LiveWell for LIFE

WORKING TOGETHER FOR HEALTHY PEOPLE AND A HEALTHY PLANET

WWF

Life

A BALANCE OF HEALTHY AND SUSTAINABLE FOOD CHOICES FOR FRANCE, SPAIN AND SWEDEN

Report

Healthy people, healthy planet.

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FOREWORD

A balance of healthy and sustainable food choices for France, Spain, and Sweden is an important report. It shows that it is possible to have a healthy, low-carbon diet that takes account of cultural preferences. It demonstrates that these diets will not necessarily cost more – and extra cost is often given as a reason to not change products and buying habits.

Food is at the heart of many key environmental issues. Growing, producing and importing food contributes substantially to climate change. It's a driving force behind habitat and biodiversity loss. And it's a huge drain on water resources. WWF's vision of a sustainable food system is one that supports vital elements of our work: conserving biodiversity, reducing water use and reducing greenhouse gas emissions.

The change in the Western diet – to one that's high in meat, dairy and processed food – is a recent phenomenon: it's developed since the 1940s. It's coincided with a growth in problems such as obesity, type II diabetes and heart disease. That's why helping to develop a sustainable food system for healthy people and a healthy planet is one of WWF's priorities and why we have joined forces with our partners *Friends of Europe* to investigate the potential for LiveWell across Europe.

The world's population has doubled since 1960, and it's predicted to increase to over nine billion by 2050. So the pressure that feeding the world is putting on the climate and ecosystems has never been so high. Global access to food is not equally distributed: half the global population is either underfed or overfed.

Many major independent reports in recent years have recognised the need for food production and consumption to change, as outlined in the literature review. They all recognise the role of production and technological changes, but the food system will not be sustainable without a change in food consumption patterns. That led WWF-UK to look at food consumption. We quickly realised that many of the highest-impact foods are the ones that, if eaten excessively, are causing health problems. Through our LiveWell work we demonstrated that a diet that follows UK government healthy-eating guidelines – containing fresh produce and not too much meat and dairy or processed foods – is a sustainable diet.

The LiveWell for low impact food in Europe (LiveWell for LIFE) project is only a *first step* towards defining a more sustainable diet. It looks at health, nutrition, carbon and affordability. Its aim is to open the debate on this topic and to get key stakeholders from the food supply chain and EU and national policy-makers to look at sustainable diets as part of a future policy agenda.

This publication is the initial result of the LiveWell for LIFE project's work to define country-specific sustainable diets for three European countries. In addition there is a summary report to enable project stakeholders to easily understand the findings of the initial research, supporting further engagement in the next stages of LiveWell for LIFE.

These findings were presented to the Network of European food stakeholders at our first project workshop – 'Appetite for change' – which was held in Brussels on 18 September 2012. Members of the Network were also invited to contribute and share their views on the report during a three-week consultation period. We received a large number of contributions, for which we are grateful.

Our responses to the Network's comments and queries collected during the consultation period, as well as changes and next steps for the project as a result of these, can be found in the *LiveWell Plate evaluation report*. The evaluation report shows that more work is needed to refine the tools that accompany and help communicate the LiveWell Plate in each country. We look forward to using this feedback to inform the development of the project and working together with stakeholders to further refine the project outcomes.

Duncan Williamson
Senior Policy Advisor (food)

WWF-UK

WORKING TOGETHER FOR HEALTHY PEOPLE AND A HEALTHY PLANET

EXECUTIVE SUMMARY

There is increasing recognition of the environmental impact of food and drink. Proposals suggest that food policy and dietary advice need to go beyond their traditional focus on nutrition to include consideration of environmental impacts. Balancing environmental, economic and social aspects with nutritional ones adds complexity to establishing dietary guidelines.

This report builds on the work done in the UK on the LiveWell diet recommendations, representing a balance between healthy and sustainable food choices, with sustainability defined only in terms of greenhouse gas emissions (GHGe). By extending this approach to a further three countries – France, Spain and Sweden – we aim to determine whether it is possible to develop corresponding diet recommendations in other countries. We also analyse the difficulties of integrating data from multiple sources to see whether these countries can be used as pilots for work elsewhere.

The key question addressed in this report is whether it is possible, in each of the countries, to develop a "LiveWell" diet which decreases GHGe by 25% from the current average[1], costs no more, meets national nutritional guidelines, and still resembles current diets sufficiently to be widely and easily accepted.

To answer this question we used a similar approach to that adopted for LiveWell UK – collating data on current consumption patterns, nutritional recommendations, public dietary guidance, GHGe of particular foods, and general price information. The quality and completeness of the data varied between the countries and we have had to make some assumptions. Nonetheless, through modelling we have sought to demonstrate that, for all three countries:

- Moves towards healthier eating can align with environmental objectives
- A healthy and sustainable diet does not necessarily cost more than the existing diet
- A healthy diet which costs no more than current amounts and reduces GHGe by 25% is possible and could be accepted by a large proportion of the population (i.e. not too far from current consumption patterns).

Our analysis substantiates all these points. We can state, specifically:

1 LiveWell UK based its reduction on 25% taking into account projected growth in population. Owing to lack of clarity in projections, in this report the 25% does not take population changes into account, i.e. it is per capita rather than for the country as a whole.

1. For all three countries it is possible to produce a healthy and sustainable diet.[2] In all cases we produced a diet which reduced GHGe by more than 25%, although there has to be compromise regarding acceptability. Despite the limitations of the methodology, the wide reductions possible demonstrate that food choices can have a real effect.

2. A healthy sustainable diet does not have to be an expensive one. Indeed, in all the general analysis, cost was not a binding constraint and only came into play in terms of choosing "acceptable" foods for the consumer. This is important because cost is often seen as a factor in consumers not adopting healthy and sustainable eating.

3. We have demonstrated that for all three countries a LiveWell diet is possible – one which complies with nutritional recommendations, reduces GHGe by 25%, and provides a choice of foodstuffs as acceptable as possible.

Comparison between the three countries can be invidious and can easily become a comparison of cuisine and eating habits rather than health, cost and sustainability. Nonetheless, a number of overall similarities between these nutritious low GHGe diets can be observed:

1. All diets show a reduction in the total amount of meat consumed. This is inevitable since these are the foods with the highest GHGe. On the other hand, we demonstrate that for a 25% reduction it is still possible to have enough meat and/or fish in the diet to comply with nutritional recommendations and maintain some traditional dishes and meal patterns.

2. All diets show an increase in the consumption of legumes as sources of protein. This again is inevitable owing to the lower GHGe of legumes relative to most other sources of protein, even if they are imported long distances. As legumes are not costly, this may help to keep the food budget constant or even to decrease it.

3. All diets show an increase in cereals and starchy foods, typically represented by increases in bread, pasta and potatoes.

4. Consumption of dairy products remains similar to now.

2 Sustainability here relating to reducing GHGe only.

This first piece of research demonstrates that healthy, sustainable food choices are possible in a variety of countries, and can be adapted to be acceptable in a variety of contexts. But it also points to further research and analysis which should be done to make this work more precise and assist in guidance to stakeholders. In particular we suggest:

- Better GHG and life-cycle analysis (LCA) data to assist in modelling and giving precise guidance
- Research into other factors that can affect the degree to which GHGe can be reduced – for example, eating seasonal foods, and different ways of preparing food (including, for example, the effect of this on bio-availability of nutrients). These are complex factors which our modelling could not take into account.
- Further research on the effect of such diets on supply and pricing, including how this should affect subsidy systems for farmers. We note that there are connections between supply of items (e.g. between meat and dairy production) which would need to be taken into account.
- Consideration of minority and regional diets, or even individual diets, rather than looking at a single sample diet for each country.
- Research into the consequences of taking wider sustainability criteria (water, biodiversity) into account.
- Research into reducing GHGe in production and distribution of food.

GLOSSARY

ANSES	French agency for food, environmental and occupational health and safety
BEDCA	Database of Spanish Food Composition
CAP	Common Agricultural Policy
CPI	Consumer Price Index
ENIDE	National Survey of Dietary Intake [Spain]
EU	European Union
FAO	United Nations Food and Agriculture Organisation
FBDG	Food-based dietary guidelines
GHGs	Greenhouse gases
GHGe	Greenhouse gas emissions
HBS	Household budget survey
HLCWG	*How Low Can We Go?* Report
INCA	Individual and National Survey on Food Consumption [France]
LCA	Life cycle analysis
PNNS	National Health and Nutrition Programme [France]
RDA	Recommended daily allowance
RDC	Regional distribution centre
SIK	Swedish Institute for Food and Biotechnology
SNO	Swedish nutritional recommendations objectified
SNR	Swedish nutritional recommendations

INTRODUCTION

This report has a number of audiences. On the one hand, this is a research project and we wish to give full details of the methodology and assumptions made. On the other hand many people will be more interested in the diet for a particular country and how it compares with what they or others eat now. To cater for both audiences, the report is divided into the following sections:

1. **Background and research questions**. This explains the background to the project, including the Livewell UK project, and the key questions which we have sought to answer.

2. **Methodology.** This explains the general approach we used and the ways in which we adapted data for the purposes of dietary modelling.

3. **The LiveWell diet**. This gives a diet for each country based on a 25% reduction in GHGe. For each diet we show the list of ingredients (compared against current consumption) and a sample menu. We compare nutritional data against average consumption and national nutritional recommendations, and look at how the LiveWell diet affects consumption of different food groups.

4. **Analysis.** This section gives greater detail on the assumptions made and the ways we approached data in different countries, including some specific national issues.

5. **Conclusions.** These include answers to the key research questions and ideas for further research.

The report has the following annexes for reference:

1. Extreme diets – maximum possible GHGe reductions
2. Detailed methodology for collating data
3. Sensitivity analysis
4. National nutritional recommendations (from Task 1)
5. Project brief
6. References

1. BACKGROUND AND RESEARCH QUESTIONS

1.1 WWF's One Planet Food programme and the Livewell diet for the UK

WWF-UK's One Planet Food programme, which runs from 2009 to 2015, aims to reduce the environmental and social impacts of UK food consumption and production. Its goals are to:

- reduce GHGe resulting from the production and consumption of food destined for the UK by 70% based on 1990 levels
- ensure that water use in the production and consumption of food destined for the UK has no unacceptable socio-economic or environmental impacts
- change trading patterns and governance structures so that UK food is making a net positive contribution to WWF's priority places for biodiversity, such as the Amazon.

The concept of a 'sustainable diet' has stimulated debate about how changes in the UK diet may go some way towards achieving these goals. Any work on diet needs to look beyond the environment and include the potential benefits to health, society, the economy and developing countries.

In 2010-11, WWF-UK commissioned the Rowett Institute of Nutrition and Health at Aberdeen University to define a diet with lower GHGe and produce the Livewell plate. This work was framed by three questions:

1. What does the average UK consumer eat and what would change if we were to follow government recommendations for a healthy, balanced diet, as outlined by the Eatwell plate[3]?
2. What would be the sustainability benefits of following the Eatwell plate guidance, and would the plate need to be modified to include sustainability criteria?
3. What would be the key principles of a sustainable diet?

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3 The Eatwell plate represents the UK government's dietary guidelines in the form of a plate showing recommended consumption of different food groups (fruit and vegetables; bread, rice, potatoes, pasta and other starchy foods; milk and dairy foods; meat, fish, eggs and beans; foods and drinks high in fat and/or sugar).

The UK Livewell project aimed to create a seven-day diet with significantly lower GHGe than the average UK diet, while also meeting dietary requirements for health.

Linear programming was used to construct a sample diet that minimised GHGe while still meeting food, energy and nutrient requirements for an adult woman in the UK. Nutrient composition and GHGe data for 82 food items were used. To ensure a realistic variety and balance of food items, the model placed consumer acceptability constraints on the amount of each food group included in the diet.

A seven-day sample diet was created that met dietary requirements and achieved a significant reduction in GHGe. It was possible to incorporate a wide variety of food without eliminating any food groups (e.g. meat, dairy products) but the quantities of some foods were reduced compared to the current diet. The retail cost of the diet was comparable to the average UK expenditure on food.

The Livewell study for the UK illustrated that many of the principles of a healthy diet are consistent with the dietary changes needed to reduce GHGe to tackle climate change. Individual food groups do not need to be eliminated, but the range and quantities of food need to be rebalanced to benefit health and the environment.

1.2 LiveWell for low impact food in Europe (LIFE)

The LiveWell for LIFE project uses the LiveWell Plate to define country-specific sustainable diets across the EU. As the food system produces considerable GHGe, moving towards sustainable diets across the EU would make an important contribution to keeping global warming below 2°C. The project examines the feasibility of EU-wide introduction of the LiveWell Plate by testing and evaluating the tool in three pilot EU member states – Sweden, Spain and France. These countries have been chosen due to the range of dietary contexts they represent and the different levels of policy readiness for adopting the sustainable diets concept.

Monitoring and evaluation (M&E) of the LiveWell Plate and of the methodology used for its application will be embedded in all demonstration actions. Establishing and developing the European network of food stakeholders is a key component of the project, essential to its longer term impact. The ultimate aim of the LiveWell for LIFE programme is to help create a conducive policy environment and influence European legislation by developing policy pathways and disseminating this widely across the EU.

The Livewell 2020 Plate produced for the UK sets out a diet that will reduce GHGe from the UK food supply chain by 25% (based on 1990 levels) by 2020. The LiveWell Plates developed for the pilot countries (France, Spain and Sweden) would provide the same 25% reduction in GHGe from these countries' food chains by 2020. As the pilot countries are large food producers this will contribute significantly towards the European Commission's overall target of a 20% reduction in overall GHGe by 2020.

The project brief is shown in Annex 5.

1.3 Key research questions

In using this report it is important to keep in mind that:

- The work addresses all three countries separately.
- Sustainable refers only to GHGe: specifically, reduction from present levels of emissions from the average diet unless an alternative figure is given.
- Economic refers to estimated costs of the diet: specifically, reduction from the estimated costs of the average diet unless an alternative figure is given.
- Minimising change means that the diet is as close to the current average diet as is possible (we consider how to define this later).
- Viable change of diet means that the change in diet is one which is acceptable to most consumers (we consider how to define this later).

In order to make the research specific, we defined a set of research questions. These are as follows:

A. Can a healthy diet be environmentally sustainable?

Is it possible to comply with national health guidelines while reducing GHGe?

Most health guidelines include a reduction in meat consumption. Meat is the major source of GHGe from food: UK figures show meat, dairy and eggs account for around one-third of the diet in terms of energy, and two-thirds of production GHGe. However, not all dietary guidelines explicitly advise reductions in meat consumption. In particular, the French dietary guidelines advise the consumption of one to two (at least one, two maximum) portions of meat, fish, poultry or egg per day. Unlike in the UK and US guidelines, nuts and legumes are not included in this group of "protein-rich" foods.

In addition, healthy diets may have high GHGe (e.g. living on exotic fruit and vegetables, higher quantities of white meat and fish). Our model needs to demonstrate that this is not the case with the proposed diet.

B. Can a diet be healthy, economic and respect the environment?

Previous studies have shown that it is difficult to eat healthily on a low budget, but that it is possible by selecting foods with a high ratio of nutritional quality to price (see reference 3). In this study, we identify food choices that reconcile healthy eating with cost-conscious household budgeting, while reducing environmental impacts from the food system. In making this static analysis we do not consider the effects of supply and demand if the whole population adopts a different diet (e.g. changing prices of foods due to demand and availability of subsidies). Pricing and the market for food is a complex subject which is beyond the scope of this report.

C. What is the lowest level of GHGe that may be reached while fulfilling nutritional recommendations and not increasing diet cost?

What diet would most reduce GHGe while following health guidelines and not increasing costs? Although cheap, such a diet would be likely to be unappealing to most consumers, having a limited variety of foods and being a long distance from current diets. Nonetheless, we seek to identify this as a benchmark to show the limits of minimising GHGe through food choices in the current environment.

D. What would be a healthy sustainable diet which reduces GHGe by 25% and minimises change from the current diet?

This is a major part of the work and results in a recommended distribution of foods as the LiveWell plate for each country.

E. What are the general implications?

As this is a first piece of research, we also review briefly further issues and indicate trends and need for further research.

Defining *minimising change*

This clearly caused some difficulties for the original LiveWell plate, as representing objective change from the current diet is not simple. We created upper and lower bounds based on factors including popularity of foodstuffs (not excluding the most popular items), portion sizes (avoiding small amounts of items which can only be bought as units), cultural preferences (potatoes vs. pasta vs. rice as a source of carbohydrate), avoiding introducing large amounts of currently unpopular foods, and ensuring variety.

We used two approaches for balancing acceptability with other factors. For France, minimisation of the change from current food intake patterns was conducted following a previously described methodology (see references 7 and 12), and only limited additional bounds were then imposed. For Spain and Sweden, we used more general bounds based on popularity and minimum portion sizes and then imposed additional constraints based on discussion with dieticians in order to produce an acceptable menu.

1.4 Literature review

There is an increasing amount of evidence for the need to look at food consumption and a sustainable diet. This comes from a variety of international bodies from the United Nations Food and Agricultural Organisation (FAO) to the Royal Society and the World Health Organisation (WHO). Though the subject is still reasonably new, there is a growing body of evidence defining what a sustainable diet should look like. The concept of sustainable eating combines healthy food with environmentally friendly food; they are seen as complementary, not separate entities. In 2010, the FAO defined a sustainable diet as:[4]

> …those diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources.

According to the United Nations Environment Programme (UNEP) an increasing population, coupled with the increased purchasing power of Asia and Africa's middle classes, an urbanising world and the increased prevalence of Western diets and lifestyles, means the demand for natural resources is accelerating at an unparalleled rate. A "business as usual" scenario will result in a tripling of annual resource extraction by 2050. This is neither sustainable nor feasible. One of the key drivers of resource use is an increased demand for resource-intensive foods such as livestock products.

[4] FAO. 2012. *Sustainable Diets and Biodiversity; Directions and Solutions for Policy, Research and Action*. Available at: www.fao.org/docrep/016/i3004e/i3004e.pdf [Accessed 13 January 2013]

A 2012 report by Professor John Beddington for CGIAR recognises that the food system has to "reshape food access and consumption patterns to ensure basic nutritional needs are met and to foster healthy and sustainable eating patterns worldwide".[5]

European food consumption and production is estimated to account for 20-30% of the EU's total environmental impact. In September 2011, the European Commission (EC) presented its Roadmap to a Resource Efficient Europe, expressing a vision of a European economy in 2050 that respects resource constraints and planetary boundaries. The roadmap sets out milestones for 2020 and a broad range of EC and member-state actions to reach them. One of the three key economic sectors identified as being a barrier for meeting the 2020 milestones is food. The 2020 milestone is defined as follows:

> By 2020, incentives to healthier and more sustainable food production and consumption will be widespread and will have driven a 20% reduction in the food chain's resource inputs. Disposal of edible food waste should have been halved in the EU.[6]

According to the Royal Society[7] the food system is one of the main drivers of environmental degradation. Their solution focuses on consumption: "In the short term it is of utmost urgency to reduce consumption and emissions that are already causing damage, for example greenhouse gases, deforestation and land use change."

