].

Cultural and societal issues have a significant influence on all of the above behaviours. Any attempt to change these behaviours would need to address the social factors associated with food choices, such as lifestyle, eating out of the home, meal planning, family unit size, amount of disposable time/income available, and the ability and willingness of people to change.

As noted in Defra' s food synthesis review, there are significant evidence gaps in terms of our understanding of what motivates consumer food choices and food behaviours. These

[25] Warburtons Bakery 2015 – Personal communication
[26] Warburtons Bakery 2015 – Personal communication
[27] UK Bread and Baked Goods, Mintel Report 2011
[28] WRAP –unpublished research
[29] Household Food and Drink Waste linked to Food and Drink Purchases, Defra, 27 July 2010
[30] The Federation of Bakers. The British Bakery Market (fact sheet 3). June 2010.

will need to be addressed as part of a process to develop effective strategies to change consumer behaviour[31].

Trade-offs

There are a number of trade-offs that need to be considered for the impact of the bakery market in light of the post-production options and consumer behavioural trends that have been outlined so far. The Sub-group has identified the following as significant -

- A predicted increase in demand for bread driven by rising domestic and global population and increasing demand in the variety of bakery products, including for wholemeal, continental, and speciality bread products (e.g. breads of the world including ethnic breads, premium and healthier varieties of bread), may increase demand for wheat and speciality ingredients (including wheat types) which could put pressure on UK crop production, with potential to replace other crops land uses in the UK or lead to greater imports. Climate change will also play a major role in the longer term, as increased temperature, heat stress, water stress and extreme weather events may impact on wheat yield and quality[32].

- In general terms, the expansion of the bread market driven by a forecasted upward trend in one-person households[33], and fuelled by a rising interest in speciality bread products may bring export opportunities if external markets are found for UK bread. Conversely, it may increase demand for wheat, a commodity which is already subject, among other things, to price pressures and land availability. This might lead to an increase in GHG emissions such as transport emissions linked to exports of bread and imports of wheat. Nevertheless, export opportunities into global markets may be hindered by the short shelf life of bread and high transport costs.

- The expansion of the wholemeal, continental, and speciality bread products market, drive for convenience, variety etc. may lead to an increase in demand per capita for accompanying/ complementary products (e.g. jam, sandwich fillers, toasters) which will impact on the environmental performance of the supply chain.

- Increased demand (and therefore assumed increase in consumption) for more variety of bakery products may lead to a reduction in the demand for other products, particularly in breakfast and lunch markets. It is, therefore, the net effect on food markets that should be observed.

- The pursuit of economic resilience in the supply chain and to meet changing consumer demand may go against investing in optimising resource use efficiency (capital equipment), which may also be hindered by poor returns on investment.

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[31] Food Synthesis Review, A research report completed for the Department for Environment, Food and Rural Affairs by The Social Marketing Practice, AD Research & Analysis, Icaro Consulting, Alex Inman Consulting, Residua and Tara Garnett, December 2009

[32] How to feed the world in 2050? FAO, 2009.
LIVESTOCK'S LONG SHADOW: environmental issues and options. FAO, 2006; UK Water Footprint: the impact of the UK's food and fibre consumption on global water resources. WWF, 2008.

[33] Synthesis Sub-group, Key Trends and Projections

- Exports may grow from a low base but are not seen as a significant percentage of UK sales.

How to address the trade-offs?

Overcoming the negatives

The Sub-group has identified a number of actions that can be taken to prevent or mitigate negative consequences arising from the pursuit of increasing productivity whilst simultaneously enhancing environmental performance.

Encouraging technological innovation, R&D developments, knowledge transfer and uptake into practice throughout the supply chain is a key factor in driving change. Consumer pull through the supply chain also drives change. Innovation is needed to help reduce emissions to air and water, energy and land required in wheat production and make it more resilient to environmental conditions. Examples of innovative developments include crop protection advances, precision technologies, improved wheat varieties, adoption of soil management and land management practices that support biodiversity, integrated farm management, better farming techniques, and improved storage of wheat. Knowledge transfer on farm and in the bread supply chain (manufacturing etc.) is also key to support take-up of efficiency reduction opportunities into practice which can be achieved through demonstration activities and knowledge exchange[34]. For example, evidence[35] shows that there are opportunities around the use of benchmarking tools to help businesses drive improvements in efficiency. Post farm-gate, technological developments should focus on innovation in flexible, resource efficient manufacturing and bakery equipment, renewable technology and encourage faster capital investment replacement cycles. In order to optimise nutritional quality, product development and reformulation are needed. This would enable manufacturers to use lower protein wheat and novel and natural ingredients to meet demand, led by industry, Government or consumers, for healthier products (e.g. less additives, more fibre) freshness, convenience and variety[36]. Focus should also be placed on packaging with a view to minimising waste impacts whilst retaining quality.

