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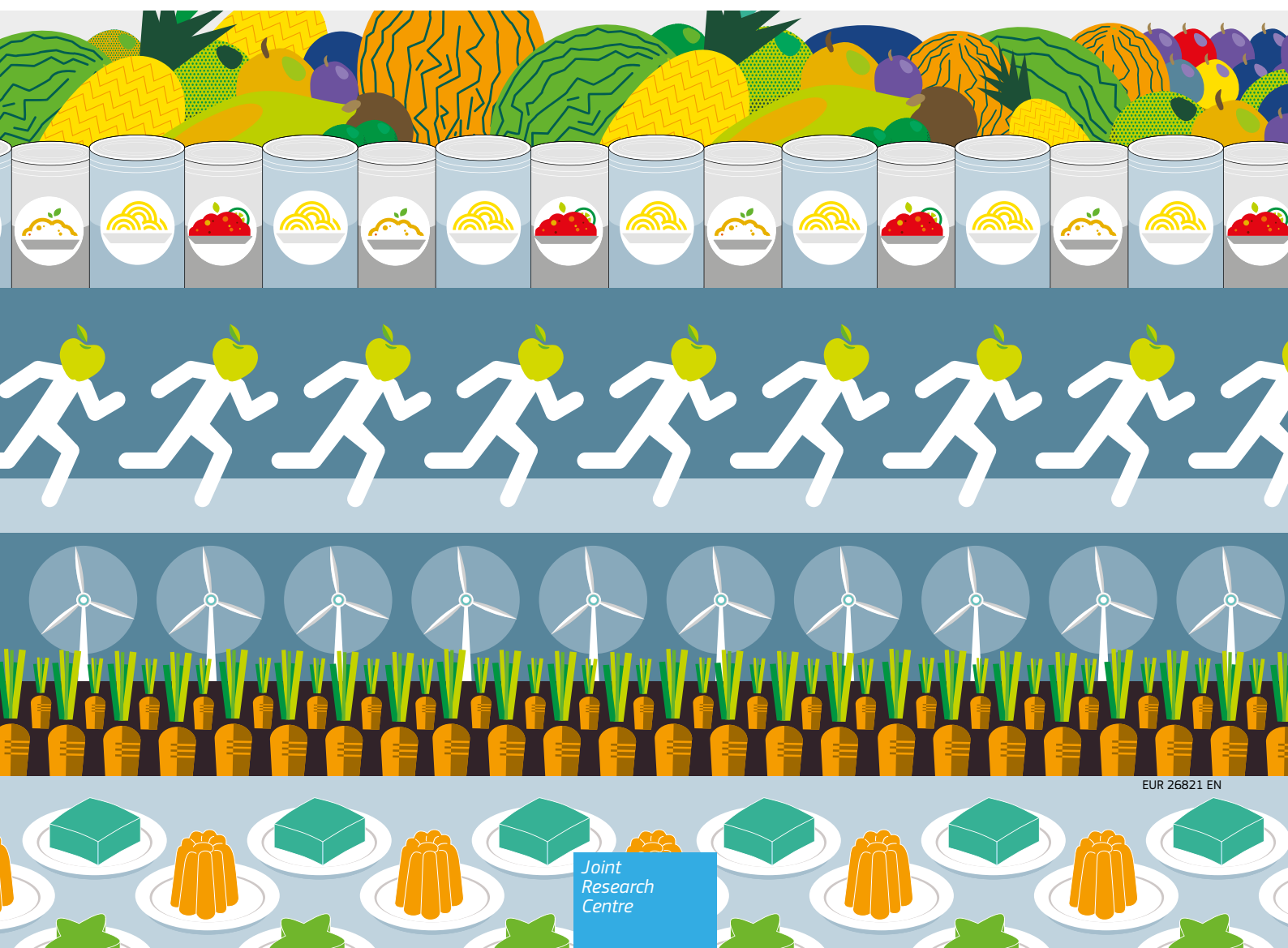
Tomorrow's Healthy Society

Research Priorities for Foods and Diets

Final Report

Anne-Katrin Bock, Petros Maragkoudakis,
Jan Wollgast, Sandra Caldeira, Agnes Czibalmos,
Malgorzata Rzychon, Bela Atzel, Franz Ulberth

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Joint
Research
Centre

European Commission
Joint Research Centre
Foresight and Behavioural Insights Unit

Contact information

Joint Research Centre
Rue du Champ de Mars 21, B-1050 Bruxelles/Brussel
E-mail: JRC-DDG-02-FORESIGHT@ec.europa.eu
Tel.: +32 2295 8650

<https://ec.europa.eu/jrc>

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Abstract

Health promotion and disease prevention through provision and consumption of healthy diets are increasingly recognised as crucial, both socially and economically, in the face of strained healthcare systems, an ageing population, and the high individual and economic costs of diseases. The Foresight study 'Tomorrow's healthy society – research priorities for foods and diets' was initiated to inform the selection of research challenges to receive funding under the Horizon 2020 programme. The exploratory scenario-building approach focused on the European consumer with the year 2050 as a long-term time horizon. Four different future scenarios were developed using the extremes of two main drivers – agricultural commodity prices (low or high) and societal values (community spirit or individualistic society). The scenarios provided the basis for the identification and prioritisation of research needs to address the challenges and opportunities arising from the different scenarios. The resulting ten research priorities fall into four thematic areas: Towards healthier eating; integrated policy-making; Food, nutrients and health: cross-interactions and emerging risks; Making individualised diets a reality; and Shaping and coping with the 2050 food system.

J R C F O R E S I G H T S T U D Y

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Preface

There is increasing evidence highlighting the significance of diets for health, beyond the basic need to provide energy and nutrients. In recent decades, changes in lifestyles and diets have made unhealthy dietary patterns one of the major risk factors for many non-communicable diseases and other medical disorders. These have serious health, social and economic implications, which are increasing in developing countries, too. Therefore, diets and health are the focus of many national, European and international initiatives, and the topic is high on research agendas.

Prevention in the form of healthy diets is a prime example for a complex challenge, being subject to manifold influences ranging from individual preferences and needs to healthcare or macroeconomic conditions. There is a need for the whole food system to contribute to healthier diets, and research will play an important role in providing the necessary knowledge for effective changes, with due attention being given to additional sustainability aspects, too.

The JRC, the Commission's in-house science service, was entrusted by DG Research and Innovation to carry out the Foresight study 'Tomorrow's healthy society – research priorities for foods and diets'. The study sets out to identify research priorities for foods and diets for health, taking into account future challenges and possible long-term developments, in order to support the implementation of Horizon 2020, the European Framework Programme for Research and Innovation for 2014-2020.

As a strategic, participatory and multidisciplinary approach, Foresight is an essential tool to support systemic thinking and the consideration of complexity for reflections on the future. It is becoming more and more important to proactively shape policies, taking into account the dynamics of change rather than linear extrapolation and wishful thinking. The JRC is in the process of strengthening its capacity in Foresight to further improve its scientific and technical policy support. This study is one of the first results of this new activity, pooling relevant expertise from different JRC institutes, too.

The study built strongly on the expertise and support of the workshop participants, for which we are very grateful. I would also like to thank the Steering Committee for their support and valuable guidance from the beginning of the study to its conclusion.

The present final report provides a summary of the study results as well as additional background information. Beyond its primary objective, we hope it will be used by all relevant stakeholders to trigger and inform further discussions on our future food system.

David Wilkinson
Director Policy Support Coordination



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Executive Summary

Health promotion and disease prevention are increasingly recognised as crucial, both socially and economically, in the face of strained healthcare systems, an ageing population, and the high individual and economic costs of diseases. Apart from infectious diseases, this applies in particular to the prevention of chronic, non-communicable diseases (NCDs), such as diabetes, cardiovascular diseases or cancer. One of the four major risk factors for NCDs is an unhealthy diet, making better nutrition and eating habits a potentially effective and cost-efficient prevention strategy.

The provision and consumption of healthy diets involves the whole food chain and the consumer, and is interlinked with many other areas such as healthcare, the economy, environment, individual lifestyles, etc., making this a very complex challenge. Research plays a vital role in increasing our understanding of nutrition needs, diet impact on health, disease mechanisms, determinants of consumer choice, development of improved and novel food production approaches, and food market and trade mechanism, to name just a few areas which are relevant in this context.

The Foresight study 'Tomorrow's healthy society – research priorities for foods and diets', carried out by the European Commission's Joint Research Centre, was initiated at the request of the Directorate-General for Research and Innovation to inform the selection of research challenges to receive funding under the Horizon 2020 programme¹. The exploratory scenario-building approach, which involved around 40 experts and stakeholders with a broad range of backgrounds in three workshops in 2012 and 2013, focused on the European consumer with the year 2050 as a long-term time horizon. Four different future scenarios were developed using the extremes of two main drivers – agricultural commodity prices (low or high) and societal values (community spirit or individualistic society).

The scenarios provided the basis for the identification and prioritisation of research needs to address the challenges and opportunities arising from the different scenarios. The resulting ten research priorities fall into four thematic areas:

1. Towards healthier eating: integrated policy-making

Improve the evidence base for adoption of healthier dietary behaviour

by providing a strong evidence base for the development of authoritative, EU-wide (and internationally) agreed dietary reference values, and the definition of healthy dietary patterns to increase the consensus on policy targets for healthy eating. Science-based tools and methodologies are needed to translate the scientific evidence base into adapted, easy to understand and take up food-based dietary guidelines.

¹ European Commission Horizon 2020 Food & Healthy Diet website (accessed in April 2014)



Developing a scientific framework for a systems approach to food and nutrition policies, including science-based, user-friendly tools to describe the food system and its key interactions as a whole; a framework to enable systems thinking in terms of research and policy design and decision-making; effective systems solutions to nutrition and health issues, and effective ways to network policies and promote coherence across policies and relevant actors, reflecting a dynamic society and industry landscape.

Provide a framework to design, monitor and evaluate policies through a science-based methodological framework for the systematic *ex-ante* and *ex-post* impact assessment of policies; the identification of effective policy measures enabling healthy and nutritionally balanced diets, including population-specific measures; and the development of tools for monitoring and the timely identification and assessment of relevant food-chain developments.

Towards healthier eating: integrated policy-making	Food, nutrients and health: cross-interactions and emerging risks	Making individualised diets a reality	Shaping and coping with the 2050 food system
<ul style="list-style-type: none"> • Improve the evidence base for adoption of healthier dietary behaviour • Developing a scientific framework for a systems approach to food and nutrition policies • Provide a framework to design, monitor and evaluate policies 	<ul style="list-style-type: none"> • Deepening the understanding of human nutrition: facing the complexities • Anticipation of emerging risks 	<ul style="list-style-type: none"> • Data needs: creation and management of necessary data for enabling individualised diets • Analysing feasibility and impacts of individualised, healthy diets 	<ul style="list-style-type: none"> • Understanding the social role of food • Towards a sustainable food system producing safe, affordable and healthy dietary components • Supporting technologies to meet societal needs

2. Food, nutrients and health: cross-interactions and emerging risks

Deepening the understanding of human nutrition: facing the complexities. This includes the development of improved and nutrition-tailored study designs for better research approaches, better integration of knowledge from different, relevant disciplines, and elucidation of the complex interaction between genes, diets, behaviour, the environment and other determinants of individual health status.

Anticipation of emerging risks through the development of an integrated anticipatory approach that entails indicators for the early identification of potentially acute food-safety risks; a systems understanding of the long-term physiological effects of novel dietary components and changed consumption patterns; and a resilient strategy to ensure food safety in a globalised complex food chain.

3. Making individualised diets a reality

Data needs: creation and management of necessary data for enabling individualised diets. This includes identification of the types of data needed and the specific technical requirements and appropriate methodologies for their collection, processing and translation into individualised dietary advice. In addition, effective approaches are needed to make this advice easily accessible and understandable for consumers, supporting adherence to such dietary advice. The development of guidelines and quality standards to ensure high-quality, reliable and evidence-based services; measures and procedures to deal with ethical and legal issues are also needed.

Analysing the feasibility and impacts of individualised, healthy diets through risk/benefit assessment and cost-effectiveness analysis of the implementation of individualised dietary advice regarding individual health status and the healthcare system; identification of the required level of consumer health and nutrition literacy and of drivers affecting consumer acceptance and adherence to individualised dietary advice, paying

particular attention to specific population sub-groups. The development of suitable and attractive products to support individualised, healthy diets and identification of the potential impacts on the food industry are additional important elements.

4. Shaping and coping with the 2050 food system

Understanding the social role of food by investigating the role of food beyond nutrition, and the social effects of eating at individual and community level; through identifying the possibilities for and the implications of a change in the perception of the importance of food and nutrition for health, for example, due to a focus on effective cures and treatments for chronic diseases.

Towards a sustainable food system producing safe, affordable and healthy dietary components. This includes the development of effective integrated approaches to establish, promote and support a sustainable food chain, for example, through effective policy measures, new approaches and technologies to improve efficiency, effective integrated approaches to reduce food waste, as well as the identification of potential risks of (highly complex) food chains and measures to ensure integrity in terms of food safety and food quality.

Supporting technologies to meet societal needs by developing novel or alternative sustainable primary production or manufacturing processes for better nutritional profiles of foods and food components; methodologies for impact assessments of technological developments in the food system and beyond, and effective approaches to communicate and gain acceptance of new food sources and technologies with potential health benefits in sustainable food production.

Most of the research priorities identified should be approached in the coming years to deliver results in the short- to mid-term (before 2030), thereby reflecting their urgency.

The research priorities developed in this study, and based on scenarios with a long-term perspective, show that we still need to know more about foods, diets and health, and that we need to have effective, integrated and acceptable policies in order to move towards a sustainable food chain providing consumers with healthy diets. Changes in consumer behaviour must go hand in hand with changes in the food supply. The scenarios developed in this study are intended to contribute to a societal dialogue on how to shape the future food system, while research will provide the evidence necessary for informed decision-making.



1. Why a foresight study on food and health?

In the EU, life expectancy is currently increasing by 2.5 years each decade. However, only 75 % (females) to 80 % (males) of total life expectancy are spent in good health². Promoting health and preventing disease is essential, not only for the high individual impact of disease but also because increasingly strained healthcare systems, an ageing population, and the high economic cost of disease make this a social as well as an economic necessity. This applies in particular to the prevention of chronic, non-communicable diseases (NCDs). In Europe, the major NCDs, such as diabetes, cardiovascular diseases, cancer, chronic respiratory diseases and mental disorders, account for 86 % of deaths and 77 % of the disease burden³. About 26 % of these deaths are premature, i.e. below the age of 70 years⁴. Susceptibility to NCDs increases with age⁵, which is particularly relevant against the background of an ageing population in Europe.

The risk factors for NCDs include poor lifestyle choices, such as smoking, alcohol abuse, physical inactivity and unhealthy diets. The latter two also contribute substantially to the increasing prevalence of overweight and obesity (in Europe and worldwide), both being associated with increased risk of heart disease, stroke, diabetes, as well as certain cancers. Worldwide, obesity prevalence has doubled since 1980: in 2008, 1.46 billion adults were overweight and one-third of those were obese⁶. Obesity is considered by the World Health Organization (WHO) as the greatest public health challenge for the 21st century. In the EU, in 2010, more than half (52 %) of the adult population was overweight, and approximately one in six (16.5 %) was obese⁷. Similar to global trends, adult obesity rates in many EU Member States have doubled since 1990. However, the prevalence differs, ranging from 8 % in Romania to more than 25 % in the UK or Hungary⁷. Childhood obesity is of particular concern since obese children are likely to remain obese into adulthood and are more likely to develop NCDs, such as diabetes and

cardiovascular diseases, at a younger age⁸. In 2010, on average 1 in 3 children in the EU aged 6-9 years old were overweight or obese, up from 1 in 4 children in 2008⁹.

Overweight and obesity also contribute to increased economic and healthcare costs: each year, 35.8 million (2.3 %) of global disability adjusted life years (DALYs) are caused by overweight or obesity¹⁰. Obesity is responsible for approximately 1-3 % of total health expenditure in most countries, while in the US it may account for up to 5-10 % of health expenditure¹¹. At the individual level, obese people have been found to incur approximately 30 % higher healthcare costs than their normal-weight peers¹².

NCDs, as well as their prime causes, namely unhealthy diets, overweight and obesity, thus constitute a major health challenge. Reduction of health-compromising behaviours, and lifestyles choices that include healthy diets and regular physical activity could prevent about 80 % of premature heart disease, stroke and diabetes¹³. The benefits of healthier diets (reduced overall fat and salt intake, improved dietary fat composition, increased intake of fresh fruits and vegetables) have been demonstrated in Finland, where coronary heart disease mortality in men fell by 80 % from 1972 to 2007, 75 % of which could be attributed to a reduction of the risk factor levels for cholesterol, blood pressure and smoking^{14,15}.

National public health campaigns to improve dietary habits and increase physical activity are complemented by initiatives at EU level. The European Commission's White paper 'A strategy for Europe on nutrition, overweight and obesity-related health issues'¹⁶ focuses on specific areas of interest to spearhead policy implementation. These areas include better-informed consumers, making the healthy option



² Eurostat Healthy life years statistics, website (accessed in April 2014)

³ WHO Europe Noncommunicable diseases, website (accessed in January 2014)

⁴ WHO (2013) Global action plan for the prevention and control of non-communicable diseases 2013-2020

⁵ United Nations (2012) Population Facts (No. 2012/1)

⁶ Finucane et al. (2011) The Lancet 9675:557-567

⁷ OECD (2012) Health at a Glance: Europe 2012

⁸ WHO Childhood overweight and obesity, website (accessed in January 2014)

⁹ WHO Regional Office for Europe (2013), presentation by J. Breda: Diet, physical activity and obesity in the EU

¹⁰ WHO (2010) Global status report on noncommunicable diseases; DALYs are the sum of the Years of Life Lost (YLL) due to premature mortality and the Years Lost due to Disability (YLD)

¹¹ Tsai et al. (2011) *Obes Rev* 12:50-61

¹² Withrow, D. & Alter, D.A. (2011) *Obes Rev* 12:131-141

¹³ WHO (2005) Preventing Chronic Diseases: A Vital Investment

¹⁴ Vartiainen et al. (2010) *Int J Epidemiol* 39:504-518

¹⁵ Valsta et al. (2010) *Public Health Nutr* 13(6A):932-938

¹⁶ European Commission (2007) White Paper on A Strategy for Europe on Nutrition, Overweight and Obesity relate health issues COM(2007) 279

easily available, encouraging physical activity, putting the emphasis on specific, vulnerable population groups (for example, children), implementing effective monitoring systems, and providing scientific evidence to support policy-making. The EU reflection process on innovative approaches for chronic diseases in public health and healthcare systems¹⁷ calls for further actions on relevant risk factors such as nutrition and physical activity. One line of action is the Chronic Diseases Joint Action launched in January 2014¹⁸; another is the EU Action Plan on Childhood Obesity published in February 2014¹⁹.

Initiatives at a global level include the WHO Global Strategy on Diet, Physical Activity and Health²⁰, the Action Plan for the prevention and control of noncommunicable diseases 2013-2020⁴, and two recent WHO declarations^{21,22}. In particular, the Vienna declaration called for evidence-based solutions to address the root causes of obesity, and the development of a new food and nutrition action plan complemented by a strategy to increase physical activity.

Research is key to providing scientific evidence to inform and strengthen policy measures in support of healthy diets. Furthermore, there are still gaps in our current scientific knowledge regarding the complex impact of diets on health and disease. The framework for food production and consumption is subject to a very broad range of influences, which might result in currently unknown or unexpected implications for the diets and health of the EU consumer.

In light of the above, the European Commission's Joint Research Centre (JRC) was requested by the Directorate-General for Research and Innovation to carry out a Foresight study to identify research priorities for foods and diets for health in order to support the implementation of Horizon 2020, the European Framework Programme for Research and Innovation 2014-2020²³.

The resulting study 'Tomorrow's Healthy Society – Research Priorities for Foods and Diets' was carried out by the JRC between March 2012 and December 2013. It focused on the European consumer and from that perspective on the factors that influence dietary habits, for example, lifestyle, working patterns, food supply, or economic situation. Based on a participatory approach, scenarios were developed to describe different possible futures for the time horizon 2050 and to identify resulting research challenges.

The present report summarises the results of this exercise. Chapter 2 describes the Foresight approach and the process; Chapter 3 maps out the system underlying food consumption with its influencing elements; the scenarios and narratives, which were developed in this study, are presented in Chapter 4, while Chapter 5 describes the research priorities identified on the basis of the scenarios. The conclusions are presented in Chapter 6. Additional material can be found in the annexes: the literature review on the state of knowledge in relevant food- and health-related areas of the food chain (Annex I), a complementary literature review on the main drivers (Annex II), schematic overviews of the scenarios (Annex III), the scenario narratives (Annex IV), a brief description of Sixth and Seventh Framework Programme research projects related to identified research challenges (Annex V), plus a list of the workshop participants (Annex VI).

The annexes have been combined in a separate document (Tomorrow's Healthy Society – Research Priorities for Foods and Diets. Annexes), which can be accessed at <https://ec.europa.eu/jrc/en/publications-list>

¹⁷ EU reflection process on chronic diseases, website (accessed in March 2014)

¹⁸ Joint Actions are activities carried out by the EU and one or more Member States or by the EU and the competent authorities in other countries; European Commission, Chronic Diseases Joint Action gets started at kick-off meeting in Madrid; website (accessed in March 2014)

¹⁹ EU Action Plan on Childhood Obesity 2014-2020

²⁰ WHO (2004) Global Strategy on Diet, Physical Activity and Health

²¹ WHO (2012) Political declaration on the Prevention and Control of Non-communicable Diseases

²² WHO (2013) Vienna Declaration on Nutrition and Noncommunicable Diseases in the Context of Health 2020

²³ http://ec.europa.eu/research/horizon2020/index_en.cfm





2. Foresight approach and process

The Foresight approach

Forward-looking reflections are vital for any policy that aims to proactively meet new challenges. Foresight is a systematic process for generating anticipatory intelligence to shape medium- to long-term policies. By gathering a wide range of stakeholders and knowledge sources, alternative perspectives on the future are explored and consensus views developed to guide today's decision-making. Foresight does not aim to predict the future; rather it invites us to consider the future as something that can be created or shaped, rather than something already defined.

In this sense, Foresight supports actors and stakeholders in actively shaping the future. Foresight methods (vision building, scenario development, Delphi survey, road mapping, etc.) are used to structure the debate on alternative futures to ensure the emergence of collective intelligence from all relevant stakeholders and experts. In addition, Foresight methods are designed to help thinking escape the constraints of established pathways, including consideration of trend breaks and disruptive events. Foresight produces benefits related to both the end product (for example, development of better strategies) and the processes involved (for example, creation and expansion of social and business networks, developing a future-oriented culture)²⁴.

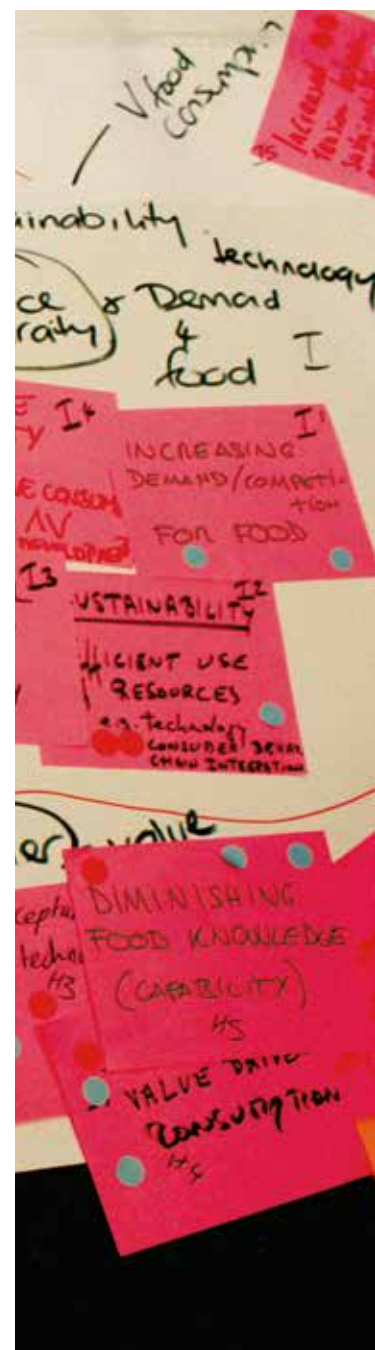
Foresight thus provides a different approach to identifying research priorities in the field of foods and diets for health in Horizon 2020, complementing other initiatives such as conventional expert workshops, or approaches and processes used by the Joint Programming Initiative 'A healthy diet for a healthy life', or the European Technology Platform 'Food for Life'.

In this study, the 'scenario development' method was chosen to explore different plausible futures in a structured manner. Scenarios are reflection tools that provide a systematic approach to illustrate possible combinations of developments and their potential impacts. They also provide the possibility to consider extreme developments in order to stimulate creativity and to break from conventional and short-term thinking.

To be effective, scenarios should have three characteristics:

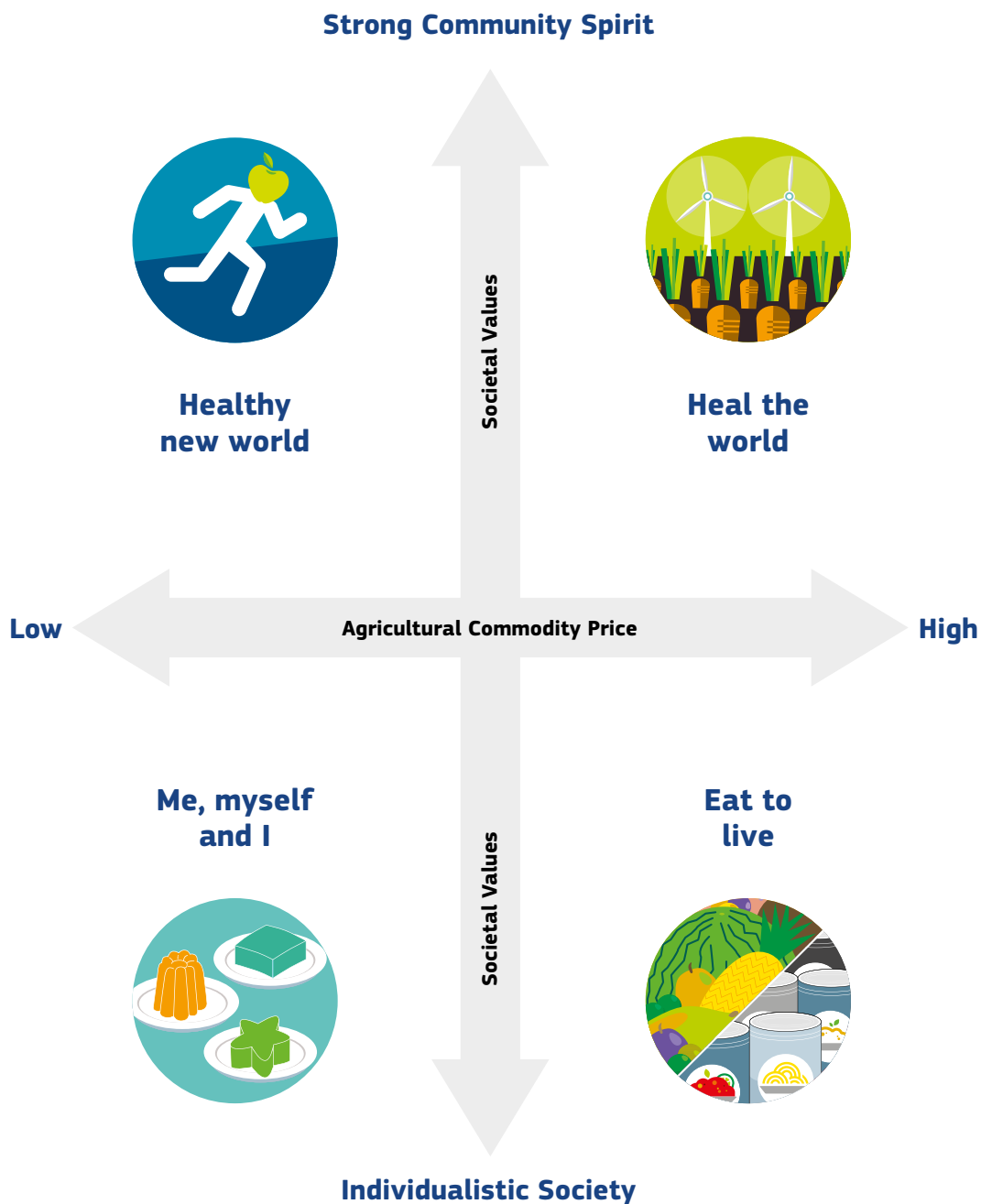
- plausibility, i.e. the scenario falls within the limits of what might conceivably happen;
- consistency, i.e. the various elements and factors in a scenario should not conflict and threaten its credibility; and
- decision-making utility, i.e. scenarios should contribute insights into the future, facilitating decision-taking on the questions at hand.

More concretely, the matrix-based scenario development approach was chosen for this study, using a selection of drivers considered most relevant and uncertain to provide for the structured and comprehensible development of a limited number of different exploratory scenarios. The scenarios describe the situation in the EU in 2050, focusing on diet-related activities and consumer preferences. So-called wild cards – low-probability, high-impact events, such as a sudden economic crisis, environmental disaster, or a large food-safety crisis – have not been considered since aspects other than the nutritional quality of food (such as food safety or security) would probably be more important under those conditions.



²⁴ For more information see http://forlearn.jrc.ec.europa.eu/guide/0_home/index.htm

Fig.1: Structural framework for the scenario development (based on the first workshop)



Foresight is by definition a participatory, multidisciplinary and discursive activity that should be based on the best available evidence and judgement. Such conditions make the use of expert panels a natural choice. In the present study, a group of around 40 experts and stakeholders participated in three workshops organised between October 2012 and October 2013. The group encompassed a broad range of different backgrounds, reflecting the relevant areas identified for the topic, including public health, nutrition, food science and technology, paediatrics, consumer science, economics, gastronomy, and Foresight analysis. In addition, participants represented different actors in the food system: academia, industry, consumer organisations, policy-makers, national public health organisations and international organisations.

A Steering Committee, representing relevant European Commission Directorates-General and additional external experts, advised the JRC study team on the scope and approach of the study, including the workshops, the experts/stakeholders to involve, and the deliverables. Committee members met five times during the course of the study, and they all participated in the workshops.

The workshops

Three consecutive workshops represent the core of the Foresight study. They provided an environment for open and highly interactive discussions, both in plenary and in smaller working groups. A number of participatory leadership approaches were used to build on every participant's contribution and to harness the diversity of expertise in the workshops. All participants received in advance a state-of-the-art literature review on food provision and consumption to provide a common reference and starting point for discussions (see Annex I).

The first workshop (23 and 24 October 2012) aimed at identifying the drivers and trends shaping the design, provision and consumption of healthy diets in the long term. Prioritisation of the results of a collective brainstorming exercise, with subsequent voting, led to the selection of the two most important and – considering their development – uncertain drivers for the food and health system: 'societal values' and 'agricultural commodity prices'. These two key drivers were used to form the axes of the basic structural framework for the scenario development (Figure 1). The extremes of the x-axis of agricultural commodity price were defined as high (i.e. a significant increase compared to today) or low (i.e. a low-to-moderate increase compared to today). The extremes of the y-axis of societal values stand for a 'strong community spirit' (importance of common goods, rights and social justice) and 'individualistic society' (individual rights and initiatives valued, self-interest before common good). Taking this structural framework as a starting point, rough outlines of the scenarios were developed.

The JRC developed the scenario outlines further, and they were revised and completed in the second workshop (23 and 24 April 2013) in scenario-specific working groups. In addition, participants created narratives for each scenario. The narratives match the scenarios by translating them into tangible stories describing the daily routine of three members of a family in 2050 (see Chapter 4).

At the third and final workshop (15 and 16 October 2013) the scenarios were revisited, completed where deemed necessary and agreed. They were then used, via the identification of scenario-specific challenges and opportunities, to define research needs. Following the challenge-based approach of Horizon 2020, high-level research topics were identified rather than very specific research projects. The results are described in Chapter 5.



3. The food consumption map

Diets and health are influenced by a very broad variety of different factors, ranging from human physiology to the environment. To better understand and represent the system underlying individual food consumption and all the elements that affect it, a conceptual model was developed which maps relevant elements of this system (Figure 2).

The two-dimensional food consumption map was built around consumer health and food consumption, reflecting the consumer-oriented perspective of this study. Four major factors directly influence food consumption and thus consumer health: 1) primary appetite control, 2) dietary choices, 3) food supply and provision, and 4) food access and affordability. These major factors are interconnected and are also affected by various other elements, which in turn can be grouped into nine fields. The closer the elements or fields are to the central circle in the map, the more direct influence they have on food consumption. The distance to the centre does not relate to the importance of a factor for food consumption. Two horizontal sets of factors span the map, potentially influencing all other fields: governance and innovation. Many of the factors included are interlinked, but for the sake of simplicity and due to the limitations of a two-dimensional representation these linkages are not visualised in the map²⁵.

The construction of the map was based on the literature review presented in Annex I as well as discussions at the first workshop. It was finalised and agreed at the second workshop. The food consumption map was used in the development of the scenarios to ensure all the relevant elements were taken into consideration.

In the map, primary appetite control relates to the biological regulation of appetite. This is directly linked to physiological nutrition needs, which in turn are affected by biological characteristics, other factors that affect physiology such as drinking and smoking, and xenobiotics such as medications. Prevention or management of diseases through diet borders between physiological needs and conscious individual decisions. Furthermore, dietary choices are the result of individual psychological factors, lifestyle, values, the acceptance of technology, etc., but are also influenced by social factors (cultural context, societal values) as well as through the provision and understanding of information (i.e. the information environment including, among others, information sources and formats). Information provision through advertising and labelling, as well as the shopping environment and the convenience and variety of products, are elements of the food supply which also influence consumer choice.