The call to look at food consumption and work towards sustainable diets has come from, among others, the EU[8] , CGIAR, the Foresight report,[9] the Royal Society, the World Bank,[10] Forum for the Future[11] and

[5] Beddington J, Asaduzzaman M, Fernandez A, Clark M, Guillou M, Jahn M, Erda L, Mamo

T, Van Bo N, Nobre CA, Scholes R, Sharma R and J Wakhungu. 2011. *Achieving food security in the face of climate change: Summary for policy makers from the Commission on Sustainable Agriculture and Climate Change*. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). Copenhagen, Denmark. Available at: www.ccafs.cgiar.org/commission [Accessed 13 January 2013]

[6] ec.europa.eu/environment/resource_efficiency/index_en.htm

[7] The Royal Society. 2012. *People and Planet*. The Royal Society Policy Centre report 01/12

[8] www.eea.europa.eu/soer

[9] webarchive.nationalarchives.gov.uk/+/http://www.bis.gov.uk/foresight/our-work/projects/current-projects/global-food-and-farming-futures

[10] World Bank. 2007. *World Development Report 2008: Agriculture for Development*. World Bank, Washington DC.

[11] www.forumforthefuture.org/sites/default/files/images/GreenFutures/Tomorrows_food_and_farms/TFTF.pdf

Prince Charles's International Sustainability Unit.[12] Even the recent Environment Outlook report from the OECD,[13] says we need to tackle meat consumption. Many health bodies have a similar message, including the WHO, the Scientific Advisory Committee on Nutrition and the World Cancer Research Fund. A WHO technical report[14] states:

> For the large majority of people in the world, particularly in developing countries, livestock products remain a desired food for nutritional value and taste. Excessive consumption of animal products in some countries and social classes can, however, lead to excessive intakes of fat. The growing demand for livestock products is likely to have an undesirable impact on the environment. For example, there will be more large-scale, industrial production, often located close to urban centres, which brings with it a range of environmental and public health risks.

Various specialists within WWF's global network have independently highlighted the need to look at diets and livestock product consumption as key to meeting conservation goals. In order to achieve WWF's target of zero net deforestation by 2020, dietary shift is needed, with many parts of the world needing to eat less meat (for global diets to be more equitable, sub-Saharan Africa and South Asia should see a per capita increase).[15] In the 2010 *Living Planet Report*, the need to reduce meat consumption is clearly recognised.[16] *The Energy Report* (2011) shows that WWF's vision of 100% renewable energy by 2050 is achievable only if Western diets become less resource intensive.[17] In 2009, WWF-UK produced *How low can we go?.*[18] This looked at the role of the food system in meeting the UK government's 2050 carbon targets. This concluded that, while production and technological changes are vital, targets will not be met without a change in food consumption patterns and defining a sustainable diet is going to be key.

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[12] www.pcfisu.org/reports

[13] www.oecd.org/document/11/0,3746,en_2649_37465_49036555_1_1_1_37465,00.html

[14] WHO/FAO. 2002. Diet, nutrition and the prevention of chronic diseases: report of a joint WHO/FAO expert consultation, Geneva, 28 January – 1 February 2002. WHO technical report series, 916. Geneva, Switzerland.

[15] wwf.panda.org/what_we_do/how_we_work/conservation/forests/zeronetdeforestation

[16] wwf.panda.org/lpr

[17] wwf.panda.org/energyreport

[18] wwf.org.uk/what_we_do/changing_the_way_we_live/food/food_publications_library.cfm?3678/How-low-can-we-go

There have been important strides towards defining a sustainable diet. WWF's LiveWell plate outlines guidance for achieving a varied and nutritionally balanced diet that would also meet UK GHGe targets. The FAO has spoken about the need to change consumption for many years, notably in *Livestock's Long Shadow*[19]. Its 2012 publication *Sustainable Diets and Biodiversity*[20] states:

> Sustainable diets can address the consumption of foods with lower water and carbon footprints, promote the use of food biodiversity, including traditional and local foods, with their many nutritionally rich species and varieties. The sustainable diets approach will contribute in the capturing efficiencies through the ecosystem approach throughout the food chain. Sustainable diets can also contribute to the transition to nutrition-sensitive and climate-smart agriculture and nutrition-driven food systems.

The Barilla Centre for Food and Nutrition has created the 'double pyramid': the familiar food pyramid (a balanced, healthy diet) and an environmental food pyramid.[21] The latter, placed alongside the food pyramid, is shown upside-down: foods with higher environmental impact are at the top and those with reduced impact are at the bottom. From this double pyramid it can be seen that those foods with higher recommended consumption levels are also those with lower environmental impact. This illustrates the connection between two different but highly relevant goals: health and environmental protection.

European governments have also recognised the need to work on sustainable diets. In 2011 the health council of the Netherlands produced "Guidelines for a healthy diet: the ecological perspective"[22]. It recognised the mutual benefits of a healthy, environmentally friendly diet for its citizens and the planet. Its two win-win guidelines are:

- A less animal-based and more plant-based diet, containing fewer meat and dairy products and more wholegrain products, legumes, vegetables, fruit and plant-derived meat substitutes. This dietary pattern is associated with a lowered risk of cardiovascular disease and also has a

[19] FAO. 2006. *Livestock's Long Shadow*. FAO, Rome, Italy.

[20] FAO. 2012. *Sustainable Diets and Biodiversity; Directions and Solutions for Policy, Research and Action.* www.fao.org/docrep/016/i3004e/i3004e.pdf

[21] Barilla Center for Food and Nutrition. 2011. *2011 Double Pyramid: Healthy food for people, sustainable for the planet.* http://www.barillacfn.com/wp-content/uploads/2010/06/pp_doppia_piramide_alimentazione_eng.pdf

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

smaller ecological impact. From a health perspective it is not necessary to avoid meat and dairy products entirely; nor does this appear to be necessary from an ecological perspective.

- The reduction of energy intake for those with an excessive body weight, in particular by eating fewer non-basic foods, such as sugary drinks, sweets, cakes and snacks. A healthy body weight is associated with a reduced risk of diabetes, cardiovascular disease, and certain forms of cancer. Lower energy intakes also reduce the demand for foods, which lowers production and consequently reduces the ecological impact.

In 2009, in Sweden the National Food Administration and Swedish Food Environmental Protection Agency (EPA) produced its environmentally friendly food choices (since withdrawn with a change in government). These highlighted the need to reduce meat and rice consumption, amongst other thing, and were the first of their kind.[23]

Successive UK governments have recognised the need to define and work on sustainable diets. There have been three key reports from government: *Food Matters* (2008)[24], *Food 2030*[25] and the *Green Food Project (2011-12)*[26], which commits the government to bring together stakeholders to work on defining a sustainable diet. Unfortunately, the reports have not been followed up or have been scrapped after a change of government.

There is a growing body of independent evidence and research around the impacts of current consumption patterns on health, the planet, society and the economy. We are no longer eating the same food as we were 50 years ago. These changes have occurred as we have changed our farming practices. We cook less, eat less as a family, and are eating more meat and processed foods than at any other time. This is clearly demonstrated in the report *Protein Puzzle*[27] which examines how European diets have changed significantly over the last 50 years, including higher intakes of meat, dairy, eggs and fish. These higher intakes have been accommodated by new agricultural production

[23] www.slv.se/upload/dokument/miljo/livsmedelsverkets_%20miljosmarta_matval_till_EU.pdf

[24] webarchive.nationalarchives.gov.uk/+/http://www.cabinetoffice.gov.uk/media/cabinetoffice/strategy/assets/food/food_matters1.pdf

[25] archive.defra.gov.uk/foodfarm/food/pdf/food2030strategy.pdf

[26] www.defra.gov.uk/publications/2012/07/10/pb13794-green-food-project

[27] Westhoek, H et al. 2011. *The Protein Puzzle*. PBL Netherlands Environmental Assessment Agency, The Hague

techniques, which have made food cheaper. The increased production and the techniques deployed have also aggravated a number of environmental impacts including effects on biodiversity, animal health and welfare and emissions of GHGs and reactive nitrogen.

Globally between 1969 and 2005 food consumption has increased on average by 360 kcal per person per day – a 15% increase.[28] The increase in global food consumption has not been equal. In sub-Saharan Africa, the per capita supply of calories has remained about the same,[29] but hunger has increased among the poorest, as has food-related ill health among the middle classes.

Global demand changes rapidly as countries become wealthier and people can afford more varied diets, and move to more meat, dairy and fish. Fish consumption, for example, increased from 9.9 kg per year in the 1960s to 17 kg per capita in 2010.[30] The consequences of this development are naturally not equally distributed; whereas fish consumption increases in wealthier countries some fisheries are seriously depleted and communities lose their main source of protein. In the developed world people are eating a narrower variety of ingredients and more homogenised diets. Future trends in food will depend on demand, driven by dietary preferences, marketing, market value and availability.

Finally the thinking around sustainable diets examines how sustainable diets can benefit our children. The report *Healthy and sustainable diets in the Early Years* by Susan Westland and Helen Crawley[31] discusses the need to ensure our diets are sustainable throughout the generations and to emphasise environmental constraints, as it is today's children who will feel the effects of the current system. Poor nutrition affects school performance, economic productivity and earning power in adult life, and this has increased costs on society both directly and from loss of ability to contribute fully to society, economic growth and taxes.

As we can see, the idea of working on consumption and sustainable diets is widely endorsed by a myriad of independent global and national bodies and scientists. Sustainable diets are a key part of a food system that addresses food security, inequality, poor health and planet-friendly agriculture.

[28] Foresight. 2011. *Synthesis Report C1:Trends in food demand and production*. Global Food and Farming Futures, UK government

[29] WHO. 2003. *Diet, nutrition and the prevention of chronic diseases*. Technical report series 916, WHO, Geneva, Switzerland.

[30] FAO. 2010. *The state of the world fisheries and aquaculture 2010*. FAO, Rome, Italy.

[31] Westland S and Crawley H. 2012. *Healthy Sustainable Diets in the Early Years. Implications of current thinking on healthy, sustainable diets for the food and nutrition intakes of children under 5 in the UK.* www.firststepsnutrition.org/pdfs/sustainability.pdf

2.1 General approach

Our general approach followed the methodology developed by Livewell UK. This had three stages, as follows:

1. Collation of relevant data

2. Production of a model, including creation of appropriate constraints

The sources for data and detailed approaches differ for each country and are explained in the analysis section. However, we used a basic approach described below.

2.1.1 Collation of data

The following data was gathered:

1. Dietary data – showing an average diet for the country and, if possible indications of popularity of particular items (percentage of the population eating a particular food item, including average consumption and standard deviation). The data was produced as a separate contract ("Task 1") and we did not need to supplement this.

2. Information on national nutritional recommendations – again this was provided by Task 1 and we did not need to supplement it. However, we note that for some trace elements (e.g. iodine) nutritional data can be unreliable so we considered carefully which items should be part of the model. National nutritional recommendations (provided by Task 1) are presented in annex 4.

3. National nutritional data – again provided by Task 1. This required a certain amount of processing because there was not data for all items, so we had to use substituted data from other countries, or in some cases there was missing data on particular nutrients. In addition, we had to estimate wider categories (for example "fish" in the Swedish dietary survey) based on other information regarding composition or derivation. Additional processing and merging databases was a particular issue for Spain owing to the wide range of specific foods identified in the dietary survey.

4. GHGe data – for this we tried where possible to use GHGe/LCA data from studies conducted for the particular country. Where this was not possible we used data from countries with the most similar GHGe patterns where possible (for example, UK in preference to France for Sweden, France in preference to UK for Spain). When using UK data (specifically HLCWG data) consideration was given to different trading patterns in estimating GHGe. Where there were several studies showing data for different stages of the life cycle (regional distribution centre (RDC), retail, final consumer), multiplications were made to ensure consistency between the figures. The result is a set of GHGe figures where the *relative* values are more reliable than the absolute values. For Sweden the figures estimate the GHGe for the full cycle to the consumer, whereas for France and Spain figures are to retail; it seemed unnecessary to estimate an additional multiplication factor which would not affect the relative values. Finally, for highly processed items where there was no national data, we used data presented by Eat England, based on UK experience, since in a global market place such goods are likely to have a similar profile across Europe, certainly in terms of relative values.

5. Price data – for France we were able to access detailed price data, but for Sweden and Spain we used a more general approach. For these two countries we did not have comprehensive price data, even though there was some detailed data on a limited range of products (generally from official statistics used to calculate consumer price inflation). We therefore used a combination of methods, making an overall estimate based on statistics from the household budget survey (HBS) for each country, which shows the amount households spend on different groups of foods. We then fine-tuned this to make sure that relative prices were valid by taking absolute figures from official statistics and checking online supermarket websites. This may create some averaging effects, but in other respects avoids problems, for example through examining figures at a particular time for seasonal foods.

6. Information on food-based dietary guidelines – in general these categorisations, provided by Task 1, are very broad and not completely quantified (for example, the Swedish recommendation is to have at least one item from each group in the "food circle" each day[32]). This data was therefore used for reporting rather than modelling.

[32] Please see *Food patterns and dietary recommendations in Spain, France and Sweden*, a report previously released by the project that investigated the eating behaviours in Spain, France and Sweden – the project's pilot countries. It compares these findings to what the people

2.1.2 Modelling

The task of optimisation can be formulated as a simple linear programming model which we then processed electronically, either through the Rglpk package (Sweden and Spain) or by using Solver in Excel (France). Rglpk is faster and more versatile regarding data manipulation, whereas Solver allows more flexibility in developing constraints.

The problem can be articulated as being to find the values of a set of variables (amounts consumed of individual foodstuffs) which optimises an output (minimum GHGe) subject to a number of constraints (minimum nutrient requirements, and others) and boundaries on particular variables (due to acceptability, portion sizes etc.).

Owing to the availability and quality of data, modelling worked slightly differently in France, compared to the other two countries. We imposed the current French dietary guidelines strictly. These are expressed as consumption frequencies of defined portion sizes of some categories and therefore can be readily translated into daily quantities. This is not the case for Spain and Sweden.

For the purpose of making a clear model for Sweden and Spain, where dietary guidelines are more qualitative, we used the following approach:

1. The definition of different foodstuffs used was the same as that used in the national dietary survey, in order to maintain comparability with current consumption.

2. Nutritional constraints were defined for key nutrients in the national nutritional recommendations where there was adequate data. For France, we used the nutrients used as constraints in the LiveWell UK report and then checked for other nutrients in the final diet. For Sweden and Spain, we used different selections of nutrients based on availability of data, though ensuring we included those that were expected to be key binding constraints (for example iron and zinc).

3. Overall acceptability constraints were defined by requiring that amounts consumed in particular food groups should be at least 60-80% of the current average consumption. Food groups were defined differently for different countries – for Sweden we used the food circle recommendations; for Spain, we used the wider categories used in the dietary survey as a guideline.

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in these countries should be eating, according to their national dietary guidelines. http://www.livewellforlife.eu/wp-content/uploads/2012/05/LiveWell_A4-Food-Patterns-Report_web.pdf

4. Bounds were set for a number of reasons, in order to produce an acceptable model (see further discussion on acceptability below). Setting of bounds is discussed in more detail for individual countries.

We ran the model to produce two outputs:

1. Optimising GHGe based only on nutritional recommendations and currently consumed foodstuffs
2. Ensuring a target of 25% reduction in GHGe subject to constraints and bounds set to ensure maximum acceptability.

For the second output, for Spain and Sweden we ran the model to optimise for GHGe and imposed successively tighter acceptability bounds until the reduction was only 25%. For France, we minimised total departure from the mean observed consumption of food in the French population, subject to nutritional constraints (both nutrient-based and food-based) and to 25% GHGe reduction, as previously described (reference 12). However, this method requires precise data on the food intakes observed in the target population. In addition, such an objective function does not fully guarantee that the modelled diet will be acceptable, particularly because:

1. It is difficult to encapsulate how different foodstuffs go together in a particular national diet (need for milk with breakfast cereal, butter/margarine with bread etc.)
2. Different sources of particular nutrients can make small differences to GHGe but the result may not be culturally acceptable. The trade-offs here are difficult to work through. For example, the basic model would suggest that in Sweden the diet could be more sustainable by eating pasta rather than potatoes. What is more important for acceptability: to eat potatoes rather than pasta, or to be able to eat slightly more meat?
3. Inevitably, any model will produce strange amounts of some minority foodstuffs which are difficult to integrate into a “normal” weekly menu – for example, more than 200g strawberry jam.

For France, we designed only one modelled diet that fulfilled the nutritional constraints subject to 25% GHGe reduction, acceptability constraints (on particular portion sizes for each food) and minimal departure from the average diet. For Spain and Sweden, we used linear programming to examine a variety of scenarios and to make some analysis of the effect of different assumptions not only on GHGe, but also on variety and composition of the diet.

3. LIVEWELL DIET

3.1 General

3.1.1 Introduction

In this section we present a LiveWell diet for each country: that is, a possible diet which is as acceptable as possible, reduces GHGe by 25% from the current average diet, costs no more than now, and complies with national nutritional recommendations.

For each country diet we show:

1. Nutritional data against average consumption and national nutritional recommendations
2. A comparison of consumption of different food groups between current consumption, the LiveWell diet, and a diet with the maximum reduction in GHGe possible through choice of foods.

In all analysis we have ignored the effect of alcohol and drinks[33] since this was too complex for the model.

Presenting our findings against public dietary recommendations proved to be difficult, since many such recommendations are qualitative. Instead, we used these to determine the categories of foods for reporting and show how the breakdown changes.

3.1.2 Comparing the three countries

There is an inevitable temptation to compare the LiveWell diets in the three countries and to derive conclusions form this. Who has the most sustainable diet? Why does people in one country eat more fruit than another? Why does another have more meat in the diet?

However, comparing the three countries can be invidious and can easily become a comparison of cuisine and eating habits, rather than a question of balancing health, cost and sustainability. We urge caution in terms of comparisons for a number of reasons:

[33] Except for fruit juices, milk, and a single cola drink.

1. We have tried to develop the diets with national acceptability in mind and the cuisine of the three countries is quite different. So we have more potatoes in Sweden and more pasta in Spain – but this is more a matter of preference than a critical difference in the diet and its sustainability or nutritional content. In the same way, whether there is a mixture of different types of meat or just a few in larger quantities is partly dependent on the ease of manufacturing a menu from the results of our modelling.

2. The models work with slightly different data. In particular, the French model was produced with women-only data (as with the original Livewell UK), but because of availability of data, Spain and Sweden are presented for an "average" person. Nutritional recommendations are averaged accordingly where they are different for men and women.

3. Nutritional recommendations (see annex 4) vary considerably between countries. We have sought to strictly comply with nutritional recommendations, so these affect the foods selected. Running a model for Spain with Swedish nutritional recommendations would inevitably produce a different LiveWell Plate.

4. The degree to which food-based dietary guidelines are used as a constraint varies between countries. For France, we interpreted the principles and used these within the model. For Sweden, the general principle of variety within the food circle was used, keeping variety similar to that of the current diet. For Spain, food-based dietary guidelines were found to be too difficult to quantify so constraints were chiefly based on acceptability criteria.

5. Absolute figures are not comparable. We spent time adjusting the data (particularly the carbon data, but also for cost) for Sweden and Spain so that the figures are consistent (i.e. relative values are defensible) since the selection of foods and quantities in the model is based on relative values, not absolute ones. For GHGe figures, for Sweden we used an estimate of the figure for the life cycle to the consumer whereas for France and Spain the figure used is only to retail.