Investment in more efficient technologies in baking plants that provide improved oven combustion efficiency, better thermal control, enable the reuse of heat and other materials represents a key issue as the baking process is a main source of impacts in the manufacturing process. Partnership initiatives such as the Carbon Trust Industrial Energy Efficiency Accelerator programme are important to move concepts arising from pure research into the realms of practical technologies that businesses can adopt. In other words, they can provide an opportunity to demonstrate commercial viability and resolve practical problems as a precursor to widespread take-up by industry. Institutions such as

[34] Royal Society Report 'Reaping the benefits – science and the sustainable intensification of global agriculture'. 2009

[35] Carbon Trust. Industrial Energy Efficiency Accelerator. 2008; Carbon Trust. Energy Performance Enhancement Toolkit For Industrial Bakeries. Dec 2005.

[36] The Federation of Bakers. The British Bakery Market. Fact sheet 3. June 2010.

the Green Investment Bank should prioritise this type of funding to transition new and evolving technologies.

Over the period 1999 to 2010 the energy used in industrial bakeries increased by 9.8% but per tonne of production has fallen by 6.5%[37]. However, there has been a noticeable trend towards products that are produced in batch and/or indirect fired ovens which is expected to continue in the future. These ovens typically have higher energy consumption per tonne of throughput than the continuous direct fired ovens used to produce standard loaves of bread. There is a need to address this through improved oven design, better operational controls and, in the longer term, the use of low carbon electricity to ensure that future efficiency improvements are maintained. In each of these cases, investment decisions need to be supported by the right industry skills, knowledge and awareness if economies of scale are to be delivered. Encouraging skills development and skills sharing in the supply chain, along with knowledge transfer and knowledge exchange is therefore paramount. The provision of incentives to promote the development and the transfer of skills and knowledge, as well as to encourage capital investment (e.g. Green Investment Bank) represents a major innovation boost.

Perceived lack of consumer acceptance of new technologies for improving bread production quality may undermine technological developments and can be addressed through education and awareness raising. Manufacturers can play an important role in influencing consumer behaviour and in sending signals to the production end of the chain to encourage the adoption of more environmentally beneficial practices that meet consumers demand. Use by consumers accounts for 25% GHG emissions in the bread supply chain[38] – and represents an area where gains can be made through raised awareness of more efficient bread shopping habits, handling and use (better storage/freezing guidance to retain freshness), more efficient consumption (toasting from frozen, smaller packs) and bread disposal in the home (less waste).

What are the implications of your proposed actions for existing initiatives by government, the private and third sectors, or for future interventions?

Implications for existing initiatives

The Subgroup believes that existing initiatives (as outlined in question 3 such as regulatory changes, voluntary agreements) can support the proposed actions and will help accelerate the process towards increasing productivity and enhancing environmental protection. In particular:

- An increased focus on collaborative applied R&D and technological innovation and knowledge transfer (such as TSB-led Sustainable Agriculture and Food Platform)

[37] Food and Drink Federation - Climate Change Agreement data
[38] Grocery and Home Improvement product hot spots October 2011.

will support the exploitation and take-up of technology into practice by industry (including demonstration activities) on farm and post production;

- Ensuring that crop variety testing is providing the right evidence for adoption of varieties which enable sustainable intensification in farming and resource efficiency in the food chain;

- More resource efficient forms of farming and enhanced biodiversity protection can be achieved through CAP reforms, and the exploitation of the R&D benefits under CAP;

- Raising awareness through provision of clear information will continue to help consumers make informed choices to reduce environmental impacts including waste and stimulate retailers to do likewise;

- The use of voluntary agreements that cut across different supply chains (i.e. collaborative supply chains can bring financial gains and lead to a more effective and sustainable use of the chains) will support a more coordinated approach to delivering outputs, encouraging skills transfer and knowledge sharing.