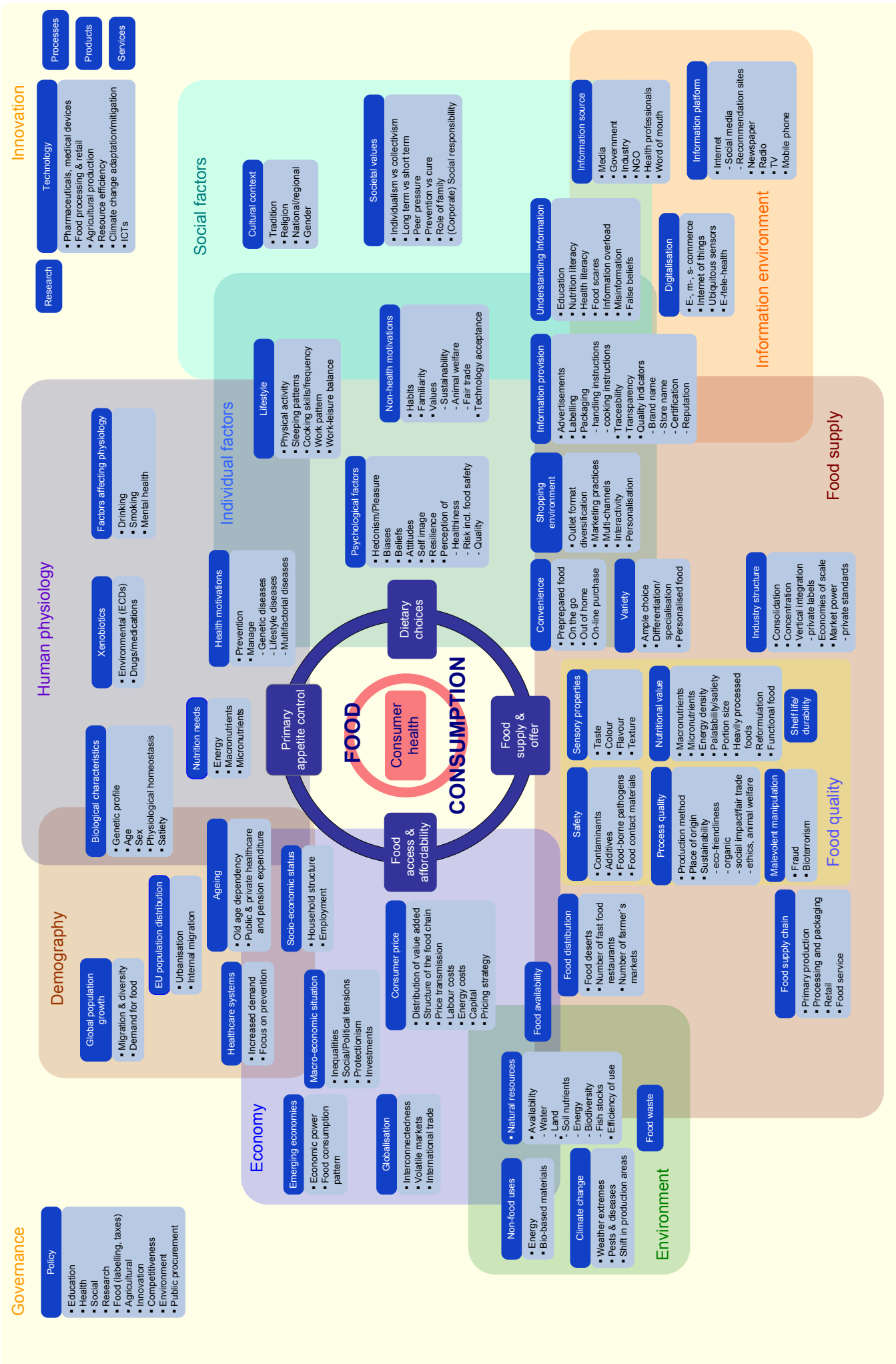


²⁵ An interesting approach to visualising interactions is the 'Obesity System Atlas' developed in the context of the UK Foresight study 'Tackling Obesities', UK Government's Foresight Programme (2007).

Fig. 2: *Food consumption map describing the system underlying individual food consumption and its elements (points listed in light blue boxes are not comprehensive)*

Food supply and provision is characterised by the underlying organisation of the food supply chain, the quality of the food that is produced and its distribution (types of food services, food deserts, etc.), the latter also affecting access to food. Environmental factors, such as climate change or use of natural resources, as well as food waste, determine food availability to a large extent. Food access and affordability are strongly influenced by economic factors, including food prices, consumers' socio-economic status (which also influences dietary choices), alongside globalisation and the development of emerging economies. Demographic developments have an effect through the impacts of an ageing population and global population growth, for example, by increasing the overall demand for food. The capacity and focus of healthcare systems, determined significantly by economic and demographic factors, can influence consumers' health status and dietary choices.

Many of the factors and fields overlap, indicating the complexity of the provision and consumption of healthy diets. An overview on the state of knowledge regarding diet-related health issues and consumer behaviour, as well as relevant areas of the food chain, is given in Annex I. Important drivers and trends linked to, for example, food prices, economy, demography, environment, lifestyle and digitalisation, are outlined in Annex II.





4. Future foods and diets – four scenarios

The structural framework depicted in Figure 1 is the basis for the four different scenarios characterised in detail here. The definition of the scenarios includes not only the agricultural commodity price and societal values but also other major drivers relevant to the future development of food production and consumption towards 2050 (such as policies, demographics, technology acceptance, work patterns and healthcare). Special attention was given in the scenario development to food supply and consumer food purchase, food preparation and eating habits.

To limit the complexity of the exercise, all scenarios share certain common characteristics related to the projections of megatrends in climate change, the EU's macroeconomy, demographics and digitalisation. It is assumed that by 2050 climate change will have caused an increase in global temperature of about 2 °C²⁶, in a world inhabited by approximately 9 billion people²⁷. Climate change is having a moderate impact on the EU. Overall, the EU is experiencing slight growth in its economy²⁸. The EU population remains more or less stable, although fertility rates have decreased and about 28 % of the population are 65 years old or older²⁸. Immigration into the EU provides for the necessary strengthening of the workforce and is contributing to a stable EU population size. Digitalisation is permeating all aspects of social and private life²⁹ enabling online shopping, information exchange, sophisticated marketing and (self-)monitoring applications.

An overview of the characteristics of the main drivers in each scenario is given in Table 1 below, followed by a description of each scenario. Schematic scenario overviews can be found in Annex III.

The scenarios are essentially exploratory thought experiments to consider alternative futures; they are not aimed at predicting the future. Many other developments might be conceivable, including different combinations of the elements in the described scenarios. The scenarios focus on the EU, but without considering national and regional differences within the EU. In this context, governance

reflects shared national objectives and approaches rather than any central EU governance.

Excerpts of narratives accompany the description of each scenario below. These narratives describe a typical day in the life of a family in 2050 – a different family in each of the four different scenarios. They follow the daily routine of three generations in the same family, from children to parents to grandparents, reflecting the population groups in the focus of attention in terms of food and health. While contextualising the scenarios, the narratives provide a glimpse of life in 2050 under different conditions. The full narratives are available in Annex IV.



²⁶ OECD Environmental Outlook to 2050 (2012) The Consequences of Inaction

²⁷ UN (2013) World Population prospects – The 2012 Revision

²⁸ European Commission (2012) The 2012 Ageing Report

²⁹ EUISS-ESPAS (2012) Global Trends 2030 – Citizens in an Interconnected and Polycentric World

Table 1: Overview of scenario characteristics

	Healthy new world	Heal the world
Agricultural commodity prices³⁰	<ul style="list-style-type: none"> • Low 	<ul style="list-style-type: none"> • High
Societal values	<ul style="list-style-type: none"> • Importance of common goods, rights and social justice 	<ul style="list-style-type: none"> • Importance of common goods, rights and social justice
Climate change	<ul style="list-style-type: none"> • Leads to temperature increases of about 2 °C, moderate effects on the EU 	
Global population	<ul style="list-style-type: none"> • Grows to about 9 billion in 2050; EU population remains more or less stable with an elderly population share increasing to about 28 %; immigration for strengthening the workforce 	
EU economy	<ul style="list-style-type: none"> • Growing slightly 	
Digitalisation	<ul style="list-style-type: none"> • Enables online shopping, information exchange, sophisticated marketing and (self-)monitoring applications 	
Working patterns & Work/leisure balance	<ul style="list-style-type: none"> • Clear distinction between work and leisure, with flexible individual work patterns 	<ul style="list-style-type: none"> • Long working days and teleworking common; flexibility required
Individual values	<ul style="list-style-type: none"> • Diets and physical activity valued as essential for healthy lifestyle 	<ul style="list-style-type: none"> • Environmental protection and environmentally sustainable food chain
Acceptance of technology	<ul style="list-style-type: none"> • Positive but careful assessment and regulation 	<ul style="list-style-type: none"> • Positive for enabling a sustainable food chain, preserving biodiversity, and cost reduction
Technological innovation	<ul style="list-style-type: none"> • Food technology combining health and nutrition standards with convenience and taste 	<ul style="list-style-type: none"> • Food technology focuses on environmentally sustainable production and distribution
Food chain business models	<ul style="list-style-type: none"> • Highly regulated market favours larger entities and consolidation; high value products provide niche markets for SMEs and local co-operatives • Online shopping coexists with physical supermarkets 	<ul style="list-style-type: none"> • Concentrated agro-food chain focus on sustainable European products, main production in the EU • Online shopping dominant
Food-related governance (nutrition, environment)	<ul style="list-style-type: none"> • Strong governance of food quality and safety, including fiscal measures • Authoritative nutrition guidelines and standards in place • Nutrition and health education considered an important public task 	<ul style="list-style-type: none"> • Focus on environmental issues and European production, including fiscal measures and strict standards • Support for those who cannot afford higher food prices • Environmental, nutrition and health education
Healthcare systems/ policy	<ul style="list-style-type: none"> • Health is a right - state-funded healthcare system, including provision of care • Focus on prevention, support given to foster healthy behaviour 	<ul style="list-style-type: none"> • State-funded system providing basic services³¹ • Extra services are paid privately making prevention increasingly important • Government support for prevention and healthy lifestyles

³⁰ Means real prices (in contrast to nominal prices) for agricultural raw materials relevant for food production, such as wheat, maize, rice, oils and meat.

Eat to live	Me, myself and I	
<ul style="list-style-type: none"> High 	<ul style="list-style-type: none"> Low 	Agricultural commodity prices³⁰
<ul style="list-style-type: none"> Individual rights and initiative valued, self-interest before the common good 	<ul style="list-style-type: none"> Individual rights and initiative valued, self-interest before the common good 	Societal values
<ul style="list-style-type: none"> Leads to temperature increases of about 2 °C, moderate effects on the EU 		Climate change
<ul style="list-style-type: none"> Grows to about 9 billion in 2050; EU population remains more or less stable with an elderly population share increasing to about 28 %; immigration for strengthening the workforce 		Global population
<ul style="list-style-type: none"> Growing slightly 		EU economy
<ul style="list-style-type: none"> Enables online shopping, information exchange, sophisticated marketing and (self-)monitoring applications 		Digitalisation
<ul style="list-style-type: none"> High flexibility required, high pressure 	<ul style="list-style-type: none"> Highly flexible individual work patterns, work/leisure boundaries blurred 	Working patterns & Work/leisure balance
<ul style="list-style-type: none"> Different food-related values, but food price is decisive 	<ul style="list-style-type: none"> Broad variety of different values; food is subjected to trends 	Individual values
<ul style="list-style-type: none"> Considered necessary to keep food prices from rising further 	<ul style="list-style-type: none"> High until proven unsafe, enabler of different lifestyles 	Acceptance of technology
<ul style="list-style-type: none"> Food technology focuses on cost-efficient convenience production 	<ul style="list-style-type: none"> Technological innovations are taken up as they become available 	Technological innovation
<ul style="list-style-type: none"> Economies of scale are priority, concentration and integration, dominance of multinational companies with global resourcing Emerging peer to peer food businesses Online shopping dominant 	<ul style="list-style-type: none"> Diverse landscape of food producers with many possibilities for SMEs; global trade enables multinationals to source materials efficiently Industry defines dietary guidelines Online and physical supermarkets and speciality shops coexist 	Food chain business models
<ul style="list-style-type: none"> Measures taken to facilitate a working market, minimal regulation Nutrition and health education not considered a public task 	<ul style="list-style-type: none"> Regulation ensures food safety, environmental protection; reliance on supply/demand mechanisms Nutrition and health education not considered a public task 	Food-related governance (nutrition, environment)
<ul style="list-style-type: none"> State funds basic services³¹, other services are paid by extra insurance or out of pocket Policy limited to provision of information on nutrition 	<ul style="list-style-type: none"> State- or private-funded State funds basic services³¹, other services covered by private insurance or out of pocket Reliance on scientific progress, policy focus on treatment and cure rather than prevention 	Healthcare systems/ policy

³¹ Basic healthcare services cover family planning, perinatal care, child health, immunisation, screening and treatment of communicable diseases, essential treatment of major chronic conditions, emergency healthcare services and preventive dental care.



Healthy new world

- **Strong community spirit**
- **Low agricultural commodity price**

4.1 'Healthy new world'

In this scenario, agricultural commodity prices are generally low³² thanks to a successful adaptation to climate change as well as the gradual use of second-generation biofuels after 2015. Average household expenditure on foods and beverages has increased slightly compared with 2013, mainly due to an overall increase in the quality of food on offer. In this scenario, society's values are characterised by a strong community spirit, giving priority and importance to common goods, rights and social justice. Social cohesion is strong, with a sense of belonging and sharing and a drive to reduce social inequalities. Although taxes and social contributions are relatively high, there is also a high level of public acceptance since these taxes are used by the state to provide social security, high living standards and extended health coverage. On the other hand, the strong social norms carry the risk of 'majority rule' and are not necessarily shared by all citizens.

In this setting, health is a right and, as a result, state-funded healthcare is available to everyone. Health policies focus on prevention measures, where the role of healthy diets is central to tackling diet-associated diseases. Mobile platform devices and applications are extensively used for monitoring health and diet, and the biomedical and dietary data collected can be made available to the state healthcare system and family and friends, 'nudging' each individual to lead a healthier lifestyle. In parallel, widespread genetic profiling and advances in nutrigenomics allow citizens to adapt food choice and intake to their personal health needs and disease prevention. As a result, the health status of the population is generally good. Among the younger generation, socio-economic status is no longer a major determinant of health. Obesity, diabetes and other diet-related diseases have decreased considerably, which translates into a reduced burden for the healthcare system as well as increase in the number of healthy years of life for citizens. However, older generations who did not benefit from prevention-focused policies still have to deal with obesity, type 2 diabetes and other preventable lifestyle diseases, and they require considerable healthcare resources. On the downside, the tracking of dietary behaviours and biomedical data challenges privacy.

Margherita, 84 (grandmother):

"...I am particularly happy, because I visited my son and grandchildren! Not all of us in the "community" (an old people's home officially) live as close to their family as I do. This thought immediately brightened up my day this morning, especially after the nightmare I had last night. I dreamed that I was young again and some children were bullying me because I was obese. I still am of course, but in the community all of us are. Same age, same problems, mainly due to being obese most of our lives... Fortunately my health monitors informed the nurse on duty of my stress levels and she came this morning to cheer me up, and of course provided me with all the medication needed for my diabetes."

Estelle, 15 (daughter):

"Mum and dad prepared the breakfast as always, checking the smart fridge to make sure that we each get what is necessary for our age. We have breakfast together every day before leaving for school, which is kind of nice... today a wholemeal baguette, fresh fruit and vegetables, cheese, cereal and some fruit jam. As we all know, breakfast is the most important meal of the day..."

Estelle, 15 (daughter)

"...After studying I joined my cooking group and prepared our lunch. We often do so in school, because apart from lessons in diets and nutrition we have practical classes supervised by real cooks three times a week. As usual we prepared a plate with various cooked and raw vegetables, but today the recipe included a small piece of meat! Yummy!..."

³² FAO (2011) Looking ahead in world food and agriculture; assumptions are based on the projections indicating low price increases.

Food policies guide consumers towards healthy diets, with authoritative state nutrition guidelines, strong regulations on food quality and safety, and fiscal measures to discourage unhealthy diets. In addition, subsidies on healthy diet components support the drive towards healthier eating. Out-of-home eating services, including fast-food outlets, restaurants and school and work canteens adhere to the nutritional guidelines, offering small portion sizes and mainly fresh foods, thus contributing to making the healthier choice the default choice. Chefs and nutritionists are now working together in many establishments, offering out-of-home eating services. In parallel, information campaigns on the role of diets for health, as well as cooking and nutrition classes in schools, have led to a nutritionally literate population which finds it easy to make the healthy choice, with health considerations being the major determinant when purchasing food. However, taste and pleasure are still very important. The sharing of information about foods and meals on interactive digital platforms also influences purchasing decisions. Peer pressure plays a big role, too, in a society such as this where social norms are very prevalent and oriented towards healthy behaviour.

As a result, nutrient-poor food, high in salt, sugar and fat, has largely disappeared from the market. Diets are mainly plant-based and include fruit and vegetables and unsaturated plant oils. Dairy products are considered as beneficial components in a diet, while red meat is eaten less frequently and in smaller portions. In general, diets are varied and customised for culture, preferences and needs (for example, the elderly). People eat out frequently, and the social aspect of eating together is highly valued. In fact, the meal is the centre of activities among family and friends, and sufficient time can be dedicated to purchasing food, cooking and spending time together.

The private food sector has experienced considerable concentration due to globalisation and high regulatory demands. New technologies and new ways of producing food provide for a range of nutritious and diverse foods. SMEs and local co-operatives are limited to market niches, but add to the diversity of diets and bring a local flavour to them. Physical supermarkets are still dominant in the retail sector, which is diversified, from local producers and traditional food grocers to multinational retail chains. Agricultural production is now aimed primarily at food production, and less at animal feed or biofuels. Red meat production has been reduced, while legumes and aquaculture have become more prominent sources of plant and animal protein.

Technological developments are generally accepted and are widely used in food production and the monitoring of diets and health. However, novel technologies have to undergo careful risk assessment and evaluation before their application. Novel preservation techniques, advances in nanotechnology for higher nutrient availability as

Estelle, 15 (daughter)

"...we jumped over the fence of the school next to the sport fields. As agreed last week, each of us brought a few sweets and candies... Some kids didn't manage to get them but we shared what we had. Our parents and teachers would have a fit if they saw us stuffed with candies and sweets! We are only allowed a few of them each week. Plus, they are really expensive with all the government taxes on fat and sugar and we can't afford them with our own pocket money... but hey, what are grandparents for anyway!"

Margherita, 84 (grandmother)

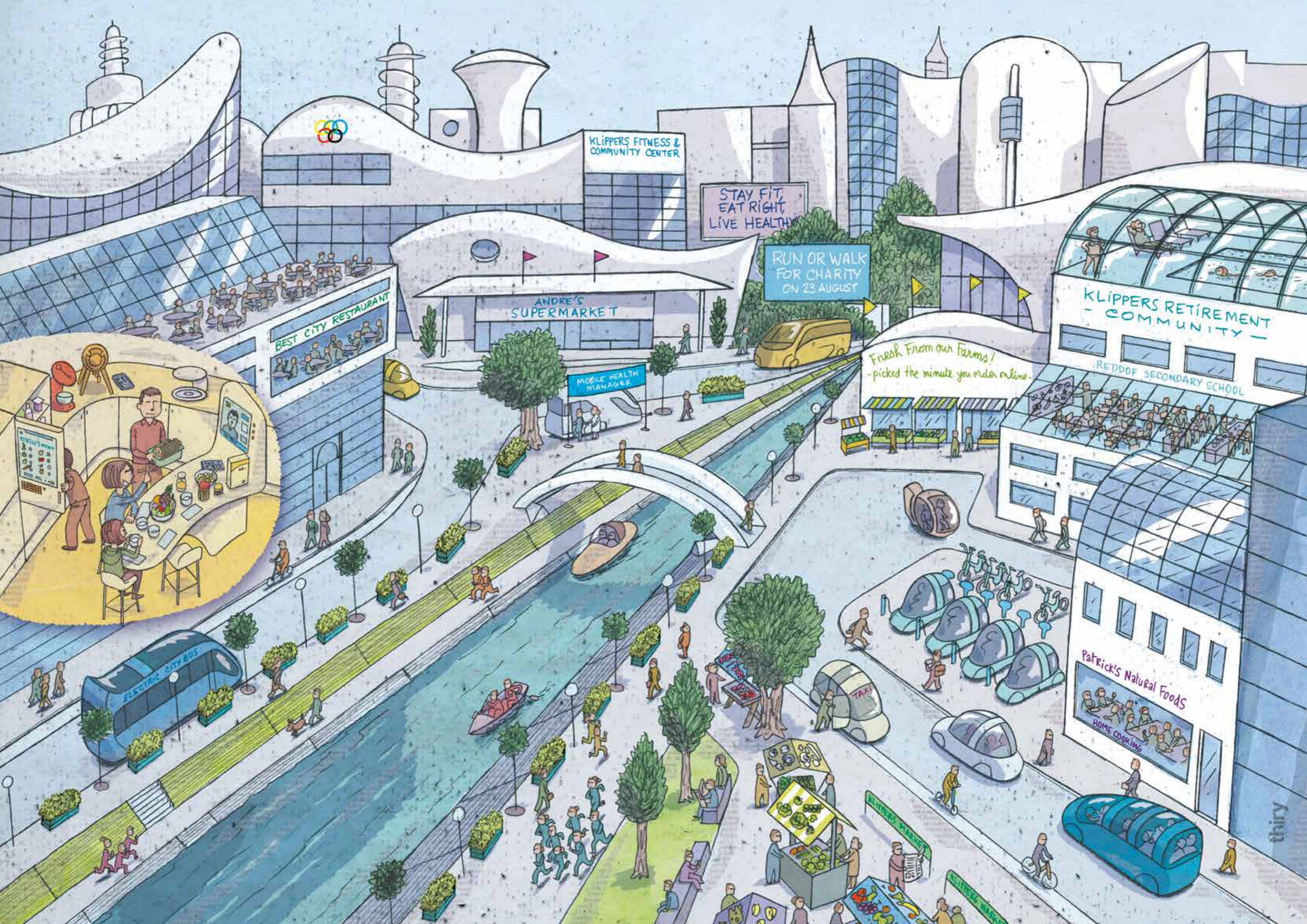
"...on my way home my glasses warned me that my blood glucose levels were low. Hmmm, what a coincidence! I guess my implanted blood glucose balancer needs to be adjusted again, but what better excuse to turn off the navi-tracker in the car (thanks to my flatmate I know how to do it) and sneak to the black market for some more sweets!"

François, 48 (father)

"...I now work in the central offices of the FTAA (Food Technology Assessment Agency). I have a customised and flexible working week, although sometimes I have to put in some long hours, so I am happy that both my kids and my mum are well taken care of by state services in school and in the home for the elderly, and that their food is of high nutritional quality. Talking about food, today we ate with colleagues in the canteen, as usual. Today was 'easy Friday', so apart from our usual assortment of vegetable dishes we had some meat choices, too. Small portions and fat-free of course. After lunch I checked my personal device to see when I last had meat, and to have a look at my health and diet monitors in general. Today I ignored the 'most appropriate dish for today' notification..."

well as improved crops with better nutrient profiles are examples of new technological applications in the service of society.

The labour market provides full employment in the present scenario: health and well-being at work are important both for the individual and for a healthy workforce. Work and private life boundaries are clear; flexible working patterns fit personal needs to make available the necessary time for leisure activities as well as family and social interactions. Child and elderly care are supported by the state, further contributing to the well-being of parents. The elderly in particular are provided with quality care according to their dietary and medical needs in state-supported facilities that are well accepted by society. Many elderly are still active, integrated and independent members of the society.



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Heal the world

- **Strong community spirit**
- **High agricultural commodity price**

4.2 'Heal the world'

In this scenario, global climate change impacts, increasingly scarce natural resources, as well as competition between biofuel and food-crop production have resulted in high global agricultural commodity prices, which are further fuelled by price volatility. As a result, food prices for EU consumers have increased considerably, in particular those for meat and dairy products, thus creating an external stressor that threatens the quality of life. At the same time, the value of food as a social good has increased, and many people have realised that the only way forward is to adhere to sustainable diets and lifestyles, both in environmental and health terms. This choice is rooted in the strong community spirit prevalent, which emphasises common goods, rights and social justice. Every approach to tackle societal challenges is based on social cohesion, solidarity and communal interest.

There is a strong drive to reduce social inequalities in this scenario but state coverage of pensions, social services and healthcare is limited. Healthcare policies are in a transition period from a previous focus on treatment to a focus on prevention. The transition is difficult, and diet-related diseases and obesity remain a concern, although their prevalence is decreasing due to a shift towards healthier diets. Degenerative diseases are another health concern, gaining importance also due to the increased life expectancy, and placing an extra burden on healthcare. In addition, limited state-funded social support services are available for vulnerable groups like the elderly, children, or people with mental or physical disabilities, so it is up to each family to cope with care needs. Health parameters can be monitored continually with wearable sensors or devices installed in the house and this information can be shared, as an option and paid, with the healthcare system. In an effort to improve health through diets, school curricula include such topics as well as cooking, resulting in an increased awareness among the general population. Apart from health benefits, cooking skills provide the necessary knowledge to facilitate the shift towards environmentally sustainable diets.

Ana, 37 (mother)

"...our family is just like any other, living together in an extended household of four generations, because the costs of living and care, especially for children and the elderly, are just way too high... Today I woke up early again. Three elderly people in the house can make a lot of noise... Søren complained about the alternative dairy products not being 'the real thing'. What else did we eat, hmmm, nuts, apples, whole grain bread. The children are already off to school with the neighbourhood biking scheme, and Helen is off to work in the hospital. She is a doctor and needs to be physically present. I work as a remote taxi driver, doing my job in front of a holo-terminal at home..."

As the result of high food prices and living costs, as well as the need to take care of the household, the children and the elderly, while managing long working hours, the extended family model has returned in this society. Living together also reduces food purchase costs and leads to better resource management in general. The labour market requires mobility and flexibility on the part of the population, while teleworking is common, saving time and transport costs. Many elderly people are active members of the society and make use of customised schemes that allow them to work beyond pension age in order to supplement their pension income and also to contribute to the family budget.

Policies are targeted at improving the sustainability of the food chain and finding solutions to reduce food prices. The EU has encouraged the development of a sustainable European food chain, including strict environmental (for example, carbon and water footprint) and ethical (for example, fair trade, child labour, animal welfare) standards, as well as taxes on 'unsustainable' foods, steering consumers towards environmentally friendly dietary patterns. Imported goods that comply with the above standards are welcomed on the EU food market, which could also have far-reaching effects, introducing change in other parts of the world. Heavy taxing of energy consumption has led to efficient energy use, an overall energy efficiency increase as well as an added source of income for the state. Precision farming and novel packaging and processing technologies have also reduced energy and resource use throughout the food chain.

The mixture of strict environmental standards and taxation and has brought about a swift change in the food market and in dietary habits, strongly supported by environmentally, ethically and price-conscious consumers. People need to plan ahead for their weekly food budget, and food is purchased more consciously; price and quality are the major determinants of food choice, together with environmental considerations. The variety of food choice is restricted; meat consumption is reduced and protein intake is now mainly from plant and other alternative sources, such as insects or cultured meat. Those who can, grow their own food in gardens, and on balconies and rooftops in small-scale vertical farms. Some local co-operatives are maintaining restaurants, which usually focus on EU cuisine and 'home-made' menus. However, high food prices mean that out-of-home eating is reduced, apart from work and school canteens. Many people prepare and share meals together with friends, family and neighbours, valuing the social aspect of eating. Finally, food waste has also been reduced to a minimum due to greater awareness, better planning of purchases and also advances in food preservation.

Peter, 75 (grandfather)

"...Coffee didn't taste so good, it was produced somewhere in Southern Europe. Our favourite coffee from Kenya is very expensive and considered a luxury; it's heavily taxed due to being environmentally unsustainable as well as not adhering to fair-trade criteria..."

Eric, 7 (son)

"...Sarah and I went to school on our bicycles, because my mums say that it's cheap, quick and also healthy for us...We also got our digital lunch boxes with us in our school packs. I saw the holo-display and inside there were vegetables and grilled grasshoppers with fat-free chocolate sauce. I love them! My great-granddad Søren says that this "fat-free junk" that they give us tastes like water! ...at school we ate together in the canteen, a lot of fruit and other nice foods that are provided by the school. It's called a 'school fruit scheme' and the teacher told us that it is a very old programme, as old as him. The teachers told us that fruit and veggies are healthy and 'sus-tain-a-ble', which means that they are good for the planet but also good for our tummies. My mums say they are also good for our pocket..."

Ana, 37 (mother)

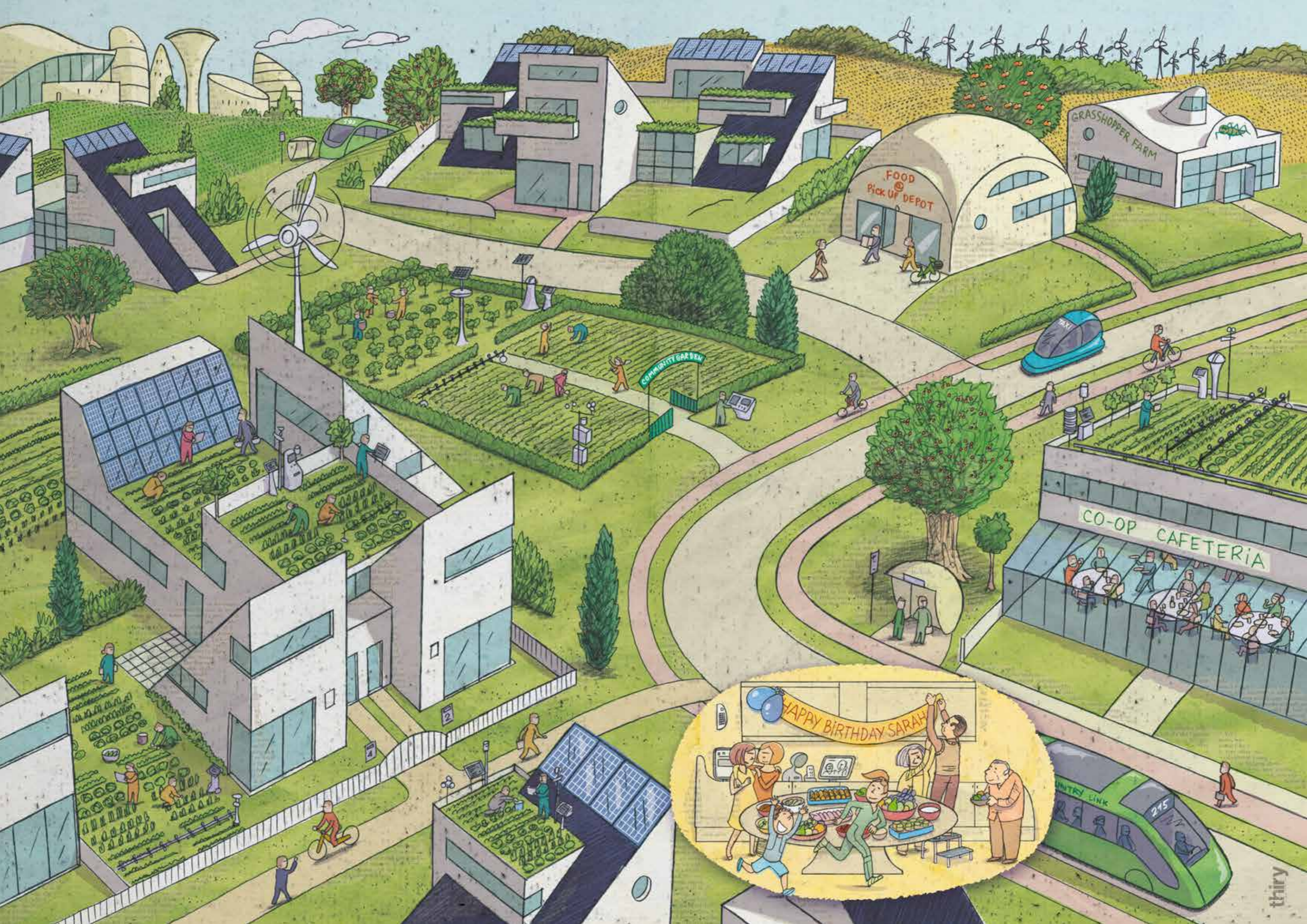
"...Helen will come home for dinner, hope she isn't late today. People work so many hours nowadays...Theoretically everybody should work 10 hours a day, but everybody knows that most people have to put in 2-3 extra hours or have two jobs. After the dinner party I will probably have to go through our budget with Helen. I can't think what we would do if the grandparents weren't giving us a hand with the kids and the house. We don't want to spoil our mood after the party, but there are a lot of taxes to pay, food is expensive, and to make sure we make it to the end of the month we have to plan ahead. Even on our daughter's birthday."

The food chain is dominated by large companies which provide the bulk of food for Europeans. Most of the food consumed in the EU is also produced in the EU, including primary production (mainly medium-sized farms and individual production within cities), which shortens food chains and increases internal market trade. The private food sector is providing ready-to-use ingredients, such as pre-cut and washed vegetables, thereby adapting to the needs of cooking under time constraints. Also, the retail sector is dominated by a limited number of large companies, while physical supermarkets have been replaced by online retail markets. In addition, local farmers and producers offer the possibility to buy local food online and have it delivered at specific collection points for pick-up by neighbours, in rotation. Due to the high cost of food, some people have reverted to the pre-monetary commercial transaction system of exchanging goods.