6. As the detail comes from dietary surveys, the number of foods in the model varies between countries (68 for France, 277 for Spain, and 88 for Sweden). This gives different opportunities for developing different diets: with a greater number of more detailed foods it is possible to produce a wider range of solutions.

3.1.3 Common features

A number of overall similarities between these nutritious low GHGe diets can be observed:

1. All diets show a reduction in the total amount of meat consumed. This is inevitable since these are the foods with the highest GHGe. On the other hand, we demonstrate that for a 25% reduction it is still possible to have enough meat and/or fish in the diet to comply with nutritional recommendations and to maintain some traditional dishes and meal patterns.

2. All diets show an increase in the consumption of legumes as sources of protein. This again is inevitable owing to the lower GHGe of legumes relative to most other sources of protein, even if they are imported long distances. . As legumes are not costly, this may help to keep the food budget constant or even to decrease it.

3. All diets show an increase in cereals and starchy foods, typically represented by increases in bread, pasta and potatoes.

4. Consumption of dairy products remains relatively similar to now.

Different assumptions about an acceptable diet would produce different diets – for example, it would be possible to run the model excluding meat altogether for vegetarians. Nonetheless we can make the following additional points:

1. Reducing GHGe by 25% while maintaining relatively recognisable meal patterns and composition is possible. We note any significant changes for each country, but there is generally enough flexibility to cater for this. At least half the meals in the week are “normal”, though there may be less meat or changes in proportion of different items.

2. All LiveWell diets strictly comply with national nutritional requirements. However, requirements for some items vary quite widely between countries: in particular, for Spain, the figures for zinc and iron are relatively high. It may be possible to produce a more acceptable diet if these constraints are partially relaxed.

3.2 LiveWell for each country

3.2.1 France

Amounts of food selected by the LiveWell model:

Food items	EPIC food groups	Average intake, g/day	Amount in the LiveWell diet, g/day
Potato chips, salted	1	1.49	0.0
Scalloped potatoes	1	7.47	7.5
Boiled potato	1	33.10	33.1
Fried potato (frozen)	1	8.99	9.0
Potato salad	1	4.95	5.0
Raw carrot	2	19.08	19.1
Raw endive	2	5.33	5.3
Canned green beans, drained	2	21.25	71.1
Cooked onion	2	4.26	4.3
Green salad without dressing	2	26.86	26.9
Raw tomatoes	2	55.75	55.8
Tomato Provençal	2	8.68	8.7
Lentils, cooked	3	8.79	150.0
Fresh banana	4	20.86	20.9

Clementine	4	22.67	60.5
Stewed apple	4	13.91	13.9
Walnuts	4	0.67	4.7
Fresh orange	4	16.02	16.0
Fresh unpeeled apple	4	87.22	80.0
French cheese (Camembert)	5	7.86	30.0
Low-fat cream	5	1.48	0.0
High-fat cream	5	2.67	0.0
Cream cheese, 20% fat	5	10.44	10.4
Gruyère cheese	5	6.37	13.5
UHT semi-skimmed milk	5	143.23	143.2
Yogurt with fruit	5	13.92	13.9
Yogurt	5	26.33	26.3
Appetizer cracker biscuit	6	1.23	0.0
Bread, baguette	6	72.81	72.8
Bread, wholegrain	6	7.24	99.5
Cooked pasta	6	41.27	41.3
Cooked white rice	6	23.41	23.4
Grilled lamb chops	7	3.72	0.0
Turkey	7	11.51	7.6

Cooked ham	7	23.38	7.0
Grilled bacon	7	3.31	0.0
Roasted chicken	7	24.24	7.7
Dried sausage	7	3.27	0.0
Ground beef, 15% fat	7	24.62	24.6
Baked cod	8	2.89	0.0
Shrimp, cooked	8	3.42	0.0
Hake, cooked	8	5.26	0.0
Sardines canned in oil, drained	8	1.00	29.0
Steamed salmon	8	9.63	0.0
Raw smoked salmon	8	1.75	0.0
Canned tuna in brine, drained	8	5.88	0.0
Boiled egg	9	14.45	14.5
Unsalted butter	10	16.11	0.0
Olive oil	10	9.56	10.0
Sunflower oil	10	3.87	10.0
Honey	11	8.32	8.3
White sugar	11	23.36	7.6
Processed cake	12	12.62	0.0

(brioche)			
Chocolate bread (pain au chocolat)	12	14.47	14.5
Fruit tart (processed)	12	39.20	0.0
Orange juice (pasteurised)	13	64.04	0.0
Cola drink	13	59.21	59.2
Low-fat margarine	15	14.11	0.0
Vegetable soup (processed)	16	17.70	17.7
Vegetable soup, home-made	16	60.00	60.0
Cassoulet (canned)	17	11.34	11.3
Cheeseburger	17	6.34	0.0
Pizza	17	14.94	0.8
Fried breaded fish	17	11.07	0.0
Quiche Lorraine	17	13.59	13.6
Meat ravioli with tomato(canned)	17	16.11	16.1
Tabbouleh	17	9.96	10.0
Stuffed tomato	17	13.76	13.8

Dietary and nutrient recommendations for French women used in the model and nutrient intake from the LiveWell diet:

	Average observed	Targets	LiveWell diet
Total amount, g/day	1304	-	1410
GHGe	3478	<2609	2609
Cost, euros/day	4.9	-	4.36

Nutrients			
Energy, kcal	1814	1800	1800
Proteins, g	68	>50	79.5
Carbohydrates, g	202	225-337 (50%-75%)	225.0 (50%)
Fibre, g	14	>25	26.3
Lipids, g	81	<70 (<35%)	63.4 (32%)
Saturated fatty acid, g	32	<20 (<10%)	20.0 (9.9%)
Sodium, mg	2053	<2365	2365
Calcium, mg	581	>900	927
Iron, mg	8	>14	14
Zinc, mg	7	>10	10

Vitamin B12, mg	3	>2.4	5.5
Vitamin B9, mg	188	>300	300
Added sugar, g	39	<45 (<10%)	18.6 (2.6%)

Food groups			
Fruit and vegetables	4.52	>5	5.4
Fruit juice	0.32	<1	0.0
Nuts	0.03	<1	0.2
Grains	2.21	>3	4.7
Dairy products	2.06	3	3
Meat, fish, eggs	1.48	1-2	1.0
Fish	0.30	>0.29	0.29
Fat	4.37	<3.5	2.0
Olive oil	0.96	>1	1
Sunflower oil	0.39	>1	1
Sweets products	4.24	<2	1.9
Sugar	3.17	<2	1.6
Drinks	0.30	<1	0.3

Since nutrient recommendations were used only for those included in the original Livewell UK research, we also show the results for some other key nutrients:

Nutrients not included in the model	Observed intake	Target	LiveWell diet
Magnesium, mg	182.8	360	249.8
Phosphorus, mg	944.6	750	1395.7
Potassium, mg	2349.8	3100	2645.1
Copper, mg	0.8	1.5	1.3
Selenium, mcg	41.3	50	36.5
Iodine, mg	82.6	150	78.8
Vitamin D, μg	2.7	3	2.8
Vitamin E, mg	11.0	12	11.7
Vitamin C, mg	87.6	110	82.1
Vitamin B1, mg	1.0	1.1	0.9
Vitamin B2, mg	1.1	1.5	1.4
Vitamin B3, mg	13.7	11	13.1
Vitamin B5, mg	3.8	5	4.8
Vitamin B6, mg	1.4	1.5	1.5

Comparison by food groups:

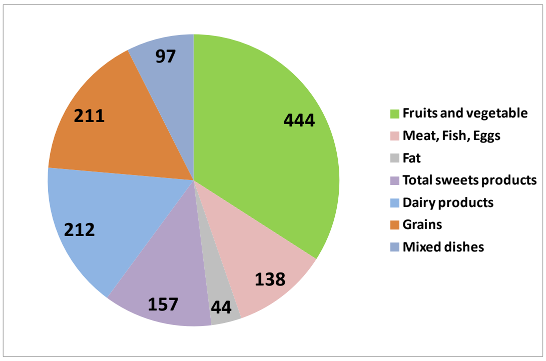
EPIC food groups	Observed average, g/day	LiveWell diet, g/day	Deviation, g
Legumes (3)	8.8	150.0	141.2
Cereals and cereal products (6)	146.0	237.0	91.0
Vegetables (2)	141.2	191.1	49.9
Fruits, seeds, nuts (4)	161.4	196.0	34.7
Dairy products (5)	212.3	237.4	25.1
Egg and egg products (9)	14.5	14.5	0.0
Soups, bouillon (16)	77.7	77.7	0.0
Fish and shellfish (8)	29.8	29.0	-0.8
Potatoes and other tubers (1)	56.0	54.5	-1.5
Fat (10)	29.6	20.0	-9.5
Condiments (15)	14.1	0.0	-14.1
Sugar and confectionery (11)	31.7	15.9	-15.8
Miscellaneous (17)	97.1	65.6	-31.5
Meat and meat products(7)	94.0	46.9	-47.1

Cakes (12)	66.3	14.5	-51.8
Non-alcoholic beverages (13)	123.3	59.2	-64.0

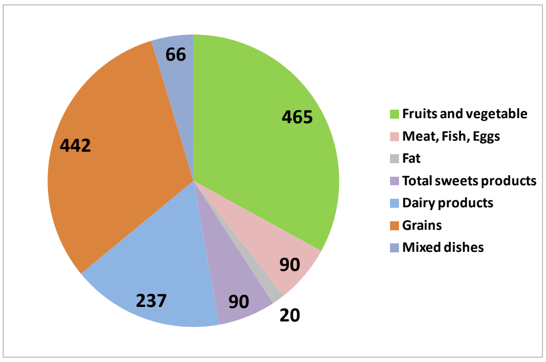
As can be seen, the biggest increases are in legumes and cereals while the biggest decreases are in meat and meat products as well as highly processed sweet foods (cakes). Consumption of dairy foods increases but only modestly. We show this graphically on the next page.

Graphical comparison:

A: Observed diet (3478g CO_2e/day)



B: LiveWell diet (25% reduction in GHGe: 2609g CO_2e/day)



3.2.2 Spain

The LiveWell diet for Spain shows a reduction in GHGe of approximately 27% and a cost equivalent to that of the current diet.

The model produces the following long list of ingredients:

Category	**Food**	**LiveWell diet (g/day)**	**Current average consumption (g/ day)**
Cereals	Bread products: rusks, peaks, breadsticks, toast and similar	6.86	2.08
	Brown rice	1.45	0.44
	Buns, including processed	5.17	17.23
	Corn, canned	1.82	1.82
	Corn and popcorn	1.91	0.58
	Corn breakfast cereal	2.51	0.76
	Muesli cereals	1.25	0.38
	Multigrain cereal	1.32	0.40
	Other cereals	5.15	1.56
	Oats, wheat, other grains	1.72	0.52
	Other types of bread	19.67	5.96

	Other types of flour	1.39	0.42
	Pastal	75.00	18.76
	Precooked patties or turnovers	1.95	0.59
	Rice	75.00	15.22
	Wheat	20.92	6.34
	Wheat breakfast cereal	2.18	0.66
	White bread	100.00	8.30
	White sandwich bread	86.31	77.14
	Wholegrain sandwich bread	4.13	1.25
	Wholewheat bread	16.34	4.95
Drinks not including milk	Citrus juices	23.00	23.85
	Peach juice	8.81	2.67
	Tomato juice	1.29	0.39
Eggs and egg products	Fresh chicken eggs	46.35	30.43
Fats and oils	Olive oil	23.00	23.03
Fruits and fruit products	Apple	25.00	41.42
	Banana	7.29	24.29
	Mandarin	5.00	9.83
	Melon	5.00	14.41

	Olives	3.48	3.48
	Orange	25.00	34.64
	Peach	5.00	14.98
	Pear	20.00	18.25
	Quince	1.16	0.35
	Strawberries	5.00	2.82
	Watermelon	5.09	16.96
Meat and meat products	Black pudding	5.00	1.30
	Chicken	15.00	32.78
	Cooked ham (York sweet, shoulder, Lacon)	5.00	8.61
	Cured ham and shoulder	15.00	12.40
	Liver	2.44	0.74
	Partridge, quail	1.02	0.31
	Pork	40.34	5.76
	Roast turkey	3.76	1.14
	Sausage, salami, fuet, secallona	10.82	3.28
Milk, dairy and milk substitutes	Cheese	5.00	25.41
	Condensed milk	1.02	0.31

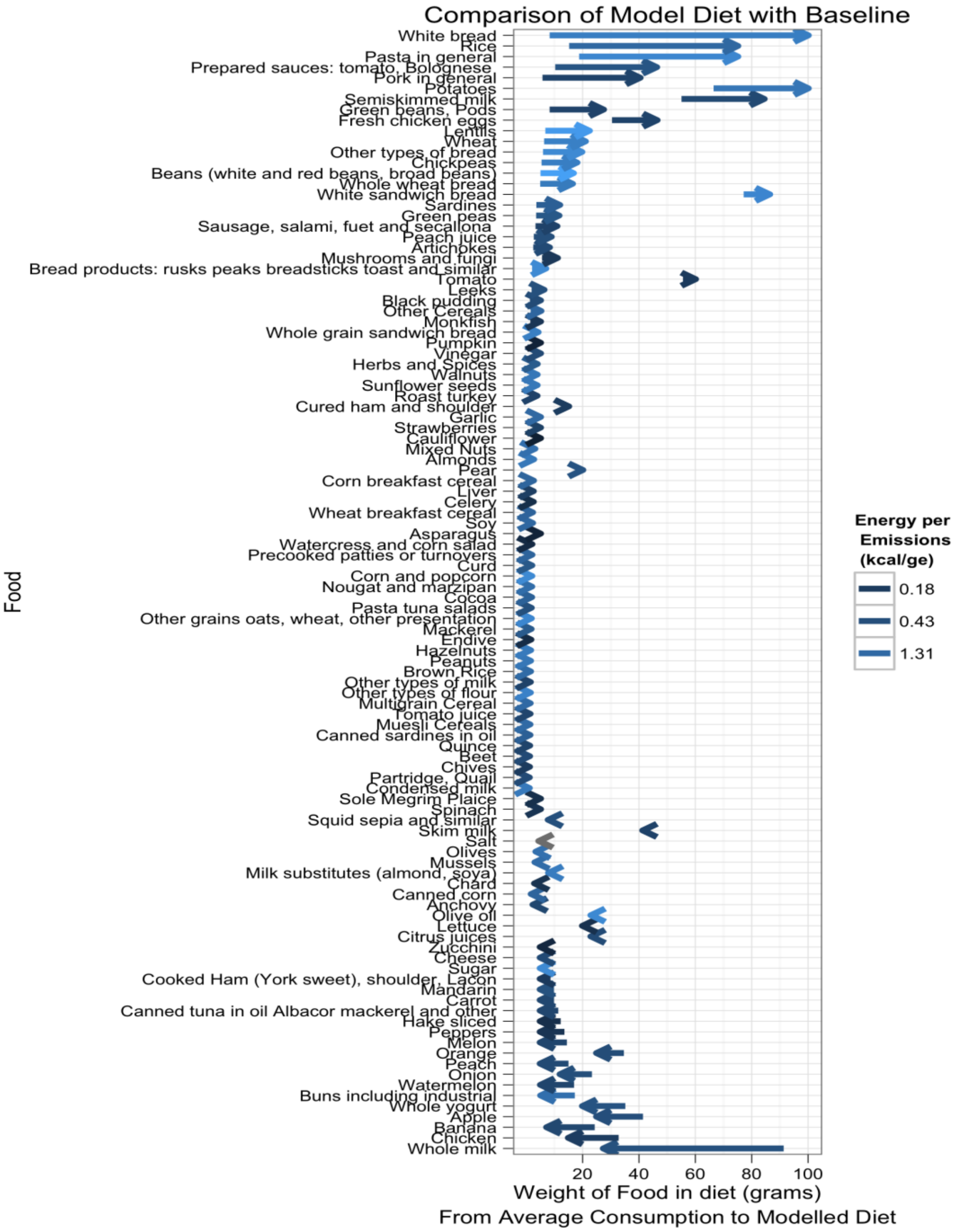
	Curd	1.91	0.58
	Milk substitutes (almond, soy)	7.96	7.96
	Other types of milk	1.39	0.42
	Semi-skimmed milk	84.36	55.08
	Skimmed milk	41.39	41.39
	Whole milk	27.40	91.34
	Whole yogurt	20.00	35.15
Miscellaneous	Herbs and spices	3.83	1.16
	Pasta tuna salad	1.72	0.52
	Prepared sauces: tomato Bolognese	46.22	10.27
	Salt	4.51	4.51
	Vinegar	5.00	2.24
Nuts and oilseeds	Almonds	2.57	0.78
	Hazelnuts	1.49	0.45
	Mixed nuts	3.00	0.91
	Peanuts	1.45	0.44
	Sunflower seeds	3.80	1.15
	Walnuts	3.80	1.15
Seafood products	Anchovy	2.45	2.45

	Canned sardines in oil	1.25	0.38
	Canned tuna in oil, albacore, mackerel and other	5.00	11.36
	Hake, sliced	5.00	12.22
	Mackerel	1.65	0.50
	Monkfish	5.00	1.45
	Mussels	3.15	3.15
	Sardines	11.81	3.58
	Sole, megrim, plaice	5.00	4.32
	Squid sepia and similar	7.85	7.85
Sugar and sugar products	Cocoa	1.85	2.70
	Nougat and marzipan	1.88	0.57
	Sugar	5.00	7.04
Vegetables and legumes	Artichoke	8.18	2.48
	Asparagus	5.00	3.58
	Beans (white and red beans, broad beans)	16.67	5.05
	Beetroot	1.12	0.34
	Carrot	5.00	9.85
	Cauliflower	5.00	2.87

Celery	2.44	0.74
Chard	2.99	2.99
Chickpeas	17.92	5.43
Chives	1.09	0.33
Endive	1.58	0.36
Garlic	5.00	2.60
Green beans, pods	27.36	8.29
Green peas	11.55	3.50
Leek	6.24	1.89
Lentils	22.34	6.77
Lettuce	20.00	20.72
Mushrooms and fungi	11.00	5.61
Onion	12.05	23.30
Pepper	5.00	13.55
Potato	100.00	66.48
Pumpkin	5.00	2.21
Soy	2.18	0.66
Spinach	5.00	4.42
Tomato	60.00	55.60
Watercress and corn salad	1.95	0.59

Zucchini	5.00	6.25

The graph below shows the major changes by food item:



A nutritional comparison reveals the following:

	Average consumption	LiveWell diet	National nutritional recommendation
Energy	1884.01	2220.38	(no rec)
Protein, g	83.83	97.22	>33.00
Fat, g	86.32	82.30	<105.00
Fat (saturated), g	25.67	21.00	<21.00
Fat (polyunsaturated), g	12.26	14.24	<30.00
Carbohydrate, g	187.35	259.84	>165.00
Vitamin A, mg	597.02	1093.16	750.00
Vitamin B1, mg	1.47	2.19	1.05
Vitamin B2, mg	1.66	2.01	1.60
Vitamin B3, mg	36.09	36.25	17.50
Vitamin B6, mg	1.99	2.28	1.70
Vitamin B11, µg	327.60	588.69	200.00
Vitamin B12, µg	5.83	6.11	2.00
Vitamin C, mg	146.16	118.87	60.00
Vitamin D, mg	5.40	5.50	2.50
Vitamin E, mg	13.56	18.27	12.00
Calcium, mg	715.32	725.00	725.00
Iron, mg	10.37	18.00	18.00
Zinc, mg	10.32	15.00	15.00

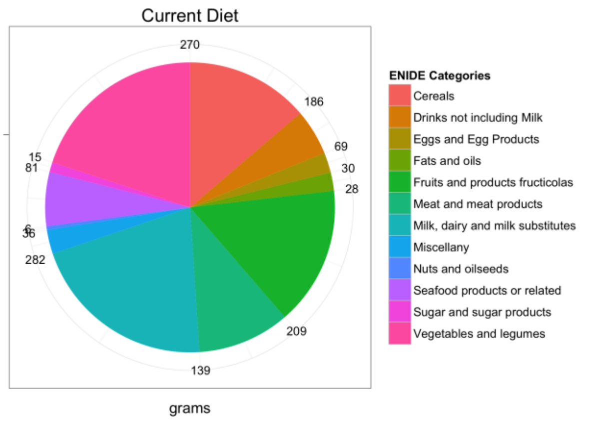
This shows that the LiveWell diet meets all recommendations for nutrient consumption where we had reliable data.[34] The figures for the average diet possibly underestimate the nutritional content since it includes foods which we did not examine in detail and where some nutrient data may be missing.