Acceptability of Trade-Offs

This report focuses on the incremental impacts where there is scope for improvement across the supply chain. It is difficult to state how acceptable the identified trade-offs between increasing production and impacts are. The extent to which any negative consequences can be mitigated depends on the development and acceptability of new technologies and innovative solutions, as well as on the development of necessary skills that will enable investment in technologies and innovation (as outlined in previous sections). The risk presented by poor returns on investments that may boost innovation may also represent a huge deterrent. Nevertheless, the Subgroup is of the opinion that current use of natural resources and current levels of emissions could be used as a benchmark against which the effect of any changes to increase production can be assessed.

What are the most radical developments that could affect your test case in the next 40 years?

Low carbon energy will be key to reducing the GHG impacts of the supply chain. A major priority identified in this report is the need to address energy efficiency across the supply chain be it for industrial ovens or domestic appliances. However, it is important to couple this work to decarbonising energy supply. The DECC Carbon Plan (December 2011) outlines the overall strategic objectives of a low carbon UK economy. This addresses the decarbonisation of electricity supply and heat production – with low carbon electricity being a possible future option substituting for current fossil fuel based heating systems. DECC are expected to publish further details of their Heat Strategy in the spring.

Developments in wheat breeding (such as nitrogen fixation, greater ability to scavenge nitrogen and greater translocation of nitrogen to the grain) and production (enabling a reduction in nitrous oxide emissions, and greater retention of nutrients in soil and crops) will also provide an invaluable opportunity to reduce environmental impacts and increase production, and combat the impacts of climate change (better drought and heat tolerance).

Developing a better understanding of consumer behaviour and social values will help bridge the gap between consumer opinion on what products they would ideally purchase, and the purchasing behaviour they actually demonstrate[39]. Radical choice-editing schemes by retailers would also evoke a step-change, i.e. moving away from free consumer choice in a free market, or promoting consumption of more brown bread (more efficient use of grain).

Price scenarios

As mentioned at the outset, the analysis provided thus far applies to each of the price scenarios proposed by the Synthesis Subgroup. Nevertheless, it is clear that a scenario with decreasing agricultural prices and relatively high input costs[40] or where agricultural prices are highly volatile[41] may deter businesses from investing in new technologies due to the risks associated with poor returns on investment. Conversely, a scenario where agricultural prices rise but input costs do not[42] may foster investment in technological development.

[39] Defra, Attitudes and Behaviours around Sustainable Food Purchasing
[40] Synthesis Sub-group, Key Trends and Projections, Scenario A
[41] Synthesis Sub-group, Key Trends and Projections, Scenario C
[42] Synthesis Sub-group, Key Trends and Projections, Scenario B

3. Conclusions and Recommendations

Conclusions

On farm:

- Focus for increased production and environmental improvement should address the primary production end of the supply chain, where the majority of environmental impacts are;

- Investment in collaborative, applied R&D, innovative science and biotechnology, knowledge transfer and its take up into practice (e.g. demonstration activities) is needed along the knowledge pipeline in wheat breeding and production to reduce inputs and impacts, including improving unit nitrogen efficiency from wheat, supported by subsequent innovation in technical specification or product design, bread quality and nutrition to meet the forecasted upward trend in consumer demand for healthy and speciality bread products;

- CAP reform provides an opportunity to promote R&D in agriculture, with longer term scope for enabling more efficient farming and enhanced biodiversity protection.

Processing/manufacture:

- Effort needs to target increasing efficiency of energy use in flexible baking plants designed to meet future demand for non wrapped bread and a wider product mix and to reduce transport and packaging impacts – including making use of existing initiatives e.g. Climate Change Agreements;

- The supply chain, including manufacturers and retailers, can play a key role in signalling back to the agri-system to influence production demands and in influencing consumer behaviour in and outside the home, including acceptability of new technologies and product choice;

- Incentives to support capital investment to boost resource efficiency in processing are also needed;

- Decarbonisation of energy initiatives will provide an opportunity to increase resource efficient and reduce environmental impacts;

- Collaborative R&D is needed to optimise efficiency of baking processes and equipment, and bread (nutritional) quality, to take account of innovative technology to improve wheat performance whilst meeting consumer demand for freshness, nutrition, quality, variety and convenience.