Technology is generally perceived in a positive way, if supported by proper risk-benefit analysis. The technological focus is on supporting a sustainable food chain and preservation of biodiversity, as well as efficiency. Governments are tasked with implementing these values and, as a result, the evaluation processes for novel technologies can be slow. The agro-food sector is experiencing increased innovation, whereby, for example, genetically modified organisms (GMOs), alternative protein sources, nanotechnology-enhanced foods, and novel farming methods are not only well accepted but are needed. Digital technologies, in the form of mobile platform applications and devices, are used both in healthcare and diets to facilitate choice, monitor health status and allow for early diagnosis, and to support the alignment of food purchasing with individual health and dietary needs and preferences.

Peter, 75 (grandfather)

“...Christina has a very important patent case in court today, defending a new process for transforming insect bodies into ‘steak type meat’ (can’t call them insect steaks due to legislation), burgers and sausages. It has gone on for several years now, since the government reviews everything so carefully to assure protection of public interests. Unfortunately, some companies have already given up investing in new processes because of the delays and strict regulations involved and have moved their research to other parts of the world. On the other hand, public research has gained momentum, especially since there is the need to find efficient sources of food.”



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Eat to live

- **Individualistic society**
- **High agricultural commodity price**

4.3 'Eat to live'

Global climate change, increasingly scarce natural resources as well as competition between biofuel and food-crop production have resulted in high global agricultural commodity prices, which are further fuelled by price volatility. In a globalised food chain, the increased costs have been passed on to the consumer, and food prices have increased far beyond general inflation. Minimally processed foods, such as meat, dairy, fruit and vegetables, have borne the brunt of price increases. The above challenge occurs in a society that favours self-interest and individual rights and initiatives over the common good and, as a result, every individual or family has to deal with the external stress factor of high food prices according to their own means. Consequently, there is growing inequality in diets and consequently in health.

The food system is a truly global food chain in this scenario, with large entities (often multinationals) in all stages of the food chain, including primary production, where companies orient their production towards crops that yield the highest revenues, which are not necessarily food crops. Staple food ingredients such as cereals are sourced globally, and the primary sector is geared towards producing large volumes at low cost. The food-retail sector has converted to online retail, with discount supermarkets becoming the dominant form of non-specialised food retail. Physical shops are reserved for special, high-end food products. Smart home appliances are linked to specific retailers that deliver conveniently to the home. Some informal, non-regulated peer-to-peer or specialised food businesses have emerged, based on own cultivation or the recovery of food waste.

Technological developments, focusing on improving food shelf-life, including packaging, are well accepted and are considered necessary to keep food prices from rising further. However, cost-effectiveness is a major determinant of innovation and, in conjunction with a food system under pressure, has led to compromised food safety and serious repercussions for public health (for example, outbreaks of food-borne disease). Food fraud is also a major concern and is undermining trust in food-chain actors. Mobile devices for health monitoring and facilitating diet choice are common and affordable. However, reliable, science-based health and diet applications are costly and thus not used by the majority of the population.

Martina, 43 (mother):

"...My worries are keeping me awake again. If it's not about my job as a manager of the food distribution system at MultiFood downtown, it's about the rising tension in the city outside the fortified living complex... I eat breakfast in a rush and leave our spacious apartment, taking the gravi-lift to the parking area and enter one of the self-driven smart vehicles there. I confirm my destination towards downtown, choosing the C alternative route to avoid the demonstrations in the main avenues and fire up the telecom terminal for the appointment with our suppliers in Africa. There is social unrest down there as well, much more than here in Europe, so I want to know whether they can deliver our primary resources of coffee beans and exotic fruits or if I need to start looking for it in another part of the globe..."

Public healthcare services cannot meet the demands of the population, leading to long waiting lists for treatment and co-payment. Those who can afford it have easy access to private, high-quality healthcare. In this scenario, socio-economic status plays a major role in determining the health status and widens health inequalities. Mental health, in particular depression, is an issue, with the unstable financial situation in private and family life being an important factor. Malnutrition is becoming more prevalent, especially in vulnerable groups like children and elderly, as are other NCD risk factors such as alcohol abuse and, to a lesser extent, smoking. In addition, poor-quality diets based on low-cost foods with high sugar, salt and fat content, cater for consumer tastes and pleasure while fuelling major public health problems like obesity (including childhood obesity), type 2 diabetes and lifestyle-associated cancers. As a consequence, disease prevention has become a concern for many.

The consumption of supplements, fortified foods and nutraceuticals, focusing on specific foods rather than on balanced diets as a whole, is perceived as a healthy dietary habit. For many, diets are confined to mass-produced, fortified foods resulting in a limited variety of available foods. Natural foods and whole foods are still available for those who can afford them. Real, non-synthetic meat and animal products are rarely consumed due to the cost involved – inexpensive protein sources such as insects are preferred instead. Food waste from both food production and households has been reduced of necessity, the latter due to the high cost of food. In addition to price, convenience, taste and health are still strong although secondary drivers.

People generally eat at home, mainly ready-to-eat meals, to save money. Out-of-home eating during the working day is done while commuting or in canteens, at fast-food services or from street vendors. Eating in restaurants is considered a luxury. Home deliveries are frequent, and most of the food offered by out-of-home services is energy dense, satiating, and fortified with nutrients. People lack cooking skills, and there are no organised efforts or authoritative guidelines to educate adults and children on the impact of diets on health; information comes from various online sources, including government, private blogs and industry. However, the various sources of information are often contradictory or carry misconceptions. Those who can afford it use smart kitchens for cooking, which automate food preparation but further reduce the need for cooking skills. In addition, automation of food purchasing via smart mobile devices makes 'conscious' shopping unnecessary and nutrition literacy less important. Even though the elderly represent a considerable share of the population, their limited purchasing power, due to previous

Maria, 96 (grandmother)

"...I miss my husband, Hans, and my family and my old life at home. My mind drifts back to the time when I shared my meal with my two boys...They are also gone, like their dad, a few years ago. One died due to a terrorist attack on the food megacorporation he was working for, and the other died from a deadly food-borne outbreak about five years ago...I keep going on... I wish I could live near my daughter-in-law and grandson, but my pension is small and I can't afford an institution in my home country. No one can afford to cover part of my expenses either. Now I live in an institution for older people in another, remote country, which became a member of the EU some time ago, but prices are still much lower here... I can leave this world if I decide to, but I am not sure yet. My genetic profile and health status predicts that, even with my obesity and diabetes, I could live up to 110 years, but I don't know if I really want that..."

Alexander, 13 (son)

"...it was the f2f day, the face-to-face day, where I could really meet all my schoolmates, and about the only time we could just relax and talk between us without any parental or teacher monitor drone hovering over us... we were kicking this real ball in the school field, when Adam kicked the ball too high, sending it over the school wall... I climbed on the tree next to the wall and meant to climb down on the other side and get the ball. As soon as I popped my head over the wall, I heard shouts and angry cries...I saw some strange children, they must have been our age, but they were dirty and quite angry... they were carrying some banners saying 'Down with mega-corporations'. They looked a bit scary as well...What's the problem with mega corps anyway? Why did they look so different? I want to ask my mum but she is always nervous and snaps back at me when I ask her things and never has time to just chat..."

low-paid jobs or periods of unemployment, means that they are not a strong consumer group. As a result, some specific products are available for senior citizens, but the variety is limited.

As a consequence of high inequalities in diets and health, social tensions and crime are on the rise, while caring for socially vulnerable groups such as children or the elderly is becoming increasingly difficult because of the lack of funds and time. There is insecurity in the labour market, and those who have managed to get a job have to adapt their private lives to working conditions, work long hours and for more years, accept limited incomes and often need to have two jobs in order to make ends meet.

Alexander, 13 (son)

"...So yesterday I tried hacking into the Nescuisine using that worm-ware that you sent me. I wanted to know what would turn up for breakfast this morning. I am bored with the usual fortified fruit salad and I wanted one of those foods I saw online. But my mum got upset when I told her, and she told me I shouldn't eat that stuff. Man, I wish she could just pop some chill-pills and relax like your mum is doing..."



BIGFOOD
BF

GLOBEFOOD
G

BUSINESS OFFICE

REST
BIG REST

REAL MEAT LUXURY BURGER

HOSPITAL

AGAINST
MULTI-
FOOD

TOO
EXPENSIVE

TAKE AWAY
READY
FORGET

Fast Food



Me, myself and I

- **Individualistic society**
- **Low agricultural commodity price**

4.4 'Me, myself and I'

In this scenario, agricultural commodity prices have been kept low (showing a moderate increase compared to today) due to the successful adaptation to climate change as well as the gradual use of second-generation biofuels from 2016 onwards.³² Consumer food prices range from very low to very high, depending on the product, but are generally affordable. The social values of this scenario are characterised by strong individualism, where personal rights, initiative and self-interest are valued above the common good. The EU is a prosperous region and has succeeded in being on the frontline of innovation and technological development, investing in education, attracting bright minds around the globe, and providing employment for all.

This scenario is permeated by the strong influence of advanced technological developments, which have enabled individualised lifestyles and the tackling and resolution of most societal challenges to date. State regulation is mainly focused on food safety, and this low level of state intervention, coupled with streamlined technology assessment procedures, has contributed to constant innovation in the fields of food and health, driven by the diverse needs of consumers. The public has a positive attitude towards technology, having seen the benefits in the past in dealing with environmental and health challenges; in fact, this society perceives technology as the basis of its welfare and lifestyles.

In medicine, technological progress has been considerable, with tissue engineering, gene therapy, advanced and efficient screening methods and novel pharmaceutical agents helping to treat or cure many diseases. Mobile platforms and devices are used to monitor in real time vital health signals and parameters that are collected by skin-friendly micro-sensors. This facilitates early medical intervention, while the high level of digitalisation allows individuals to manage their own preventive and screening activities, supported by digital/virtual personal assistants. The multifunctional devices can also constantly monitor food consumption and combine food preferences with biological needs. Advances in genetic profiling have enabled targeted and personalised therapies, changing the structure of the healthcare system and reducing the strain on resources.

Daniel, 48 (father)

"...I also have to do my medical check-up later today. I am getting a bit worried as I am getting older; I wonder how long it will take them to invent a real anti-ageing pill, not of course the fake ones that they sell in those subscription holo-sites. You don't know who to trust anymore on issues like health and food. I also have to check if my solar hover car is fully charged and if the autopilot has downloaded all the recent updates to take me to my health insurance agent appointment. He proposes a scheme which will cover every possible treatment I will ever need, plus some more treatments I never knew even existed. It costs quite a lot, but successful designer food specialists, like me, earn enough."

Healthcare is mainly private and affordable for most of the population, with only some state services provided on a universal basis. Prevention of diseases is not the focus of healthcare policies: there is no urgent need for prevention, since effective cures have been developed for existing health problems, while newly described diseases are effectively and rapidly dealt with using novel therapies. Obesity, type 2 diabetes and diet-associated cancers are still prevalent, and thus are compromising behaviour like alcohol abuse, and to a lesser extent, smoking. However, their importance as major public health issues has decreased compared to the beginning of the 21st century: their negative impact on personal health and on healthcare costs has been contained, mainly due to medical technological developments leading to effective treatments or even cures, for example for heart disease, diabetes and co-morbidities.

Technology also provides the means to personalise diets according to dietary preferences as well as biological needs. As a result, diets are extensively tailored, becoming a means to project individual identity, and are even a fashion statement. A wide variety of foods are available, ranging from local to exotic and from organic vegetables to highly processed and enhanced foods. Eating natural, traditional foods is an individual choice like any other, while the origin of food is not an issue; ethical issues like fair trade, animal welfare or food waste are not mainstream concerns. The use of nutraceuticals and supplements is frequent, while foods improving gut health and mental performance and cognition are in high demand. Pleasure, taste and appearance play a major role in food choice, which is often automated by devices pre-set to genotypes as well as preferences, suggesting foods and doing shopping automatically. However, the underlying dietary guidelines differ between the various providers of automated home appliances or mobile platforms. Eating together is not frequent and has lost its social value. Instead, advanced social network gadgets help individuals to match their working schedules, food preferences and health status and to connect them electronically to others with similar profiles.

Digitalised home appliances or mobile devices organise food shopping and recommend foods and recipes according to individual wishes, nutritional needs and health status; many people choose not to get involved in selecting food but instead defer decisions to these automated systems. Food shopping, when done consciously by an individual, can be online for convenience or in physical shops as an opportunity for non-virtual social interaction. Actual cooking is a hobby for few who have the time and will, as it is no longer necessary. Nutrition is not part of school curricula – instead, handling the above food and health multifunctional devices is being taught in kindergartens.

Daniel, 48 father):

"...I am thinking about how to get inspiration for my next design food that has to be marketed quite soon, when people are already serving food from Mars that was colonised just a few years ago. I have to stay ahead of my game and it's getting quite tough lately... I still need to finish my breakfast, most importantly those wonderful, real, and actually yellow bananas that were flown in overnight from Ecuador. This brings me an idea. Today will be my yellow day! I programme my holo-assistant accordingly and order yellow-based natural or arti-coloured food for the rest of the day. I feel the inspiration coming on!"

Sophie, 16 (daughter)

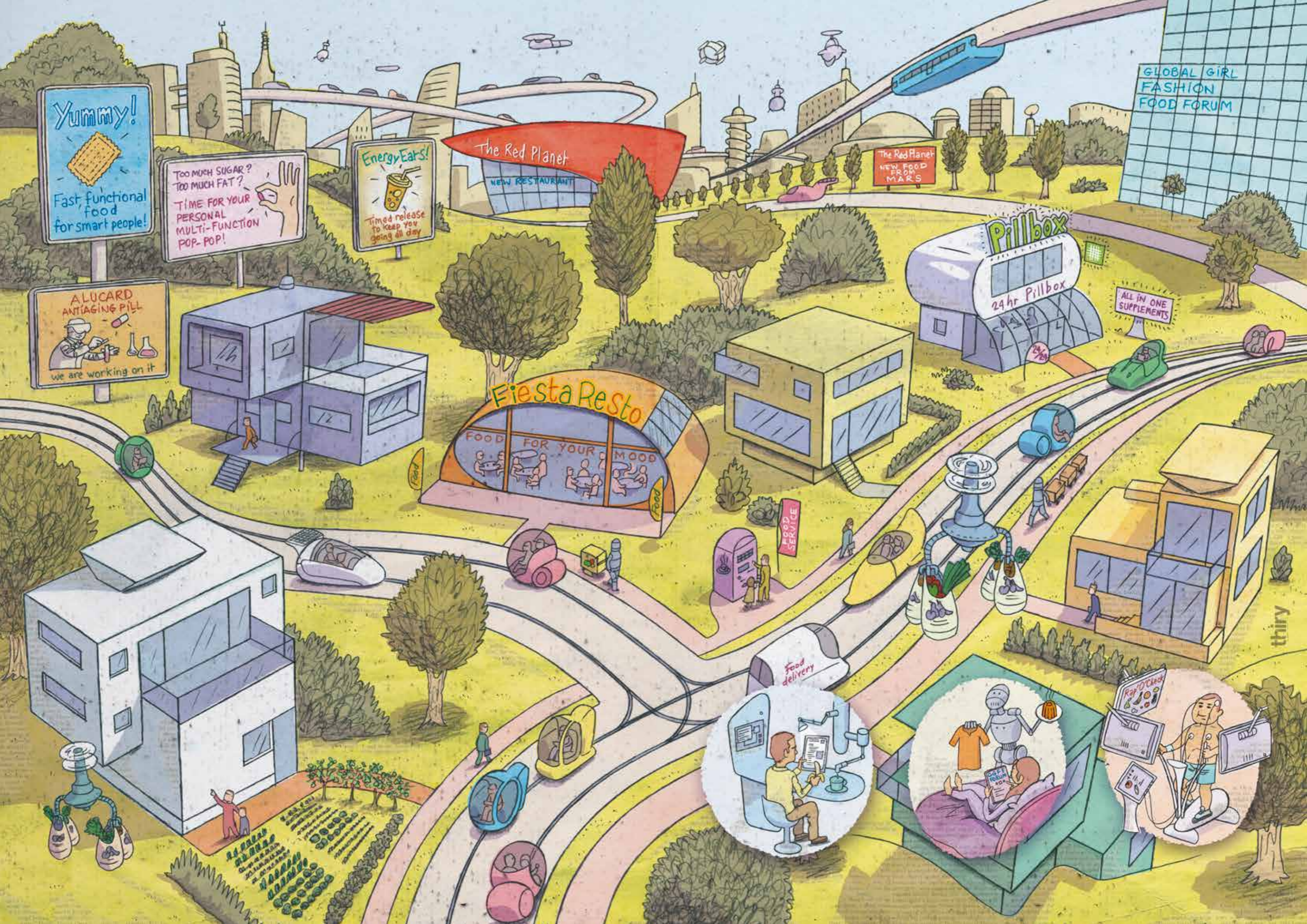
"...Flint is my social cyborg, he keeps me company, connects me to the rest of the world and advises me on many issues, like when to study and when not, when to go for a walk and to play with my friends, when to eat and, of course, on the moooost fashionable food to eat!... I wear some sensors attached to my clothes and Flint can read my body needs concerning food. My dad Daniel has installed my genetic profile as add-on software on Flint, and now Flint has access to my genetic make-up, age and dietary profile. The perfect mix to suggest what food would fit yours truly! The best thing though is that Flint can also sense my mood via my clothes sensors! We have a wireless connection all the time and so he can sense my emotions and add emotional food to my diet as needed. To cheer me up, or to slow me down if I get too excited!"

The primary food sector includes enterprises of all sizes and is both specialised and automated. Agricultural commodities destined for food use are already functionalised with enhanced nutritional profiles at the moment of production, with the help of novel breeding and *in-vitro* production methods. The food industry offers a variety of products, using customised marketing techniques for different groups. Industry has also stepped in to fill the gap regarding formal nutrition guidelines. The EU food chain is diverse; SMEs and micro-enterprises manage to compete with multinationals in local markets by targeting specific social groups. However, raw materials can be of global origin, depending on price and availability. Targeted processing techniques combine consumer demands for specific sensory properties and ingredients of high nutritional quality. A large share of the business has gone to the food-services sector, which follows the general trend and offers solutions according to individual preferences, both when eating out or when delivering food to the home. Cosmetics and pharmaceutical companies have established food as an additional business sector, providing food with benefits for health and beauty. However, the true power behind the food sector is retail, which has managed to use personal data in order to determine product needs according to consumer demands. Online shopping is common, involving home-delivery services as well as collection from predetermined points.

Another example of technological impacts is the boost to the labour market, which provides jobs for all. Demand-driven high flexibility with significant information and communication technology involvement allows for tailored working schemes regarding, for example, time and location. On the one hand, this easily blurs the boundaries between private life and work, but on the other hand, it allows for increased flexibility of working schedules and recuperation of time to be allocated to personal interests. Flexible pension ages and customised employment for seniors have created an active elderly workforce, with lifelong learning supports staying in touch with the latest technological developments.

Bruno, 80 (grandfather)

"...Usually I get up at 06:00 every morning and have my complete health Rap'O'Check. You know the usual things, urine, exhale tests, blood from the thumb, etc...Then my health device suggests what is the most fitting breakfast, taking into account my age and physical status (it gets the data from Rap'O'Check). For the last few months, milk and eggs have been locked; I am only allowed to choose from fruit and some supplements. I complete my early morning with a fast session in the gym before I take this hover-train to work in the city centre... Yes, I am indeed retired officially but I have kept this part-time job as it helps me stay sharp and connected, even though it is a bit far away from home..."



Yummy!
Fast, functional food for smart people!

Too much SUGAR?
Too much FAT?
TIME FOR YOUR PERSONAL MULTI-FUNCTION POP-POP!

EnergyEars!
Timed release to keep you going all day

ALUCARD ANTIAGING PILL
we are working on it

The Red Planet
NEW RESTAURANT

The Red Planet
NEW FOOD FROM MARS

GLOBAL GIRL FASHION FOOD FORUM

Pillbox
24hr Pillbox
ALL IN ONE SUPPLEMENTS

Fiesta Resto
FOOD FOR YOUR MOOD

FOOD SERVICE

Food delivery

WELCOME TO THE FUTURE OF FOOD
OUR MENU IS FULL OF INNOVATION
AND TASTE. VISIT US TODAY
FOR THE LATEST IN FOOD TECHNOLOGY.
WE'RE CHANGING THE WAY WE EAT.
JOIN THE REVOLUTION.

thirty



4.5 Indications from the scenarios

The four exploratory scenarios generated in this study, showing possible but not preferred futures, are characterised by four major differing developments: strong disease-prevention efforts ('Healthy new world'), a move towards an environmentally sustainable European food chain ('Heal the world'), significantly increased inequalities ('Eat to live'), and technological progress ('Me, myself and I'). In all four different futures there are elements of framework conditions for healthier diets, but the healthy diet for all citizens remains elusive.

In 'Healthy new world' and 'Heal the world', consumers have changed their habits considerably towards healthy diets and lifestyles. In the former, this is due to a strengthening of relevant societal values, triggered by an increased disease burden and an overly strained healthcare system. Environmental deterioration and limited food security worldwide were the prompts in 'Heal the world', but both scenarios include strong governance to establish a framework complementing the societal values.

In contrast, the 'Me, myself and I' society has followed a path of technological solutions, resulting in a combination of some beneficial changes in behaviour, treatments and cures, which ease the individual effects of diet-related diseases.

The society in 'Eat to live', characterised by inequalities and against the background of a global food chain featuring large enterprises and a relatively weak governance, is unable to find a sustainable approach to the burden of disease or to environmental challenges (due to the continuing dominance of short-term thinking and actions). This society probably does not have a long-term stable future, but rather reflects an intermediate state towards any of the other futures described.

These assumptions imply an important role for governance in changing foods, diets and behaviour, directly as in 'Healthy new world' and 'Heal the world', or more indirectly as in 'Me, myself and I' (providing a framework for progress which has the potential to lead to healthier lifestyles). A lack of control by civil society could have negative consequences, as shown in 'Eat to live'. In addition, aspects of freedom of choice, individual responsibility and privacy are critical issues in all scenarios. Overall, in three out of four scenarios an

improvement in public health with respect to diet-related diseases would seem possible.

Despite different combinations of driver developments, the scenarios show some additional common elements:

- By 2050, the effects of food and food components on health are well understood scientifically, as are the specific nutrition needs of population groups and the underlying reasons for individually modulated responses to foods;
- This knowledge, in combination with low-cost technology for physiological monitoring and genetic analysis, is assumed to be being applied to individualise diets, supporting everybody's food choice with tailored advice, although access and quality can be an issue;
- Low-cost technology makes health monitoring and self-management a common element, to which children have access, too. The service behind the technology, for example access to the healthcare system, or quality, evidence-based dietary advice becomes the costly item and thus not easily accessible to everybody.
- Access to healthcare is a common theme: apart from 'Healthy new world', healthcare systems have reduced coverage of basic services implying the need for additional insurance or out-of-pocket payments, as well as a stronger focus on disease prevention;
- Technology in 2050 supports behaviour change. For example, it facilitates the preparation and provision of meals at home, from home delivery of ready meals or food purchases to availability of all required information and automated preparation. This reduces the time needed to prepare a healthy meal and is assumed to support adherence to healthy diets. The availability of alternative protein sources, such as insect proteins and *in-vitro* meat, supports a reduction in 'real' meat consumption, be it for health, environmental and/or cost reasons, as in three of the four scenarios. This can have a positive environmental effect in less environmentally conscious societies (such as 'Eat to live').

The four scenarios were developed to provide a basis for the identification of relevant research priorities. The results of this process are presented in Chapter 5.



5. Identifying research priorities

Following workshops 1 and 2, a third workshop was organised in which the scenarios and narratives were used to identify research priorities for the provision and consumption of healthy diets towards 2050. In line with the challenge-based approach of Horizon 2020, the aim was to identify high-level challenges

for which research is needed. The starting point was the identification of scenario-specific challenges and opportunities that are: i) key to the provision and consumption of healthy diets in each scenario; and ii) could be reasonably tackled by research. The results of this first step are summarised in Figure 3.

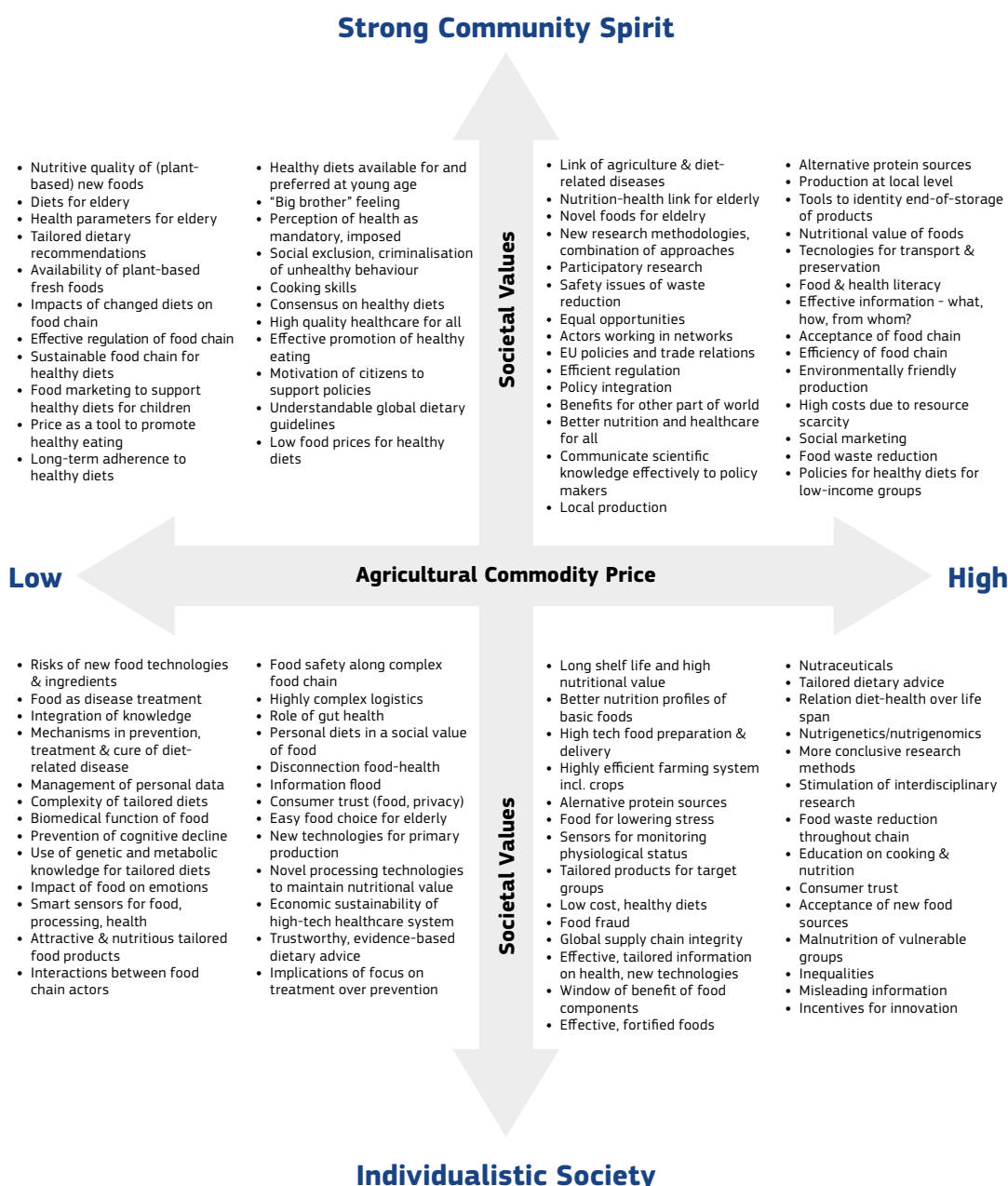


Fig. 3: Scenario-specific opportunities and challenges identified in Workshop 3

Depending on the scenario, more emphasis was given to policies ('Healthy new world' and 'Heal the world'), food production and technologies ('Eat to live' and 'Me, myself and I') or consumer related issues ('Me, myself and I' and 'Healthy new world'). In a second step, using the criteria of importance and novelty, the most relevant challenges and opportunities were selected to be further developed into research priorities: research topics were proposed either to address the challenges or to make use of the identified opportunities. Their description included developing a set of research questions, the rationale, potential impacts of the respective research results as well as the type of organisations and scientific disciplines that should be involved in the research proposed. A time horizon for when the research results are needed (short-, mid- or long-term) was also included.

The sections below present the research priorities identified through this process. All four scenarios were used equally as the basis for identifying research priorities. The different items have been uncoupled from the individual scenarios, and merged and regrouped under four thematic areas. They thus represent a general, not scenario-specific indication for research towards a healthier society in 2050. They are not intended to comprehensively cover all currently unsolved issues, but rather to prioritise knowledge gaps to be filled in order to be better prepared for the future.

5.1 Research priorities towards 2050 – an overview

The research topics fall into four main thematic areas, namely: **'Towards healthier eating: integrated policy-making'; 'Food, nutrients and health: cross-interactions and emerging**

risks'; 'Making individualised diets a reality'; and 'Shaping and coping with the 2050 food system'. These are then further subcategorised into ten overriding research priorities (see Figure 4).

Fig. 4: Overview of ten research priorities identified in the study as well as the four main thematic areas they address

Towards healthier eating: integrated policy-making	Food, nutrients and health: cross-interactions and emerging risks	Making individualised diets a reality	Shaping and coping with the 2050 food system
<ul style="list-style-type: none"> • Improve the evidence base for adoption of healthier dietary behaviour • Developing a scientific framework for a systems approach to food and nutrition policies • Provide a framework to design, monitor and evaluate policies 	<ul style="list-style-type: none"> • Deepening the understanding of human nutrition: facing the complexities • Anticipation of emerging risks 	<ul style="list-style-type: none"> • Data needs: creation and management of necessary data for enabling individualised diets • Analysing feasibility and impacts of individualised, healthy diets 	<ul style="list-style-type: none"> • Understanding the social role of food • Towards a sustainable food system producing safe, affordable and healthy dietary components • Supporting technologies to meet social needs

Each of the four thematic areas is briefly described below along with a thorough description of the research priorities. As in the current Horizon 2020 calls for project proposals, each of the ten research priorities (Figure 4) is described along with an analysis of its scope (i.e. a clear definition of the point(s) that need to be addressed) and its expected impact (i.e. what will be achieved by addressing this point). Potential actors which should be engaged in addressing the specific challenges as well as the time frame for action are also included.

An important element that characterises all identified research priorities is the need for a holistic, interdisciplinary approach that reflects a systems view on the societal challenges and opportunities. Food availability and affordability as well as citizens' diets are affected by individual physiology and preferences, social factors, as well as the food chain and the wider socio-economic environment (see Figure 2, food consumption map). All these can also interact and influence each other directly or indirectly. Applying a systems approach to considering the food

system as the complex network it is, identification of the crucial nodes and how they interact will facilitate the recognition and consideration of interrelationships between all the different elements.

Thus, even though the various research topics are described separately and are grouped into four broad areas here, they should be seen as part of that bigger and broader functional system.

5.2 Towards healthier eating: integrated policy-making

Unless a society sees its citizens entirely as individually responsible for making food- and diet-related decisions (thus with no role for governments), there are a range of different policy approaches to promoting healthier diets³³. For example, governments can assume the role of guiding consumer choice or ensuring that a healthier option is available and promoting it through various means. The four scenarios in this Foresight study evidence different approaches and a different mix of policy measures: the 'Healthy new world' and 'Heal the world' societies are characterised by a strong community spirit and strong food chain and health governance, with regulation of the sector and fiscal measures where necessary and appropriate, authoritative nutrition guidelines, and extensive consumer education and awareness. A clear focus on prevention can be seen, including state-provided social and healthcare services and measures that discourage consumption of unhealthy or environmentally unsustainable diets. On the other hand, the societies in 'Me, myself and I' and 'Eat to live' rely on individual initiatives; governments provide for market-enabling food information as well as basic services such as health and education but no major state initiatives on prevention, food and health education or specific measures to guide consumers' dietary choices.

All the societies described in the four scenarios have addressed or will need to address the challenges related to chronic diseases and their key risk factors to avoid the collapse of healthcare systems and deterioration of public health and citizens' well-being. Policy-makers will increasingly need to identify (cost-) effective measures acceptable to society, monitor progress as well as evaluate and learn from policy measures in place. Therefore, the participants in this study have proposed an increasingly important role for science in providing both the tools and methodologies for designing, monitoring and evaluating policies and the necessary evidence for future effective policy-making towards healthier societies.

5.2.1 Improve the evidence base for adoption of healthier dietary behaviour

Societies need to find ways to move towards healthier dietary behaviour. However, although official dietary guidelines and dietary reference values (DRVs) exist (for example, recommended intake amounts or intake frequencies of certain nutrients, foods, food groups or dietary patterns),

diverging views or contradictory results from scientific studies hamper a wider consensus among all relevant actors on concrete, solid definitions of healthy diets and behaviour. Similarly, despite the existence of national and regional food-based recommendations for a nutritionally balanced and healthy diet, a large part of the population does not follow such guidance, as evidenced by today's malnutrition issues (for example, overweight/obesity rates or frailty and nutrition deficiencies in the elderly). A more solid scientific-evidence basis has the potential of bringing together relevant actors from policy-makers to industry and civil society towards the adoption of healthy diets, as well as reducing confusion for consumers.

Scope:

- Provision of a strong evidence base for, and supporting the development of authoritative, EU-wide (and internationally) agreed dietary reference values that provide the basis for dietary guidance, food information, food fortification, and food reformulation;
- Provisions of a strong evidence base for defining healthy dietary patterns, in terms of consumption (frequency) of food groups as well as certain critical nutrients to increase the consensus on policy targets for healthy eating;
- Development of science-based tools and methodologies for translating the scientific-evidence base into easy-to-understand and adopt food-based dietary guidelines that take local, seasonal, cultural, social, ethical and environmental aspects into account.