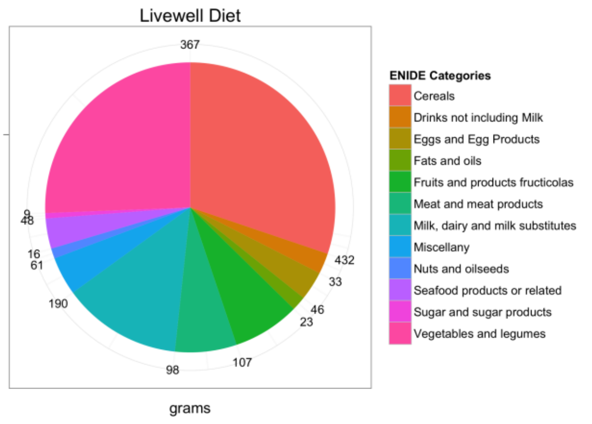
Comparisons between food groups are shown below, demonstrating the pattern seen in other sustainable diets of an increase in cereals and starchy foods, an increase in legumes, and a decrease in meat and seafood. The diet showing maximal decrease in GHGe consists largely of legumes. The

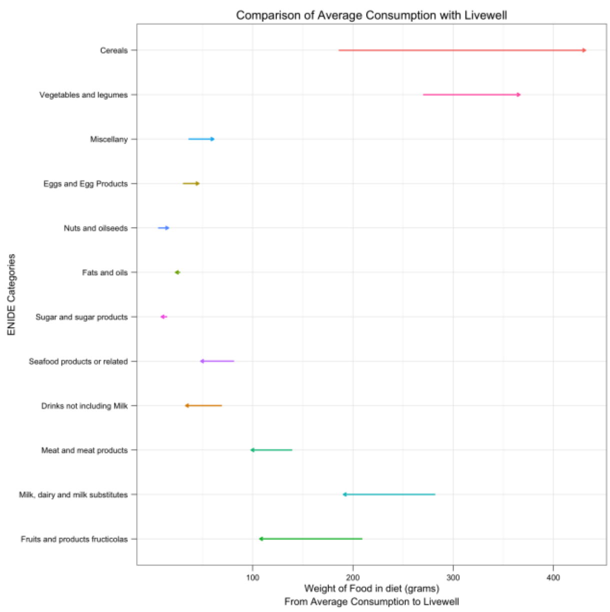
[34] We excluded iodine, for example, due to unreliable figures in nutritional tables.

decrease in fruit and vegetables may seem surprising but represents the balance between the different food groups.

Pie chart comparison







3.2.3 Sweden

The Swedish diet similarly shows a reduction in GHGe of 25% at a cost approaching that of the current diet.

Food	LiveWell diet (g/day)	Current average consumption (g/day)[35]
Boiled potato	108.67	92.50
Mashed potato	23.42	21.88
Lentils	38.00	11.88
Wholegrain bread	67.79	33.13
Rye bread	29.48	26.88
White bread	39.00	48.13
Cereals, muesli	20.00	8.75
Rice, rice dishes, grains	20.00	34.38
Spaghetti, macaroni	105.00	50.63
Wheat bread, rusks	5.10	21.25
Carrot	38.00	11.88
Other root vegetables	20.00	4.38
Cucumber	10.00	10.63
Tomato	68.36	32.50

[35] Allowing for 25% under-reporting

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Cabbage	13.50	5.63
Mixed salad	68.00	21.25
Mushroom	7.50	3.13
Peas, mixed vegetables	28.00	8.75
Stewed vegetables	2.00	1.25
Other vegetables	52.00	32.50
Banana	15.00	37.50
Citrus fruits	100.00	41.25
Apple, pear	105.00	52.50
Kiwi	6.00	3.75
Berries	9.00	5.63
Cheese (around 28% fat)	14.00	26.88
Yoghurt (3% fat)	114.00	47.50
Skimmed sour yoghurt (0.5% fat)	42.00	26.25
Milk (3% fat)	53.00	65.63
Fruit yoghurt	16.00	10.00
Yoghurt with fruit	13.00	8.13
Semi-skimmed milk (1.5% fat)	107.64	146.88
Fermented milk (1.5% fat)	24.00	15.00
Beef dishes	12.00	28.13

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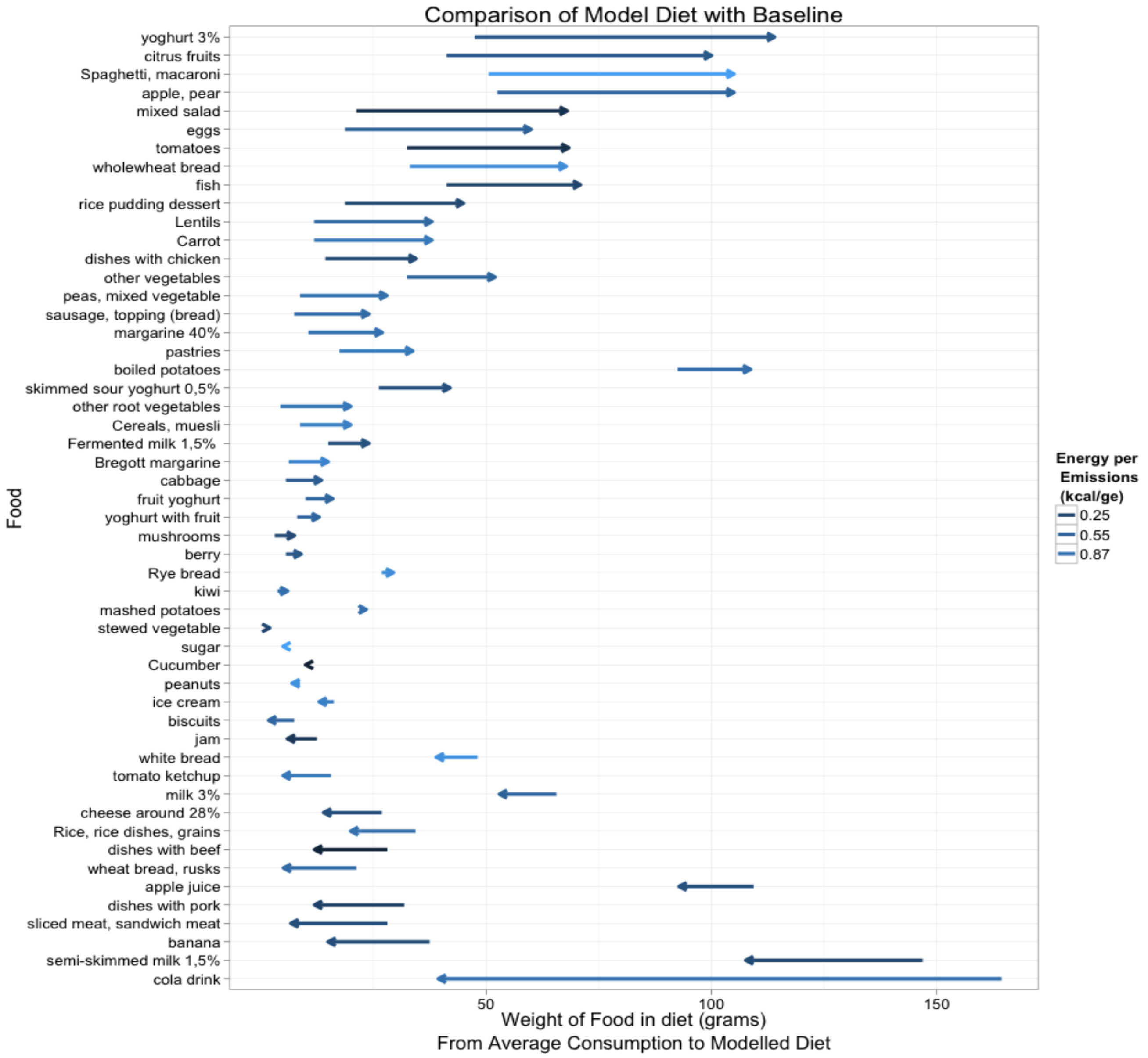
Pork dishes	12.00	31.88
Chicken dishes	34.50	14.38
Sliced meat, sandwich meat	6.75	28.13
Sausage, topping (bread)	24.00	7.50
Fish[36]	70.96	41.25
Eggs	60.00	18.75
Bregott margarine	15.00	6.25
Margarine (40% fat)	26.97	10.63
Sugar	5.00	5.63
Tomato ketchup	5.00	15.63
Peanuts	7.00	8.75
Pastries	33.76	17.50
Biscuits	1.80	7.50
Ice cream	13.00	16.25
Rice pudding dessert	45.00	18.75
Jam	5.97	12.50
Apple juice	92.85	109.38
Cola soft drinks	39.45	164.38

[36] Represented by 60% salmon, 30% cod and 10% herring

A number of the items here are rather generic, but for the purposes of modelling we chose either a specific item as a representative or averaged the values for a number of items (e.g. fish). This allowed us to make direct comparisons with the average consumption, shown graphically below:



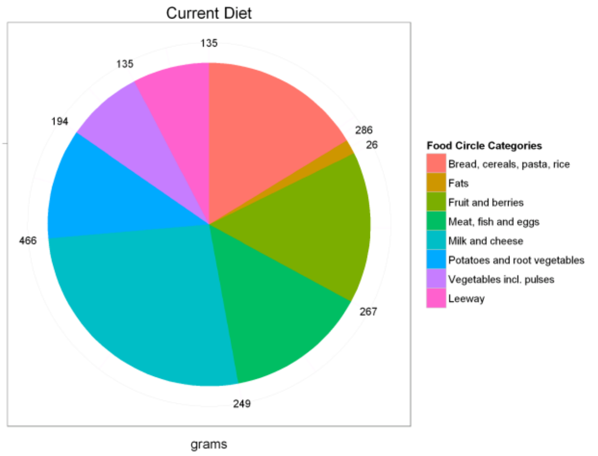
The diet above follows strictly the Swedish Nutritional Recommendations as follows:

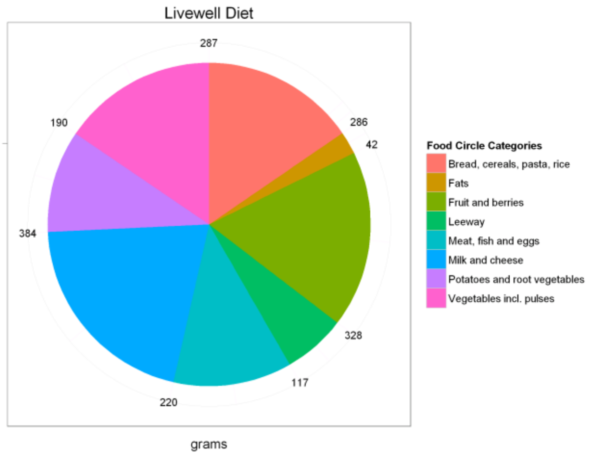
	Average consumption	LiveWell diet	National nutritional recommendation
Energy, kcal	2509.25	2450.00	>2450.00
Protein, g	102.26	94.88	>37.50
Fat, g	92.51	87.20	<90.00
Carbohydrate, g	301.53	303.82	>180.00
Fibre, g	25.58	30.00	>30.00
Thiamin, mg	1.77	1.50	1.25
Riboflavin, mg	2.16	1.94	1.45
Vitamin C, mg	94.21	142.26	60.00
Niacin equivalents	41.94	40.30	17.00
Vitamin B6, mg	2.53	2.44	1.35
Folate, µg	294.35	415.54	300.00
Vitamin B12, µg	8.75	6.99	2.00
Vitamin D, µg	8.77	13.05	5.00
Vitamin E, mg	10.45	14.16	9.00
Calcium, mg	1126.38	896.30	800.00
Phosphorus, mg	1767.75	1649.37	600.00
Potassium, mg	3662.10	3605.97	3300.00
Sodium, mg	2903.67	2171.67	2000.00
Iron, mg	11.96	12.50	12.50
Zinc, mg	14.29	11.95	8.00
Selenium, µg	49.31	57.10	45.00
Magnesium, mg	359.94	383.28	315.00

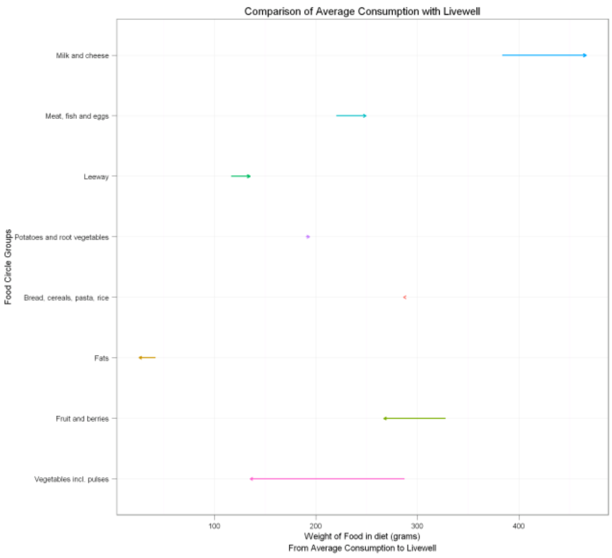
Below we show a comparison based on the categories used for the food circle – where the instructions are to eat at least one item from every sector each day. This shows a decrease in meat and "leeway" (items not necessary for the diet) and an increase in vegetables and dairy products. In some ways this is misleading, because as can be seen from the initial table in this section, there is a real change in the composition of the categories, with big increases in lentils and carrots and a shift in meat consumption from beef and pork towards chicken. Sources of protein show real increases in both fish and egg consumption. There is a decrease in cheese but increases in other dairy products, particularly yoghurt.

A diet with maximal reduction in emissions shows these tendencies taken further with an increase in root vegetables and cereals as well as legumes.

Pie chart comparison







4. ANALYSIS

This section explains in more detail the way in which we approached the modelling and how we addressed a number of issues in doing this.

4.1 Approach to data

For detailed discussion of our methodology in finding appropriate data see annex 4.

The quality and consistency of the data varied between the three countries and in some cases this created challenges. In approaching questions related to data (or deficiencies within the data) we took the following general approach:

1. Where possible we used national data and filled in any gaps with data from other countries, even when the other countries' data was of better quality or more comprehensive. For all three countries there were existing dietary surveys, nutritional recommendations and nutritional information (provided by task 1 – see annex 4). Specifically for Spain, the nutritional information had some gaps which we sought to fill by using data from Sweden and France and through estimation where appropriate.

2. For the purposes of the model, the key question is the *consistency* and *comparability* of the data. Therefore we sought to make sure that data derived from different sources (e.g. for GHGe) was as consistent as possible, by comparing a set of common items and through this deriving a "conversion" factor. This was a particular issue for GHGe: there are very different estimates for the same item, but the relative values and trends are much more consistent (beef has a much higher GHG footprint than pork, for example) – see reference 5 regarding reviews of data sources for meat in Sweden, for example.

This approach has some effect on the final results of our work. In particular we note the following:

1. Comparability between countries is limited because the basis of figures is slightly different. The results should therefore be used to examine the effects of change, rather than, for example, seeking to determine which country has the most sustainable diet. In any case, constraints related to cost, nutrition and sustainability have varied between countries so the diets are not strictly comparable even if we had completely accurate and comparable GHGe data.

2. Although we quote absolute figures in our reports, we have more confidence in relative figures. So, for example, we can have confidence that the GHGe of the LiveWell diet are substantially less than the current average diet, and that the cost is not more. On the other hand, the estimate of average GHGe in absolute terms is more open to discussion.

4.2 Approach to defining acceptability

"Acceptability" is a nebulous concept and we can conceive of a number of acceptable diets which conform to the LiveWell criteria. Again we used slightly different approaches for France and for the other two countries.

For France, acceptability was defined using upper bound constraints (expressed in maximum number of daily portions acceptable) for each food, and by minimising the difference for each food variable between the current diet and the LiveWell diet (that is, between the observed amount eaten in the population of adult women and the optimised quantity chosen by the solver). See reference 7 for an explanation of the methodology used here.

For Spain and Sweden, we used the following approach to work on acceptability through iteration and putting bounds on particular foodstuffs by:

1. Ensuring that popular[37] foods were not removed from the diet, generally ensuring that at least 30% of the most popular foods remained.

2. Ensuring that there was appropriate variety by putting an upper bound on most foods. Initially we put higher bounds (in terms of multiples of the current average consumption and/or standard deviations) for more popular foods, specifically to avoid introducing large amounts of unpopular foods into the diet.

3. Where appropriate removing foods which were present only in small amounts in the average diet to avoid creating a shopping list with too many small items.

4. Following health recommendations for particular specific types of food (e.g. semi-skimmed rather than full-fat milk, wholemeal rather than white bread). In general we did not take this to an extreme, but rather limited any increase in the total to being through healthy options.

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[37] Popularity was defined using what data we had from dietary surveys – see sections on individual countries for details.

5. Removing small items of ambiguous composition (sauces etc.) to increase confidence in the nutritional composition of the final diet.

6. Putting lower bounds, particularly on popular foods, in order to regulate minimum portion sizes (one piece of fruit, a piece of meat which can be used in one meal etc.).

7. Moving the model in a particular direction for cultural reasons. For example, bread, potatoes and pasta have fairly similar characteristics as far as GHGe and prices are concerned, but the model will seek to optimise one particular foodstuff. For this reason consumption of pasta was limited in Sweden and potatoes in Spain.

8. Finally, a certain amount of trial and error was used to create a diet with ingredients which could be combined.

Nutritional constraints introduced in the French model included constraints ensuring that national dietary guidelines were fulfilled. Because these guidelines are expressed in consumption frequencies of predefined portion sizes of food groups, this helped (but did not guarantee) the introduction of integer portions for some foods (i.e. when the upper or lower bounds for a given food group were reached and when they were reached with only one food).