Consumption:

- Consumer behaviour and household bread waste make a significant contribution to overall impacts. These can be reduced by developing smarter more efficient products (e.g. appliances for toasting and refrigeration), and by raising consumer awareness of impacts by providing consumers with clear guidance to enable them to make better use of bread through correct in home storage and challenging perceptions around shelf life to reduce wastage.

There are changes that can be made across the whole supply chain that whilst having minimal impact or benefit at the stage where implemented could have a significant positive impact on the environmental, economic and social aspects of bread production. As a result, incentives may be required to convince individual parts of the supply chain to take forward the changes at their local level. For example, at the agricultural end of the supply chain, there is currently no business case using nitrification inhibitors, despite the potential reduction in GHG emissions they may enable. Therefore a farmer/producer would need incentivising to make this change or having a share of the benefits from the contribution of this activity/ change to the market. Similarly, targeted capital investment by industry outside planned investment cycles for equipment (e.g. ovens, transport fleets) will make a more significant impact when coupled with similarly timed changes throughout the supply chain.

Whilst the recommendations set out below may not appear radical/highly impactive individually, collectively they could offer a significant improvement in efficiency. Market mechanisms that value ecosystem services, and therefore internalise some externalities may be required.

Recommendations

1. Promoting the UK's competitive edge by putting in place ways of overcoming market failure in realising benefits which do not provide sufficient return at the level of individual business, but which would in aggregate deliver worthwhile change (e.g. incentive schemes or other pump priming support packages)

2. Developing a common sense pragmatic approach to science biotechnology and innovation and its regulation so it can be fully exploited and create an environment to promote innovation and facilitate acceptance of technological and developments in food e.g. GM and novel ingredients

3. Optimising use of collaborative R&D mechanisms such as TSB-led Programmes and Green Investment Bank to boost innovation and encourage its up take into practice through better knowledge transfer and demonstration activities and initiatives

4. Carry out research to identify where there are opportunities for change to occur and engage producers, manufacturers, retailers and consumers to maximise potential from these changes

5. Target environmental improvements and waste reductions in the home, food service and retail through better understanding of consumer motivators, attitudes and behaviours (purchasing and consumption) and provision of information to raise awareness of bread use, storage and disposal

Annex 1

Synthesis Subgroup's questions

The Bread Subgroup has prioritised the Synthesis Subgroup's questions to focus on the end product category rather than pre-farm gate aspects. Only those questions relevant to the post-farm gate end of the supply chain have been addressed fully in this report. Specifically -

1. **What specific post-production actions (in particular considering waste and transport) could lead to higher value/less environmentally damaging food reaching the consumer?**

    a) *Will consumer behaviour be a required driver for change?*

    b) *And if so, will consumer behaviour need to change to deliver the outcome?*

    c) *What are the trade-offs?*

2. **Looking at the trade-offs identified between increasing productivity and improving environmental performance:**

    a) Is there potential to avoid or mitigate the negatives? (For example through skills development, new technologies, improved techniques or changes in land use)

    b) How might the negatives be off-set with other actions you have identified?

    c) How acceptable are these trade-offs likely to be?

    d) Where might future technological development mitigate the negatives? How might they make the impacts worse?

3. **What are the implications of your proposed actions for existing initiatives by government, the private and third sectors, or for future interventions? For instance how might your actions be supported or accelerated by:**

    a) changes to institutional structures (international and domestic)

    b) legislative, fiscal or regulatory change (for example how should we shape the future Common Agricultural Policy)

    c) incentives to change behaviour

    d) education, awareness, guidance, training (educate consumers and retailers)

    e) knowledge transfer and extension services

    f) voluntary agreements (reduced waste; service sector voluntary agreement)

g) research and development (development of innovation and new technologies for cooling, storage, processing systems)

h) market creation (e.g. the carbon trading scheme, payments for ecosystem services)

4. **What is the most radical development that could affect your test case in the next 40 years? What might drive this change? And would it create new pressures or bring new opportunities:**

a) For enhancing the environment

b) For increasing food production