Time frame and actors:

Providing the basis for progress towards healthier diets, this research topic has a rather short-term time horizon. This task should involve mainly governmental and public research institutions and agencies, including nutritionists, epidemiologists, public health experts, agronomists as well as anthropologists, behavioural scientists and communication experts.

Expected impacts:

- Consensus among all stakeholders towards common definitions and objectives of nutrient, food and diet-related policy targets;
- Provision of an authoritative scientific basis for dietary advice, a benchmark resulting in more clarity for consumers regarding healthy diets;

³³ Hawkes et al. (2013) *Obes. Rev.* 14 Suppl 2:159-168

- Facilitation of a coalition across all sectors aiming at a concerted action on the provision and consumption of healthy diets;
- Improved acceptance of policy interventions by consumers and better adherence to healthy diets;
- Potential for enhanced global cooperation towards healthy diets in a globalised food chain system with similar diet- and food-related societal challenges.

5.2.2 Developing a scientific framework for a systems approach to food and nutrition policies

The provision and consumption of healthy diets involve and are influenced by multiple factors (see also Figure 2, food consumption map), and different actors at various stages of the food chain and beyond. This includes primary production, food manufacture, retail, and food service, as well as non-food-related stakeholders in healthcare, education, media, etc. In addition, different policy areas overlap within this field, including agricultural, fisheries, food, consumer health, energy, social justice, etc.

Integrated approaches are increasingly being promoted in the field of nutrition and health at all levels from community to supranational policy-making, and attempts are being made to influence other policies to implement a 'health-in-all-policies' approach. Nevertheless, while most would agree that care must be taken to ensure that new measures implemented in one policy portfolio do not undermine health-related efforts made elsewhere, such impacts are only rarely systematically assessed and considered. Synergies and policy coherence should be sought to multiply the benefits of individual initiatives. Furthermore, since the measures taken should be evidence-based, emerging scientific evidence and advice need to feed into this process effectively.

Scope:

- Development of science-based, user-friendly tools that describe the food system as a whole, its key interactions and how the system's elements influence and are influenced by one another;
- Provision of a framework to enable systems thinking in terms of research and policy design and decision-making;
- Identification and impact analysis of effective systems solutions to nutrition and health issues, as well as other issues pertinent to the food system;
- Identification of effective ways to network policies and promote coherence across policies and relevant actors, reflecting a dynamic society and industry landscape.

Time frame and actors:

While the complexity of the challenges relating to nutrition, obesity and health as well as to other social aspects is increasingly being acknowledged, there is still a gap between the recognition of systems thinking and its application in generating scientific knowledge and policy-making. Therefore, this research priority should be addressed on a short-term basis, but must continue with a mid- and long-term horizon, especially on aspects like evaluating the effectiveness and improvement of systems- and science-based policy-making. The successful engagement of all stakeholders and relevant scientific fields continues to be a priority.

Expected impacts:

- Increased recognition by relevant actors of complex systems and challenges underlying nutrition and health as well as a better understanding of the interlinkage of elements both within this system and to related elements in other social fields;
- Availability of user-friendly tools and an improved science basis enabling policy-making in a more holistic, comprehensive and effective manner;
- Better implementation of the 'health-in-all-policies' approach through an improved evidence base supporting policy coherence in general and more successful food and nutrition policies in particular.

5.2.3 Provide a framework to design, monitor and evaluate policies

Food-related policy measures in place today include fiscal measures such as taxes³⁴ and subsidies (often in tandem³⁵), proscription of particular food components, restriction of food-related marketing practices, or they provide education, information campaigns and food and nutrition labelling. However, the effectiveness of these measures is not always understood or proven – for example, it is often unclear which particular elements of the measures create positive effects or behaviour. In addition, the development of new food processes and products or new marketing strategies are also progressing in parallel, generating new challenges and opportunities for consumers and policy-makers seeking healthier diets.

Vulnerable groups, such as children and low socio-economic status (SES) groups, need specific attention. In particular, the latter would be affected by increasing food prices. Food price is a strong determinant of food choice, and an increase in prices could result in consumers purchasing less expensive but also less healthy diets^{36,37}. The resulting

³⁴ Food taxation in Europe (2012) European Public Health Alliance

³⁵ Thow et al. (2010) Bull World Health Org. 88: 609-614

³⁶ Monsivais et al. (2010) Food Policy 35:514-520

³⁷ Institute for Fiscal Studies (2013) Food expenditure and nutritional quality over the Great Recession

increasing difficulties in accessing healthy diets³⁸ would exacerbate existing health inequalities³⁹. Future economic crises and fluctuations in food prices might aggravate this effect even further. Consequently, measures targeting low SES groups could have an important impact on reducing health inequalities.

In addition, a thorough understanding of other factors determining food choices and consumption is needed to ensure that consensual dietary guidelines effectively support health-promoting behaviour by all actors in the food system. Behavioural science-inspired measures include, but are not limited to, consumers. These and other such measures need to be taken across the food system, from primary production to manufacture, retail and food services to ensure the provision and consumption of healthy diets.

Scope:

- Development of a science-based methodological framework to systematically assess *ex ante*, and monitor and evaluate *ex post* the impact of policies on healthy diets;
- Identification of policy measures that enable healthy and nutritionally balanced diets;
- Identification of population-specific measures (for example, targeted at children or low SES groups) that improve the access, food education, food choices and eating behaviour of these populations;
- Development of monitoring and assessment tools for the timely identification and assessment of food-chain developments, including private-food-sector marketing strategies, that may support or counteract policy measures related to the provision of affordable healthy diets.

Time frame and actors:

Increasing the availability, affordability and attractiveness of healthy dietary choices for all

sections of society and finding ways to improve consumer adherence to healthy diets is paramount in a prevention-focused improvement of public health status. Moreover, due to the nature of the challenge and the urgency of the issue, this research challenge should be tackled on a short-term time horizon. Although many aspects of this topic are in the public policy research portfolio, the involvement of the private sector will be crucial. This task should include governmental and public research institutions and, with an emphasis on the trans-disciplinary nature of this issue, expert knowledge from various fields will be required, including social sciences, agricultural production, food technology, agro-economy, market analysis, nutrition, public health, epidemiology, town planning, consumer sciences, neurosciences, communication sciences, economics, marketing and psychology.

Expected impacts:

- A range of policy options available that ensure the provision and consumption of healthy diets. Clear evidence-based description of costs, benefits and effectiveness for all parts and aspects of society facilitates informed policy decisions and societal debates;
- Increased availability and transparency of science-based evaluation of policy measures will provide the basis for improved policies and wide societal consensus of desired and acceptable rules and standards;
- Improved evidence-based understanding of and contribution to efficient policies aimed at reducing dietary and health inequalities in vulnerable population groups across the EU;
- Better access and adherence to healthy diets will have a positive effect on the prevention of non-communicable diseases across all parts of society and will also help to reduce health inequalities by improving the health status of lower SES groups.

5.3 Food, nutrients and health: cross-interactions and emerging risks

All the scenarios assume a considerable advance in our understanding of human physiology, metabolic regulation and of the interconnection of all aspects of nutrition with health and disease, from specific dietary components to foods and dietary patterns. Currently, however, many knowledge gaps remain in our understanding of the key physiological processes involved in the development of chronic diseases and how they may be affected by nutrition, as well as other factors such as inflammation or oxidative stress. Also, a complex hormonal and metabolic regulation underlies homeostasis, appetite and satiation and, in general, many elements of human

physiology. A better understanding of these and other mechanistic linkages and identifying the possibilities to affect them via nutrition provide opportunities to ameliorate public health and reduce Europe's major health and economic burden.

5.3.1 Deepening the understanding of human nutrition: facing the complexity

Currently, evidence-based medicine relies primarily on randomised control trials (RCTs), which are considered to be the gold standard in experimental studies. This is also the case for nutrition sciences, although it can be argued that RCTs, as conceived for medical sciences, are often not the appropriate tool to study the effects of nutrients on health: intervention studies in nutrition

³⁸ World Heart Federation factsheet (2013) Global dietary changes threaten health

³⁹ Devaux (2013) Eur J Health Econ December 2013 (Epub ahead of print, accessed in June 2014)

are costly, time consuming and difficult to perform and control. The results of many current studies are often insufficiently conclusive. Nutrition studies, especially if food-based, are inherently more complex than traditional pharmaceutical clinical trials^{40,41} due to effects of many confounders which are not always easy to control – for example, lifestyle, variation in the composition of foods or the whole dietary intake, in addition to the particular component under investigation. Complex, yet unclear feedback mechanisms orchestrate metabolic regulation through, for example, hormonal and neural regulation of appetite and satiation. Moreover, the effect of nutrition on health is more commonly studied in the context of disease prevention rather than treatment. Therefore, any effects on reducing the risk of disease from foods and diets for individuals in good health are usually subtle and can only be observed over long periods of time. More often than not, the observed effects (or the lack of) cannot be explained by simple one-way causality. As a result, any further improvement of research methodologies in this field, as well as a culture of data-sharing, would be of considerable value, including modern analytical platforms, bioinformatics and modelling, incorporating data from multiple types of studies, and broader research platforms^{42,43,44}. A systems biology approach would greatly benefit the understanding of the complex interactions between diets and human health and would help to design more concrete hypothesis-driven research.

Scope:

- Development of improved and nutrition-tailored RCTs and/or other study designs for better research approaches to deal with the complexity of food and health interactions;
- Better integration of knowledge from nutritional sciences and other disciplines such as molecular and systems biology, neurosciences and epidemiology;
- Elucidation of the complex interaction between genes, diets, behaviour, environment and other determinants of individual health status, including disease or nutrient-pharmaceuticals interactions. Some specific examples:
 - Investigation of the effects dietary components or dietary patterns have on human microbiota composition and activity (including gut flora) and their consequences for human health status and vice versa;
 - Understanding the specific interactions between diet and health in the elderly;
 - Better understanding the role of specific nutrients during various critical periods of life, such as embryo development, childhood, adolescence, ageing, as well as the specific effects of nutrients or diets before, during or after suffering from a disease;

- Investigation of impacts of dietary components or patterns on psychological and mental health status (for example, emotions, stress, depression) as well as effects on cognition (in particular in the elderly), and mental performance and vice versa.

Time frame and actors:

Most of the above research priorities are envisaged within a short- to medium-term horizon. The need for a better understanding of the effects of foods and diets on human physiology and metabolic regulation in general is a prerequisite for improved disease prevention through diets as well as the application of personalised dietary advice. Similarly, the development of improved research approaches to nutritional studies is a short-term need, whereas evaluation of the efficacy of such approaches has a mid- to long-term time frame. Public and private partnerships should be set up to better tackle the above challenges, drawing from expertise in medicine, life sciences (genetics, microbiology), nutrition, food science and technology, as well as social sciences, neuroscience and psychology.

Expected impacts:

- Generation of a stronger evidence base on nutrition-health linkages through the application of more hypothesis-driven studies and improved and better integrated research approaches;
- Better understanding of physiology and metabolic regulation in health and disease development, including the proposition of possible (nutritional) means for therapy;
- Improved understanding of human variations in response to nutrition factors and other external agents, and the better translation of this knowledge into innovative, individualised (when appropriate), food and nutrition solutions to improve citizens' health;
- Improved public health via knowledge implementation into clinical and dietary guidelines.

5.3.2 Anticipation of emerging risks

All of the scenarios describe a future abundant in innovative foods and production processes for novel food, new foods, additives and food components of natural or synthetic origin, novel sources of macronutrients, technological progress in primary production, food manufacture and the automation of cooking⁴⁵, and the introduction of individualised diets. Some current practices, in particular the introduction of innovative products and processes could, in addition to beneficial effects, potentially result in new food safety and health challenges which need to be flagged up early on to protect public health and, importantly, too avoid loss of consumer trust in technological developments.

⁴⁰ Blumberg et al. (2010) *Nutr Rev* 68:478-484

⁴¹ Shao, A. & Mackay, D. (2010) *Nat Med J Commentary* 12/012010

⁴² Victora et al. (2004) *Am J Public Health* 94:400-405

⁴³ Peinemann et al. (2013) *PLoS One* 8:e85035

⁴⁴ English et al. (2011) *Bull World Health Org* 89:907-912

⁴⁵ Trend Hunter website (2013) article on smart kitchens

Apart from acute food-safety issues (microbiological or chemical), the long-term, chronic effects on human health of consuming certain substances present in food as well as of new food-processing methods should also be investigated.

Scope:

- Development of an integrated anticipatory approach that entails:
 - Indicators for the early identification of potentially acute food-safety risks (microbiological, chemical) due to the introduction of novel food materials as well as new processes and technologies in agricultural production and food manufacture;
 - A systems understanding of the long-term physiological effects of novel dietary components (for example, alternative sources of proteins such as insect-based or laboratory grown) and changes in consumption patterns;
 - A resilient strategy to ensure food safety in a globalised complex food chain.

Time frame and actors:

The research priorities for this topic should be developed in tandem with the innovative approaches in question and within a short time frame, as the specific technological development requires. At the same time, chronic effects of consumption of new dietary components have a long-term research horizon. Due to the nature of the specific research priorities, close collaboration between public authorities and the private sector is needed to best tackle the challenge, drawing on the expertise of food scientists and technologists, public health and agriculture experts, microbiologists, toxicologists, medical and veterinary doctors as well as nutritionists, economists, trade specialists and modellers.

Expected impacts:

- Better preparedness and availability of integrated tools for improved risk anticipation;
- Reduction of the risk of future food crises impacting on citizens' health and trust in food-chain operators and policies;
- Increased safety of the food chain, especially in innovative sectors;
- Increased trust in and, as a consequence, acceptance of novel products and technologies.

5.4 Making individualised diets a reality

Tailored diets can potentially be a major element of personal healthcare and disease prevention, given the importance of diets and nutrition in many chronic diseases and mental health. Individualised dietary advice, based on comprehensive information concerning dietary elements, as well as both phenotype and genotype, is a common theme in all four scenarios. The research items proposed in Section 5.3.1 (Deepening the understanding of human nutrition: facing the complexity) will enable advances in understanding the complex relationship between food and health, including individual food components, their combination in a diet, physiologic, genetic and epigenetic factors, as well as the environment. However, obtaining and processing unprecedented amounts of individual data for every single factor investigated is a massive challenge that requires technological developments to realise individualised diets by 2050.

In the broader context of individualised diets, several research challenges have been identified focusing on data management, implementation and the impact of such dietary advice.

5.4.1 Data needs: creation and management of necessary data for enabling individualised diets

To make individualised diets a reality, personal data, including (but probably not limited to) age, physiological, nutritional and health markers along

with genetic and epigenetic profiles as well as microbiome analysis need to be collected, processed and analysed. In combination with data on diets and the health effects of dietary components, this will provide the basis for tailored dietary recommendations. However, many technical and governance-related hurdles must be overcome for the implementation of these concepts and to provide the basis for consumer acceptance. Some of the questions in the field concern the kind of biological and nutritional data needed, data collection, the required data quality, data processing and storage, and last but not least, the use of and access to this information.

Scope:

- Identification of the types of data needed for the provision of tailored dietary advice;
- Identification of specific technical requirements and appropriate methodologies (for example, monitoring of physiological and nutritional status, genetic testing) to collect such data and extract meaningful concrete diet-related information;
- Translation of relevant data into individualised dietary advice;
- Identification of effective ways to make the advice easily accessible and understandable for consumers, supporting adherence to the dietary advice;
- Development of guidelines and quality standards for both the data required and the methodologies involved in the generation and communication of individualised dietary advice, in order to ensure high-quality, reliable and evidence-based services;

- Identification of measures and procedures to define ownership, establish clear conditions of use, safeguard privacy and avoid misuse of personal data.

Time frame and actors:

This research challenge should be tackled within a short-term horizon to facilitate developments in tailored dietary-advice services. Experts from multiple biology-related disciplines, nutrition sciences, analytical chemistry and diagnostics, public health, social and behavioural sciences, information and communication science and technologies, consumer sciences, bioinformatics, data management as well as law and ethics should be included.

Expected impacts:

- Development of high-quality frameworks and databases that enable the generation of a solid evidence base for individualised dietary advice;
- Creation of tools that combine different data and translate it into individual dietary advice;
- Increased consumer trust due to clear governance and data security;
- Ultimately, the realisation of evidence-based, quality individualised dietary advice enabling individuals to make the most of dietary prevention of disease as well as the promotion of health and well-being;
- Self-management of health and disease prevention.

5.4.2 Analysing feasibility and impacts of individualised, healthy diets

Dietary advice tailored to the individual is a complex endeavour. Apart from the scientific knowledge, and the availability of required personal data, there are several social, ethical and economic questions to be investigated. To be effective, individualised diets and dietary advice, and the supporting processes, such as monitoring of physiological parameters or genetic testing, must be compatible with daily life and accepted by consumers^{46,47}. Dietary advice can take advantage of the rise in ICT applications⁴⁸, empowering and motivating the individual to take action on his/her own health, including lasting changes in behaviour towards eating a healthy diet. However, the risks and benefits for consumers,

healthcare systems, the food industry and society in general need to be assessed and discussed.

Scope:

- Risk/benefit assessment and cost-effectiveness analysis of the implementation of individualised dietary advice on individual health status and healthcare system, in the context of prevention-focused public health policies;
- Identification of the required level of consumer health and nutrition literacy in order to be able to deal with individualised diets, including self-management of health;
- Identification of drivers affecting consumer acceptance and adherence to individualised dietary advice;
- Development of approaches for customising individualised dietary advice for specific population subgroups (for example, children, elderly) and incorporating it into, or to complement, other Member States' or EU-wide prevention-focused public health policies;
- Development of suitable and attractive products to support individualised, healthy diets;
- Identification of potential impacts on food industry (for example, shift to a much more consumer demand-driven system).

Time frame and actors:

The research challenges above should be tackled within a short- to mid-term horizon and, due to the nature of the topic, should involve both public- and private-sector stakeholders, covering life and social sciences, for example, nutrition, public health and medical experts to economists, consumer scientists, psychologists and behavioural experts.

Expected impacts:

- Understanding the potential role and impact of individualised diets in improving public health;
- Increased insight into the elements necessary for the successful, socially acceptable and beneficial application of individualised dietary advice as a precondition for developing an effective and efficient framework for individualised diets;
- Insights into elements needed for improved consumer understanding and uptake of information on individualised dietary advice.

5.5 Shaping and coping with the 2050 food system

It is evident that the health aspects linked to food supply and dietary choices cannot be considered in isolation from the economic, social or environmental aspects which all affect consumer behaviour simultaneously (see, for example, the food consumption map, Figure 2, Chapter 3). While this

study's focus is on the future dietary behaviour and related health of consumers, these aspects cannot be uncoupled from other challenges within the food system, such as ecosystem degradation, resource scarcity and social inequalities. High levels of food waste at all stages along the food chain illustrate the inadequacy of the current system. Moreover, the role of the food system's current design in providing and promoting foods high in fat, sugar and salt has

⁴⁶ Ronteltap et al. (2009) Br J Nutr 101:132-144

⁴⁷ Fallaize et al. (2013) Nutr Res Rev 26:39-48

⁴⁸ Bouwman et al. (2005) Eur J Clin Nutr 59:S108-S116

been repeatedly discussed in the context of obesity and diet-related diseases^{49,50}. Despite these and other issues in the current food system, it still provides the majority of the EU population with sufficient and varied food which is affordable and safe. However, as the scenarios suggest, this should not be taken for granted for the future. There is a case for urgent change in the food system, aligned with values such as environmental sustainability, public health and social justice. New foods may enter the chain in future to cover shortages of certain nutrients or provide more nutritious foods to enable consumers to follow a healthy diet. Other aspects of a future food system that would seem relevant are the consequences of introducing highly customised diets and new foods and food replacements, and the potential loss of the social aspects implicated in sharing meals.

5.5.1 Understanding the social role of food

A shift in eating habits and the current social trend towards individualisation (for example, increase in single-person households, shift from physical to virtual social contacts), as well as the demands of working life and related time constraints may, in future, limit the possibility of, and interest in, preparing and sharing a meal. As a consequence, food and eating could lose their traditional social value. This situation is reflected in the 'Me, myself and I' scenario, and to a lesser extent in 'Eat to live', which are defined by an individualistic societal outlook. However, it is less evident in the other two scenarios where social cohesion is stronger and food and eating are also valued as a social activity. The implications of this possible shift for both the individual citizen and for society as a whole (for example, social participation and cohesion) have yet to be systematically investigated.

Scope:

- Investigation of the role of food beyond nutrition; the social effects of eating at individual and community level;
 - Investigation of the implications of highly individualised lives and lifestyles, including eating habits, for the social fabric of a community and its constituents (individual, groups, communities, organisations), and the effect on adhering to healthy diets;
 - Investigation into the social consequences of a potential future globalised food system with a high prevalence of new foods or food replacements and a strong reduction in traditional food
- Identification of the possibility for and the implications of change in the perception of the importance of food and nutrition for health, for example, due to a focus on effective cures and treatments of chronic diseases.

Time frame and actors:

This research challenge should be tackled with a mid- to long-term horizon. A variety of expertise is necessary to address these issues and different experts would be required at different stages of analysis: food scientists from the public and private sector, nutritionists and healthcare practitioners, mental health experts, social scientists, psychologists, anthropologists, agricultural economists, philosophers and ethicists.

Expected impacts:

- Improved understanding of the role of food in society and the role societal developments and norms may play in the diets of individuals and the population as a whole;
- Insights that can be translated into policy measures to mitigate or counter any unwanted developments due to the individualisation of eating and shifts in current dietary patterns.

5.5.2 Towards a sustainable food system producing safe, affordable and healthy dietary components

Sustainable diets, as defined by the Food and Agriculture Organization of the United Nations (FAO)⁵¹, cover environmental, social, economic and health aspects. Their realisation requires a holistic food-chain perspective, aiming at an economically viable system for all actors within the food chain, including consumers, which is environmentally benign while, at the same time, provides the population with a varied range of healthy choices. This topic comes across as particularly vital in the 'Heal the world' scenario, where the food chain is characterised by environmental sustainability, but also in the 'Healthy new world' where consumer food prices are kept relatively low while producing healthy and environmentally sustainable food. The need to reduce food waste is of primal importance in both the 'Heal the world' and 'Eat to live' scenarios.

Given the focus of the study, the research topics described below, although covering only certain aspects of a sustainable food system, recognise the utmost importance of a holistic appreciation in building a sustainable and resilient food system towards 2050.

⁵¹ "Sustainable diets are 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 optimising natural and human resources." <http://www.fao.org/ag/humannutrition/biodiversity/en/>; accessed in April 2014

⁴⁹ The PLoS Medicine Editors (2012) PLoS Med 9:e1001246

⁵⁰ Moodie et al. (2013) Lancet 381:670-679

Scope:

- Development of effective integrated approaches to establishing, promoting and supporting a sustainable food chain (offering a broad range of healthy, affordable choices while minimising the environmental footprint). This should include:
 - Identification of effective policy measures towards a sustainable food chain;
 - Integrated analysis of impacts on the sustainability of actions and practices by every element along the food chain with the aim of identifying potential key contributions towards a more sustainable food chain, as well as trade-offs and synergies, such as between health and environmental impact;
 - Assessment of the potential role of local production, urban farming, (re)-introduction of underutilised and under-researched plant or animal species in the sustainable food chain system, including an analysis of potential impacts on diets and health;
 - Identification of new approaches and technologies to improve efficiency, including transport and logistics;
 - Identification of effective integrated approaches to reducing food waste, including assessing the role of the different food-chain actors, technical solutions to increase and clearly identify shelf-life, investigating possible food-safety issues, and ensuring consumers' overall acceptance and contributions;
 - Identification of potential risks of (highly complex) food chains and measures to ensure integrity in terms of food safety and food quality.

Time frame and actors:

Due to the urgency of the issue and the potential long-term effects of action or inaction in creating a sustainable food chain, this research priority should be addressed with a short- to medium-term time horizon. Research institutes and universities should draw on the expertise of agronomists, economists, food technologists, consumer scientists, political scientists, IT engineers, as well as authority/government and industry experts to tackle this challenge.

Expected impacts:

- Fostering a systems thinking that favours integrated and effective action towards sustainability and innovation on the basis of the provision of safe, nutritious and affordable food for EU citizens;
- Identification of specific measures that improve sustainability across the food chain;
- Identification of elements that align sustainable production with the provision of healthy diet constituents;
- Implementation of food-waste reduction initiatives along the food chain.

5.5.3 Supporting technologies to meet societal needs

The use of novel and/or alternative food sources as well as food replacements or new production methods is linked to the challenge of establishing a sustainable food chain. Many possibilities are currently being explored – from food supplements/replacements to alternative protein sources from insects, algae, or *in-vitro* (laboratory-grown) meat, genetically modified organisms and urban farming. Technological development throughout the food chain is a key theme relevant to all the scenarios as the need for cost-efficient, fair and sustainable ways of producing food in a future is clear, given a growing world population and declining natural resources. The potential impacts of the introduction or broad use of these developments on diets, the society and the environment, as well as their acceptance by the consumer, must be considered.

Scope:

- Development of novel or alternative sustainable primary production or manufacturing processes for better nutritional profiles of foods and food components;
- Development of methodologies for impact assessments of technological developments on the food system and beyond;
- Development of effective approaches to communicating and gaining acceptance of new food sources and technologies with potential health benefits in sustainable food production.

Time frame and actors:

Public and private sector as well as civil society collaborations are necessary to address the complexity of this research priority, which has a medium-term time horizon, involving agronomists, economists, food technologists, social and consumer scientists, nutritionists and marketing experts.

Expected impacts:

- Improved availability and supply of safe, affordable, and nutritious foods and food components with reduced harmful environmental or societal consequences;
- Better consumer acceptance of new food technologies and products, and the possibility to realise the potential of novel, sustainable foods.

5.6 Concluding remarks on the research priorities

The research priorities identified reflect the perceived diet-related opportunities and challenges in the scenarios and the resulting research topics to address them.

Due to the specific approach of this study – i.e. the consumer focus, the use of Foresight methodology, and the 2050 time horizon, as well as the broad involvement of experts and stakeholders – its results complement the research agendas established by two European initiatives (European Technology Platform (ETP) on Food for Life and the Joint Programming Initiative (JPI) A healthy diet for a healthy life^{52,53}) which, among other sources, also feed into the Horizon 2020 research agenda. While the ETP has a stronger focus on food-production-related issues, to a large extent the JPI covers diets, lifestyle and health interactions. In that respect, the latter is closer to this study as it also touches upon some of the identified research challenges, for example, research into food/health interaction, the need for trans-disciplinary research, and the need to look at new types of study designs, as well as evaluating policy intervention.

Overall, both the identified research priorities and the scenarios highlight the following areas that need attention:

Need for a systems approach

The scenarios showed that healthier eating behaviour is closely linked to societal values, supported by effective policies and technologies. Consumers and their food choice play an important role in healthy diets, but cannot be separated from the rest of the food chain. All of the closely linked and complex elements need to be considered to find ways to reduce the importance of diet as a risk factor for non-communicable, chronic diseases in the EU.

With a view to long-term availability, accessibility, safety and healthfulness of foods and diets, the overall food chain needs to become sustainable, i.e. environmentally benign, economically viable and socially responsible. Current discussions on food security and NCDs further emphasise this need. The role and value of food in society closely influence the importance of, and acceptable trade-offs among these requirements.

The selected research priorities reflect the complexity of the diet-health system and in principle cover all elements of the inner circle of the food consumption map (Chapter 3). A recurring element is the call for a holistic, interdisciplinary approach that takes into account the whole food system. Compartmentalisation in research or policies is considered to impede efficient approaches.

Need for effective, integrated policies

Policies appear to be a major topic for further research, reflecting their perceived importance to advance healthy eating through changes in supply and demand, as well as the lack of evidence concerning the effectiveness of policies currently in place. This strongly supports the call for evidence-based policies, and the important role of science for informing policy-makers. In particular, vulnerable groups such as low socio-economic status groups and children need to receive attention.

Furthermore, a strong scientific basis for healthy diets could facilitate the formation of a powerful coalition between all the relevant actors in the food chain, working towards the provision and consumption of healthy diets. Similarly, unambiguous messages to consumers from authorities, the media, consumer organisations and industry would be an important element in this, reducing confusion and increasing the public's knowledge concerning the importance and characteristics of healthy diets. Thus, strong scientific evidence could create the basis for successful prevention-focused and coherent policy-making.

Need to support the development of individualised diets as the future healthy diets

Tailored diets are seen as a development which is certain to take place, in parallel with personalised healthcare, also implying increased self-management of diets and health and possibly greater empowerment of the consumer. Individualised dietary advice could make an important contribution to healthier diets, providing that high-quality, evidence-based information and advice is easily recognisable and accessible within the growing number of messages and information sources available. The clarification of ethical and legal issues such as data privacy is a precondition, which should also include vulnerable groups and their capacity for self-management.

As a first step, a consensus-based, EU or global approach to the establishment of dietary reference values, adaptable to consumer groups, could strengthen the authority, acceptance and application of dietary advice. This would be supported by a better understanding of the effects of diet and its components on health (including, for example, school performance) and disease. Nevertheless, behavioural aspects, such as motivation and decision-making processes, need to be better understood, as well supporting adherence to (individualised) dietary advice.

⁵² European Technology Platform on Food for Life; Strategic Research Agenda 2007-2020 (2013 -2020 and Beyond) Executive Summary

⁵³ Joint Programming Initiative A Healthy Diet for a Healthy Life (2012) Strategic Research Agenda 2012-2020 and beyond

Most of the research priorities identified should be addressed in the coming years to deliver results in the short- to mid-term (before 2030), thus reflecting their urgency. Since the diet-health system is complex, time will be needed to reach conclusive results. However, as pointed out in the UK Foresight study on obesity⁵⁴, the need for urgent action (on obesity) might also require working with the “best evidence available”, with the risk of some interventions failing to reach their objectives.

⁵⁴ UK Government Office for Science (2007) Foresight Tackling Obesity: Future Choices - Project Report



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ANNEXES

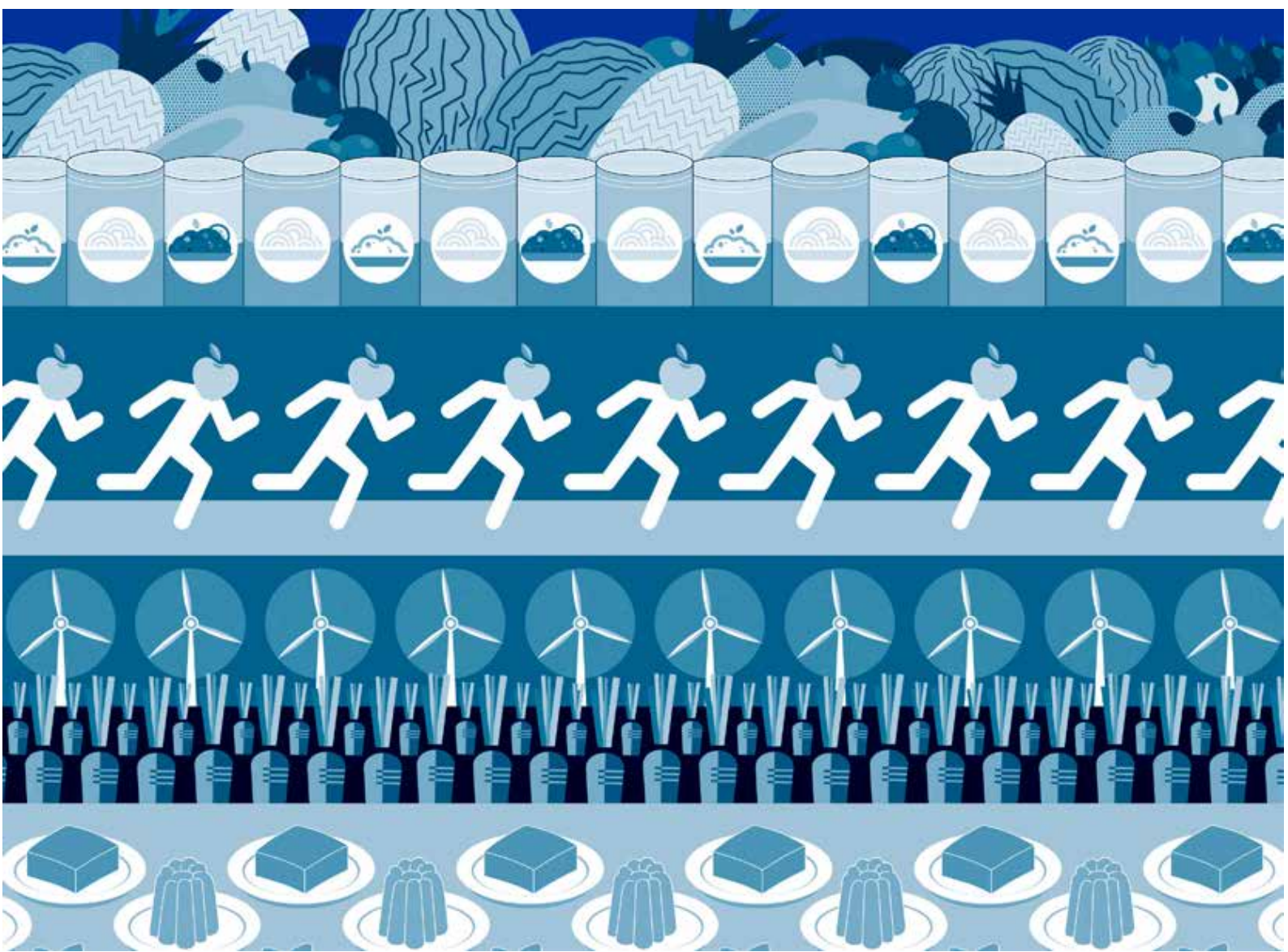


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ANNEX I

BACKGROUND DOCUMENT LITERATURE REVIEW

This literature review was prepared for the first workshop of this foresight study in October 2012 with the aim of creating a common starting point for discussions. It provides a brief overview of the state of knowledge of relevant topics in relation to diets and health, and was updated in July 2013.