While we tried to make this systematic, a key point here is that other decisions could have produced an equally valid diet – for example, it is not necessarily the case that popular foods should be increased in greater percentages than unpopular ones (the population may like pasta but it doesn't mean that they want to eat it every day; just because carrots are the most popular vegetable doesn't mean that there isn't a need for variety). Our aim for variety was also influenced by the idea that we were producing a weekly shopping list and sample menu, limiting the number of items we should buy. If we had produced a list for a longer period it would have been more appropriate to include a larger number of small items (for example varieties of fish in Spain).

For France we had data which was more clearly related to the current diet, so we were able to design a diet which resembles it as closely as possible.

It is not only the modelling approach that is responsible for producing somewhat unrealistic food combinations and quantities, but also the definition of what is an "average" diet. A mean diet is in itself unrealistic because, by definition, nobody does eat the average diet, since individual's eating patterns vary greatly. The average diet gives an average consumption for each food by dividing the total quantity of all foods consumed by the total population – including people who may not consume that particular food at all. For instance, if only 1 in 20 individuals consume 50g of liver per week, the mean diet will contain 2.5g of liver per person per week (50/20 = 2.5) – a totally unrealistic quantity, since nobody would cook 2.5g of liver. Something which is acceptable to the "average" person may in reality be acceptable to only a small proportion of the population.

Another assumption is made when modelled diets derived from average population diets are proposed as acceptable diets for individuals. Individuals are assumed to have a greater food repertoire than they do in reality (because, by definition, in the average diet, all the foods are present, even in very small amounts). In the present study, this *over*estimating was counterbalanced by at least two instances of *under*estimating food diversity. First, due to the lack/incompleteness of dietary data (in particular GHGe food data) the models included a relatively small list of food variables. Second, the diet modelling process in itself is likely to decrease food diversity because it selects foods with a good nutritional quality for their GHGe value.

We have not sought to analyse the spread of different types of diet within the population (nor do we have full data on this). Further research needs to consider approaches to creating acceptable diets for minority groups. To increase the acceptability of modelled diets, individual diet modelling approaches (as opposed to population diet modelling) have been developed – see reference 13. However, these require precise individual food intake data and specific modelling techniques that were beyond the scope of the present study.

4.3 Approach to modelling

The basic approach to modelling the diets using linear programming is the same in all three cases, but the way in which we used the model in order to produce the LiveWell diet varied between the countries.

For Spain and Sweden we used a methodology equivalent to that used for the Livewell UK diet, as follows:

- The model was optimised to minimise GHGe while complying with nutritional guidelines.

- General constraints were included to comply with food-based dietary guidelines and overall acceptability (for example, encouraging more of popular foods and excluding unpopular ones; minimum portion sizes).
- Additional bounds were put on individual foods in an iterative process to produce a diet where foods could be combined in an acceptable way while GHGe were reduced by at least 25%.

For France we took a different approach to the same dietary model:

- We developed an "acceptability" function showing the variation from the current diet and this was optimised subject to a 25% reduction in GHGe and compliance with nutritional guidelines.
- Constraints were included to comply with food-based dietary guidelines and portion sizes
- We put additional acceptability bounds on individual foods to fine-tune the result.

It was easier to use this approach in France than in the other two countries because of better quality, detailed data including, for example, portion sizes.

The different approaches would not be expected to produce different final results. Rather, the model gives a wide variety of ways of meeting the overall constraints (GHGe at 25%, cost not increased, compliance with nutritional guidelines) and a strategy needs to be developed to find the most acceptable diet within this. The approach depends on the availability of detailed information and personal choice, and the results should not be seen as qualitatively different from each other.

We hope that exhibiting different approaches gives some useful guidance for researchers developing diets in other countries or with other data.

4.4 Extreme diets

For each country we ran the model to determine the degree to which GHGe could be reduced, keeping constraints only on nutrition and cost (i.e., not including acceptability). Actual details of the diets produced are shown in annex 1.

These diets give an idea of how much further we could reduce GHGe, although some caution is needed in examining them because:

- The reduced variety and increased amount of particular foods will create some inaccuracy in nutritional values (in any case, some foods are not “pure” and may vary in nutritional content). In general it is good nutritional policy to have wider variety.
- The figures for GHGe and cost are also approximate and therefore not accurate at the extremes.

Nonetheless, we can conclude the following:

- It is possible to reduce GHGe by considerably more than 25% through choice of diet, and almost certainly by more than 50%.[38]
- We did not make a detailed examination of diets with 50% reduction but note that it is possible to do this through choosing from existing foodstuffs. However, extreme diets are likely to be unrecognisable and unacceptable to the majority of the population.

4.5 Areas outside the model

A number of areas were not examined that would affect GHGe, even within the proposed diet:

1. We did not consider seasonality – which can have an important effect not only on price but also on GHGe. While the GHGe for an average tomato imported from Spain to Sweden are less than an average hot-housed tomato from Sweden itself, this does not apply for tomatoes grown seasonally. Seasonal eating of fruit and vegetables could have an impact on GHGe, although this is difficult to estimate since it would alter other patterns of eating (if we only eat local apples, then what fruit do we eat out of season?).
2. We used quite broad categorisations of food, particularly due to the nature of dietary surveys. It may be possible to be more specific in terms of which foods are eaten and through this to reduce GHGe. Nutritional categories sometimes contain items which have widely differing GHGe. The data on GHGe is still in its infancy, but better data could inform consumer choice in this respect.
3. Surprisingly, guidelines on nutrients vary significantly between countries. For example the recommendation for zinc for a Swedish woman is 7mg compared to 15mg and 10mg for Spanish and French women, respectively, and a 4.9mg general WHO recommendation for women. It could

[38] This figure relates to primary production; the final net reduction would be lower. See reference 2 for a more detailed overall estimate.

be interesting to discover whether this has a significant effect on GHGe through modelling. Certainly, for example, zinc was a key constraint on the model in Spain.

4. We found it difficult to disaggregate energy spent on cooking and processing foods in the home, but this is clearly a component of GHGe: more efficient ways of cooking and less processing could therefore reduce GHGe. It seems possible that more energy-efficient methods of food preparation could also be healthier, but this needs to be tested.

5. We used data on the nutritional composition of foods without consideration of the actual bio-availability (i.e. the ability of the body to absorb the nutrient from the food). For example, it is suggested that the absorption of zinc and iron from cereals is less efficient than from meat (see reference 8). To some degree this can be mitigated by methods of food preparation (for example fermentation, soaking and sprouting of grains). We considered this issue to be too complex for analysis here and further work is required.

6. We avoided consideration of drinks outside fruit juices, milk and one soft cola drink – and in particular excluded alcohol from the model. Drinks cause some data issues, for example related to relative level of dilution and, in any case, tend to be a personal choice which is not seen as part of the diet (i.e. a change in the menu will not have a significant effect on what the average person drinks with their meal). On the other hand, drinks can be a significant contributor to GHGe (for example tea and coffee) while alcohol may have other nutritional impacts (for example on overall energy).

4.6 Cost of the diet

Cost was never a binding constraint in terms of finding a solution that reduced GHGe appropriately, showing that a healthy and sustainable diet is not necessarily an expensive one – see annex 3 for more details of sensitivity analysis. In general key constraints related to nutrition. In some cases we used recommendations which were higher than the average consumption reported in the dietary survey (for example the recommended intake of zinc is almost 50% higher than the average consumption in Spain).

Cost did have some binding effect on acceptability, however. For both the Spanish and Swedish sample menus, the cost is estimated to be the same as the current average diet. Cheaper menus would have been possible, but these would have been further from current consumption.

4.7 Specific issues for each country

4.7.1 France

Data for France was based on the diet consumed by women participating in the nationally representative INCA 2 dietary survey (2007 – reference 14). After exclusion of energy under-reporters following the appropriate procedures (see reference 15), dietary data from 1,142 women were used to estimate the mean population diet, i.e. the observed diet consumed by women in France. To limit the bias of acceptability induced by the estimation of the mean population diet, average consumption of food items was weighted. A weight was estimated for each food item according to its consumption among an EPIC[39] food group. More precisely, this weight was calculated by the ratio between the consumption of this corresponding food item and the sum of the consumption of selected food item in the EPIC food group. This led to a weight value between 0 and 1, with the sum of each weight in a given EPIC group being 1. Then, average consumption of each EPIC food group was calculated. Finally, each food item weight was applied to the average consumption of its EPIC food group, leading to a weighted average consumption for each food item.

All models were run using **linear programming**. When applied to nutrition, linear programming is a mathematical tool used to find the optimal solution of a linear function (the **objective function**) of **food variables** fulfilling a set of linear equality and inequality **constraints**. In the present study, two kinds of models were developed. The first model was built to produce a LiveWell diet: it minimised total departure from the mean population diet (objective function) while achieving nutritional constraints subject to a 25% GHGe reduction. A sensitivity analysis was run by increasing the reduction of GHGe to 50% and 70% (see Annex 3). The second set of models (A, B and C) aimed to directly minimise total GHGe while achieving nutritional constraints (results in appendices). The nutrient content and GHGe values were available for a list of 68 frequently consumed food items, which constituted the **food variables** in all the models.

To ensure the healthiness of the modelled diets, they had to fulfil several **nutritional constraints**, i.e. a set of constraints on nutrients (using the same list of nutrients as in the original UK LiveWell diet) plus another set of constraints on food groups. These were based on the French food-based dietary

[39] EPIC food groups were used as a neutral system of classification, although they do not correspond exactly to either the INCA survey or French food-based dietary guidelines.

guidelines (FBDGs) for the general population (www.mangerbouger.fr). In the LiveWell model, social **acceptability constraints** were added to avoid an unrealistic diet.

To analyse the impact of a cost reduction on GHGe, we conducted a cost sensitivity analysis (see annex 3).

The details of the methodology for each model are displayed in table 1.

Table 1: Summary of linear programming models

	LiveWell model	GHG minimised models		
		M1	M2	M3
Minimised objective function	Sum of the absolute deviation from average individual food intake[40]	Total GHGe of the diet	Total GHGe of the diet	Total GHGe of the diet
GHGe constraint	Total GHGe lower than 75% of observed GHGe (i.e. 25% reduction)	-	-	-
Nutritional constraints	Nutrient recommendations (see table 2) plus: French FBDGs (see table 3)	Nutrient recommendations (see table 2)	French FBDGs (see table 3)	Nutrient recommendations (see table 2) plus: French FBDGs (see table 3)
Cost	None	None	None	None
Acceptability constraints	Maximum number of portions of each individual food (see table 4)	-	-	-

[40] This function was non-linear. To apply linear programming the function was transformed into a linear function using a published method (see reference 7).

Table 2: Daily energy and nutrient intakes of French women (n=1142) based on the INCA2 dietary survey (2007, reference 14), and corresponding nutrient-based recommendations for that population (reference 16), used as nutrient-based constraints where needed.

	Observed mean intakes	**Corresponding recommendations**	
Nutrient		**Minimum**	**Maximum**
Energy, kcal	1814	1800	1800
Proteins, g	68	50	
Carbohydrates, g (%TE)	202 (44.5%)	225 (50%)	337 (75%)
Fibre, g	14	25	
Lipids, g (%TE)	81 (40%)		70 (35%)
Saturated fatty acids, g (%TE)	32 (15.8%)		20 (10%)
Sodium, mg	2053		2365
Calcium, mg	581	900	
Iron, mg	8	14	
Zinc, mg	7	10	
Vitamin B12, µg	3	2,4	
Folates, µg	188	300	
Added sugars, g (%TE)	39 (8.6%)		45 (10%)

Table 3: Food group intakes of French women (n=1142) based on the INCA2 dietary survey (2007, reference 14), and corresponding FBDGs, used as constraints on food groups where needed.

	Observed mean intakes	**Corresponding FBDGs**	
French PNNS food groups	**Portions/day**	**Minimum**	**Maximum**
Fruit and vegetables	**4.52**	**5**	
Fruit juice	*0.32*		*1*
Nuts	*0.03*		*1*
Starchy food	**2.21**	**3**	
Dairy products	**2.06**	**2.5**	**3.5**
Meat, fish, eggs	**1.48**	**1**	**2**
Fish	*0.30*	*0.29*	
Fat	**4.37**		**3.5**
Olive oil	*0.96*	*1*	
Sunflower oil	*0.39*	*1*	
Sweet products	**4.24**		**2**
White sugar and honey	**3.17**		**2**
Drinks	**0.30**		**1**

Table 4: List of foods (with portion size) used as variables in the models and their average consumption by French adult women

Food items	EPIC food group[1]	Average intake, g/day	Portion size, g	Maximum number of portions*
Potato chips, salted	1	1.49	150	1
Scalloped potatoes	1	7.47	150	1
Boiled potato	1	33.10	150	1
Fried potato (frozen)	1	8.99	150	1
Potato salad	1	4.95	150	1
Raw carrot	2	19.08	80	1
Raw endive	2	5.33	80	1
Canned green beans, drained	2	21.25	80	1
Cooked onion	2	4.26	80	1
Green salad without dressing	2	26.86	80	1
Raw tomatoes	2	55.75	80	1
Tomato Provençal	2	8.68	80	1
Lentils, cooked	3	8.79	150	1
Fresh banana	4	20.86	80	1

Clementine	4	22.67	80	1
Stewed apple	4	13.91	80	1
Walnuts	4	0.67	20	1
Fresh orange	4	16.02	80	1
Fresh unpeeled apple	4	87.22	80	1
French cheese (Camembert)	5	7.86	30	1
Low-fat cream	5	1.48	125	1
High-fat cream	5	2.67	125	1
Cream cheese, 20% fat	5	10.44	125	1
Gruyère cheese	5	6.37	30	1
UHT semi-skimmed milk	5	143.23	200	1
Yogurt with fruit	5	13.92	125	1
Yogurt	5	26.33	125	1
Appetizer cracker biscuit	6	1.23	150	1
Bread, baguette	6	72.81	60	3
Bread, wholegrain	6	7.24	60	3
Cooked pasta	6	41.27	150	1

Cooked white rice	6	23.41	150	1
Grilled lamb chops	7	3.72	100	1
Turkey	7	11.51	100	1
Cooked ham	7	23.38	100	1
Grilled bacon	7	3.31	100	1
Roasted chicken	7	24.24	100	1
Dried sausage	7	3.27	100	1
Ground beef, 15% fat	7	24.62	100	1
Baked cod	8	2.89	100	1
Cooked shrimp	8	3.42	100	1
Hake, cooked	8	5.26	100	1
Sardines canned in oil, drained	8	1.00	100	1
Steamed salmon	8	9.63	100	1
Raw smoked salmon	8	1.75	100	1
Canned tuna in brine, drained	8	5.88	100	1
Boiled egg	9	14.45	60	1
Unsalted butter	10	16.11	10	3
Olive oil	10	9.56	10	3

Sunflower oil	10	3.87	10	3
Honey	11	8.32	10	1
White sugar	11	23.36	10	1
Processed packed cake (brioche)	12	12.62	40	1
Chocolate bread (pain au chocolat)	12	14.47	40	1
Fruit tart (processed)	12	39.20	100	1
Orange juice 100% (pasteurised)	13	64.04	200	1
Cola drink	13	59.21	200	1
Low-fat margarine	15	14.11	10	1
Vegetable soup (processed)	16	17.70	200	1
Vegetable soup home-made	16	60.00	200	1
Cassoulet (canned)	17	11.34	200	1
Cheeseburger	17	6.34	200	1
Pizza	17	14.94	200	1
Fried breaded fish	17	11.07	200	1
Quiche Lorraine	17	13.59	200	1

Meat ravioli with tomato (canned)	17	16.11	200	1
Tabbouleh	17	9.96	200	1
Stuffed tomato	17	13.76	200	1

* A maximum number of portions per day was imposed to each food variable to help ensure social acceptability of the LiveWell diet

[1] See task 1 for references on definition of EPIC food groups

4.7.2 Spain

Spain has produced a remarkably comprehensive and detailed dietary survey, detailing consumption of many individual and infrequent items such as specific types of fish and seafood. Dealing with this wide range of foods (the final model had 277 different foods) caused some challenges in developing the data for modelling, particularly the following:

1. Lack of GHGe data specifically for Spain – as explained in annex 2 we adapted data from elsewhere. Many of the specific items where data was difficult to find had very low consumption, and for these we believe that estimates from comparable foodstuffs suffice.

2. Some deficiencies in the nutritional data – the BEDCA database for Spain does not cover all the foodstuffs in the ENIDE national dietary survey. We used data from France and Sweden to cover the gaps for nutritional information. In addition, inspection of details for individual foods showed some missing figures, specifically related to iron and zinc, which we estimated from comparable foods.[41] Inspection of data suggested that iodide composition was not in all figures and was unreliable, so we took this out of the model even though it is a Spanish nutritional recommendation.

Spanish recommendations for iron and zinc (and iodide content) are relatively high compared to other countries and we note that the average diet does not fulfil the recommended amounts for these

[41] The missing figures were generally related to areas where there was a benchmark figure e.g. different cuts of meat from the same animal.

minerals. We considered whether to adjust for under-reporting based on this fact – but since it is possible to produce a diet without this adjustment we have not done so.

To define general bounds for different foods we defined popular foods using comparison of the standard deviation to the mean (Tchebyshev's inequality[42]). We started modelling with a combination of the following constraints:

1. For popular foods we allowed consumption to increase by 4.5 times, and not to fall below 30% of the average value or 5g/day.

2. For other foods we allowed consumption to increase by 3.3 times and excluded foods where the maximum would be less than 1g a day (to avoid excessive numbers of small items).

The figures chosen here were determined empirically in order to create a diet with appropriate variety and acceptability.

Additional bounds were imposed in order to produce an acceptable diet. Some discussion was necessary here because the nutritional recommendations (specifically related to iron) resulted in small amounts of liver and black pudding in the diet which were difficult to integrate into the menu. Initially we tried to put restrictions on the degree of divergence of food groups from the average but experimentation showed that it was difficult to produce an acceptable menu with these conditions.

The very large number of small items in the dietary survey suggests wide differences in individual diets, and we certainly suppose that there are real regional differences within Spain in the cost and availability of different foods, and actual menus. However, we have based our research purely on an average menu.

42 We had figures for the deviation and the mean but no indication directly of the percentage of the population eating each foodstuff.

4.7.3 Sweden

The latest dietary survey (Riksmaten) at the time of modelling was more than 10 years old, though it has since been reviewed. This caused some issues with price information, which we took from a recent household budget survey (2009), but checking items on online supermarket portals suggests that there is an acceptable match and that the average Swedish diet has not changed markedly during this period.

The fact that the survey is old does not in itself have a marked effect on modelling, since the data used for the model (GHGe, nutrition and cost) is up to date. However, the survey data caused some issues, most specifically that some items were very generic (e.g. fish in total). Since we used the survey as a benchmark and reported change against it, we were obliged to use the same categories in our modelling.

For generic items we made estimates for GHGe, nutrition and cost data. For example for fish we estimated consumption based on HBS data and current prices and produced GHGe estimates and nutritional data based on this. In modelling, however, this produces a LiveWell diet categorised in the same way, which does not consider the effects of different combinations (e.g. more herring and less cod). We left this position since it fits more clearly with acceptability criteria and in any case the model produces a feasible solution.

The energy from the average diet is considerably less than the levels recommended in Swedish nutritional recommendations (SNR), probably because of under-reporting. To avoid distortions created by increasing foods purely for energy content, and noting experience from elsewhere (for example decisions made in the LiveWell UK work), we increased consumption by 25%.