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1. Foods, diets and health

Sufficient food of good quality is one of the important prerequisites for a healthy life. Today in the EU, the quantity, variety and safety of foods available to most consumers is unprecedented. However, this does not necessarily lead to a diet and food choice that promotes health and well-being. While life expectancy in the EU has steadily increased to currently 77 years for men and 83 years for women, roughly one-quarter of this lifespan is spent with limitations and a poorer quality of life largely due to **non-communicable diseases** (NCDs)¹. NCDs comprise a group of chronic diseases, including heart disease and stroke, cancer, lung disease and diabetes, which account for 86 % of deaths and 77 % of disease burden in Europe². They not only cause death or reduce the quality of life but also put an increasing strain on healthcare systems and economic development. This is due to direct healthcare costs as well as losses resulting from diminished resources within families, prolonged disability, reduced productivity and the creation of capital³. In this context, it is noteworthy that mental health issues alone are estimated to account for half the economic loss³. Although mental health and NCDs might require distinct strategies and action plans², recent findings increasingly suggest that both share common risk factors, including obesity and poor dietary habits^{4,5}. While tobacco use, harmful use of alcohol, physical inactivity and unhealthy diet are all recognised major modifiable risk factors of NCDs and are interconnected, this chapter focuses only on the main health issues related to foods and diets in the EU, including but not limited to NCDs.

1.1 Dietary patterns and health

Combination of the four unfavourable behavioural risk factors for NCDs – mainly poor diets and lack of physical activity and, to a lesser extent, tobacco use and alcohol abuse – lead to **four key metabolic/physiological changes**: raised blood

pressure, overweight/obesity, hyperglycemia and hyperlipidemia. On a global scale, these are among the leading NCD risk factors in terms of attributable deaths⁶, and a large part of the European population carries one or more of them:

- The prevalence of **overweight and obesity** among adults now exceeds 50 % in no less than 15 of 27 EU Member States⁷.
- As for **hypertension**, between 1980 and 2008, systolic blood pressure levels decreased in most European countries⁸. Nevertheless, the prevalence of hypertension estimated at the beginning of the 2000s was close to 50 % in six European countries⁹.
- As for **hyperlipidemia**, the best available health data are linked to total blood cholesterol; although it has been declining since 1980, the prevalence of raised blood cholesterol in the World Health Organization (WHO) European region is still high at 54 %^{10,11}.
- The EU average prevalence of manifest **diabetes** is 8.7 % of the population and is expected to increase to 10.3 % in 2025¹². A further 10 % of the population has been diagnosed with impaired glucose tolerance (IGT), a form of pre-diabetes, which is also projected to increase over the next 20 years¹³. The increased prevalence of overweight and obesity in children and adolescents is expected to contribute to a higher prevalence of type 2 diabetes among that population group¹⁴. Moreover, it should be noted that an estimated 50 % of diabetes cases remains undiagnosed, a percentage that may be even higher for IGT, implying the problem of hyperglycemia would also appear to be substantial.

1.1.1 Dietary patterns and nutrient intake

Not surprisingly, dietary patterns and **nutrient intake vary greatly** between EU Member States and regions. The most important characteristics of these

¹ Eurostat (2012) Europe in figures - Eurostat yearbook 2011

² WHO Europe (2011) Action plan for implementation of the European Strategy for the Prevention and Control of Noncommunicable Diseases 2012-2016

³ World Economic Forum (2011) The Global Economic Burden of Non-communicable Diseases

⁴ Trivedi B (2012) Food for thought: Eat your way to dementia

⁵ Dyer O (2005) Is Alzheimer's really just type III diabetes?

⁶ WHO (2011) Global status report on noncommunicable diseases 2010

⁷ European Commission, OECD, WHO (2010) Health at a Glance, Europe 2010

⁸ Danaei et al. (2011) Lancet 377:568-77

⁹ Wolf-Maier et al. (2003) JAMA 289:2363-2369

¹⁰ WHO Global Health Observatory (GHO) - Raised Cholesterol (accessed in June 2012)

¹¹ Farzadfar et al. (2011) Lancet 377: 578-86

¹² WHO (2009) Health in the European Union: trends and analysis

¹³ International Diabetes Foundation IDF Diabetes Atlas 5th edition (accessed in July 2012)

¹⁴ Kiess, W. et al. (2003) Horm Res 59 (suppl 1):77-84

dietary patterns and consequent nutrient intakes which have health implications are the following¹⁵:

- With respect to intake of **macronutrients**, diets among the European population are characterised by intakes at or up to twofold the population reference intake of protein¹⁶, too-high intakes of fat – more specifically, saturated fat¹⁷ – as well as too-high intakes of simple carbohydrates (sugars) and too low intakes of complex carbohydrates¹⁸. In addition, the intake of essential polyunsaturated fatty acids (PUFA), in particular omega-3 PUFA, are generally too low; intakes of dietary cholesterol are widely unproblematic being at or below recommended threshold values; trans fatty acids (TFA) intakes have generally fallen to below the recommended thresholds in Europe. Nevertheless, for the latter it is likely there are still parts of the population, in particular those individuals consuming a diet at 'high risk of TFA' (fast foods, processed foods with partially hydrogenated fat still used as ingredients), with critically high TFA intakes¹⁹. As regards the obesity epidemic, it is surprising that the European Nutrition and Health Report 2009¹⁵ reported energy intakes of all age groups in most countries below the German-Austrian-Swiss reference intakes (for the year 2000: 10.5 to 12.5 MJ/day in males and 8.5 to 10.0 MJ/day in females). However, in addition to the possible under-reporting of food intake, the level of physical activity may also have been low in many cases, hence the increase in overweight and obesity in Europe. In fact, leisure time physical activity was described as having a clear south-north upward gradient and was also associated with age and education¹⁵.
- With regard to **micronutrients**, Vitamin D and folate intakes were generally low in nearly all age groups. Issues resulting from low intakes were also observed for calcium, magnesium, selenium, iron (in women), iodine (in some age groups), as well as, less frequently and only in some age groups, for Vitamin B12, Vitamin C, copper and zinc²⁰. The sodium intake, in form of sodium chloride (i.e. salt), was above the recommendations in all EU Member States.
- Regarding **intake of specific foods or food groups**, Europeans generally consume too few fruits and vegetables (mainly cereals, potatoes and pulses) and too much meat and meat products. Large differences exist for fruit and vegetable intakes between the south of Europe (highest supply) and the north of Europe (lowest supply), and between seasons; **food supplements** are taken by an increasing proportion of the population, in particular by women and by the 35-50 years age group.

1.1.2 Health consequences – overweight and obesity

The WHO 'World Health Statistics 2012' report²¹ has reconfirmed that **obesity** continues to be a **major health threat worldwide**: 12 % of the world's adult population is obese. The distribution is not homogeneous and, as can be seen in Figure 1.1 which illustrates the distribution of obesity prevalence among females worldwide, in many European countries the prevalence of obesity is well above that value.

Similar data presented by the International Association for the Study of Obesity (IASO) shows that the levels of overweight children and adolescents in many EU Member States are equally high – on average, above 25 % of boys and girls²². In the UK, projections indicate that 60 % of adult men, 50 % of adult women and about 25 % of all children under 16 could be obese by 2050²³. A more recent study²⁴ forecasts a 33 % increase in obesity prevalence and a 130 % increase in severe obesity prevalence over the next two decades in the US. It is reasonable to assume that this upward trend will be replicated in most other countries worldwide.

Obesity increases the risk of a range of chronic diseases, particularly type 2 diabetes, stroke and coronary heart disease as well as cancer and arthritis. Healthcare costs associated with obesity are another important factor to be considered. As reviewed by the OECD²⁵, these include the costs of obesity per se as well as the costs stemming from the higher incidence of chronic illnesses. Estimates suggest that obesity is responsible for approximately **1 % to 3 % of total health expenditure** in most countries, except in the US where obesity may account for 5 % to 10 % of health expenditure²⁶. An obese person incurs healthcare expenditures at about 30 % higher than a person of normal weight, according to a range of studies from a variety of countries²⁷. There is a time lag between the onset of obesity and the related need for healthcare, suggesting that the rise in obesity in recent years will mean higher healthcare costs in the future. For example, the UK obesity foresight study²³ estimates that National Health Service costs attributable to overweight and obesity will double to £10 billion a year by 2050. The wider costs to society and business are estimated to reach £49.9 billion a year (at 2007 prices). Thus, the issue is high on the agenda worldwide and the WHO's European Charter on Counteracting Obesity²⁸ calls for "visible progress, especially relating to children and adolescents" and indicates that it should be possible to reverse the obesity trend by 2015 at the latest.

¹⁵ Elmadfa et al. (2009) European Nutrition and Health Report 2009

¹⁶ EFSA Journal 2012:10:2557

¹⁷ EFSA Journal 2010:8:1461

¹⁸ EFSA Journal 2010:8:1462

¹⁹ Stender et al. (2006) *Atheroscler Suppl* 7:47-52

²⁰ Vinas (2011) *Ann Nutr Metab* 59:84-95

²¹ WHO (2012) *Global Health Observatory - World Health Statistics 2012*

²² IASO (accessed June 2012) *Pre- and post-adolescent overweight and obesity in Europe*

²³ UK Government Office for Science (2007) *Tackling obesity: Future Choices - Project Report*

²⁴ Finkelstein et al. (2012) *Am J Prev Med* 42: 563-570

²⁵ OECD (2010) *Obesity and the Economics of Prevention: Fit not Fat*

²⁶ Tsai et al. (2011) *Obes Rev* 12:50-61

²⁷ Withrow et al. (2011) *Obes Rev* 12:131-141

²⁸ WHO (2006) *European Charter on Counteracting Obesity*

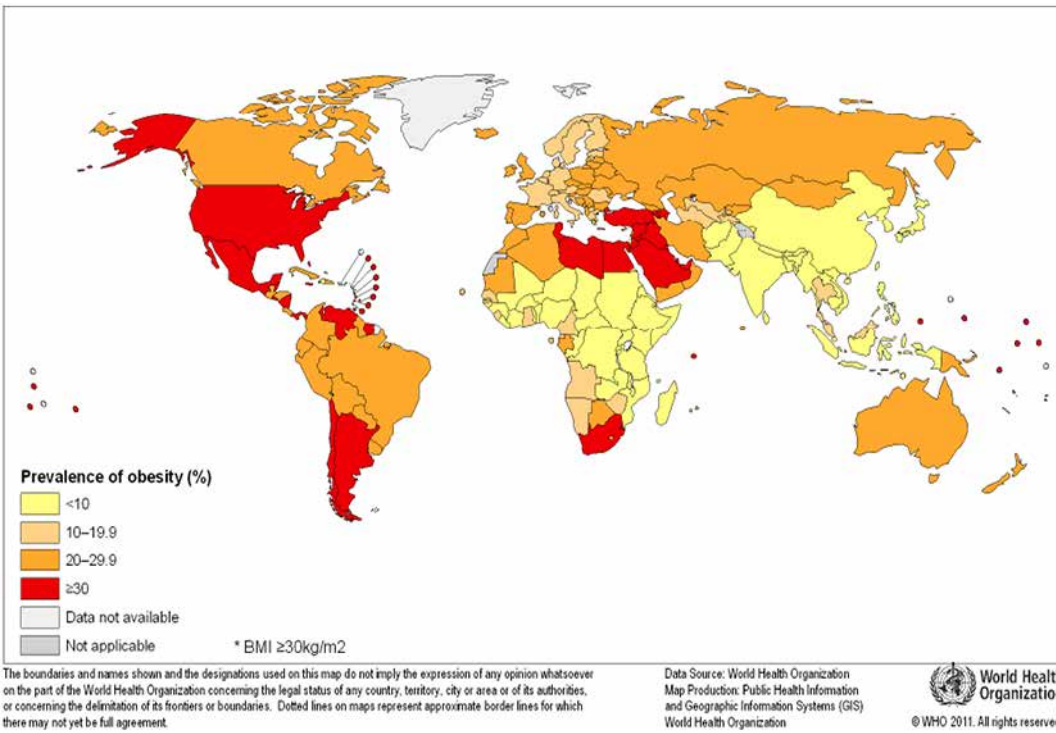


Fig 1.1: Adult female obesity prevalence worldwide; data are age (20+) standardised, 2008 (reproduced with permission from ²⁹)

Causes of obesity

Obesity is a disease (E-66 in ICD10³⁰) of great complexity. At the individual level, the most simplistic way to consider it is as an energy balance that arises when energy intake (E_{in} , energy taken from food in the form of calories) exceeds energy expenditure (E_{out} , energy consumed in resting energy expenditure, thermic effect of food and physical activity). **Energy balance** can be affected by genetic, behavioural and environmental factors, particular disorders or drugs and medications throughout development and adulthood. Some of the factors related to obesity are illustrated in Figure 1.2.

Not all causes are well studied or understood. For example, there is currently much debate for example regarding the **contribution particular food components** make to obesity; some³¹ think that calories from fructose are more readily metabolised to fat than calories from other sources. Also, energy expenditure involves more than simple physical activity. **Brown adipose tissue (BAT)** thermogenesis is now recognised as an important contributor to energy expenditure, and the manipulation of BAT is seen as a novel means of targeting obesity and the development of metabolic disease³² (see also Section 1.5 for pharmacological obesity treatments).

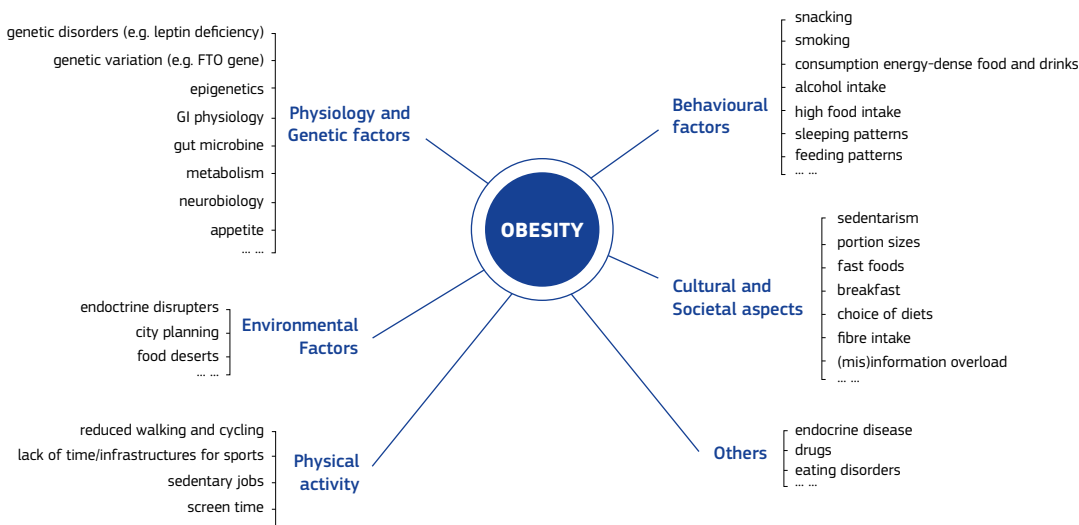


Fig 1.2: Some factors thought to be associated with obesity

²⁹ WHO Global Health Observatory Map Gallery (accessed in July 2013)
³⁰ WHO International Statistical Classification of Diseases and Related Health Problems V10 (accessed in June 2012)
³¹ Lustig, RH et al. (2012) Nature 482, 27-29
³² Bartelt, A. & Heeren, J. (2012) Curr Opin Lipidol 23, 190-195

1.1.3 Health consequences – other non-communicable diseases

Although obesity is arguably the main focus of nutrition-related public health policy, there are many relations between diet, health and chronic diseases that are directly linked to dietary quality, i.e. how foods are combined resulting in more or less “healthy” combinations of nutrients. In Europe, dietary patterns vary considerably. Nevertheless, there are certain characteristics in the diets across Europe that can explain part of the burden from NCDs.

From a nutrient point of view, those characteristics relate to a **high total fat intake** – in particular an unfavourable **fatty acid pattern** in the diets – the **high intake of simple sugars** at the expense of complex carbohydrates and fibres, as well as a **high sodium intake**. Some of these relations are described below:

- There is convincing evidence that reducing **saturated fatty acids (SFA)** and **TFA** lowers the risk of coronary heart disease through a decrease in LDL (bad) cholesterol and in the total/HDL (good) cholesterol ratio. This effect is particularly strong when SFAs are replaced with PUFAs and less so with mono-unsaturated fatty acids (MUFA)³³. There is also a potential link between SFA intake and breast cancer development³⁴. Efforts are ongoing in many EU Member States to improve the dietary fatty acid profile, and further progress towards reformulations as well as the substitution of foods and food ingredients in processed foods and ready meals are expected, based on a common EU structure³⁵. Scientific evaluation of progress and their effects on public health will be critical in monitoring the effectiveness of these public health interventions.
- **PUFAs** have other beneficial effects on blood lipids and cardiovascular health¹⁷. Moreover, omega-3 PUFA, in particular intakes of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) also benefit blood pressure³⁶. Other proposed additional benefits for omega-3 PUFAs concern the immune system, reduction of inflammation, glucose tolerance and insulin sensitivity, body-weight control, cognitive function and cancer prevention. Some scientists suggest that today a too-high omega-6 to omega-3 PUFA ratio in typical European diets explains part of the burden from NCDs^{37,38}. This reasoning may influence future dietary recommendations or efforts towards food reformulation, although more research is needed to establish solid causality links.

- The health benefits of **dietary fibre**, such as a lower risk of constipation, diverticulosis, colon cancer, gallstone formation, overweight, hypercholesterolaemia, diabetes mellitus type 2, cardiovascular diseases, and atherosclerosis have long been recognised and have led to recommended intakes of 25–35g/day in the EU and elsewhere¹⁸. Today, dietary fibre intake is based mainly on fruits, vegetables and whole grains. However, there is potential for future food reformulation and development of foods bearing health claims in Europe following the favourable opinion expressed by the European Food Safety Authority (EFSA) related to beta-glucans from oats and barley³⁹.
- The nutrient-health relation is not straightforward for **sugars** (mono- and disaccharides). The suggested implications on dietary energy and nutrient density, on body weight, glucose tolerance and insulin sensitivity, serum lipids, cardiovascular disease, type 2 diabetes and dental caries were all reviewed by EFSA¹⁸. It states that “frequent consumption of sugar-containing foods can increase dental caries” and that intakes of more than 20 % of total energy intake (E %) in the form of sugars may have adverse effects on blood lipids. However, an upper limit for sugar intake could not be established from the available data. Also, for the other proposed health effects EFSA considers the current evidence of a causal link insufficient to set an upper limit. Nevertheless, some authorities, such as those in the Netherlands, United Kingdom or in Northern Europe, recommend limiting daily (added) sugar intake to below 10 E %. The need to reduce sugar intake for public health reasons continues to be discussed³¹. If public health action in the future focuses on reducing sugars in the diet this is likely to influence food product composition and nutrient intake. More scientific clarity on the relationship between sugars and health would benefit future policy decisions.
- In the past, several countries have taken action to reduce dietary **sodium intake**, in particular in the form of salt. Parts of the observed lowering of blood pressure and, via this risk factor, also heart disease, have been attributed to reductions in sodium intake. It is noteworthy that the EU has agreed a salt reduction framework and Member States are now starting to implement measures, which means that results are likely to be seen in the coming years⁴⁰.
- Beyond its established role in bone health in combination with calcium, **Vitamin D** has also been linked to innate and adaptive immune function, inflammation (especially related to obesity), cancer, glucose metabolism and metabolic risk, hypertension, diabetes, cardiovascular diseases, cognitive decline, as well as infectious disease outcomes, including respiratory infections^{41,42}.

³³ WHO/FAO (2008) Interim Summary of Conclusions and Dietary Recommendations on Total Fat & Fatty Acids

³⁴ German Nutrition Society (DGE, 2006): Evidenzbasierte Leitlinie (Evidence-based guidelines, in German)

³⁵ High Level Group on Nutrition and Physical Activity (2012) 15th plenary meeting

³⁶ EFSA Journal 2010 8:1796

³⁷ Ailhaud et al. (2008) Br J Nutr 100:461-470

³⁸ Simopoulos (2008) Exp Biol Med 233:674-688

³⁹ EFSA Journal 2011 9:2207

⁴⁰ European Commission DG Health and Consumers (2012): Implementation of the EU Salt Reduction Framework

⁴¹ Cashman et al. (2011) Br J Nutr 106:1617-1627

⁴² Norman et al. (2010) Exp Biol Med 235:1034-1045

Since there is a risk of acute toxicity from high Vitamin D intake and possible adverse effects of long-term high Vitamin D intake below acute toxicity levels, future research is needed to fill existing gaps in the understanding of Vitamin D's role in prevention beyond those of rickets in children and osteomalacia in adults. Nevertheless, some countries already have mandatory or voluntary Vitamin D food fortification in place and an increasing number of Europeans take Vitamin D supplements, a trend that should be critically monitored.

It is widely accepted that adherence to a balanced and healthy diet, as recommended by various national and international authorities and organisations, would lead to a more favourable nutrient composition of the European diet as well as various health benefits. However, a large number of European citizens regularly consume **processed and ready-to-eat convenience foods, eat out of home in restaurants** and canteens, or are served by **caterers** and **communal canteens**. The extent to which these foods and food outlets can be improved towards a more favourable nutrient composition (e.g. through food reformulation) may well determine whether the future diet of Europeans will be more balanced and beneficial to health. Future challenges may be related to food technology, costs, and sensory or taste properties as well as to reluctance to change stemming from vested economic interests, with consumers sticking to the status quo and the lack of political will on behalf of public and private stakeholders. Lastly, food supplements are being taken by an increasing number of Europeans and may be considered a promising future market for the increasingly health-conscious consumer. Nevertheless, some promised benefits may not stand up to sound scientific scrutiny⁴³ and there may even be risks associated with the regular intake of supplements⁴⁴ that are not widely known or well understood.

1.2 Individual nutrition needs

From the nutrition and health-related issues reviewed above, it may be deduced that the general European population does not follow the recommendations for healthy eating and, as a consequence, has an imbalanced intake of nutrients. However, this reflection raises two issues: what are the nutritional needs of Europeans, and what diets should the increasing number of health-conscious people follow when wanting to choose the best for their own health and well-being?

1.2.1 Nutritional needs of specific population groups

The concept of average nutritional needs of a general population has little meaning given the **heterogeneity of the population** with respect to age, sex, genetic background and physiological condition.

Moreover, nutrient requirements also vary widely between individuals within any such sub-groups. In fact, particularly amongst the elderly, variability in both functional capacity and energy expenditure appears higher than in younger adults. This is reflected in dietary recommendations for different life stages and gender groups⁴⁵. However, precise data is often lacking, thus requiring interpolations and extrapolations. In this respect, future advances in science may improve dietary reference values and enable more targeted dietary advice. Progress in identifying and systematically applying valid biomarkers in nutritional research is likely to have a particular role to play in the future⁴⁶.

Besides healthy individuals in the 'general population', many people live with some form of ill health, often with **multiple disorders, allergy or intolerances** forcing them to follow special diets or making it impossible for them to consume certain foods. Similarly, **medication** can also interfere with appetite, nutrient bioavailability, energy and nutrient metabolism, etc.

People with endocrine, nutritional and metabolic diseases are often restricted in the foods they can eat. In particular, inborn errors in metabolism can affect basically every part of nutrient metabolism. Such errors are quite rare individually, but when considered as a group are estimated to affect 1 in 1000 individuals. **Special diets and supplements** are often used in their treatment as supportive therapy⁴⁷.

It is very difficult to get sound data on incidence of **food allergy or intolerance**, as concluded in a recent meta-analysis, due to big differences in study data and between assessments ranging from self-reported hypersensitivity to objective measurements such as skin prick test (SBT) or IgE assessments⁴⁸. Figures for self-reported hypersensitivity to any food ranged from 3 to 35 %, from 4 to 6 % for IgE assessment and from 7 to 17 % for SBT measurements, with similar orders of differences for intolerance/allergy to milk, eggs, peanuts, fish and shellfish. Notwithstanding the high uncertainty in the data, the high self-reported prevalence of food allergy gives an indication of the dimension of this challenge since this reflects probably the part of the population that will respond in their food choice and diet composition.

An important and **increasing amount of food is eaten out of home**. Studies have shown that for voluntary out-of-home eating (e.g. restaurants), diets tend to be too high in fat, saturated fats and sugars and too low in fibre, calcium and vitamin C^{49,50}. Other, less voluntary forms of out-of-home eating, such as food given to

⁴³ Rizos et al. (2012) JAMA 308:1024-1033

⁴⁴ Bjelakovic et al. (2007) JAMA 297:842-857

⁴⁵ EFSA Journal (2010) 8:1458

⁴⁶ Intern. Life Sciences Institute (ILSI Europe) – Marker Initiative in Nutrition Research (accessed in July 2012)

⁴⁷ Encyclopaedia Britannica – Metabolic Disease (accessed in July 2012)

⁴⁸ Rona et al. (2007) J Allergy Clin Immunol 120:638-46

⁴⁹ Orfanos et al. (2009) Eur J Clin Nutr (2009) 63: S239-S262

⁵⁰ FP6 'HECTOR' project report (2009) Current and optimal out-of-home dietary patterns of European consumers

children and adolescents in day-care or education facilities, have been the focus of past research and policy interventions⁵¹. There still appears to be a significant **unexploited potential for delivering better foods and diets** to patients, the elderly, the disabled and people in need of food aid. For example, in 2010, more than 18 million people in participating EU Member States received food through the EU's 'Food for the most deprived programme'. In the past, because of legal constraints, Member States could not distribute certain foods, including fruit and vegetables, fish or meat, in their national programmes. The legal base changed in 2012⁵² and, as a result, from the 2012 annual plan onwards Spain, for example, will also distribute olive oil, pulses, canned tuna, fruit juice, canned fruit without added sugar, and canned green beans together with more 'traditional' cereal-based products.

1.2.2 Special diets and eating disorders

Due to the variation in nutritional needs of the respective individual, recommendations for a healthy diet can only provide **general advice** concerning the combination of foods or groups of foods in the context of existing dietary habits. Pending the EFSA's development of European food-based dietary guidelines⁵³, EU Member States either follow their own recommendations or refer to those of other sources. Most of them include general advice, such as to:

- i) eat a varied diet;
- ii) increase fruit and vegetable intake;
- iii) eat plenty of cereal products (preferably whole grain) and potatoes;
- iv) frequently consume milk and dairy products, preferably reduced-fat alternatives,
- v) moderate intake of meat and meat products;
- vi) limit consumption of sugary and salty products;
- vii) drink enough (preferably water and unsweetened liquids);
- viii) aim to keep or achieve a healthy bodyweight and follow an active lifestyle⁵⁴.

The effectiveness of adherence to such recommendations in preventing chronic diseases has been repeatedly and convincingly shown in the scientific literature – in some cases, the benefits of diet and lifestyle interventions were even more effective than pharmacological treatment and persisted beyond the intervention period, such as for diabetes^{55,56} and cardiovascular diseases^{57,58,59}.

Nevertheless, many people seek a **diet that is healthy or fulfils other purposes**, such as weight loss, environmental sustainability, animal welfare, religious rules, or is based on other reasoning (scientific or otherwise). The dietary patterns that result from these concerns may have advantages over average current dietary practices, in particular if these are varied or mainly plant-based diets, although they can also lead to nutrient deficiencies, especially if practised for extended periods and imposed on vulnerable groups such as children⁶⁰.

Across the EU, **weight-loss diets** are a growing market in which people are often confronted with aggressive promotions of special diets, such as high-protein low-carbohydrate or the opposite, low-fat diets or diets based on blood groups, etc. While numerous publications can be found to prove or disprove these diets, evidence from long-term studies with solid study designs show no difference in weight loss from different macronutrients in isocaloric diets^{61,62,63,64}. Rather, it is the individual's behaviour that is essential to successful weight loss⁶⁵. Those studies also show little difference in other secondary health parameters, such as blood lipids or insulin sensitivity. However, recent epidemiological studies have associated increased cardiovascular risk with low-carbohydrate diets among Swedish populations^{66,67}.

While the science of **personalising diets** based on genetic or metabolic testing is still largely in a phase which is too early to translate the findings into sound personalised nutrition recommendations, the market already offers – and an increasing number of people are also looking for and following – personalised recommendations. Media and popular science books have their share of the many different and often contradictory diet recommendations that reach the public. There is a growing interest among the population in the role of diet in managing their own health. Therefore, it is highly desirable to ensure consumers can access truthful and science-based dietary information and education.

1.3 Food safety

Current EU legislation and precautionary measures are effective in maintaining the low risk of **food-borne diseases or non-biological contaminations** in the food chain. The latest RASFF (Rapid Alert System for Food and Feed) report⁶⁸ refers to 3812 original notifications, mostly triggered either by controls at the outer European

⁵⁵ Diabetes Prevention Program Research Group (2002) *N Engl J Med* 346:393-403

⁵⁶ Diabetes Prevention Program Research Group (2009) *The Lancet* 374:1677-1686

⁵⁷ Vartiainen et al. (2010) *Int. J. Epidemiol.* 2010 39:504-518

⁵⁸ Valsta et al. (2010) *Public Health Nutr* 13:932-938

⁵⁹ Aspelund et al. (2010) *PLoS ONE* 5: e13957

⁶⁰ Sabaté (2003) *Am J Clin Nutr* 78 (suppl):5025-75

⁶¹ American Society for Nutrition (accessed in July 2012)

⁶² Shai et al. (2008) *N Engl J Med* 359:229-41

⁶³ Foster et al. (2010) *Ann Intern Med* 153:147-57

⁶⁴ Sacks et al. (2009) *N Engl J Med* 360:859-73

⁶⁵ Foster et al. (2005) *Am J Clin Nutr* 82:2305-55

⁶⁶ Pagona et al. (2012) *Br Med J* 2012:344

⁶⁷ Johansson et al. (2012) *Nutr J* 2012:11-40

⁵¹ European Commission DG Health and Consumers (2010) Implementation progress report of the Strategy for Europe on nutrition, overweight and obesity-related health issues

⁵² Regulation (EU) N° 121/2012 of the European Parliament and of the Council of 15 February 2012 amending Council Regulations (EC) N° 1290/2005 and (EC) N° 1234/2007 as regards distribution of food products to the most deprived persons in the Union

⁵³ EFSA Journal (2010) 8:1460

⁵⁴ For example, see recommendations from Germany (10 Regeln der Deutsche Gesellschaft für Ernährung e.V.) or the United Kingdom (Food Standards Agency Nutrient and Food-Based Guidelines for UK Institutions)

Economic Area (EEA) borders or by official controls in the internal EU market. In 2011, the most frequent hazard to health notified in RAASF was the presence of **aflatoxins** in both feed and foods. This threat is likely to continue or even increase since climate change might cause an increase in the mycotoxin and plant toxin content of foods.

In 2010, as reported by the EFSA⁶⁹, a total of 5262 food-borne outbreaks were reported in the EU, causing 43 473 human cases and 25 deaths. Most of the reported outbreaks were caused by **Salmonella**, **viruses**, **Campylobacter** and **bacterial toxins**. The most important food sources were eggs and egg products, mixed or buffet meals, and vegetables and products thereof. The number of outbreaks caused by vegetables and vegetable products has increased compared to previous years although the number of salmonellosis cases in humans has decreased over the past six years in a statistically significant manner. It should be noted that the numbers only reflect those cases that were reported and may therefore be an underestimate of the actual cases of food poisoning. While they may provide some reassurance, strict controls are needed, as the 2011 Shiga toxin-producing *E. coli* outbreak has shown. This was one of the largest food-borne outbreaks reported in Europe in decades and was linked to more than 50 deaths⁶⁸.

When considering food safety, the use of antibiotics in farming animals is also important. These are used not only to treat infections but also to prevent disease and promote animal growth. Their (over)use has been linked to increased antibiotic resistance to (human) pathogens and although health authorities are moving towards tighter regulation on the use of antibiotics on farms⁷⁰, antibiotic resistance may still linger on farms even after the drugs have been discontinued⁷¹. Fraudulent adulteration of food products will probably remain a concern as some feel that economic conditions and a higher cost of living may promote such practices⁷². A closer look at water and the safety of drinking water may also be needed, in particular regarding long-term exposure to low levels of chemicals.

In addition, the **emergence of novel infectious agents and zoonotic diseases** must be considered. Animals are an important source of infectious agents: about 75 % of new diseases that have affected humans over the past 10 years have originated from animals or products of animal origin⁷³. Many of these are food-borne or can be transmitted through direct contact or proximity to edible animals. Previous outbreaks of transmissible spongiform encephalopathies or avian influenza illustrate the importance of zoonotic diseases.

1.4 Socio-economic aspects

Health is largely determined by the socio-economic, cultural and environmental conditions in which we live. Although EU citizens today live, on average, longer and healthier lives than previous generations, the Union is faced with an important challenge: the **inequalities in health** which exist between and within EU Member States⁷⁴. Research has shown that health inequalities are mainly caused by higher exposure of lower socio-economic groups to **low income, health risks in the physical environment, psychosocial and behavioural risk factors**⁷⁵. In particular, inequalities in mortality from cardiovascular disease account for almost half of the excess mortality in lower socio-economic groups in most countries. This is particularly severe in vulnerable and socially excluded groups, such as people from some migrant or ethnic minority backgrounds, the homeless or the disabled.

Food-related ill health may contribute to this phenomenon. The diets of low-income groups are more likely to be inadequate because they often have problems gaining access to a variety of healthy, safe and nutritious foods⁷⁶. In 2006, an estimated 43 million people in the EU-25 faced **food poverty** or were at least at risk of it^{52,77}. Food poverty is defined as people eating what they can afford, and often results in poor diets which, in rich countries, increases the risk of developing obesity, cardiovascular disease and other NCDs⁷⁸. Food poverty is even more critical for vulnerable population groups, such as children, adolescents, pregnant and lactating women, as they have greater physiological needs, or those suffering from the impaired bioavailability and metabolism of nutrients, such as older people and those with a disease.

There are indications that **health inequalities may be growing** in the EU. As a result of the persistent economic crisis, the purchasing power of many is decreasing, unemployment in the EU reached 11 % in 2012⁷⁹, and social benefits have been reduced. It remains to be seen how this situation will affect food choice, diets and lifestyles and, as a consequence, the health of Europeans. Possible increases in food prices, in particular for cereals, meat and dairy products, could further aggravate the situation for the lower income layer of society⁸⁰.

⁷³ EFSA Zoonotic diseases (accessed in October 2012)

⁷⁴ Communication from the European Commission on Solidarity in Health: Reducing health inequalities in the EU COM(2009) 567 final

⁷⁵ UK presidency of the EU (2006) Report: Health Inequalities: Europe in Profile

⁷⁶ Robertson, A. (2001) Public Health Nutr 4: 1371-1373

⁷⁷ European Parliament (2006) P6_TA(2006)0125 Declaration on supplying approved charities working to implement the European food aid programme for the most deprived

⁷⁸ Food Ethics Council (2012) Food Poverty (accessed in June 2012)

⁷⁹ Eurostat (2012) Statistics in focus: Populations and social conditions

⁸⁰ European Commission (2008) COM(2008) 321 final, Communication on "Tackling the challenge of rising food prices Directions for EU action"

⁶⁸ European Commission (2011) The Rapid Alert System for Food and Feed, Annual Report

⁶⁹ EFSA Journal (2012) 10:2597

⁷⁰ Gilbert, N. (2012) Nature 481:125

⁷¹ Pakpour et al. (2012) Microb Ecol 63: 41-50

⁷² BBC news 16 March 2012 Why you might want to look a bit closer at what you're eating

1.5 Progress in science, technology and medicine

Understanding the relationship between diets and health is not a simple exercise and the field of nutritional sciences often witnesses controversies and conflicting evidence. One of the reasons that may underlie seemingly contradictory data is the inherent **genetic differences** between individuals and populations and how these may result in very different responses to nutrients. Equally confounding may be epigenetic differences (induced prenatal or post-natal) and the microbial composition of the **gut flora**^{81,82}. Understanding the interactions between these factors and our response to foods is an emerging field, although the rapid development of genomic (and other -omic) tools and sciences predict important advances in this area. Whole genome analyses are becoming increasingly available and now allow for a deeper understanding of gene/metabolism interactions (both in terms of macro- and micronutrients). Tailor-made dietary recommendations and personalised nutrition counselling are already available to the consumer. However, given the lack of solid data behind these recommendations, they are still met with scepticism by most experts. This is likely to change as research efforts shed light on individual responses to foods and diets.

There are indications that food taste and food acceptance can be influenced early in life. Individual acceptance towards the taste and texture of foods seems to be partly determined by inherited willingness and moderated by cultural background. Modelling and flavour conditioning may contribute to a better understanding of the mechanisms influencing food acceptance, and could support effective health-promotion programmes⁸³.

Future advances in nutrition science will probably pinpoint some solutions to the food-related health problems we are facing today. For example, **stronger preventive measures** could come from clearly identifying dietetic 'culprits' in target populations and limiting them in diets (e.g. salt, sugar, trans and saturated fats). The opposite approach, i.e. exploiting the beneficial properties of some foods or their components and promoting their consumption is equally valid. Moving towards understanding the **physiologic responses to nutrients** at the individual level may mean adapting preventive public health measures to target individuals rather than whole populations. It is also likely that we will witness further developments in and the increased uptake of **therapeutic drugs** (e.g. anti-obesity drugs) and **medical devices or interventions** (e.g. bariatric surgery) for diet-related health issues. For example, the market for obesity treatments is expected to more than double (and even triple in the US) between 2012 and 2019⁸⁴. Therapeutic drugs can be taken as pills or capsules or – as is already the case – extracted from foods or given together with foods (e.g. cholesterol-lowering products). The existence

of effective therapies for food-related illnesses may, however, have an important drawback. Knowing that a 'cure' exists may reduce even further the likelihood that people will follow healthier dietary and lifestyle patterns. The reimbursement of such treatments may also be controversial and will determine the extent of their uptake.

The use of foods and diets as vehicles for delivering health-promoting (or disease-preventing) agents is already practised today via **functional or bioactive foods**. There are currently 222 authorised health claims in the EU⁸⁵. The numbers illustrate the interest in the market but also the great potential for its development. In this context, **nanotechnology** is a promising technology although there is still work to be done concerning the evaluation of the safety of certain nano-sized materials. Nanoparticles can be used, for example, to enhance nutrient delivery or as contamination sensors. The application of nanoparticles to improve texture and flavour may also have health implications as they can be used to improve stability, for spreadability (replacing fats) and also to enhance flavours like salt or sweet or to block bitter tastes. Furthermore, the continuous discovery of new natural or artificial food additives can also promote the consumption of healthier foods by, for example, providing or enhancing pleasurable tastes and/or blocking and modifying unpleasant ones.

The **genetic modification** of crops has so far resulted in few applications targeting the consumer. Apart from the potential to increase food production and reduce hunger, genetic modification could also contribute to healthier diets. Golden Rice is probably the most popular and controversial example (modified rice with higher levels of β -carotene to help prevent vitamin A deficiency)⁸⁶, but there are many other potential applications for the technology, such as the enrichment of tomatoes with health-promoting anthocyanins⁸⁷. In addition to genetically modifying existing foods, the introduction of **new foods** must also be considered. **Insects** as an additional source of proteins are the focus of investigation⁸⁸ and there are examples of commercially viable insect or worm caterers, such as Don Bugito in the US⁸⁹. Algae also have great potential in the development of new foods either as foods per se or for the production of food commodities such as oils, protein and starch. The health implications of the introducing these foods into Europe are not clear, but it is worth noting

⁸¹ Arumugam et al. (2011) Nature 473:174-180

⁸² Snedeker (2012) Environ Health Perspect 120:332-339

⁸³ Harris (2008) Curr Opin Clin Nutr Metab Care (3):315-9

⁸⁴ Driscoll, P. (2012), MEDCITY news: Trends in obesity treatment going in different directions in the US vs. Europe

⁸⁵ European Commission DG Health and Consumers - EU Register of nutrition and health claims made on foods (accessed in July 2012)

⁸⁶ Tang et al. (2008) Am J Clin Nutr 89, 1776-1783

⁸⁷ Butelli et al. (2008) Nat Biotechnol 26, 1301-1308

⁸⁸ European Commission (2011) FP7 Cooperation Work Programme: Food, Agriculture and Fisheries, and Biotechnologies

⁸⁹ Don Bugito webpage (accessed in July 2012)

that grasshoppers, caterpillars and several algae species are part of the diet in other parts of the world. *In vitro*, laboratory-produced **meat** may be another viable alternative source of animal protein which is currently being explored⁹⁰. The technology should allow for the fine-tuning of the meat nutrient composition to create a healthier profile.

2. Consumers

What food we consume determines to a great extent how healthy we are (see Chapter 1). Even though most people seem to know, more or less, what combination of foods make up a healthy diet, many do not apply this knowledge in their daily lives. Numerous factors influence diet and lifestyle choices, and although interconnected, can be broadly divided into two categories: those that are external, shaping the environment around the consumer, and those that stem from the consumer and influence interactions with the environment.

2.1 The European consumer

The **heterogeneity** between different EU Member States, as well as the differences observed on a regional level, make it inherently **difficult to describe a single, representative European consumer**. Therefore, the following general demographic and economic characteristics are to be taken as indications.

The **EU population** is projected to increase only slightly from 502 million in 2010 to about 526 million in 2040, before declining until 2060 to reach 517 million. Developments are not equal across the different Member States: for example, the strongest population growth is projected in Ireland (+46 %), Cyprus (+41 %), the United Kingdom (+27 %) and Belgium (+24 %), and the sharpest decline in Bulgaria (-27 %), Latvia (-26 %), Romania and Germany (both -19 %). In addition, the EU population is **ageing** and the number of people over 65 will almost double in the next 50 years (to 152.6 million in 2060), with the numbers of those aged 80 or more almost tripling (from 23.7 million in 2010 to 62.4 million in 2060), thus becoming as numerous as those in the 0-14 years group (12 % and 14 % respectively). This will result in demographic old-age dependency of 52.5 % by 2060, up from the current 26 %⁹¹.

The EU consumer is mainly a city dweller – **75 % live in urban environments**, and this is expected to rise to 80 % by 2020⁹². According to Eurostat⁹³, **each household in the EU-27 has on average 2.3 persons**, and the average **age for leaving the workforce is 61.4 years**⁹¹. The average **unemployment rate is 12.0 %**, ranging between 4.9 % (AT) and 5.3 % (DE) to 26.2 % (ES) and 27.6 % (EL)⁹⁴.

Another important characteristic is the consumer's economic power, which can directly affect the choice of food purchases. In 2012, the EU-27 average gross domestic product (GDP) in Member States ranged between 47 % (BG) to 263 % (LU)⁹⁵, while the **GDP at market prices expressed as purchasing power standards (PSS) per inhabitant was EUR 25 600 and EUR 27 700 on average for the EU-27 and the euro zone respectively in 2012**, but ranging from EUR 12 100 (BG) to EUR 67 100 (LU)⁹⁶.

Adding to the inherent variation is the movement of EU citizens between Member States (2.5 % of the total EU population), as well as the number of **immigrants coming from regions and countries outside the EU** (4.0 % of the EU population)⁹⁷, who may have different dietary needs and preferences. Figures for 2008 indicate Morocco, China, India, Albania and Ukraine as the main countries of origin, but any political and environmental crisis could easily change that picture⁹⁸.

Finally, the education level of the EU consumer is another important characteristic to consider. In 2010 in the EU, **79 % of people aged 20-24 had completed at least an upper secondary education**, while **26.7 % of consumers aged 24-64 held a university level qualification**. The latter figure has increased since 2000⁹⁹.

2.2 The consumer environment

The current consumer environment is an **obesogenic** one, i.e. it promotes or favours, either directly or indirectly, the spread of the obesity epidemic (see Section 1.1). It is characterised by energy-dense foods and increasing portion sizes coupled with non-active lifestyles. The **access to foods** that constitute a healthy diet depend not only on the **physical presence** of those foods in retail or catering services but also on how **affordable** they are to the average consumer **in terms of price**¹⁰⁰. Often, the less healthy food choices, such as ready meals, vending-machine snacks or fast foods, are cheap and readily available, while fruits and vegetables may not be available in the vicinity, therefore incurring extra cost in terms of time and money. The decrease in the number of purchases from small grocery stores, as a result of consumer preference for super- and hypermarkets¹⁰¹ (Fig. 2.1), may result in fresh foods not being readily available in the immediate vicinity of low-income

⁹⁰ Post, M. (2012) Meat Sci 92, 297-30

⁹¹ European Commission (2012) The 2012 Ageing Report

⁹² European Environment Agency (2006) Urban sprawl in Europe

⁹³ Eurostat - Number of persons in households web page (accessed in July 2013)

⁹⁴ Eurostat - Harmonised unemployment rate (accessed in July 2013)

⁹⁵ Eurostat - GDP per capita, consumption per capita and price level indices (accessed in April 2013)

⁹⁶ Eurostat - Gross domestic product at market prices (accessed in July 2013)

⁹⁷ Eurostat - Migration and migrant population statistics (accessed in June 2012)

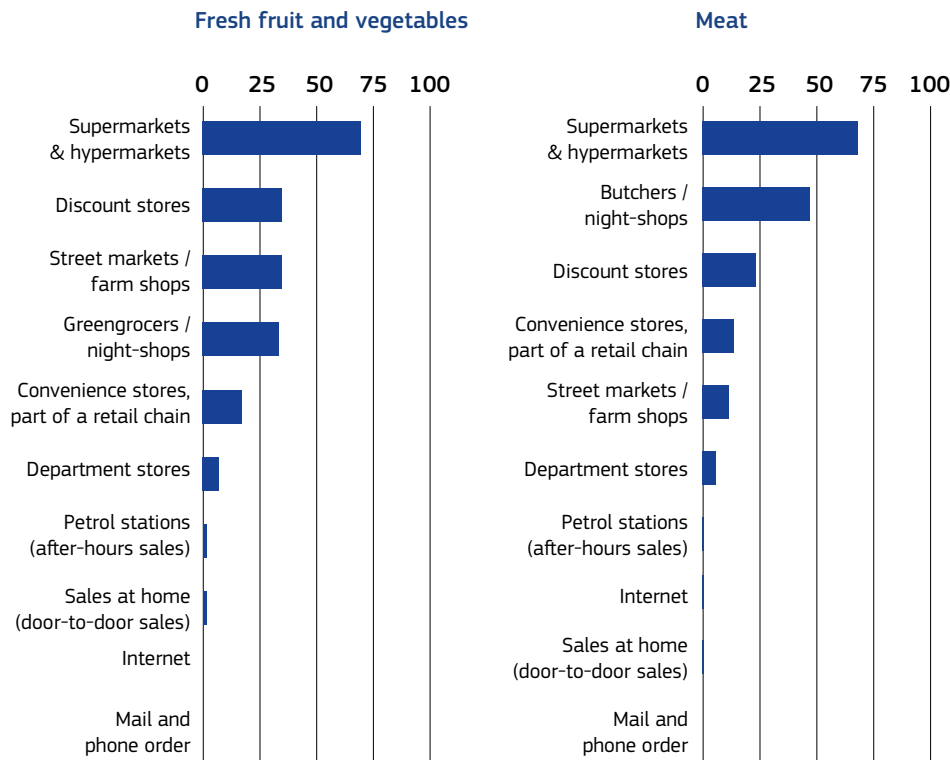
⁹⁸ Eurostat (2011) Migrants in Europe

⁹⁹ Eurydice Network and Eurostat (2012) Key Data on Education in Europe 2012

¹⁰⁰ Ericksen, P. (2008) Global Env Change 18:234-245

¹⁰¹ Eurostat (2009) Consumers in Europe

Fig. 2.1: EU consumer shopping location preferences (%), EU-27, 2008 (Source: ¹⁰¹, page 133)



neighbourhoods¹⁰², creating the so-called ‘**food deserts**’. This is already happening in the United States, although the situation in the EU is less clear. With the advent of **mass media** in the last century and the **explosion of internet-based communications** over the last two decades, the information directed at or made available to the consumer has increased dramatically to the point of creating an **overload of information** and an **overexposure to advertising**. Food labelling is also providing consumers with an increasing volume of information. In addition, the liberalisation of world trade and the European single market have both increased the volume of products and information now available. However, this **plethora of information** on diets and well-being **does not correlate with increased nutritional literacy**. On the contrary, lack of information about what we eat and what constitutes a healthy diet, as well as the accessibility of contradictory and confusing information account for 43 % of the reasons that make a healthy choice difficult for consumers¹⁰³ (see Fig. 2.4).

This overexposure to information often leads to **misinformation, confusion** and **false beliefs**. In addition, dubious ‘**trendy**’ diets and drastic or easy solutions focusing on **losing weight** (20 % of EU citizens were on a diet during 2006¹⁰³) find fertile ground in consumers who are increasingly **wary of nutrition-related disorders** such as obesity. In spite of the above, EU consumers claim to understand the basics of a healthy diet (Fig. 2.2)¹⁰³, and 66 % (ranging from 25 % in BG to 79 % in the NL) actually

think that it is easy to eat a healthy diet. However, this understanding is not sufficiently translated into behaviour, judging by the high number of overweight and obese individuals in the EU (see Section 1.1.2).

Nutritional misinformation in particular can confuse and steer consumers away from healthy diets and lifestyles. Mass media, such as the press, radio and television, rarely provide enough context so that the consumer can correctly apply the advice offered¹⁰⁴. In addition, the expansion of web usage has led to quasi-scientific, semi-anonymous **nutritional advice and opinions of questionable value**¹⁰⁴. The European Commission aims to increase citizens’ awareness of consumer issues^{105,106} in order to **empower them** and help them **make the healthy choice**. A recent survey revealed that 70 %, 60 % and 50-60 % of consumers feel confident, knowledgeable/well informed and protected by consumer law, respectively, while revealing geographical divisions within the EU, whereby consumers from Northern Europe feel more empowered than Southern Europeans¹⁰⁷. As regards **food labelling**, the main obstacles preventing consumers from reading and understanding the nutrition-related information on food packages is the **lack of both attention and motivation**. Health-conscious consumers are more likely to focus on and understand food labels¹⁰⁸.

¹⁰² US Department of Agriculture (2009) Economic Research Service - Access to Affordable and Nutritious Food: Measuring and Understanding Food Deserts and Their Consequences
¹⁰³ European Commission (2006) Special Eurobarometer 246: Health and Food

¹⁰⁴ Wansink (2006) J Am Diet Assoc 106:601-607
¹⁰⁵ European Commission DG Health and Consumers (2006) Factsheet on Consumer education
¹⁰⁶ European Commission (2012) Working document on knowledge-enhancing aspects of consumer empowerment
¹⁰⁷ European Commission (2011) Special Eurobarometer 342: Consumer empowerment
¹⁰⁸ Flabel (2012) Food Labelling to Advance Better Education for Life - results leaflet

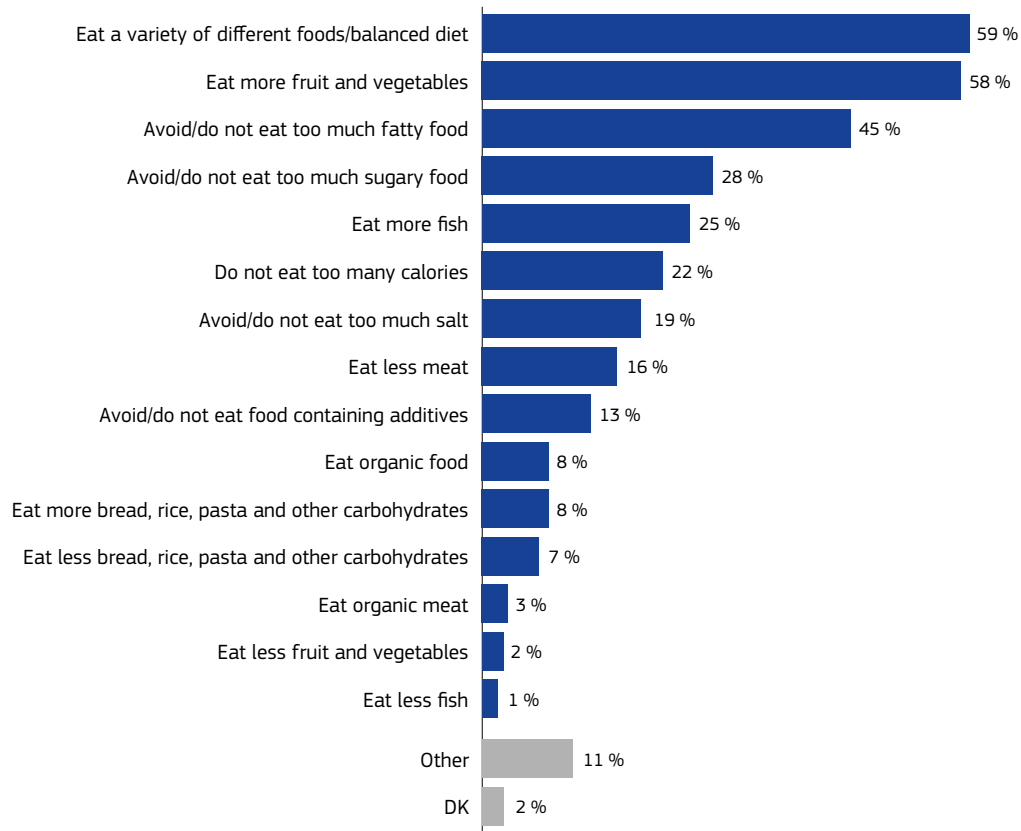


Fig. 2.2: ‘What constitutes a healthy diet?’ EU consumer responses (%), multiple answers possible (Source: ¹⁰³, page 19)

The private food sector provides information directly to consumers, either via direct **advertisement**, promotional material and campaigns or on labelling (food packaging, menus). In addition, advertisement in schools and to **sensitive population groups**, such as children, plays an important role in shaping current and future consumer beliefs and habits. In the media, strategies such as product placement “have created an environment in which children and adults are assaulted with visions of eating and drinking that are creating global shifts in food demand”¹⁰⁹. **Television advertising** features child-oriented persuasive techniques: “most advertisements promote unhealthy foods, high in total energy, sugars and fats, and low in nutrients”¹¹⁰. Internet-based media are also employed by the private sector to **indirectly influence consumers**, e.g. through social networks focused on products or company websites featuring games for kids. Authorities at the EU or national level have imposed rules to protect the most sensitive consumers, such as children, and regulate the information flow¹¹¹. However, to date no such control has been possible for the internet, which is being used more and more for information searching¹⁰⁶ related to shopping (27 % of consumers) and online shopping (18 % visit online shops), online information provision, and e-health services and applications.

Consumers’ **economic purchasing power** is another major factor influencing the accessibility of healthy diet components. The percentage of household budget dedicated to food and non-alcoholic beverages provision is not homogenous throughout the EU-27¹⁰¹ (Fig. 2.3). Consumers from countries with less purchasing power seem to spend a higher proportion of their budget on food and drink. In addition, during periods of **economic depression** the consumers’ purchasing power is reduced, so food expenditure may need to be cut, resulting in cheaper and perhaps poorer dietary choices.

In a study examining the effect of the 2008 Iceland economic crisis on consumer health behaviour, it was found that health-compromising behaviour (e.g. smoking, heavy drinking, consumption of sugared soft drinks, sweets and fast food) was reduced. In addition, certain health-promoting behaviour increased (e.g. consumption of fish oil) while others decreased (e.g. consumption of fruits and vegetables). Prices seemed to play a large role¹¹².

Various non-governmental, **bottom-up social initiatives**^{113, 114}, counter-movements and approaches have also been implemented to dampen the effects of economic depression on food availability.

¹⁰⁹ Popkin et al. (2012) Nutr Rev 70:3-21

¹¹⁰ United Nations Human Rights Council (2011) Report submitted by the Special Rapporteur on the right to food, Olivier De Schutter

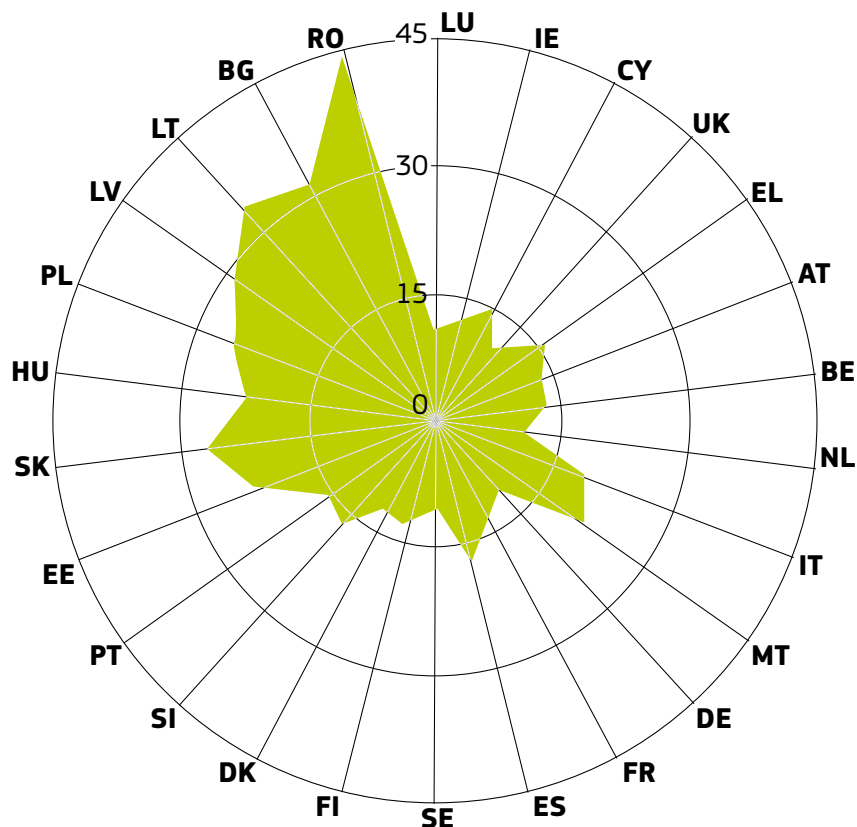
¹¹¹ European Commission (2010) Directive 2010/13/EU Audiovisual Media Services

¹¹² Ásgeirsdóttir et al. (2012) Nat Bur Econ Res, working paper 18233

¹¹³ Henley, J. (2012) The Guardian ‘Special series report: the ‘Potato Movement’ in Greece (accessed in June 2012)

¹¹⁴ The Last Minute Market movement in Italy (accessed in June 2012)

Fig. 2.3: Percentage of household budget spent on food and non-alcoholic beverages in EU countries 2005, CZ not available (Source: ¹⁰¹, page 143)



2.3 Diets and lifestyle

Our society is characterised by sedentary lifestyles where **convenience, time and low prices** have become priorities, as evidenced by the spread of the fast-food and takeaway/delivery sector in recent decades, at the expense of healthy eating habits. In fact, *“the lifestyle of EU citizens seems to be the main obstacle to healthy eating”*¹⁰⁵ (Fig. 2.4), in particular the length of time associated with choosing and preparing a healthy diet, as well as the ‘lack of control’ over what a person eats in the context of food prepared by others or regularly eating out of home (among younger and more active groups). As a consequence, **out-of-home eating** services (fast foods, catering) are important players in determining our dietary options. Out-of-home eating in general is associated with sedentary lifestyles, an increased intake of total energy, fat and sugar, and a lower intake of micronutrients^{115, 116, 117}. Fast food in particular has been linked with both, increased energy intake and portion sizes^{118, 119}.

In the EU, the time allocated to **food preparation at home** varies between 11 minutes and 97 minutes¹⁰¹. For comparison, the average US citizen

spends 75 minutes eating and drinking, and 34 minutes preparing food and cleaning up each day¹²⁰. Spending less time **preparing food at home** may have other, unforeseen, side effects for the younger generation, such as reduced nutritional and food literacy¹²¹, and perhaps even less understanding of the basic principles of good hygienic practices for preparing food at home. In addition, novel, post-modern ways of preparing food (e.g. the so-called “molecular cuisine”), while currently representing a niche environment that few may be interested in or can afford, could take on a more mainstream aspect in the future and change our dietary habits, directly influencing our eating frequency, portion sizes or energy/nutrient intake.

Cultural differences play a role in the way out-of-home eating is done or perceived: in Southern Europe, as a leisure weekend activity where the food choice differs from home cooking as against during-the-week out-of-home eating, similar to in-home cooking, in Northern Europe²⁰. Restaurants in particular affect our dietary habits: portion sizes, availability of vegetables on the menu, caloric labelling and prices can all influence consumer behaviour.

Ageing is one of the key determinants affecting consumer lifestyle. Mental and physical decline changes eating, and more generally, consumption

¹¹⁵ Orfanos et al. (2009) Eur J Cl Nutr 63:5239-262

¹¹⁶ Lachat et al. (2012) Obes Rev 13:329-346

¹¹⁷ Orfanos et al. (2007) Publ Health Nutr 10:1515-1525

¹¹⁸ Rosenheck, R. (2008) Obes Rev 9:537-547

¹¹⁹ Bowman et al. (2004) J Am Coll Nutr 23:163-168

¹²⁰ US Department of Labor - Bureau of Labor Statistics (accessed in June 2012)

¹²¹ EUFIC (2010) From Farm to Fork: Food and the Consumer, A Shared Responsibility

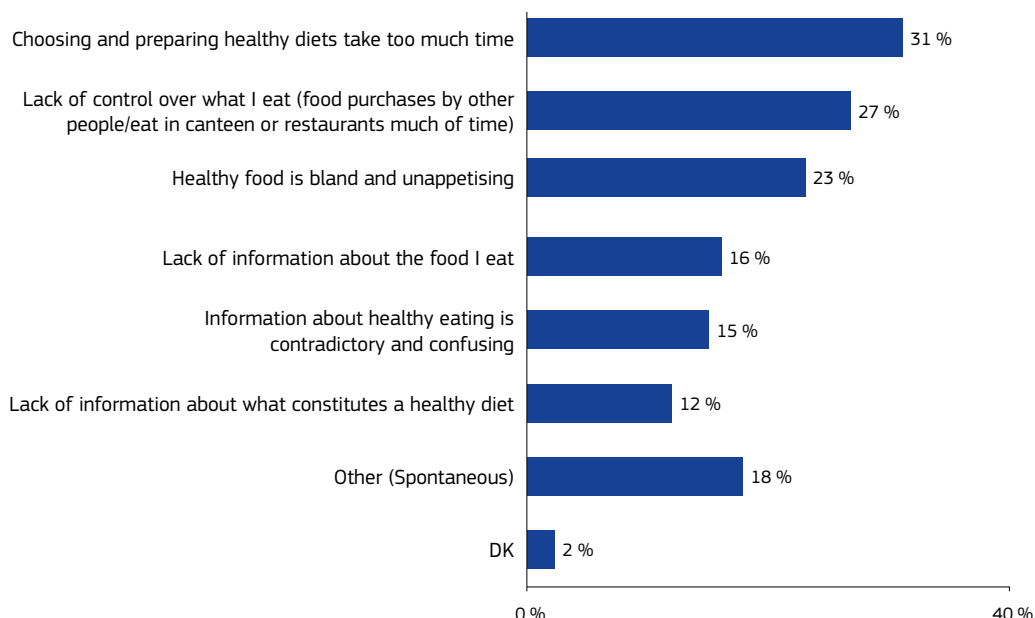


Fig. 2.4: 'What makes healthy eating difficult?' EU consumer responses (%), multiple answers possible (Source: ¹⁰³, page 27)

behaviour. It can physically impede the ability to eat and to be physically active, as well as reduce the perception of taste and the will-power required to adhere to a healthy lifestyle. This applies especially to the institutionalised elderly, over 70 years old, who are often undernourished (30-65 %). Suggested ways of improving nutritional status in this sub-population are: (i) adapting the social context of a meal; (ii) appropriate nutritional care; and (iii) ensuring the palatability of nutrient-rich foods (i.e. they need to be tasty)¹²². The direct social environment also has an effect on the eating habits and lifestyles of the elderly, e.g. social isolation is associated with nutrient deficiencies.

Apart from ageing, our societies are also characterised by **consumerism**, i.e. purchasing goods in larger quantities than needed and beyond what may be environmentally sustainable. This is related to prosperity and could potentially change according to consumers' economic situation. Coupled with this phenomenon, **wasting food** is having a serious impact on household resources, besides its negative effects on the sustainability of the food system – 50 % of edible foods are wasted in the EU, nearly half of which occurs at the household level¹²³.

Currently, 12 % of the EU population live in one-person households, while over 4 % are single parents¹²⁴. Although few in number, all projections concerning future household structures for developed countries foresee a drop in the average number of people per household and an increase in the percentage of single parents. As a result, in future **changing household** structures¹²⁵ might lead to different eating habits and lifestyles.

2.4 Consumer needs, preferences and expectations

Unlike preferences, consumer needs concerning diet and health are fundamental and refer to access to **safe, sufficient, affordable** and **quality** food. Consumer requirements in the EU go beyond safety or quantity as the availability of food (in kcal/person/day) is currently sufficient¹²⁶ and worldwide hunger is declining and will continue to decline, at least until 2050¹²⁷. Therefore, an important consumer need for Europeans is to have **healthy diets and foods** that deliver adequate amounts of macro- and micronutrients. Although **micronutrient deficiencies** are not a major public health concern in Europe, they do exist¹²⁸.

In addition, certain groups in society have increased needs for specific nutrients and require **specialised nutrition**, e.g. the elderly, people with **specific diseases** (including **obesity**), allergies, lactating women, and children (see Section 1.2.1).

Furthermore, there is a need for clear, **non-misleading information on nutrition and health claims**¹²⁹ and what constitutes a healthy lifestyle and eating pattern in general.

The most important factors for consumers when shopping for food are **quality** and **price**, followed by appearance/freshness, **taste** and **health**¹⁰¹ (Fig. 2.5). Obviously, since health is also both a need and a preference for the consumer, there is a large and growing market for products that contribute, or claim to contribute, to improving health, as illustrated by

¹²² Van Staveren et al. (2011) J Am Coll Nutr 80: 429s-437s

¹²³ European Commission DG Environment (2010) Technical Report: Preparatory Study on Food Waste Across EU 27

¹²⁴ OECD (2008) The Future of the Family to 2030

¹²⁵ German Institute for Economic Research (2007) Research Note: Household Patterns

¹²⁶ WHO European health for all database (HFA-DB) (accessed in June 2012)

¹²⁷ FAO (2012) Food outlook towards 2050

¹²⁸ European Commission, Joint Research Centre (2012) How can science support policy makers in addressing nutritional challenges of Europe? EUR25165EN

¹²⁹ EFSA (2012) Health claims: looking beyond the label (accessed in June 2012)

a report on the emerging functional-food market in the US¹³⁰, or by 44 000 health-claim applications submitted to the European Food Safety Authority (EFSA) for evaluation.