As initial constraints for the model we used the following for acceptability:

1. Consumption of foods in each of the food circle categories were kept to at least 75% of the current Swedish nutritional recommendations.

2. Popular foods (those which at least 50% of either men or women eat) could be increased by up to four times, and not reduced below 30% of current average consumption.

3. Unpopular foods (those eaten by less than 25% of men or women) were limited to no more than twice current average consumption.

4. Other foods could be increased by up to three times average current consumption.

Additional bounds were imposed in order to produce an acceptable diet

The figures chosen here were determined empirically in order to create a diet with appropriate variety and acceptability.

5. CONCLUSIONS

5.1 General

The research here shows that it is possible to work in three different European countries using the principles and methods embodied in the LiveWell UK research. Although there were differences in the availability and quality of data, we have demonstrated linear programming models which show that it is certainly possible to reduce GHGe through choice of foods without increasing the cost of the diet, falling outside nutritional guidelines, or producing menus which would be unacceptable to the majority.

In doing this, as well as producing a set of sample menus which demonstrate the possibility of achieving a 25% reduction in GHGe, we have produced:

1. Sensitivity analysis showing in general terms what is achievable
2. Details of methodologies for developing an acceptable diet based on a linear programming model, but working on slightly different bases
3. Approaches to coping with data deficiencies and making sufficient assumptions in order to draw valid conclusions.

We hope this report can guide future researchers in the same topic in other countries and situations, and be a first step in creating sustainable diets in the three countries under observation.

5.2 Research questions

We return to the key research questions which we sought to answer.

5.2.1 Can a healthy diet be more environmentally sustainable?

Answer: Yes, for all three countries

Although nutritional recommendations act as binding constraints, it was relatively easy to construct a healthy diet which reduces GHGe. In doing this we should recognise some limitations of the methodology and the need to have better information on nutrients. Specifically:

- Some constraints (such as specific fatty acids) were missing from recommendations and from nutritional data.
- We did not take into account differential nutrient bio-availability depending on the sources of nutrients (important for iron, zinc, calcium, proteins, vitamin A) – this is an important factor, bearing in mind that, for example, iron and zinc are chiefly sourced from meat and dairy in current diets and the degree of absorption is higher from meat than vegetable sources: for further discussion see reference 8.

Nonetheless, we can suppose that this result partly relates to the "unhealthy" part of the current diet, which to some degree can include over-consumption in general and unnecessarily high consumption of high-GHG foods (specifically meat).

5.2.2 Can a diet be healthy, economic and respect the environment?

Answer: Yes, for all three countries.

Although the cost of the LiveWell diets approached that of the current average diet, this related in general to choices made to enhance acceptability. Without acceptability constraints, healthy diets which reduce GHGe are very likely to be cheaper than current diets.

5.2.3 What is the lowest level of GHGe that may be reached while fulfilling nutritional recommendations and not increasing diet cost?

Our models suggest that it is possible to have a diet which fulfils current dietary recommendations and reduces GHGe by at least 50%. Although the models show that it is possible to reduce emissions further than this, the resultant diets have a limited number of foods (very low variety) and are so extreme that the validity of the data is questionable. Even with a 50% reduction in emissions the diet would be unrecognisable to most consumers, typically requiring a reliance on legumes as a source of protein, a much larger amount of vegetables, and much less meat.

5.2.4 What would be a healthy, sustainable diet which reduces GHGe by 25% and minimises change from the current diet?

The LiveWell diets shown in this report demonstrate three such possibilities. Our experience in creating these diets suggests that there is a variety of diets which would also meet the criteria, particularly noting that the concepts of "acceptability" and "change from the current diet" are inevitably partially subjective. We note from the reception of the LiveWell UK report that detailed menus can create quite strong reactions and we again emphasise that these are samples: the evidence suggests that there are other solutions which may be more acceptable to different sectors of society than those we exhibit. On the other hand, a reduction of 25% does mean real changes in the diet, not the same things in a different combination. All the diets show significant changes in composition, particularly the decrease in meat, and increase in cereals and legumes.

5.2.5 How can we show consumers that this is a viable change in diet?

We have demonstrated that it is possible to produce an "acceptable" weekly menu which can be used as a tool in promoting a more sustainable diet.

More work needs to be done on communication. Many years of public nutritional guidance and food-based dietary guidelines seem to have had disappointingly little effect on people's eating habits. However, we hope sustainability can be incorporated into national guidelines as they develop in the future.

5.2.6 What are the general implications?

We can see from the analysis here that it is possible to produce a LiveWell diet for three very different Western European countries. The implication is that the same exercise could be done for other European countries and a diet for each developed. We hope that this report demonstrates a methodology which could be used and explains the ways in which we adapted data for cases where it was fragmentary, inconsistent or non-existent.

It seems likely that with judicious adjustment of the diet (for example, eating local and seasonal foods in preference to imported ones, and accepting a lower amount of meat) it would be possible to decrease

GHGe even further. The 25% reduction is an arbitrary figure for the exercise based on overall carbon targets and does not represent a boundary for acceptability or possibilities of reduction.

It is not clear whether the same approach will produce a valid result in countries further afield. Countries in Eastern Europe have different supply chains (until fairly recently, the countries participated much less in the global food market), have more markedly different eating habits, have a greater percentage of the population who produce their own food, and are currently in transition to a more globalised economy. We can hypothesise that diets are sufficiently similar that a similar result could be obtained, but we feel there is need for further research. We had difficulty getting data for Spain and therefore had to make widespread assumptions regarding applicability of data for other countries. We suspect that this will be a greater challenge for Eastern Europe since it will be more difficult to support assumptions based on comparisons with Western Europe.

We also seek to identify the impact of the LiveWell diet on farmers in Europe. We can make the following observations:

1. The changes will reduce the consumption of livestock products and this will have an effect on agricultural output. Several studies have shown that this switch reduces the monetary value of farm-gate sales (reference 17).

2. Widespread adoption of a LiveWell diet would reduce the demand for meat and dairy products and reduce these sectors' production changes in line with consumption.

3. The changes are unlikely to be abrupt and will be absorbed by market adjustments. However, change at the margins may be significant in this adjustment phase. The immediate effect would be a contracting domestic market for meat and dairy products which will depress prices and reduce incentives for production expansion.

4. Less meat might offer the potential for some producers to enter the higher-value, lower-volume markets. Farmers, environmental and animal welfare organisations and industry would need to work together to come up with ways of reducing our consumption footprint that support rural livelihoods.

5. There will be opportunities for other sectors such as horticulture, feed and the potato industries to increase market share and sales as people move to more plant-based, lower-input foods. Some farmers could be supported to move into these areas.

However, a number of additional factors come in to play and need to be considered:

1. There are links between production of different foodstuffs, most particularly between beef (meat) production and dairy.
2. The current food system is heavily dependent on comparative advantage for cereal and maize production for animal feed in Europe complemented by protein crop production in South America. The change would lead to a fundamental restructuring, for example up to a 75% reduction in the need for imported soy (see reference 18).
3. Optimising the food system in terms of GHGe reduction requires better LCA data (though this should not be an excuse for inaction). The environmental costs of production are not reflected in consumer prices and as a result options that increase GHGe may be cheaper. In some cases, reducing GHGe may be counter-intuitive, for example when food transported over long distances has a lower impact compared with locally grown food.
4. The effect on prices can be complex. If the population consumes less meat then in the short term the price would fall.[43] There is a danger that this would naturally give the consumer an incentive to start buying more meat again. Changing the food system requires careful planning and adjustments of prices.

5.3 Need for further research

This type of analysis is in its infancy and there is much further work to be done. We would like to highlight the following as areas for further work:

1. Generation of better and more consistent GHGe data. Already some work has been done (for example HLCWG, LCA food and Eat England) which groups together data to allow some idea of a consistent database for other countries, but there is still a need to add to this. Full LCA needs to

[43] We temporarily ignore the effect of subsidies and supermarket monopoly/monopsony.

take into account effects of land-use change, which we have ignored for the purposes of the current report.

2. Research on the question of seasonality in food. To what degree would diets with a strong seasonal component have an effect on GHGe? And would there be adverse health implications?
3. Research into the question of GHGe related to cooking and preparation of food. We did not take this into account systematically.
4. Further research and consideration of the effect on farmers of a changing diet, and the way in which subsidy and support mechanisms need to be adjusted to support this. Such research should consider links between production of different foods (e.g. meat and dairy).
5. Consideration of minority and regional diets. For large and diverse countries such as the UK, France and Spain, should there be different LiveWell diets for different geographical locations and sectors of society?
6. Research into the bio-availability of certain key nutrients and the effects of changing their sources. Specifically we need more data on sources for iron, zinc and calcium. A better understanding here would allow more consistent guidelines for recommended amounts of these nutrients in the diet.
7. Research into shopping habits and how this can affect GHGe. For example, what are trade-offs between better variety of low-GHG food and the GHG and economic costs of transport to find it?
8. Incorporation of other factors in the definition of sustainability, including water and biodiversity.
9. It may be appropriate to revisit the Swedish diet in the light of the renewed survey in autumn 2012.

ANNEX 1 – EXTREME DIETS

These diets take the model to its extreme by looking only at nutritional constraints and ignoring acceptability to minimise GHGe using the same foods as in the national dietary surveys.

For France, we can exhibit a diet (fulfilling nutrient recommendations only) which reduces GHGe by up to 74% (921g CO_2e/day) and cost by up to 45% (€2.7/day).

Table 1: Minimised GHGe model with nutrient constraints only

Food items	Quantity (g/day)
Total diet	1119
Lentils, cooked	465
Pasta, cooked	419
Sardines canned in oil, drained	158
Sunflower oil	31
White sugar	45

Fulfilling French FBDGs only we can display a diet which reduces GHGe by up to 64% (1243g CO_2e/day) and cost by up to 33% (€3.3/day).

Table 2: Minimised GHGe model with French FBDGs only

	Amount, g/day
Total diet	1686
Food items	
Vegetable soup to warm	640
Pasta, cooked	558
UHT semi-skimmed milk	313
Sardines canned in oil, drained	100
Sunflower oil	25
White sugar	20
Walnuts	20
Olive oil	10

We can display a diet (fulfilling nutrient recommendations and French FBDGs) which reduces GHGe by up to 57% (1499g CO_2e/day) and cost by up to 20% (€3.9/day).

Table 3: Minimized GHGe model with nutrient recommendations and French FBDGs

	Amount, g/day
Total diet	1851
Food items	
Cooked pasta	477
Vegetable soup, homemade	398
Yoghurt with fruits	375
Vegetable soup (processed)	250
Lentils, cooked	213
Sardines canned in oil, drained	100
Walnuts	19
Sunflower oil	10
Olive oil	10

For Spain we can exhibit a diet which reduces GHGe by more than 90% and cost by 75%.

Category	Food	Quantity, g
Meat and meat products	Liver	4.291
Miscellaneous	Bouillon cube	6.750
Miscellaneous	Herbs and spices	42.091
Miscellaneous	Mayonnaise and other dressings with the same ingredients	60.693

Category	Food	Quantity, g
Seafood products or related	Eel	7.177
Seafood products or related	Oysters	3.499
Vegetables	White pinto beans	430.109

For Sweden we have a diet which reduces GHGe by more than 70% with a cost reduction of 25%.

Food	Quantity, g
Wholegrain bread	103.91
White bread	263.44
Cracker	150.45
Other root vegetables	674.82
Cabbage	80.58
Milk (3% fat)	187.77
Eggs	96.61
Margarine (40% fat)	16.24

None of these are realistic, not only because of acceptability (it would be difficult to make interesting or in any way “normal” meals from the ingredients) but also because the lack of variety and large amounts of foods which are normally eaten in small quantities gives rise to suspicion about the margin of error on nutritional and GHGe figures. These diets do, however, give an indication of the maximum reduction which could be achieved using current foods and methods of production.

ANNEX 2 – DATA METHODOLOGY

This annex explains how we approached gathering data for the different countries.

A. France

1. Breakdown of foods

The INCA2 cross-sectional dietary survey ("*Enquête Individuelle et Nationale sur les Consommations Alimentaires" [Individual and National Survey on Food Consumption]*) conducted in 2006-2007 by ANSES (French agency for food, environmental and occupational health and safety) was used to estimate mean/median consumption.

2. Availability of GHGe data

We selected 73 widely consumed food items as representative of French diets, by preferentially choosing foods with the highest percentage of consumers. Then, we collected the GHGe associated with the consumption of these 73 representative food items from the available literature and from studies conducted in France. Only studies using LCA were used to quantify the environmental impacts generated by a product throughout its life cycle, and we assumed that the selected food items were all obtained through the conventional and most frequent production and distribution processes in France. The food-related GHGe values covered the stages of agricultural production, processing, packaging and transportation to retail outlets but the stages that occur after purchase (transportation from store to home, storage, preparation and cooking at home, waste disposal) were not included due to a lack of data.

3. Conversion of data – approach

For nutritional, cost and GHGe data, we applied a factor for consumed food to take into account wastage, cooking and hydration.

4. Nutritional data

All of the food items participants in the survey declared as consumed (including the 73 highly consumed foods) were listed in a survey-associated food database giving the nutritional composition of each food item. The nutritional composition of the foods was computed from the INCA2 food composition database.

5. Cost data

The cost of all the food items declared as consumed (including the 73 highly consumed foods) was collected from two types of sources:

- From the TNS Worldpanel 2006 study (c.90% of the listed food items)
- From supermarkets (c.10% of the listed food items)

6. Constraints – nutrition

Constraints on nutrition can be separated into two categories: food-based dietary guidelines and nutrient recommendations.

The French FBDGs define nine rules (eight on food consumption and one on physical activity) expressed in frequency (at least five fruit and vegetable portions per day) or in grams (not more than 8g of salt a day) [see Task 1 report 2.1.2]. For rules expressed in frequency, we have had to make decisions in order to assess a portion size to each food item.

Nutrient recommendations were collected from the recommended daily intake in France published by the French agency for food (ANSES). In task 1 French recommendation for fibres was missing. The minimum recommended intake for fibre is 19g/day for French women.

7. Constraints – acceptability

A first diet modelling was run to reach a target energy intake of 1800Kcal, which is the recommended energy level for French women.

Acceptability constraints for each food item were then added:

- A minimum value equal to the 5th percentile of consumption observed in the population (non-consumers included).
- A maximum of the 95th percentile of consumption observed in the population (non-consumers excluded).

We tried other acceptability constraints depending on the preliminary results from first LP model runs.

B. Spain

1. Breakdown of foods

The ENIDE survey gives a comprehensive breakdown of foods. Most items are clear and can be triangulated against possible GHGe and nutrition data.

2. Availability of GHGe data

Examination of the literature produces almost no direct data on GHGe related to food in Spain. Although there have been a number of papers, in general they use data estimated from international sources.

One exception is a paper on the carbon footprint of the Galician fishing industry (reference 11), which we have used to estimate GHGe figures for different types of fish.

3. Conversion of data – approach

In view of the difficulties of making any overall estimates of GHGe, we have used the following general approach:

- GHGe data is “to retailer” but adjusted for amounts consumed.
- Where possible we have used data from France, which is the nearest country where there is a set of consistent and comparable data.

Where there are gaps we have used the following substitutes:

- Data for fishing based on the Galician fishing fleet
- Data from HLCWG, using a multiplication factor to allow for transport etc. between RDC and retail. The multiplication factor is based on comparison of similar foods where there is French data available. Some allowance is made for origin of e.g. fruits in choosing a base figure.
- Conversion factors from McCance and Widdowson
- Some processed foods from Eat England data
- Estimations from comparable data (e.g. LCA food regarding some fish and mussels).

For important foods (e.g. olives) we made some estimates of our own based on comparable or constituent products (for example papers produced on LCA of olive oil).

This still leaves some areas where there is no data, although in general these are areas of low consumption. In these cases we have made educated estimates.

4. Nutritional data

Where possible we used information from the BEDCA online database. As this was not comprehensive enough, we supplemented it with data from French and Swedish sources. Examination of the data showed a need to find additional data on iron and zinc in a small number of cases. Iodide figures appear unreliable and not comprehensive so we did not use these, even though iodide is included in nutritional recommendations.

5. Cost data

We use a triangulation of the HBS with the ENIDE survey.

C. Sweden

1. Breakdown of foods

The only data on current diet is the Riksmaten survey, as noted by Task 1. This is not in all cases very detailed and requires assumptions to be made regarding recipes, preparation methods and detailed costs.

Specifically we note categories:

- where the actual ingredients or proportion of ingredients are unclear (muesli, pancakes, pizza)
- where the origin/animal is unclear (meats, offal, sausages, fish)
- which are very vague (cakes, desserts).

We explain our assumptions for this below.

2. Availability of GHGe data

There are a number of papers on GHGe of food, but for the purpose of the exercise we needed to have a set of data which was consistent and reasonably comprehensive. This requires examination of the full life cycle (different studies use different endpoints) and consideration of how imported goods are treated.

A study which has considerable data is that of Wallén et al. (reference 9) estimating emissions from farm to RDC. However, examination shows that this has been produced by examining energy requirements and converting this directly to CO_2, leading to a conclusion that emissions from pork and beef are roughly similar. In addition, examination of individual figures suggests that the authors assumed that production of imported goods had the same footprint as those produced locally (for example, compare values for tomatoes with those from HLCWG). We therefore regretfully did not use this data.

A more useful survey is done by Carlsson-Kanyama (AJCN 2009) (reference 6) which makes estimates from farm to table for a number of items. This appears well worked out and consistent, but has many missing items.

The Swedish Institute for Food and Biotechnology has produced a number of LCAs for different food products (see reference 5). The figures shown include emissions to the point of consumption. Generally estimates appear low, for example compared with HLCWG, although this can be partly explained by the fact that domestic energy emissions in Sweden have lower carbon content (greater reliance on hydro and nuclear power).

Figures for energy estimates can be derived from Carlsson-Kanyama and Faist and we sought to use these in making figures compatible. A survey by Orremo (1999) (quoted in SIK report 804 – see reference 5) states that the average shopping trip is 7.81km and 59% of trips are by private car so estimates for this component of emissions can be made in the same way as for HLCWG.

Statistics Sweden (2006) estimates the emissions related to different purposes, including food, based on “operation of vehicles” and “heat energy”, although figures do not include private consumption. An older report (2003) seeks to categorise emissions by household activity and therefore gives an overall estimate for emissions for “cooking” (including food) and “shopping” (including food shopping) (reference 10). This, together with more general assumptions regarding the percentage of emissions from food (estimated in the range 18-29% in different literature) can give overall figures for emissions where detail is unavailable.

3. Conversion of data – approach

First of all we make some overall top-down estimates – these are to be used for validation and as benchmarks only.

Statistics Sweden estimates GHGe both directly and indirectly associated with cooking food as 14.39MtCO_2e. This does not include shopping, where total direct burden is 8.55MtCO_2e, including other shopping and leisure activities. However, the latest transport survey suggests that 44% of trips not connected with work relate to shopping and elsewhere that 50% of shopping trips relate to food shopping. This would give an estimate of the total burden of food consumption as around 16MtCO_2e.