Taste has always been a major motivation for selecting (or not) a certain food¹³¹. Foods high in sugar, fat and salt tend to have the highest hedonic (liking) rankings. In addition, the lack of taste seems to be an important factor that makes choosing a healthy diet more difficult (Fig. 2.4), especially for the youngest (27 %) and the oldest (25 %) consumers¹⁰³.

The **price** of food is important and the demand for cheap foods is likely to increase following the financial crisis that has affected many European economies. When measured per calorie, unhealthy diets seem to be cheaper, as the current perception seems to imply. However, a recent report commissioned by the US Department of Agriculture (USDA) showed that when the price is based on the “*edible weight*” or “*average portion size*” the **cost of a healthy diet** is much lower¹³².

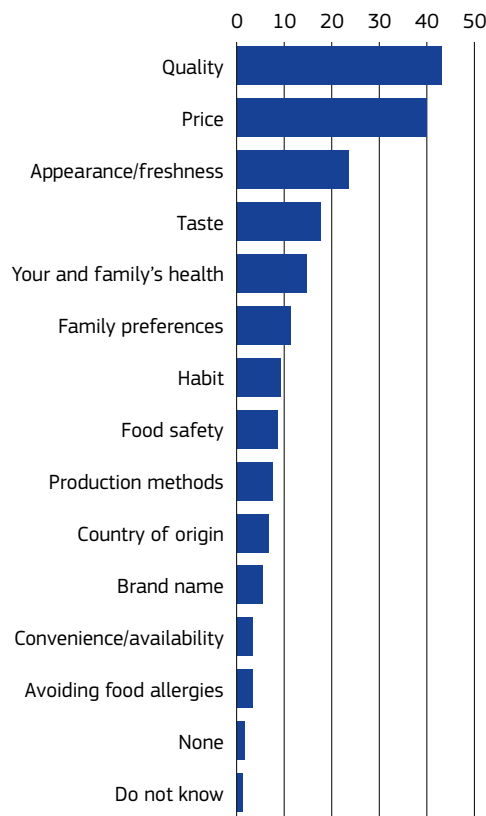
Food safety is another factor influencing consumer choice (Fig 2.6). In 2010, consumers perceived a possible “*risk of food damaging one’s health*” as being “*very likely*” (11 %) and “*fairly likely*” (37 %). The latter is an 11 % increase

compared to 2005¹³³. Another motivation in food selection is **convenience** which often reflects healthier options as such products are processed (refined grains, added sugar, lower micronutrient content) and designed (prepared, packed and marketed) for immediate consumption and, as a consequence, provide easy access to calories. **Online shopping** for groceries is an upcoming type of convenience that is expected to grow in popularity in the coming years¹³⁴.

Foods and diets in Europe can have strong **cultural** or **traditional roots**, and can be **regional** or **national**. This is reflected by the number and variety of protected geographical indication (PGI) and protected designation of origin (PDO) specialised food products, varying between 90-250^{101,135} in countries like France, Italy, Greece, Spain and Portugal. Even though European diets may have strong traditional roots, **foods and diets are changing** with time and may become less healthy as they deviate from the original, e.g. the **Mediterranean diet**¹³⁶. In addition, there is a demand for **variety**, in parallel with consumer expectations to be able to buy their favourite products all year round. **Family preferences** or **habits** were also mentioned as factors for food selection. New dietary styles have been introduced by non-EU **immigrants** and in some cases diets may also have **religious roots** (kosher, halal).

Ethical factors are becoming more important in consumers’ buying decisions¹³⁷. Among these are **sustainability**, e.g. the slow food movement¹³⁸, ‘localism’/km-0 foods produced locally, **animal welfare**, **organic foods** or **fair trade** foods (aiming to ensure honest prices for local producers, such as banana, coffee and cocoa farmers). Worldwide ethical consumerism is forecast to grow at 10 % and 25 % per year until 2015 for organic and fair trade foods, respectively¹³⁹. In addition, ethical foods currently command higher prices, although these margins are expected to narrow because of high consumer demand and the entry of multinational food companies into this market. The latter could pose a risk to the credibility of ethical foods, due to their reputation and marketing approaches¹³⁹.

Fig. 2.5: Factors that consumers take into account when buying food (%), EU-25, 2005 (Source: ¹⁰¹, page 134)



¹³⁰ PricewaterhouseCoopers (2009) Leveraging growth in the emerging functional foods industry: Trends and market opportunities
¹³¹ International Food Information Council Foundation (2011) Food & Health Survey
¹³² US Department of Agriculture (2012) Economic Information Bulletin No.96 - Are Healthy Foods Really More Expensive? It Depends on How You Measure the Price
¹³³ European Commission (2010) Special Eurobarometer 354: Food-related risks
¹³⁴ Food Navigator USA Article (29/08/2012) - Online grocery shopping still small, but growing rapidly, says Nielsen (accessed in August 2012)
¹³⁵ European Commission DOOR database: list of PDO/PGI products
¹³⁶ Vardavas et al. (2010) Eur J Cardiovasc Prev Rehab 17:440- 446
¹³⁷ Hainmueller et al (2011) Consumer demand for the fair trade label: Evidence from a multi-store field experiment. Social Science Research Network
¹³⁸ Slow Food movement website (accessed in June 2012)
¹³⁹ Australian Government Rural Industries Research and Development Corporation (2012) Ethical Foods: International situation assessment, opportunities and threats; RIRDC Publication No 11/147

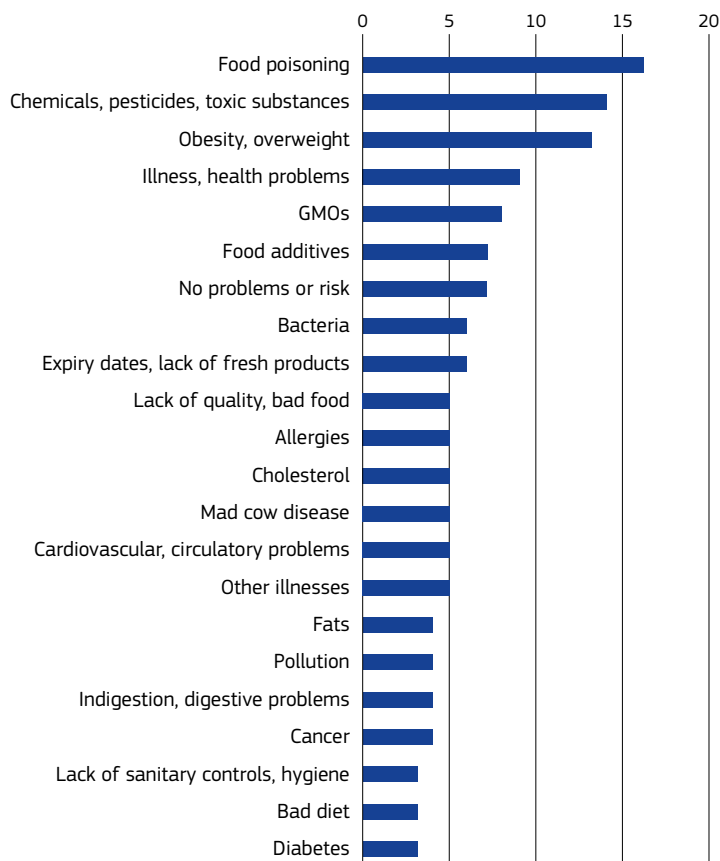


Fig. 2.6: Consumer perception on food-associated risks (%), EU-25, 2005 (Source: ¹⁰¹, page 155)

2.5 The psychology of food choice

In economic considerations, it is assumed that people usually act rationally to maximise the benefits of their actions. However, **humans are not always rational and are prone to biases** when it comes to behaviour. The certain immediate **hedonic pleasures** from eating and drinking but also smoking or being inactive often outweigh the possible, but long-term burden from chronic diseases, prolonged disability or a poor well-being appearing later in life¹⁴⁰. Still, the decision to choose short-term gratification over long-term health benefits also includes rationality: people make trade-offs when deciding what to eat, with health not necessarily being the driving force. Such rational choices include buying more of a food when it becomes cheaper, buying convenience food when time is an issue, giving less weight to health, and discounting distant possible negative consequences at a young age¹⁴¹. It is therefore important to understand the **psychology of food choice** and to know how it can play a role in improving diets and contributing to weight management and health.

Food choice involves considerations such as **what, how much, where and with whom**, and might **develop and change over time**¹⁴². Understanding food choice is complex and involves many disciplines, including **biology** (including genetics), **psychology**,

sociology, anthropology, economics, marketing, history and medicine. One of the difficulties is that research into food choice often tends to study the impact of the different factors in isolation¹⁴³. The first thing that comes to mind when people think about food is **taste and pleasure**, followed by **hunger and health** in third and fourth place¹⁴⁴ (Fig. 2.7). The innate preference for energy-dense foods, associated with **sweet taste** and **fatty texture**¹⁴⁵, is considered a **biological** mechanism related to energy regulation. This makes sense from an evolutionary point of view within the scope of survival in surroundings where food is scarce. The **sensing of fat** has recently been associated with obesity¹⁴⁶: a low taste sensitivity of fatty acids has been related to a higher intake of fat in the diet and a higher BMI¹⁴⁷. Other biological 'signals' are the feelings of **hunger and thirst** linked to a lack of energy and water, respectively. In addition, there is some evidence of the presence of a third system sensing **sodium deficit**¹⁴⁵. The preference for these attributes, presented by **visual cues** as well as **smell**, is a strong subconscious trigger that attracts people to consuming energy-dense foods. The intake of these foods might activate neural pathways similar to those for drugs (dopamine system)¹⁴⁸, which may explain the **craving** for or **addiction** to certain highly palatable foods. Tasty foods can also affect a person's **mood**, thereby influencing (short-term) **well-being**.

¹⁴⁰ Thaler, R. & Sunstein, C. (2008) *Nudge: Improving Decisions About Health, Wealth and Happiness*

¹⁴¹ Grunert et al. (2012) *Trends in Food Sci & Technol* 28 (2): 132-142

¹⁴² Sobal et al. (2006) in *The Psychology of Food Choice* pp. 1-19, Shepherd, R. & Raats, M. (eds.); CAB International

¹⁴³ Shepherd, R. & Raats, M. (2006) *The Psychology of Food Choice* (Preface); CAB International

¹⁴⁴ European Commission (2006) *Special Eurobarometer Risk Issues: Executive Summary on Food Safety*

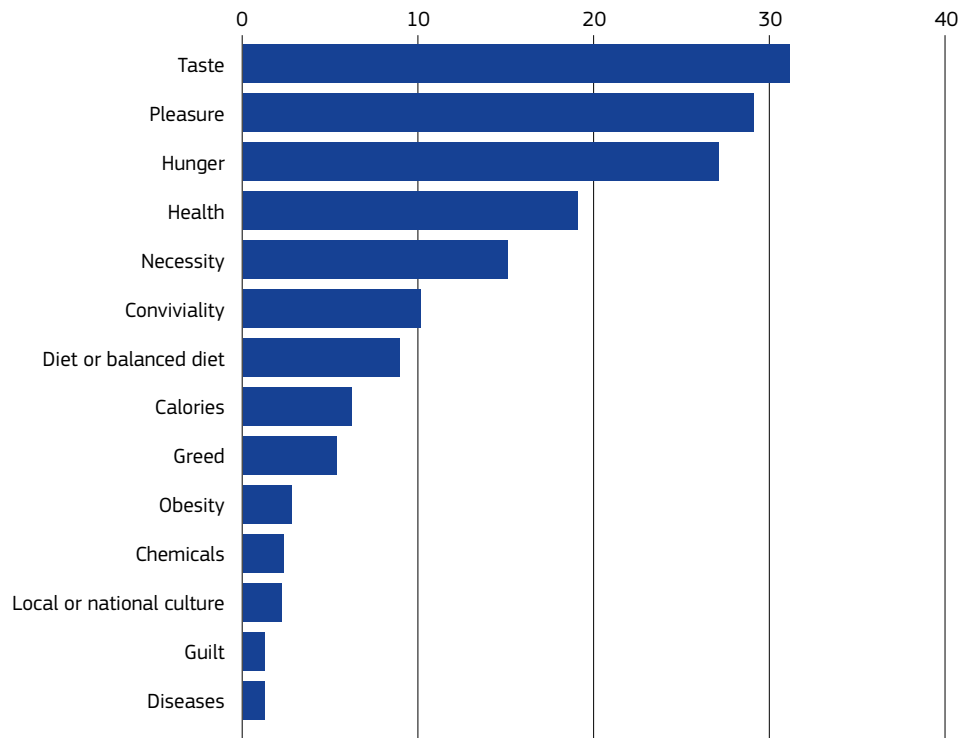
¹⁴⁵ Rozin (2006) in *The Psychology of Food Choice* pp 19-40, Shepherd, R. & Raats, M. (eds.); CAB International

¹⁴⁶ Crow, J. (2012) *Nature* 486:s12-s13

¹⁴⁷ Stewart et al. (2011) *Clin Nutr* 30:838- 844

¹⁴⁸ Avena et al. (2009) *J Nutr* 139:623-628

Fig. 2.7: What words come to mind when EU consumers think of food (%), EU-25, 2005 (Source: ¹⁰¹, page 152)



Most of the research in the field of food **psychology** is about the regulation of food intake and its failure in obesity and eating disorders, and more particularly on meal onset and termination. Important aspects include the **degree of hunger**, the **amount of food available**, **palatability**, **variety**, the **social setting**, the **occasion**, **cultural** rules about appropriate amounts to eat, times to eat, **time** and **competing activities**, as well as **memory** of recent eating¹⁴⁵.

Behaviour is influenced by **attitudes** (what is the individual's belief about the consequence/outcome), **normative beliefs** (what is the individual's belief about what his/her social surroundings think), and **control beliefs** (the perceived ease or difficulty of performing the particular behaviour/self-efficacy)¹⁴⁹. Eating and living healthily might be well understood and looked upon positively (attitude), but the ease of performing accordingly (self-efficacy) might be overvalued as people seem to overestimate their fruit and vegetable intake and underestimate their fat consumption¹⁵⁰.

A factor related to our biological instinct is the **fear of hunger**, i.e. running out of foods in times of crises, and is based in human primal instincts. An increase in food price and the subsequent worry that foods will become inaccessible has been associated with social unrest conditions that can trigger riots¹⁵¹.

Eating disorders have been associated with an obsession concerning the consumption of either very little (anorexia) or excessive (binge eating, bulimia) amounts of foods, or even only eating foods perceived as pure and healthy (orthorexia). Recent

trends show stability in the incidence of eating disorders in Europe¹⁵², although there are reports that 'Westernisation' spreads eating disorders (e.g. among Asian women in America).

Recently, policy-making options have emerged¹⁵³ that take into account insights from consumer behaviour and **behavioural economics** in particular, and may present **alternative options** for the future, considering how traditional policy-making has failed to curb major public health issues, such as the obesity epidemic.

3. Food retail and service

Until reaching the final consumer, food passes through various food and beverage retailers or **food consumer services** like hotels, restaurants, canteens, etc. Within the food and beverage retailers, the general distinction is made between **specialised retailers** (such as bakers or butchers) and **non-specialised retailers** (grocery stores, supermarkets). Traditionally, consumers travel to the retailer to buy products over the counter or by self-service; however, they can also choose to order via the internet or phone. A key component of ongoing food system changes is the **industrialisation of retailing** linked to new developments in packaging, distributing, selling, trading and cooking food^{154,155}.

¹⁴⁹ Ajzen, I. (1991) *Organ Behav Hum Decis Process* 50: 179-211

¹⁵⁰ Hebert et al. (2008) *J Nutr* 138:2265-2345

¹⁵¹ MIT Technology Review (2011) *The Cause of Riots and the Price of Food*

¹⁵² Currin et al. (2005) *Br J Psychiatry* 186:132-135

¹⁵³ Bovens, L. (2012) *Eur J Risk Regul* 1:43-46

¹⁵⁴ Lang et al. (2004) *Food Wars: The Global Battle for Mouths, Minds and Markets*. Sterling, VA, London

¹⁵⁵ Popkin et al. (2012) *Nutr Rev* 70(1):3-21

3.1 Concentration in the retail sector

In recent years, the trend has been to give consumers the opportunity to do the majority of their shopping (including both food and non-food commodities) under one roof, which is a process often called supermarketisation or hypermarketisation)^{156, 157, 158}. This is leading to the **disappearance of local, independent grocers** who cannot benefit from the cost advantage of a centralised purchasing system and are thus less price-competitive. The speed and current stage of this process across the EU Member States depends on the maturity, the cultural or the geographical characteristics of the local market¹⁵⁹. In 2008¹⁵⁶, in the EU as a whole, **non-specialised retailers accounted for 86.1 % of turnover** for the retail sale of food, beverages and tobacco. Between 2004 and 2009, the number of small local grocery shops (with less than 10 employees) fell by 3.7 %¹⁶⁰.

Another principal trend in food retail in recent years has been the tendency to consolidate, leading to an **increasing domination by the major owners**. In most EU Member States, the market share of the top three retailers ranges from 30 % to 50 %¹⁵⁷. Northern Europe has higher concentration levels (up to almost 90 % of the top three retailers' market share in Denmark and Finland) than Southern or Eastern European Member States (e.g. from 23 % market share of top three retailers in Italy to nearly 40 % in Portugal). However, since the 1990s, the degree of concentration in Eastern Member States has grown rapidly (in 2010, the market share of the top five retailers was 21.8 % in Poland and 42.1 % in the Czech Republic)^{157, 158, 161}.

Although 'traditional' supermarkets are the leading retail outlets in the euro area (over 33 % of grocery sales), the large retailers pursue diversification and multi-format strategies. The discount format is becoming increasingly successful – for instance, in Germany **discounters** achieved 41.3 % share of sales in 2010 and 46.6 % share of all outlets in food retailing in 2011 (a 9.5 % increase since 2006)^{159, 161}.

After years of increasing average store sizes, the past few years have seen the growing popularity of small food stores within urban environments. Large retail chains diversify their store formats and develop **small-format convenience stores** that attract customers with the ease of shopping and proximity¹⁶¹. They have emerged in response to changing consumer lifestyles and shopping patterns¹⁶². A shift to smaller stores, with no room for unproductive inventory items, is also seen as one of the potential consequences of urbanisation¹⁶³. Smaller store formats are more effective in attracting niche consumer segments and can be more easily tailored to meet various demands¹⁶².

Implications of the consolidation and **expansion of retail chains** are significant for consumers, manufacturers and producers alike. The food supply

and value chains are often illustrated by a funnel whose bottleneck represents a small number of companies that **control the dynamics of the whole industry**¹⁶⁴. An example is the case of the major UK retailers which effectively blocked the market for genetically modified products by deciding not to stock them in response to consumer concerns¹⁵⁵.

3.1.1 Impact on suppliers

A key element of supermarkets' competitiveness is the modernization of procurement in order to allow a large reduction in costs and prices. This transformation covers **centralisation of procurement**, the decline of the traditional wholesale system (vertical integration of the wholesale and retail level), and the shift to the use of preferred supplier systems (lists of farmers and food processors)¹⁵⁹.

As a result of a growing control over the agri-food value chain, supermarkets increasingly set up and oblige their suppliers to get certified according to **demanding private standards**. Private standards have emerged in response to strict public regulations shifting responsibility for food safety to the private sector and as a way of product differentiation, making use of consumer demands for safety and quality of food^{165, 166}. They refer to food safety, integrity of food systems, food provenance, environmental impact, social impact, animal welfare etc. and are frequently **more stringent and extensive than public standards**. They are set by individual firms (mainly large food retailers) or by collective organisations operating at national (e.g. British Retail Consortium (BRC) standards) or international level (e.g. International Food Standard (IFS)); however, since they are adopted across the food supply chain, each of them may have an international reach. Their presence has raised several concerns; small producers which supply large supermarkets may have difficulties to meet them (**too complex and too expensive**); they could act as barriers to entry into international markets for developing countries; they could challenge the position of established international public institutions; and they could drive the process of consolidation and integration of the agri-food chain further, thus **enhancing the power of dominant firms**^{165, 166}.

¹⁵⁶ Eurostat (2011) Food: from farm to fork statistics. 2011 edition.

¹⁵⁷ FoodDrinkEurope (2011) Data & Trends of the European Food and Drink Industry

¹⁵⁸ FAO Investment Centre/EBRD Cooperation Programme, Central and Eastern Europe (2005) Impact of Food Retail Investments on the Food Chain.

¹⁵⁹ European Commission (2010) Commission staff working document on Retail Services in the Internal Market SEC(2010)807

¹⁶⁰ European Commission (2010) Retail market monitoring report "Towards more efficient and fairer retail services in the internal market for 2020" COM(2010)355

¹⁶¹ Metro Group (2011) Metro retail compendium 2011/2012

¹⁶² Agriculture and Agri-Food Canada (2010) Global Trends. Grocery Retailing. Implications for Suppliers and Manufacturers

¹⁶³ The Consumer Goods Forum et al. (2011) Future value chain 2020. Building strategies for the new decade

¹⁶⁴ Barling et al. (2009) in European Food Systems in a Changing World. ESF-COST Forward Look. Rabbinge et al. (eds.) IREG, Strasbourg

¹⁶⁵ Smith, G. (2009) Interaction of Public and Private Standards in the Food Chain. OECD Food, Agriculture and Fisheries Working Papers 15, OECD Publishing

¹⁶⁶ Henson et al. (2009) The Impacts of Private Food standards on the food chain and on public standard-setting processes. Paper prepared for FAO/WHO

Retailers increasingly contract manufacturers to produce goods that are sold under the retailers' brand name or as a white label product¹⁵⁹. Currently, Europe is the world leader in **private-label** sales with a share of 23 % in 2009 (40 % in UK, 35 % in Germany)¹⁵⁷. Traditionally, these goods have been perceived as a lower-price and lower-quality alternative to branded products. However, over time their quality has improved and they are frequently developed as sophisticated product lines targeting consumers focused on gastronomic quality, health, environment or social values. For supermarkets, private labels provide **higher profits** than national (i.e. producers') brands, and because they also **create loyalty to a particular supermarket chain** rather than to a national brand¹⁶⁷. For manufacturers, their emergence means greater investment in strengthening the position of their own brand or producing private label products for major retailers following their stipulations, without any **recognition among consumers**. Sometimes branded manufacturers produce private-label products to make use of excess capacity at their own production plants.

The big food retailers put cost and quality pressures on food manufacturers and producers. Issues of concern are **imbalances in the negotiating power** between large retail groups and food suppliers that may lead to abusive exercise of market power (and, for example, unfair business practices such as charging manufacturers fees for display, retroactive changing of contracts, etc.)¹⁶⁸. These result in increased competition and the exclusion of many small producers, whereas large multinational food manufacturers of must-stock products remain less affected (retailers may in fact have a weak bargaining position in relation to suppliers of must-stock items¹⁶⁷). Recently, the multi-stakeholder High Level Forum for a Better Functioning Food Supply Chain tackled business-to-business contractual practices and developed a set of good practice principles on vertical relationships in the food supply chain¹⁶⁹.

3.1.2 Impact on consumers and diets

From the consumer perspective, the rise of supermarkets means lower prices, wider selection of products (including year-round supply of seasonal and exotic products) and greater product safety. It also results in a general **upgrading of the supply chains** in terms of efficiency, innovation, product quality and consumer orientation¹⁵⁸. The positive dietary implications include making a more diverse diet available and accessible to more people. However, the **greater availability and variety** of food products at lower prices offered by big retailers may lead to both convenience and confusion, and to **excessive caloric intakes**, especially by less affluent consumers¹⁷⁰.

¹⁶⁷ European Commission DG Enterprise and Industry (2011) The impact of private labels on the competitiveness of the European food supply chain

¹⁶⁸ European Competition Network Subgroup Food (2012) ECN activities in the food sector: Report on competition law enforcement and market monitoring activities by European competition authorities in the food sector

On the other hand, the growing consolidation trend raises concerns about the secure supply of nourishing food, particularly for disadvantaged groups. A decline in the number of stores can lead to inequalities in access to food, especially affecting those for whom the proximity of shops is of greatest importance (the elderly, disabled, socially isolated, living in sparsely populated areas, those who cannot afford a car, etc.)¹⁶¹. A WHO report on food and health in Europe¹⁷¹ mentions the business practice of some large retail chains adjusting their prices and range of food according to store location¹⁷¹ and depending on the level of competition within local shopping areas¹⁶¹. This may result in restricted access to healthier (e.g. low-fat or low-sugar) versions of foods at a reasonable price in low-income neighbourhoods¹⁷².

To attract customers and increase sales, supermarket operators use **marketing practices** such as introducing larger portion sizes for a minimal price, buy-one-get-one-free promotions, price discounts, fidelity schemes like the distribution of coupons and loyalty cards, and even store layouts are designed specifically to promote greater purchasing (e.g. optimised length of aisles, placing items that are often bought on impulse near the entrance, music, aromas, etc.)^{173,174}. Customers may consume more of the products they purchase on promotion, and may be **enticed to consume more** than they intend. Frequently, promotional strategies are targeting the most responsive audiences, especially **children** (e.g. certain items are placed at the children's eye level near the checkout)^{173,174,175}.

Supermarket operators determine the range of foods made available, shelf space allocation, pricing of different types of foods, style of promotion, etc. These factors can significantly affect customers' purchasing decisions^{171,176}. The focus frequently given to 'value-added' **processed food** categories is of particular concern because this may encourage the consumption of energy-dense, nutrient-poor, highly processed foods (see also Chapter 4)¹⁷⁴. The cost of packaged, processed foods can be cut more easily due to their ease of handling and stocking and the efficiency of dealing with large suppliers. Nevertheless, there is also a tendency for some supermarkets to include a **specialist retail offer** suited to specific consumer segments, including minimally processed products which are healthy, sustainable, fresh, organic, etc.

¹⁶⁹ High Level Forum for a Better Functioning Food Supply Chain (2011) Vertical relationships in the Food Supply Chain: Principles of Good Practice

¹⁷⁰ FAO (2007) Report of the panel of eminent experts on ethics in food and agriculture

¹⁷¹ Robertson et al. (eds.) (2004) Food and health in Europe: a new basis for action. WHO Regional Publications European Series 96

¹⁷² WHO Regional Office for Europe (2008) WHO European action plan for food and nutrition policy 2007-2012

¹⁷³ Witkowski, T. H. (2007) J Macromarketing 27(126):126-137

¹⁷⁴ Hawkes, C. (2008) Dev Policy Rev 26(6):657-692

¹⁷⁵ United Nations Human Rights Council (2010) Report submitted by the Special Rapporteur on the right to food, Olivier De Schutter A/HRC/16/49

¹⁷⁶ Glanz et al. (2012) Am J Prev Med 42(5):503-512

It is debatable whether supermarkets' activities respond to consumer preferences or whether they **shape and create consumer demand**. Generally, they encourage consumers to buy and thus to **consume more**¹⁷⁷.

3.1.3 Globalisation

The supply chains for food products are extending beyond national borders as a result of **trade liberalisation**, which has facilitated cross-border mergers and **foreign direct investments**. Drivers of food retail globalisation include saturation of local markets, search for suppliers offering the best price, and the growing sophistication of consumers¹⁵⁴. The European retail grocery industry is expanding and entering different geographical markets. In addition to current global players, there is the possibility of a new generation of globally competitive companies emerging from developing markets¹⁶³. Initially, the large multinational companies operated as if the entire world were a single entity, selling the same things in the same way everywhere¹⁷⁸. However, the strategy that has proved more successful while entering new markets is the customisation of market models and product offers in order to meet **local needs** and preferences¹⁷⁹.

In Europe, global sourcing of food products means that **foods are less seasonal** and diets may be **more diverse** as most products are available all year round. Consumers are encouraged to try **new foods** such as exotic fruits and vegetables that have not featured before in their diets¹⁷⁴. On the other hand, this trend has driven a decline in traditional domestic foods and the standardisation of diets across the globe¹⁷⁵. It also raises concerns associated with imports from countries where **food safety** systems are less developed. The globalisation of the food market and the spread of supermarkets are contributing to a **dietary transition** towards energy-dense diets composed predominantly of highly processed foodstuffs¹⁵⁵.

Counter-trends

Growing interest in the idea of **buying local** is one of the trends opposing the globalisation of the agri-food system. Nine out of ten people surveyed by Eurobarometer in 2011 agree that buying local products is beneficial and that the EU should help to promote their availability¹⁸⁰. Currently, just 20 % of European food production is sold locally because of the focus on large-scale, industrialised food production¹⁸¹. Advocates of buying locally produced food mention economic, social and environmental benefits, such as supporting traditional agrarian structures, restoring the bond between the people who produce food and the people who eat it, and the reduction in 'food miles'^{181, 182}.

This focus on local food reflects the more general tendency to think critically about the food system. There is a wide range of **global counter-movements**, such as the Slow Food movement¹⁸³, questioning the standardisation of food taste and culture, supporting environmental sustainability, or addressing issues around the social justice and power of the food industry multinationals. More customers are willing to pay higher prices for food that is fair trade or organic (see also Section 3.4).

3.2 The food-service sector

Out-of-home consumption accounts for a significant and **growing proportion of European food intake**¹⁸⁴. Food and beverage consumer services generated almost one-quarter of the turnover of the total food, beverages and tobacco retailing in the EU-27 in 2008¹⁵⁶. The food-service sector in the EU-27 is **fragmented** – in 2008, it comprised almost 1.5 million enterprises, typically micro or small in size (almost 70 %) ¹⁵⁶. Restaurants and mobile food services have dominated the sector, accounting for more than half (55.1 %) of all the enterprises in 2009, while beverage-serving activities accounted for 40.6 % of the remaining enterprises, and the share of the event catering and other food-services subsector was below 5 %¹⁸⁵. Food-service sales account for approximately one-third of consumer expenditure on food¹⁸⁶. Nevertheless, the food-service industry has been severely affected by the financial and economic crisis which resulted in a 5.4 % reduction in the volume of EU-27 household expenditure on catering services between 2008 and 2009 compared to a 2.4 % reduction in total food and beverages expenditure¹⁵⁶.

According to 2008 data, the highest numbers of food-service enterprises were located in Spain and Italy (18.4 % and 17.1 % respectively)¹⁵⁶. These were typically small family-run enterprises, while in Northern Europe it has become relatively common to find a number of food and beverage chains (especially in Latvia, Lithuania, Finland and the UK)¹⁵⁶. This trend correlates with the growth of major **fast-food chains** that successfully tapped into the increasing demand for swift, convenient meal solutions at affordable prices¹⁵⁴. In the UK, 50.4 % of all meals eaten out of home were purchased at quick-service restaurants in 2011 (up from 47.3 % in 2009)¹⁸⁷.

¹⁷⁸ Coca-Stefaniak et al. (2010) *Int J Retail Distr Manag* 38(9):677-697

¹⁷⁹ Deloitte (2012) *Switching channels. Global Powers of Retailing 2012*

¹⁸⁰ European Commission (2011) *Special Eurobarometer 368: The Common Agricultural Policy*

¹⁸¹ Committee of the Regions (2011) *EU CoR Press Release COR/11/3*

¹⁸² European Commission (2012) *Proceedings of the Conference 'Local farming and short food supply chains', held in Brussels 20/04/2012*

¹⁸³ Slow Food International webpage (accessed in July 2012)

¹⁸⁴ Watkiss, P. (2009) in *European Food Systems in a Changing World. ESF-COST forward look*. Rabbinge et al. (eds.) IREG, Strasbourg

¹⁸⁵ Eurostat (2012) *Accommodation and food service statistics - NACE Rev. 2* (accessed in June 2012)

¹⁸⁶ European Commission DG Enterprise and Industry (2007) *Competitiveness of the European Food Industry*

¹⁸⁷ Wallop, H. (2012) *The Telegraph*; Fast food becomes the UK's meal of choice

¹⁷⁷ Reardon et al. (2010) in *Trade, Food, Diet and Health: Perspectives and Policy Options*. Hawkes et al. (eds.) Wiley-Blackwell

An increase in eating out has significant dietary implications. These depend on the service providers' decisions about the available menu choices, which are made according to criteria such as cost, preparation time, ease of cooking, storage needs and shelf-life¹⁷⁰. Food can be produced on-site using traditional methods or assembled from standard ingredients including frozen or chilled products.

Generally speaking, food consumed away from the home is associated with a **higher total energy intake**¹⁸⁸. Out-of-home foods are usually richer in fat, including saturated fat, and lower in fibre, micronutrients and overall nutritional value compared to food eaten at home^{154, 188}. This is particularly true for fast-food outlets offering a limited range of easily cooked dishes which can be assembled rapidly from standard ingredients¹⁷⁰. Greater attention has also been paid to the nutritional quality of **food served in public institutions** (health and social services, childcare services, **schools**, workplaces, etc., including vending machines) as they are one of the most important sources of eating out of home in terms of energy intake, especially for schoolchildren^{170, 188}.

In this context, it is necessary to mention the strong marketing power of fast-food chains which is linked to the **promotion of energy-dense and nutrient-poor foods** and unhealthy eating habits (excessive portion sizes) among children¹⁷⁰. Furthermore, the growing importance of the food-service sector and its ability to absorb higher and higher consumer expenditure inspires growing **competition** between food service and food retailing¹⁵⁴. Supermarkets respond to this challenge by introducing more ready-to-eat or ready-to-heat foods, thus also supporting the change in consumption patterns towards more processed food.

3.3 Relevance of information and communication technologies

Use of information and communication technologies (ICT) has been one of the main drivers of change within society and businesses for more than a decade. Innovation in ICT is seen as a way to maintain or increase market shares.

Rise of online grocery retailing

Electronic commerce continues to grow in the EU, but still lags behind the Asia-Pacific region and currently accounts for only 3.4 % of retail sales (food and non-food), with a very uneven distribution among Member States and a North-South divide. Online grocery retailing is a relatively undeveloped sector with 7 % of sales online in 2008¹⁸⁹ (1.5 % of total grocery spend in 2011¹⁹⁰). However, online purchasing is expected to be the **fastest growing** channel in grocery retailing in the next few years¹⁸⁹ (22.1 % growth for online in 2011 compared to 2.5 % growth for total grocery¹⁹⁰).