From an equally top-down point of view, analysis in other countries suggests that food represents somewhere between 18% and 29% of overall GHGe. Eurostat figures for 2009 give the total emissions for Sweden as 59.994Mt giving an estimate for food-related emissions of between 10.8 and 17.4MtCO_2e. We can hypothesise that Sweden will be towards the higher end bearing in mind that it has a generally low per capita emissions pattern but that this is due to the composition of electricity, while significant parts of the food life cycle relate to carbon-based transport and agriculture.

Using these figures and examining parallels with HLCWG as well as individual LCA reports for Sweden from SIK, we propose a benchmark of 15MtCO_2e: 57% pre-RDC (8.5Mt), 20% RDC to retail including processing (3.1Mt), 13% transport to consumer (1.9Mt), and 10% cooking and household (1.5Mt).

As with the original LiveWell report, we divide the RDC-to-retail figure in proportion to weight. While this may not be the most appropriate division, it is difficult to determine from the consumption data whether food was cooked at home or was bought as ready-meals, so apportioning processing between before and after retail is not possible in a consistent way.

Where it is possible to use figures from either CK or SIK we have done so, adapting these by appropriate multiplication factors from the analysis above to gain a figure/kg for the product finally consumed.

Where there is no figure available we have used HLCWG figures, adapted for post-RDC emissions and in proportion to imports based on FAOSTAT data, or figures provided by Eat England (generally for processed foods). For these figures we have also taken into account the fact that consumed weight may not be the same as the weight at RDC due to wastage (banana skins, bones), cooking (meat shrinkage) and hydration (pasta). Conversion factors are taken from McCance and Widdowson.

For areas where the categories are broad or vague we have chosen a value based on typical figures for that type of food using the sources above and informed by any likely concentration (e.g. of types of fish).

In a few areas, there were significant differences between Swedish (CK + SIK) data and UK-based (HLCWG and Eat England) data. Notably these include eggs and milk. In these cases we have used Swedish data.

4. Nutritional data

Nutritional data is taken from a public database of nutritional content of different foods. Generally this gives a more specific value than the broad categories in the Riksmaten survey and so “representative” foods have been chosen. We revisited some definitions when it became clear which foods are important.

5. Cost data

We have produced very broad-brush cost data using the approach of triangulating the 2009 HBS from Statistics Sweden with the Riksmaten survey. This has some dangers, since changes in relative consumption of different food categories will have an effect on the apparent price (e.g. if Swedes now eat proportionately more cheese, then the apparent price of cheese will go up). In any case, for some categories (e.g. dishes with beef) the price can vary by several multiples depending on the quality of the base item.

Initial comparison of relative prices with those found for a Swedish online retailer suggests that the relative figures are reasonably consistent.

6. Constraints – nutrition

Sweden publishes two recommendations on diet: the food circle (FC) – see Task 1 report 2.1.3 – and recommendations on minima and maxima for nutrients (SNR). These are complemented by a study named Swedish Nutrition Recommendations Objectified (SNO). SNO is not really a “recommendation” as such, more a way of using the nutritional recommendations to create a specific diet.

The actual recommendation to the general public is to eat at least one portion from each segment of the food circle each day. This does create a constraint because it requires a significant amount of meat and dairy. On the other hand, portion sizes seem to be poorly defined and we have had to make estimates in this respect.

We considered using SNO as a constraint for acceptability, but this proved too difficult: following SNO in detail results in a rigid diet which cannot reduce GHGe adequately, while loosening the bounds merely means that the constraints are ineffective. Instead, we used the food circle as categorisations and added a constraint that the relative proportions of foods should not change too much – specifically that for each food circle category, the LiveWell diet should include consumption of at least 80% of values used for the SNO diet.

SNO produces a set of sample diets, which we ued when developing a sample LiveWell menu.

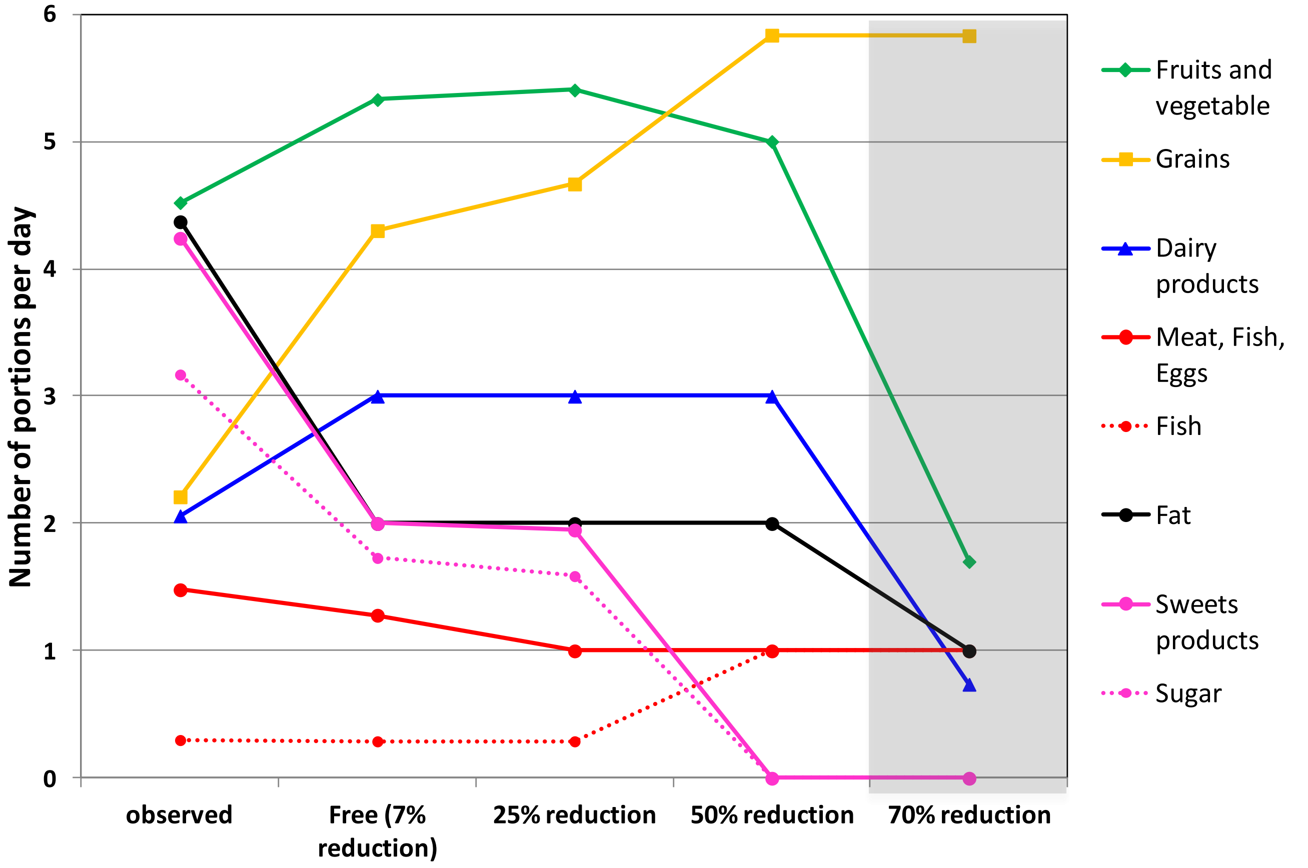
ANNEX 3 – SENSITIVITY ANALYSIS

France

1. GHGe sensitivity analysis

To analyse the consequences of a step-by-step reduction of GHGe in a healthy diet, we ran four LiveWell models. The first model has no constraint on GHGe; the others imposed a 25%, 50% and 70% (related to the 2050 target in UK LiveWell plate) reduction of GHGe. Figure 1 displays the impact on food choices represented by the National Health and Nutrition Programme (PNNS) food groups. The model simulating a 70% reduction of GHGe was not feasible. Indeed, the minimum achievable reduction of GHGe was 1499g CO_2e/day (57% reduction) subject to nutrient recommendations as well as to French FBDGs (Appendix 1). This means that it is not possible to make a healthy diet with a 70% reduction.

Figure 1: Observed diet and optimal food patterns modelling a reduction of GHGe, expressed in PNNS food groups.



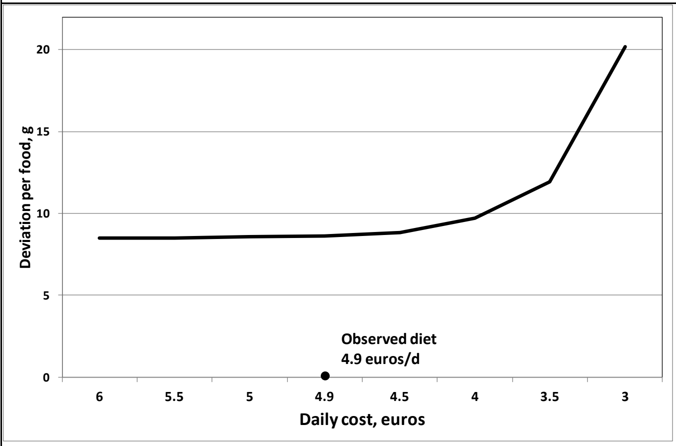
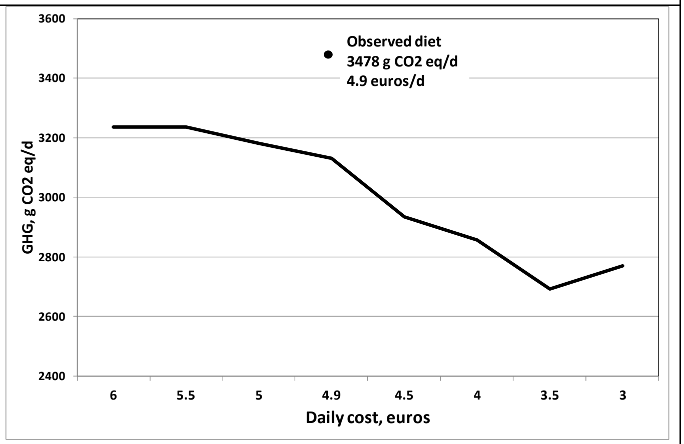
Dashed line indicates food categories which were not included in the major food group (indicated by the same colour).

The grey area indicates that the model was not feasible subject to a 70% reduction of GHGe. For example, the number of portions of fruit and vegetables do not match with the recommendation (i.e. at least five portions of fruit and vegetables).

2. Cost sensitivity analysis

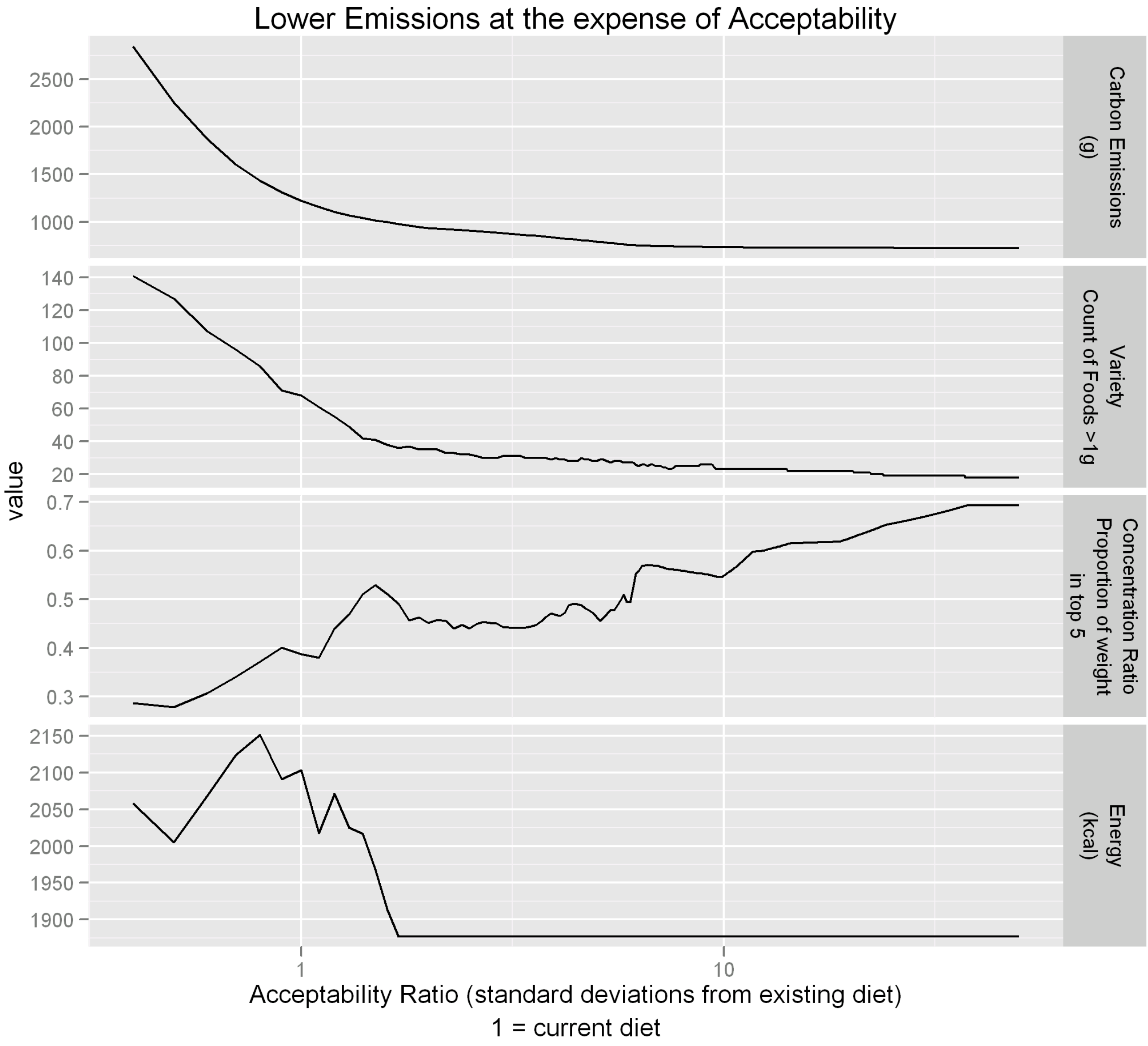
Imposing a reduction of cost induced a decrease in GHGe and an increase of the deviation from observed diet. The minimal cost achievable assuming a healthy diet was €3 per day. A low-cost healthy diet was compatible with a reduction in GHGe (i.e. 20% from the actual) but huge modifications of food habits were needed.

Figure 2. Impact of a decreasing cost constraint on GHGe (Panel A) and on the deviation from food habits (Panel B)

Panel A	Panel B
	

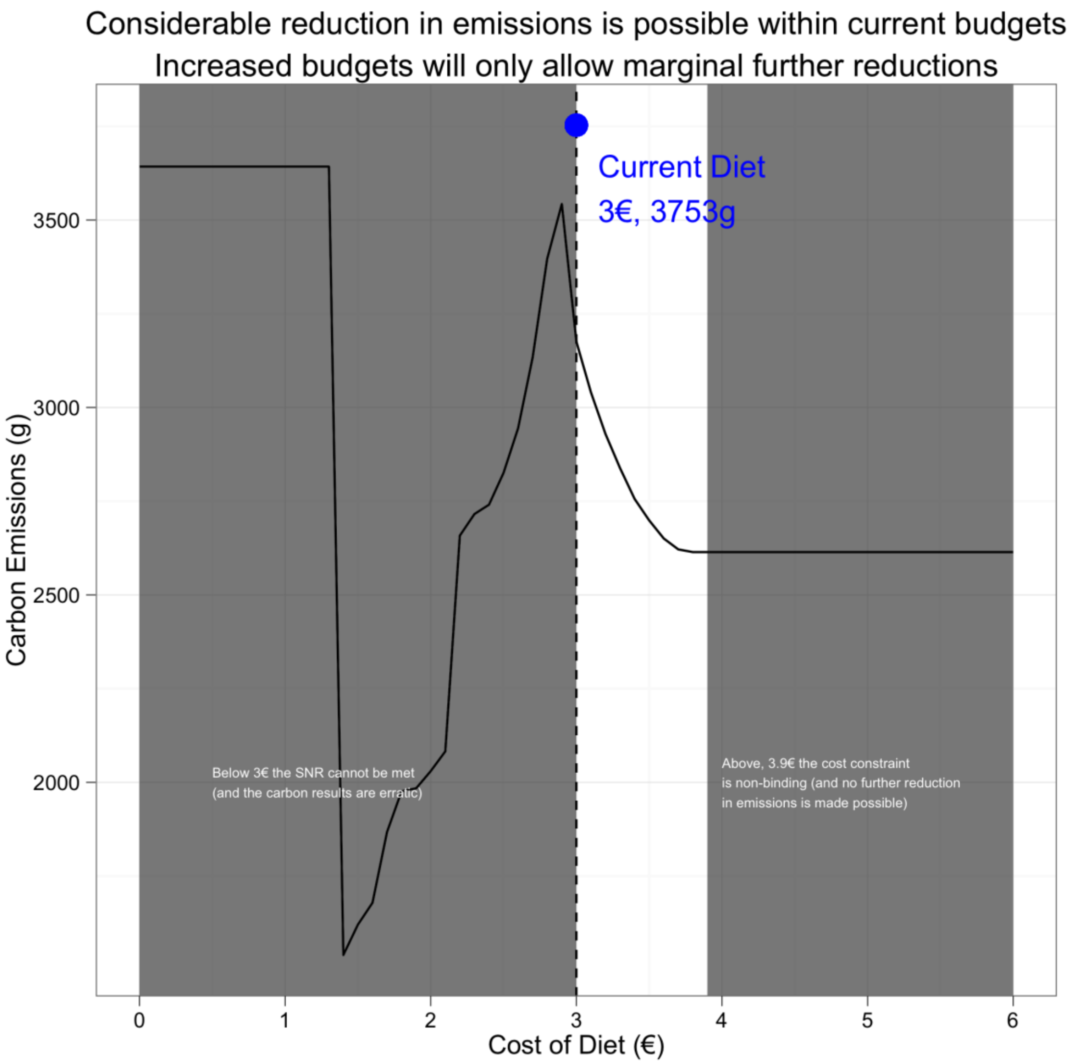
Spain

A more general analysis shows a trade-off between reducing emissions and ensuring acceptability which is not wholly simple. The figure below shows the effect of constraining each foodstuff by numbers of standard deviations from the current average diet and the effect that this has on GHGe and degree of variety of foods. This shows that after a certain point making the diet more extreme has little effect on GHGe. Of course diets here are probably not culturally acceptable, but the graphic gives an impression of the degree of change needed – and the fact that it does not take a great deal of movement in order to reduce GHGe by 75%.



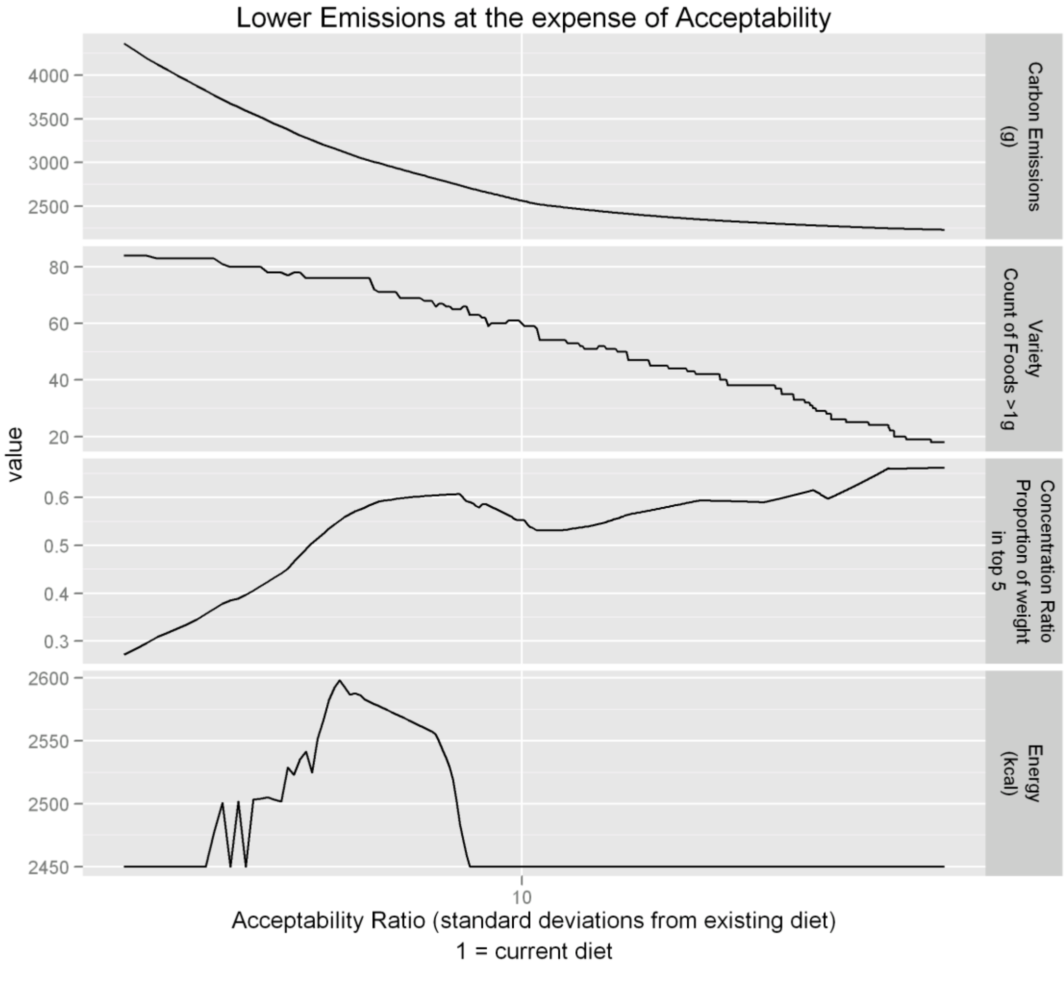
As noted, cost was not a binding constraint.[44] The analysis below from running the model with different constraints shows that, although spending more can reduce GHGe, this is not significant and that it is possible to find a diet which is cheaper than the current one while meeting nutritional requirements.

[44] Though we should note that adjustments to the final LiveWell diet in order to make it acceptable moved the price to something comparable with current spending.

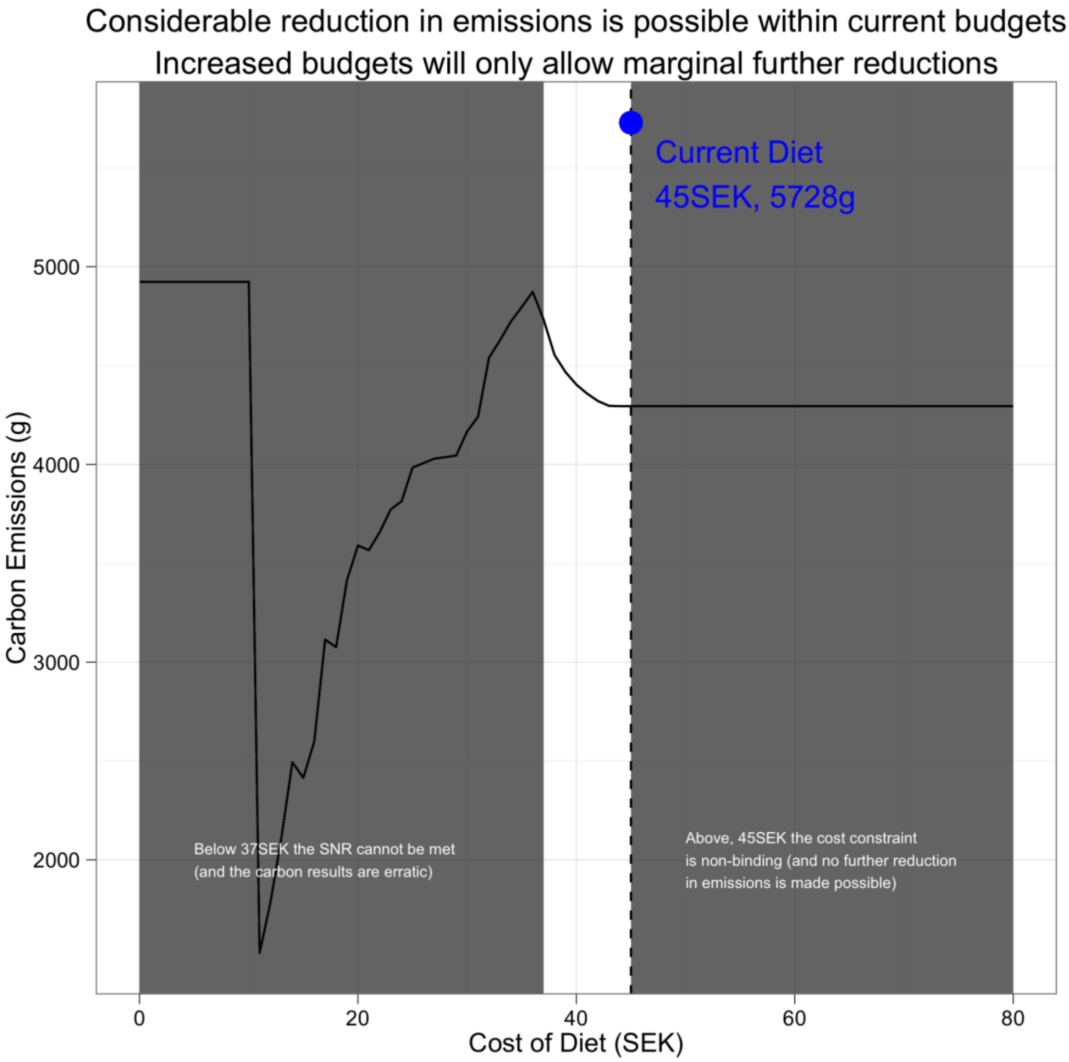

Considerable reduction in emissions is possible within current budgets
Increased budgets will only allow marginal further reductions
Current Diet
3€, 3753g
Below 3€ the SNR cannot be met
(and the carbon results are erratic)
Above, 3.9€ the cost constraint
is non-binding (and no further reduction
in emissions is made possible)
Carbon Emissions (g)
3500
3000
2500
2000
0
1
2
3
4
5
6
Cost of Diet (€)

Sweden

A more general analysis shows a trade-off between reducing emissions and ensuring acceptability which is not wholly simple. The figure below shows the effect of constraining each foodstuff by multiples based on consumption of the current average diet and the effect that this has on GHGe and degree of variety of foods. This shows that after a certain point making the diet more extreme has little effect on GHGe. Of course diets here are probably not culturally acceptable, but the graphic gives an impression of the degree of change needed – and the fact that it does not take a great deal of movement in order to reduce GHGe by 75%.



As noted, cost was not a binding constraint.[45] The analysis below from running the model with different constraints shows that, although spending more can reduce GHGe, this is not significant and that it is possible to find a diet which is cheaper than the current one while meeting nutritional requirements.



45 Though we should note that adjustments to the final LiveWell diet in order to make it acceptable moved the price to something comparable with current spending.

ANNEX 4 – NATIONAL NUTRITIONAL RECOMMENDATIONS

Table taken from Task 1

		France		Spain		Sweden		WHO		EU	
Nutrient	**Unit**	**Men**	**Women**	**Men**	**Women**	**Men**	**Women**	**Men**	**Women**	**Men**	**Women**
Energy	kcal	2500-2700	2000-2200			2700	2200				
Protein	en%	11-15	11-15	10-12	10-12	10-15 e	10-15 e				
Fat	en%	30-35	30-35	<35	<35	<30	<30	20-35	20-35		
saturated	en%			<7	<7	<10	<10	<10	<10		
monounsaturated	en%			13-18	13-18	10-15e	10-15 e	15-20	15-20		
polyunsaturated	en%			<10	<10	5-10 e	5-10 e	6-11	6-11		
n-3 fatty acids	-			0.2-2 g/d	0.2-2 g/d	1 en%	1 en%	0.5-2 en%	0.5-2 en%		
trans fatty acids								<1	<1		
Carbohydrates	en%	50-55	50-55	50-60	50-60	55-65 e	55-60 e	>55	>55		
saccharose	en%					<10	<10				
Dietary fiber	g					25-35	25-35				
Alcohol	en%			<10	<10	<5	<5				
Alcohol	g			<30	<30	<20	<10				
vitamin A	µg RE	800	600	750	750	900	800	600	500	700	600
B1 thiamin	mg	1.3	1.1	1.2	0.9	1.4	1.1	1.2	1.1	1.1	0.9
B2 riboflavin	mg	1.6	1.5	1.8	1.4	1.6	1.3	1.3	1.1	1.6	1.3
B3 niacin	mg NE	14	11	20	15	19	15	16	14	18	14
B5 Pantothetic acid	mg	5	5					5	5	3--12	3--12
B6	mg	1.8	1.5	1.8	1.6	1.5	1.2	1.3	1.3	1.5	1.1
B7 Biotin	µg	50	50					30	30	15-100	15-100
folate	µg	330	300	200	200	300	300	400	400	200	200
B12	µg	2.4	2.4	2	2	2	2	2.4	2.4	1.4	1.4
vitamin C	mg	110	110	60	60	60	60	45	45	45	45
vitamin D	µg	5	5	2.5	2.5	5	5	5	5	0-10	0-10
vitamin E	mg	12	12	12	12	10	8	10	7.5	0.4*	>4->3
vitamin K	µg	45	45					65	55		
calcium	mg	900	900	600-850	600-850	800	800	1000	1000	700	700
phosphorus	mg	750	750			600	600			550	550
potassium	mg					3500	3100			3100	3100
sodium	mg	3200	3200			2000	2000	2000	2000	575- 3500	575- 3500
iron	mg	9	16	10-15	18	10	15 (12-18)	9	20	9	20
zinc	mg	12	10	15	15	9	7	7	4.9	9.5	7
copper	mg	2	1.5							1.1	1.1
iodine	µg	150	150	140-145	110-115			130	110	130	130
selenium	µg	60	50			50	40	34-26	34-26	55	55
magnesium	mg	420	360	350-400	330	350	280	260	220	150-500	150-500
Manganese	mg	2.0-5.0	2.0-5.0							1-10	1-10
Chromium	µg	30-100	30-100								
Molybdene	mg	50-100	50-100								
Fluoride	mg	2.5	2								
Sources: WHO/FAO, SCF 2004, AESAN, SENC, SEDCA, ANSES, Nordic Nutrition Recommendations 2004											

Note that fat, carbohydrate and protein are expressed as en%. For the purpose of modelling we converted these to g/day equivalents.

ANNEX 5 – PROJECT BRIEF

Note – the brief for task 1 is included for completeness, but this report relates only to task 2

Task 1 – To produce resource material on each pilot country's current dietary patterns

WWF proposes outlining the content of an average person's diet from France, Spain and Sweden, using existing national dietary data. Alongside this the diet related health problems in each country will be quantified. This will be compared to healthy eating advice in the form the Eatwell plate.

There is plenty of evidence available that the average person in the developed world is eating too much of the wrong type of food per day resulting in the related health problems. This is an issue recognised in the EU, and some industry bodies, such as Scientific Advisory Committee on Nutrition, the Food Standards Agency and the British Dietetic Association in the UK and organisations such as Cancer Research, the British Heart Foundation and the National Obesity Forum. A key part of this work will be clarifying the current consumption patterns and their relationship to dietary advice.

The Eatwell plate, published by the UK's Department of Health, is seen as one of the clearest and most recognised guides available that demonstrates pictorially the correct amount of food in your diet. Though it does not display quantities by the different parts, of the plate it is a clear, simple representation of what a balanced diet should look like. Most European countries take a similar approach and publish dietary guidance, usually either in plate or pyramid form, though France uses the less common staircase. This report will take as a basis for nutritional advice from the pilot countries using it as the definition of that country's healthy diet. The report will then use each definition of a healthy plate of food and use it to highlight the difference between that and the average diet in each of the pilot countries, based on national food consumption data and information from others sources such as the FAO.

The nutritional advice in the pilot countries will be compared to that in the UK and that in Brussels and produce a clear comparison of the advice and highlight similarities and differences.

For each country the final report will compare the current diet to a traditional one, identify reasons for change and where food tends to be sourced. What if any are the health issues and costs of these issues associated with the new current diet? Are any future trends identifiable if business as usual continues?

For details of an example of sources of information go to appendix 1, though these are not to be seen as a definitive list, other sources can and will be used.

This task, when completed, will form the basis for task 2 which will further develop these findings.

Outputs

- Quantification of current eating habits for each pilot country
- Comparison to nutritional advice
- Pictorial representation of results
- Accompanying report which compares reasons for change, health issues and costs.

Task 2 – To conduct analysis and produce a case study for each pilot country

The environment

WWF has recognised that the current food system has substantial impacts on the environment. As part of the One Planet Food programme we are looking at both production and consumption, and are working on seafood, soy, palm oil, meat and dairy, water and agriculture. We are aware that the current dietary habits of the developed countries are unsustainable and as more and more people start moving towards the developed world's high livestock product diet the impact on the natural world will be magnified and will accelerate habitat destruction and climate change. This will be compounded by the growing concern around food prices since the 2008 and 2011 price spikes and global food security.

As part of our work on consumption WWF is looking at the role of diet and its impact on the environment with the various elements being mapped out. Any diet will need to look at the impacts of food consumption in the pilot country and internationally. The investigation will need to incorporate local and seasonal food as well as food from the developing world. Where foods come from and the role of farmers will be different for each country, thus necessitating the need to look at these areas.

LiveWell for LIFE

WWF believes that a healthy diet is sustainable and the questions WWF are asking are 'is a healthy diet sustainable? Is it possible? Can we create a LiveWell plate for each of the pilot countries – France, Spain and Sweden?' And 'If current dietary advice is not sustainable what changes would be needed?'

As part of this WWF feels it is important to show that meat, dairy and seafood can be part of a healthy, environmentally friendly diet.

WWF understands that the carbon data might not be available for each individual part of the diet and this should not be seen as a problem as there is evidence available as to the carbon footprint of many foods and there has been work conducted recently looking at the sustainable diets of various European countries (appendix 1) these and others can be used as building blocks for the research. The aim will be to produce a defined sustainable diet for each pilot country, similar to the LiveWell work in the UK.

WWF-UK is looking for one lead body who if needed can outsource some of the work to the relevant experts in each country. The aim is not to compare the different diets but to demonstrate what the diet looks like for each country.

The LiveWell plate for each country could be designed in 2 formats, one with more general sections, such as the current UK LiveWell plate (appendix 1), with the second more compartmentalised into the different types of protein, carbohydrates and other nutrients. As there are many sources of proteins it would be useful to demonstrate the different types and where they can be found. This will demonstrate that there are many different sources of protein beyond meat and wild caught fish.

An often expressed objection to following the healthy diet or to any changes is food consumption is that it will be difficult to make the transition or the resultant diet will be dull. This study will need to quantify the amount of food a person can eat in a week when following the recommendations. The resulting weekly menus will need to be varied and representative of the country's culinary heritage.

The proposed diet is meant to be practical, and much like the current Eatwell plate, a section will need to include foods high in fat and sugar.

Using the research a clear definition of a sustainable diet for each country will be made that can be expressed pictorially and verbally.

For each country a weekly shopping list will be produced as well as a weekly menu of suggested foods that incorporates some traditional dishes and cooking styles.

The final recommendations need to be easily communicable as guidance for consumers, based in science as a tool for retailers and government to build upon. The final plates should have some headline principles that go with it that are appropriate for each country and others for the EU as a whole; WWF will be able to help with these messages.

The research needs to be nutritionally correct and as such the final LiveWell plate should be presented to a relevant nutritional body for consultation and approval.

The end work will outline the key principles of a sustainable diet and will be able to be translated in to a LiveWell plate, with the economic and carbon potential savings being quantified

Once the LiveWell plate has been defined to make it truly sustainable it would be beneficial to explore whether the diet would have social, economic and other benefits.

Outputs

- LiveWell plate for each country in 2 formats
- Identify different protein sources
- A clear definition of a sustainable diet for each country
- A weekly shopping list and menu including typical costs in each country – incorporating traditional dishes and cooking styles
- Easy-to-communicate principles
- Economic and carbon savings will be quantified.

Summary

This assignment seeks to show:

- Current dietary habits in the pilot countries and the health impacts
- The environmental impacts of current consumption patterns in the pilot countries
- A sustainable diet for each pilot country
- How the LiveWell plate will benefit local traditions and food sectors.
- What a weekly diet will consist of, look like and cost for each pilot country
- A definition of a sustainable diet for each pilot country

The main work for this assignment is outlined above. Subsequent to task 2, consultants are expected to provide further commentary around the results and to deal qualitatively with some of the issues not directly covered by the analysis. The commentary should cover the following questions:

A. How would the diet be potentially different for someone in other European states? Northern European, Southern, Eastern and Western.
B. How would a change to a sustainable diet impact on EU farmers?

This final diet needs to be seen by an approved nutritional or health body to ensure it is possible and ideally have appropriate publishable support. The final plates need to be peer reviewed.

ANNEX 6 – REFERENCES

1 WWF. 2011. *Livewell: a balance of healthy and sustainable food choices*. WWF-UK, Godalming, UK

2 WWF. 2010. *How Low Can We Go?: An assessment of greenhouse gas emissions from the UK food system and the scope to reduce them by 2050.* WWF-UK, Godalming, UK

3 Maillot M, Darmon N and A Drewnowski. 2010. Are the lowest-cost healthful food plans culturally and socially acceptable? *Public Health Nutrition* 13:1178-1185

4 Task 1 report

5 SIK reports, particularly:

794 *Greenhouse gas emissions from Swedish consumption of meat, milk and eggs 1990 and 2005* (2009)

802 *Food Production and Emissions of Greenhouse Gases – An overview of the climate impact of different product groups* (2010)

804 *Environmental Life Cycle Assessment (LCA) of ready meals* (2010)

828 *Emissions of Greenhouse Gases from Production of Horticultural Products* (2011)

6 Carlsson-Kanyama A and González AD. 2009. Potential contributions of food consumption patterns to climate change. *American Journal of Clinical Nutrition* 89(5):1704S-1709S

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15 Black AE. 2000. Critical evaluation of energy intake using the Goldberg cut-off for energy intake:basal metabolic rate. A practical guide to its calculation, use and limitations. *International Journal of Obesity and Related Metabolic Disorders* 24: 1119-30

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18 Westhoek H, Murphy-Bokern D. and others. 2012. *European Nitrogen Assessment. Special report on nitrogen and food*. In review in public. Available at: www.clrtap-tfrn.org [Accessed 13 January 2013]