Mobile and wireless technologies

Growth of online sales is linked to the increasing uptake of consumer technologies. **Smart phones** are emerging as the most dominant consumer technology platform¹⁷⁹ and it is forecast that by 2013 more than 2 billion mobile users globally will have made a purchase via their handsets¹⁷⁷. At present in the EU, m-commerce (electronic commerce conducted from a mobile phone, tablet, etc.) is still less-well developed and its growth is slower than in the US and Japan. Nevertheless, the percentage of EU consumers who visited an online retailer site from their mobile phone increased from 10 % in 2008 to 28 % in 2010 (compared to 41 % in the Asia-Pacific region)¹⁸⁹.

Simultaneously, retailers are extending **supply-chain technology** capabilities¹⁷⁷. Developments such as 2D/matrix/QR (Quick Response) or barcodes, magnetic stripes on credit or loyalty cards, and RFID (radio-frequency identification) tags and readers have not only enhanced supply-chain efficiency (**real-time** visibility into inventory and buying trends) but have also created new levels of communication between retailers and consumers, enabling a more personalised service.

The dissemination of smart phones has been also increasingly supplying customers with personal barcode and RFID readers, too. These lend themselves to **providing information** in a rapid and easy-to-use format whilst shopping, thus becoming the focus of **advertising** strategy as well as providing easy access to more detailed information, for instance, for consumers suffering from food allergies. They are used for enhanced online shopping – for example, in Korea, virtual grocery stores are being set up in the form of billboards with photographs of products and QR codes to scan with the smart phone. The mobile technology is also changing the nature of **checking out, billing and charging** consumers (instant/self-checkout, personalised marketing: coupons and discounts offered based on the purchasing list and loyalty programmes).

Through mobile technologies, retailers can reach consumers anywhere at any time. At the same time, online and mobile technologies create a virtual extension of the storefront where customers can expect and demand **services 24 hours a day**¹⁷⁷. Adoption of consumer technologies will define new service models that move beyond selling individual products to deliver an improved customer experience¹⁷⁹.

¹⁸⁸ Lachat, C. et al. (2012) *Obes Rev* 13(4):329-346

¹⁸⁹ European Commission (2012) Staff working document: Online services, including e-commerce, in the Single Market SEC (2011)1641 final

¹⁹⁰ ResearchFarm Ltd (2012) Online Grocery Retailing in the EU 2012

Use of social media/multi-channels

Adoption of ICT is also of growing relevance to retailers and their suppliers in the context of **multi-channel retailing** (retailing that combines several types of sales channels, such as physical stores, internet, mobile, catalogues, call centres, social networking and digital displays, to reach more and different consumers).

Consumers increasingly identify and use many different channels and sources of information to optimise the different elements of their grocery shopping (e.g. comparison between offer and price)¹⁷⁹. A key element is the **spread of social media** by which consumers get discounts, look for collective buying opportunities (e.g. Groupon) and, above all, influence the buying behaviour of other consumers (reviews, evaluation, **recommendation sites**, etc.). To successfully adopt multi-channel strategies, retailers (and also food-producing companies) will increasingly develop these new tools to reach consumer groups and impact their behaviour by interacting with selected social communities and managing communication on the sites^{177,191}.

Data analytics and personalisation

The multitude of channels through which retailers are interacting with consumers and the spread of ICT amplify the **amount of consumer data** that can be collected. These include analysis of transactions (products purchased, financial records), tracking the physical location of consumers, visits to websites, social media posts, surveys, etc. The increased need to leverage the huge amounts of information about consumers and their shopping behaviour will stimulate further development of customer data analytics solutions and advanced prediction tools^{177,179}. These tools are used to **analyse consumers' behaviour patterns** and **build consumer profiles** to get valuable insights about their expectations and responses to various marketing strategies (promotions, brands, channels, messages, etc.). This information is used to develop **personalised marketing** campaigns, services and customer experiences, for pricing and promotional decisions, and for fostering customer loyalty. Nevertheless, the industry methods for assessing consumer behaviour may also be used by public health researchers and authorities to build strategies promoting healthy dietary patterns¹⁷⁵.

3.4 Other trends shaping marketing strategies

The general trend shaping the food industry is to provide unique products that meet consumer needs. The debate continues as to whether consumer demand influences retailer behaviour or retailers influence consumer preferences through their product selection and marketing. Nevertheless, a number of trends most likely to affect the food industry in the coming years can be identified.

Increased importance of health and well-being

Consumers are paying greater attention to aligning their food choices with a **healthy lifestyle**, a trend (and consumer segment) that is expected to grow significantly^{163,177,192}. There have also been **calls by governments and civil society** aimed at retailers and food caterers to play a greater role in addressing obesity. At the same time, consumers want convenience and to maintain a certain food-related quality of life (i.e. eating habits, food choice, meal patterns, etc.).

Meeting these seemingly contradictory demands is a substantial challenge. To **attract health-conscious consumers**, retailers have been developing nutrition-related activities, such as reformulating and developing healthy lines of own-brand products, introducing front-of-pack nutrition labels, promoting fruits and vegetables, and implementing nutrition-education initiatives (e.g. sponsoring sports events). Fast-food companies have started to declare the nutritional composition of their products, have initiated changes in cooking practices in an attempt to lower fat, salt and sugar levels, have introduced healthier options (e.g. salads with low-fat dressing, no sugar-sweetened beverages) and some portion sizes have been reduced^{170,193}. Nevertheless, many of these initiatives have been criticised for their lack of efficiency¹⁷³.

Growing concern about sustainability

Another trend that will require a response from the sector is an increase in **consumer awareness** regarding sustainability. A major **environmental concern** is **food waste**, resulting from logistical and technical malfunctioning in the retail industry (overstocking, marketing strategies, quality standards), and from issues including portion size, packaging, storage, (lack of) awareness, individual preferences, planning, and socio-economic factors in the food service¹⁹⁴. The retail and wholesale sector is responsible for 5 % and the food-service sector for 14 % of EU-27 food waste.

Particular attention is also increasingly being paid to **societal issues** covering human rights, fair working conditions of food producers, animal welfare, and global food security. These are often extended to topics such as nutrition and healthy lifestyles (responsible marketing, targeting children, etc.). More and more consumers in Europe are willing to opt for fair trade and 'green' products¹⁹². Sustainability issues are also likely to significantly influence the retail sector (new approaches to energy consumption, packaging, transport, logistics, certification, quality control, pricing strategies, etc.) as they are increasingly being seen as a way of keeping ahead of the **competition**¹⁵⁹.

¹⁹¹ Rutsaert et al. (2013) Trends in Food Sci & Technol 30 (1): 84-91

¹⁹² Videira et al. (2012) Background paper on Sustainable Food Consumption and Growth. RESPONDER project

¹⁹³ European Modern Restaurant Association (2008) Our commitments to the EU Platform

¹⁹⁴ European Commission DG Environment (2010) Technical Report: Preparatory Study on Food Waste across EU27

Drive for transparency

Food safety concerns, growing **consumer awareness** (health, sustainability), and interest in how their food is produced and transported, and what it contains, have been driving the demand for food transparency, which is yet another trend facing the retail sector¹⁶³.

A key element of ensuring **food safety** and providing information on food products is food **traceability**. Traceability systems enable rapid and precise food recalls, involving the ability to identify, at any specified stage in the food chain (from production to distribution) where the food came from and where it went (the so-called OUOD: 'one-up, one-down' system). This is crucial for building consumer trust in the safety of the food supply chain. Given the multiplicity of ingredients used to produce foods and their global sourcing, the technologies in current use will have to be improved or replaced to simplify data collection and standardisation and to satisfy an increase in requirements regarding the speed of traceability systems (emerging 'critical tracking events' system)¹⁹⁵.

Information about food products provided through **labelling** and **advertising** has played a major part in **marketing strategies**, offering consumers the possibility to differentiate between products. In the EU, labelling rules are put in place to enable consumers to obtain comprehensive information (ingredients, quantity, durability, allergen content, origin, etc.) and to protect them against claims that could be **misleading** (see also Chapters 4.6 and 6). Nevertheless, possible confusion among consumers resulting from the proliferation of voluntary labelling schemes and lack of convergence between them has become a concern¹⁹⁶. In addition to the tendency to demand and deliver more and more information about foodstuffs, there is also a need for reduction of complexity and simplification of labels¹⁹⁷.

New business models

Along with advances in ICT solutions and the increasing adoption of multi-channel strategies, the physical store is becoming one piece in a larger, more connected and interactive **customer experience** (including activities such as crowdsourcing, competitions, games)^{179, 198}. Store visits will become increasingly **personalised** (personalised promotions, recipe inspirations and advice, etc.), enhanced by tools such as dynamic displays, in-store bars, product tasting and trials, all to attract and retain customer interest^{177, 198}.

To target various needs and preferences, and to remain competitive, retailers must also continue to **diversify** their business¹⁶⁷. In search for more lucrative niches, they are launching specific advertising campaigns or new product lines and providing completely new services. Increasingly, retailers are seeking a competitive advantage in responding to demographic changes such as population ageing or smaller households (e.g. single parents). The current business model might need to

be adapted to better serve the **needs of an older population**, including, for example, providing shuttle transport, improved home delivery services, easier-to-read labels, changes to outlet design (e.g. wider aisles), or developing specific products¹⁷⁷.

4. Food processing and packaging

Processing and packaging food involves the various transformations primary agricultural products (cereals, vegetables, fruits and animals) undergo before they reach the retail market for sale through various distribution channels. All of these activities significantly alter the characteristics of the raw material, making it more palatable and familiar to consumers, and 'adding value' in an economic sense¹⁹⁹.

4.1 Goals, means and consequences of processing

Nearly all food undergoes processing. Historically, the most important reason to process foods was to **preserve** them against spoiling and to ensure the provision of **safe** and **edible** food. Food-treatment techniques have been further developed to preserve and **modify** the organoleptic and nutritional properties of foodstuffs, to provide greater **variety** in food supply, and to maintain or raise **nutrient** levels. Finally, developments in processing technology facilitate delivery of easy, everyday nutrition solutions such as ready-to-eat and semi-prepared foods²⁰⁰. From an industry perspective, the main purpose of food processing is to provide safe and **high-quality** food according to consumer demands, and to add value.

Food-processing technologies

Primarily, processes to preserve foods²⁰¹ include microbial **stabilisation** (destruction of pathogens and inactivation of their natural toxins and enzymes), as well as chemical (against oxidation, Maillard reaction), biochemical (against enzymatic degradation) and physical (against phase separation, loss of consistency, drying, etc.) stabilisation. These are most frequently achieved by using techniques such as pasteurisation, sterilisation, refrigeration, freezing, fermentation, drying, adding salt or sugar (or other preservatives) and packaging.

¹⁹⁵ Welt et al. (2012) Food Traceability. IUFOST Scientific Information Bulletin (SIB)

¹⁹⁶ High Level Forum for a Better Functioning Food Supply Chain (2011) Report on Food Labelling Practices

¹⁹⁷ McGuire S. (2012) Adv in Nutr. (3): 332-333 Front-of-Package Nutrition Rating Systems and Symbols

¹⁹⁸ Gunz, J. (2012) Five industry trends making an impact in 2012. IGD webpage (accessed in July 2012)

¹⁹⁹ Ericksen, P. J. (2007) Global Environ Change 18(1):234-245

²⁰⁰ van Boekel et al. (2010) Mol Nutr Food Res 54(9):1215-1247

Raw materials are converted into foods via a variety of additional **transformation** processes, such as extrusion, hydrogenation of fats, emulsification, extraction, etc., which often significantly alter their appearance, properties and content. Next, food technology is used to extract components or ingredients (starches, flours, oils, fats, sugars, etc.) from raw materials by phase or molecular **separation** processes (filters, membranes, centrifugation, crystallisation, distillation)²⁰¹. Finally, manufactured foods are made from various ingredients, such as products in which some components have been replaced by others (e.g. soya protein substituting milk protein), or ready-made meals²⁰¹. Foods made from combinations of other processed foods and processed food ingredients are called highly processed foods as opposed to minimally processed foods that have not been substantially changed from their raw, unprocessed form.

Nutritional implications of food processing

The principal **beneficial aspect** of food processing is **food safety** and the prolongation of storage life. Next, an important beneficial effect is the enhanced **digestibility** of food and **bioavailability** of nutrients (e.g. denaturation of proteins or gelatinisation of starch facilitates hydrolysis by digestive enzymes). Processing technologies may promote the formation of **desired compounds** (flavours, antioxidants, colouring agents) including health-promoting compounds such as vitamins and bioactive peptides produced during fermentation. The development of industrial processing technologies has enabled the global sourcing of foods, thereby contributing to more **diversity** and less seasonality in diets. Last but not least, processing enhances the **sensory quality** of food and enhances quality of life by offering convenience in the preparation of meals²⁰⁰.

While food processing offers both industry and consumers many benefits, certain aspects raise **nutritional concerns**. Processing may negatively impact on the nutritional value of foods due to the **loss of some essential nutrients**, such as certain minerals or vitamins (e.g. refined grains deprived of iron, losses in activity of heat-labile vitamin C, thiamine, riboflavin, folate during thermal processing). Processing may also adversely **affect a product's satiety properties** (e.g. processed grains are more easily digested and therefore have lower satiety). Moreover, some methods of food and drink modification can trigger the **formation of undesired compounds**, such as carcinogenic heterocyclic amines, trans fatty acids (TFA) or polycyclic aromatic hydrocarbons (PAH) (e.g. when frying meat at high temperatures) or acrylamide (during the intense and prolonged industrial cooking of starch-based foods like crisps, French fries). Some substances used to

preserve food or to enhance its taste, flavour and appearance can also adversely affect human health. Finally, processing practices may have undesired consequences for food quality, such as loss of texture, discoloration, or a negative effect on flavour²⁰⁰. In addition to issues inherent to the technologies being used, food processing poses the risk of food contamination (biological, chemical) in processing plants. In the EU, food-production practices, as well as **food additives and contaminants** resulting from food manufacturing and processing, are regulated by **legislation** to minimise the risks to **food safety**.

Another category of prominent nutritional implications of food processing is related to the growth in consumption of highly (or 'ultra') processed foods and their relative importance within diets. Although **highly processed foods** are not detrimental to health as such, many foods in this category are energy-dense, high in added sugar, sodium, saturated fats or trans fats, grossly depleted of micronutrients, and contain little dietary fibre. The issue is the proportion of diets they occupy. Their frequent consumption **unbalances diets**, leading to nutritional deficiencies or chronic diseases. Highly processed products are formulated to be **convenient** (ready to eat or ready to heat) and **tempting** (appetising, visually attractive and impressively packaged). They are typically branded, very profitable and therefore **heavily advertised** and marketed (also in supersized packages and portions at discounted prices). All these factors may undermine the normal processes of appetite control, encourage **unhealthy eating patterns** and drive **over-consumption** (and obesity)²⁰².

4.2 Packaging goals

Increased industrial processing of food, greater international trade in food products, extra distribution steps, more information on labels required by consumers and legislation, and less time available for preparing fresh foods (more convenience foods) have all contributed to an increase in packaging. Originally, food packaging was simply a container to hold food but over time its **multifunctionality** has grown.

The main function of packaging is **protection from damage** and preservation from external **contamination**. This involves slowing down deterioration, extending product lifetime (**durability**) and maintaining the quality and safety of packaged food. Packaging includes barriers to environmental influences such as oxygen, moisture, flavours, heat, light, pressure, enzymes, micro-organisms, insects, dirt and dust particles, etc.²⁰³. It ensures **containment** (that a product has not been intentionally spilt or dispersed). Packaging is also used for **convenience** (to reduce cooking/preparation time), communicating **information** (labelling), **marketing** and branding (to increase the attractiveness of products), and serves the functionality of the supply chain and distribution (**traceability**).

²⁰¹ de Vries et al. (2009) in European Food Systems in a Changing World. ESF-COST Forward Look. Rabbinge et al. (eds.) IREG, Strasbourg

²⁰² Monteiro, C. (2009) Public Health Nutr 12(5):729-731

²⁰³ Brody et al. (2008) J Food Sci 73(8)

Traditionally, the ideal packaging material had to be inert and able to prevent molecular transfer from or to packaging materials. Nowadays, the concept of **active and intelligent packaging** has emerged, which allows packages to interact with food and the environment and play a dynamic role in ensuring food quality. In the EU, food contact materials should be manufactured in compliance with regulations so that any potential transfer to foods does not raise **safety** concerns, change the composition of the food in an unacceptable way, or have adverse effects on product taste and odour.

4.3 Food industry in the EU

The food industry in the EU comprises around 288 000 companies, provides jobs for more than 4 million people, and is considered to be one of the **main industrial sectors**. The food-processing sector is quite fragmented, with **numerous small- and medium-sized enterprises** (ca. 99 %) but, at the same time, is **dominated by large companies** (1 % of companies provide 52 % of the turnover and 37 % of the jobs)¹⁵⁶.

One of the most important trends is **globalisation**, based on cheap transport and the search for the cheapest mass producers. Although globalisation facilitates the year-round supply of certain foods, at the same time it raises new food safety concerns (e.g. food-borne-disease epidemics, unpredictable nature of food fraud, different attitudes to food safety in different countries) and has put pressure on natural resources. Geographical shifts in food production and new emerging markets have also had an impact on the industry. The EU is a net exporter of food and drink products, but the industry's export market share worldwide has been declining, in favour of emerging economies^{204, 205}.

A related important trend is structural change. Mass production and economies of scale are major elements of being competitive, particularly on a global scale. In addition, the **consolidation** trend within the food industry has been driven by a **shift in control** over the food economy towards **food retailing and service**. Small-scale companies try to remain competitive through more specialisation, serving local markets, and concentrating on regional preferences. Large companies compete on the global market and respond to the power of international food retailers by putting a new emphasis on branding and marketing^{206, 207, 163}.

The food industry is increasingly being challenged by **changing consumer preferences** (due to income developments, shifts in population structure, new lifestyles, more out-of-home and ready-meal consumption, more demand for meat, organic, local, fair trade products, etc.) and regulatory issues (food safety, animal welfare, environmental quality, etc.). As in retailing, the debate continues around the extent to which consumer needs influence industry

and how much food-processing companies influence consumer choice. Other key trends shaping the food industry include a new focus on **health** and nutrition, **sustainability** issues and new **technological developments**.

4.4 Growing importance of health and nutrition

One of the key challenges facing the food industry is the need to react to the greater emphasis **consumers, governments and international organisations** are putting on health and the relationship between diet and disease. Food manufacturers are confronted with **dietary concerns** related to the consumption of highly processed foods (see Section 4.1) and marketing and advertising strategies that encourage unhealthy behaviours (see Chapter 2). On the other hand, this trend also offers an opportunity to capture the **growing market in health-promoting food products**. Health may become both a marketing tool and a commitment²⁰⁷ for companies. The emergence of functional foods and reformulated products and other health-related activities (e.g. sponsoring sports events) come in response to these challenges.

Reformulation

Recently, in the EU, many initiatives have been taken to reformulate foods, led by industry and governments (e.g. WHO European Action Plan for Food and Nutrition Policy and the EU Platform for Action on Diet, Physical Activity and Health)^{208, 209}. Reformulation activities include the reduction of certain nutrients (sodium (salt), saturated fats, industrially produced trans fats, sugars) in processed foods and/or their fortification with other nutrients (vitamins, minerals, etc.), and portion-size reduction. They aim to modify/reduce nutrient and energy intake in diets.

A number of issues affect product reformulations²¹⁰. Reformulation creates **costs** for industry. **Technical challenges** include the need for technologies to drastically reduce sugar, salt and fat without compromising **sensory properties** (taste, texture) and food **safety** (durability, artificial sweeteners). Reformulated products can face a lack of **consumer enthusiasm** (change in taste, reluctance to consume 'artificial' ingredients, perception of decline in quality, higher price). The potential for reformulation is also

²⁰⁴ European Commission DG Enterprise and Industry (2009) High Level Group on the Competitiveness of the Agro-Food Industry: Report on the Competitiveness of the European Agro-Food Industry

²⁰⁵ Robertson et al. (eds.) (2004) Food and health in Europe: a new basis for action. WHO Regional Publications European Series 96

²⁰⁶ European Commission Joint Research Centre (2008) Analysis of the European Food Industry. EUR23247EN

²⁰⁷ Lang et al. (2004) Food Wars. The Global Battle for Mouths, Minds and Markets. Sterling, VA, London

²⁰⁸ WHO Regional Office for Europe (2008) WHO European Action Plan for Food and Nutrition Policy 2007-2012

²⁰⁹ European Commission EU Platform for Action on Diet, Physical Activity and Health (accessed in July 2012)

²¹⁰ Webster, J. (2009) Reformulating food products for health: context and key issues for moving forward in Europe. Working paper on reformulation for health - the way forward

influenced by regulatory issues, such as standards, defining criteria, recommendations and target values for food composition. Finally, although some of these modifications are positive, others may be harmful (e.g. replacing fat with higher sugar content and 'light' products with reduced but still too high energy density).

Functional foods

A functional food is a "food that beneficially affects one or more target functions in the body beyond adequate nutritional effects in a way that is relevant to either an improved state of health and well-being and/or reduction of risk of disease. It is consumed as part of a normal food pattern. It is not a pill, a capsule or any form of dietary supplement"²¹¹. Examples include food in which one or several components have been modified, replaced or enhanced. The list of promising **dietary active compounds** continues to grow (vitamins, carotenoids, fatty acids, synbiotics (probiotics/prebiotics), minerals, trace elements, antioxidant enzymes, etc.) and thus the types and potential applications of functional foods are growing steadily (products for gastrointestinal health, immune function, mental health, physical performance, early development, etc.).

Fortification has been a common strategy in functional food development. Simple techniques, such as formulation and blending, have been used successfully in the control of deficiencies of, for example, vitamins A (fortification of margarine) and D (fortification of milk), and iodine (salt iodisation). The composition of foods may be also modified by breeding or biotechnology (vitamin A-enriched rice, vitamin E-enriched vegetable oils). Technologies are also emerging that aim to improve the nutritional properties of food by preventing the deterioration of physiologically active compounds (microencapsulation, edible films and coatings, vacuum impregnation), although they have yet to become widely used^{211, 212, 213}.

The expansion of functional foods may be further driven by a greater knowledge of **nutrigenomics** (metabolomics, proteomics, bioinformatics, and the development of nutritional markers). This may enable the development of foods for targeted population groups (suffering from allergies, diabetes, cardiovascular disease, etc.) or even foods tailored to individual needs (**personalised nutrition**). Although dietary advice based on DNA is already commercially available (e.g. through numerous internet sites), translation of genetic knowledge into meaningful and reliable dietary recommendations is currently valid in only a few cases (e.g. phenylketonuria, galactosemia – see also Section 1.2.2).

Due to the lack of a commonly used definition and limited data, the EU market for functional food can only be estimated: it ranges from EUR 6 to 20 billion, representing 1-3 % of the total EU food market. However, available information indicates that the **market is growing** and is expected to do so for the foreseeable future²¹⁴. Functional foods

promise health benefits but while some of these **benefits** are well established, the health efficiency of some products remains **unverified**²¹³. Moreover, they have the potential to **mislead** consumers as, for example, fortification of an unhealthy product with micronutrients does not make it healthy, although consumers are led to believe it does²⁰².

4.5 Growing interest in sustainability

The transition towards healthier, and more environmentally friendly and socially fair food is increasingly driving the shift to a more sustainable food supply²¹⁵.

Increased adoption of Corporate Social Responsibility regimes

Food **products tend to become services** more than industrial products, i.e. more focus is put on their non-physical characteristics. Interest in ethical and responsible food consumption is increasing (see Section 3.4). Governments, NGOs and the media together with internet-based social networks are pushing companies to account for the **social consequences** of their activities²¹⁵. Retailers, who are becoming very influential in specifying the requirements of the foods they put on sale, are exerting **pressure** on food manufacturers to adopt sustainable manufacturing processes (see Section 3.1.1)²¹⁶. Finally, companies are looking to make more use of strategic social positioning in the markets. Consequently, sustainable ('green') projects are increasingly not only part of corporate social responsibility (CSR) programmes, but also an **integral element of strategy**²¹⁵.

Environmental sustainability

From an environmental and economic point of view, sustainable food production requires efficient use of resources and minimised waste generation. The food manufacturing industry produces 39 % of EU-27 food waste, resulting largely from logistical or **technical malfunctions** such as overproduction, misshapen products, and product and packaging damage²¹⁷. Minimising waste at the manufacturing level includes strategies such as **reuse, recycling and recovery** (e.g. producing bioenergy from waste and finding uses for by-products)²¹⁸.

Packaging can prevent more waste than it generates by providing protection for and minimising the damage of transported goods and thus

²¹¹ European Commission DG Research (2010) Functional Foods

²¹² Betoret et al. (2011) Trends in Food Sci Tech 22: 498-508

²¹³ Arundel et al. (2009) OECD Journal: General Papers 2009(3):113-207

²¹⁴ European Commission Joint Research Centre (2008) Functional Food in the European Union. EUR23380EN

²¹⁵ European Commission (2011). Sustainable food consumption and production in a resource-constrained world – The 3rd SCAR Foresight Exercise

²¹⁶ Sellahewa et al. (2010) Aspects Appl Biol 102:91-98

²¹⁷ European Commission DG Environment (2010) Technical Report: Preparatory Study on Food Waste Across EU 27

²¹⁸ FoodDrinkEurope (2012) Environmental sustainability vision towards 2030

minimising wastage²¹⁹. For most products and environmental indicators, the share of packaging in the environmental impact of a product's life cycle is less than 10 % (one of the main exceptions being the packaging of beverages)²²⁰. The environmental impact of packaging is being addressed by using biobased materials, biodegradable materials, reusable packaging and recycling of packaging materials²¹⁸ (see Section 4.8). However, currently is number of issues remain to be solved such as low practicability of recycling, confusions related to sorting plastics (e.g. some incorrectly sorted biodegradable packages may contaminate the recycling chain of non-biodegradable materials) or environmental impact of bioplastics over the lifecycle (use of resources, use of hazardous chemicals during production etc.).

Efforts to enhance **resource efficiency** cover sustainable sourcing (supporting sustainable agricultural practices to protect and promote natural resources and biodiversity), improving energy performance (process optimisation and control), cutting greenhouse gas emissions (using by-products and waste as a source of renewable energy, investments in low-carbon technologies), improving water management (improving wastewater quality, water recovery and reuse) and development of innovative packaging materials with improved environmental impact²¹⁸. Resource-efficient food production is challenged by a number of factors, e.g. minimisation of water use has not proved very effective due to the limited use of recycled water (negative consumer perception) and because it is very often cheaper to pay for fresh water than investing capital in water-purification plants²¹⁶.

Another topic of debate is **transport**. Across Europe, food travels increasingly longer distances with the growing number of distribution steps. An immediate and plausible solution for reducing the adverse environmental impacts of transport would be to shift from global sourcing to local production. However, the simple sustainability indicator based on total food kilometres ('food miles' concept) has proven to be inadequate because food imported into an area may be produced more sustainably than locally available food, even if the latter has a lower transport footprint²¹⁹. The adverse environmental impact of transport can be reduced through improved efficiencies in product sourcing, modal shifts, distribution networks, route planning and vehicle choice²¹⁸.

Social justice

In general, the main areas of ethical concern in food production are food and water security,

food safety, nutritional technologies and specific production practices and conditions (animal welfare, environment, fair working conditions, new (bio- and nano-) technologies, etc.)²²⁰. The European market for fairly traded food products is growing – the most frequently sold products being coffee, bananas, orange juice, tea and chocolate. However, the overall market share only represents around 1 %. It is worth noting that fair trade and working conditions are an issue not only for developing nations – European farmers also require fair payment for their produce. Companies can manage ethical workplace conditions by following international standards, such as the Social Accountability Standard 8000 (SA 8000) or the ISO standard for CSR (ISO 26000)²²⁰.

4.6 Informing the consumer

Ethically responsible food production (reformulation, fortification, shift to environmentally friendly or socially just production, etc.) involves investment in both cost and time. Once such an effort has been made, industry seeks to communicate this fact to consumers and to use it as a **marketing tool**. At the same time, consumers search for information about food they want to buy. To support **informed choices**, a label (presentation, promotional campaign) should be scientifically valid, understandable and **not misleading**.

In the EU, the scientific substantiation of **nutrition and health claims** has to be verified by the European Food Safety Authority (EFSA) and approved by the European Commission before they can be used in labelling and marketing²²¹. The recently performed authorisation process has revealed a number of issues related to insufficient levels of characterisation of products/substances (e.g. probiotic products) that claim to bring health benefits, and the lack of a solid scientific foundation for cause-and-effect relationships supporting such health claims. Furthermore, the latest revision of the rules on **nutrition labelling** has created intense debate between industry, governments, consumers and public health organisations over methods for setting up nutritional profiles, defining recommended daily values, the adequacy of GDAs (Guideline Daily Amounts) and colour coding (traffic light) system, consequences of nutrition declaration on a per-portion basis vs. per 100g/ml, and the need for 'front-of-pack' nutrition labelling (currently voluntary), etc. Nutrition labelling and health claims are high on stakeholders' agendas because they **effect consumer perception** of the 'healthiness' of foods and thereby influence purchase decisions and nutritional behaviour.

Another issue concerns the communication of the **environmental impact of a food product**²²². The main difficulty is the lack of uniform environmental assessment methodologies for food and drink, which is related to the high diversity of food commodities and the range and complexity of environmental

²¹⁹ Watkiss, P. (2009) in European food systems in a changing world. ESF-COST forward look. Rabbinge et al. (eds.) IREG, Strasbourg

²²⁰ CORPUS (2010) Discussion paper 1 on Sustainable Food Consumption

²²¹ European Commission DG Health and Consumers: Health & Nutrition Claims; http://ec.europa.eu/food/food/labellingnutrition/claims/index_en.htm (accessed in July 2012)

²²² European Food Sustainable Consumption and Production Round Table (accessed in July 2012)

factors and impacts along the food chain. The existing indicators of food product sustainability include food miles, air freight, the product's carbon footprint, water footprint, etc. However, the validity and method of calculating some of these indicators remain under discussion. The global Ecolabel Index²²³ lists 147 labelling schemes for food. They differ in terms of scope, coverage of different phases of the life cycle, and their relation to agriculture, geographic coverage and certifying criteria. The multi-stakeholder initiative 'European Food Sustainable Consumption and Production (SCP) Round Table' establishes reliable and harmonised environmental assessment methods for food products (the ENVIFOOD Protocol, based on life-cycle assessments). It is also developing recommendations on tools for environmental communication, aiming at preventing the use of misleading claims ('green washing')²²².

4.7 Emerging technological developments in food processing

New technologies, such as microwaving and steam-cooking, have changed the way domestic cooking is performed, including the availability and use of (semi-) finished processed foods in everyday cooking. Food-processing technologies are subject to many changes for several reasons, **safety and productivity** being among the main drivers. An overview of reasons for change is given in Table 4.1.

Push	Pull
TECHNOLOGY <ul style="list-style-type: none"> • High pressure • Pulsed electrical fields • Pulsed light • Irradiation • Ultrasound • Cold plasma 	PRODUCT <ul style="list-style-type: none"> • Quality • Safety • Convenience • Freshness • Extended shelf-life
ECONOMY <ul style="list-style-type: none"> • Cost reduction • Increased productivity • Process reliability • Sustainable production • Availability of raw materials 	CONSUMER <ul style="list-style-type: none"> • Healthy diet • Well-being • Ethical production • Eco-friendliness • Hedonism • Price

Table 4.1: Drivers for innovation in food processing (based on ²⁰¹)

Traditionally, thermal processes have been used extensively in food technology. Other technologies have only started to emerge recently, among them being high-hydrostatic pressure, pulsed electric fields, cold plasma, and ultrasound applications. Along with **inactivating pathogens** and enhancing the **shelf-life** of the treated foods, several of these emerging techniques have the potential for **food-structure engineering** (novel textures). High-pressure treatment can gelatinise starch granules and proteins; the resulting structures have different properties in comparison to heat-induced gelatinisation and may be used to create products with novel biological and technological functionalities. An overview of emerging processing techniques is given in Table 4.2.

Process	Advantage	Disadvantage	Application
High pressure	No formation of undesired compounds Nutritional quality largely maintained Retention of freshness Physical modification (novel textures)	No formation of desired heat-induced flavour Not continuous Expensive	Fruits, vegetables, cold cuts
Pulsed electric field	No formation of undesired compounds Gentle processing, retention of freshness Cell disintegration Improvements of mass transfer processes Physical modification (novel textures)	Spores are not inactivated No formation of desired heat-induced flavour No inactivation of anti-nutrients and enzymes	Conductive foods
Ultrasound	Facilitates heat and mass transfer Physical disruption	Limited microbial stabilisation High cost	Used in combination with other techniques
Pulsed light	No thermal damage	Only active at surfaces, or in transparent liquids	Packaging material Transparent liquids

Table 4.2: Emerging technologies in food processing (adapted from ²²⁴)

²²³ Ecolabel Index (accessed in July 2012)

²²⁴ Knorr et al. (2011) Annu Rev Food Sci Technol 2:203-235

Nanotechnology has three main application areas in food technology (excluding packaging and distribution)²²⁵:

- **Quality control:** nano-based sensing systems have the potential to detect chemical as well as microbial contaminants in the supply chain with high specificity and sensitivity; other fields of application include electronic noses and tongues.
- **Processing:** nanotechnology enables surface coatings to control the adhesion of macromolecules and microbes, thus reducing biofilm formation which can lead to food spoilage and contamination.
- **Nanofiltration** technologies have the ability to separate and concentrate useful components from waste (e.g. recycling of water and recovery of valuable side-stream products).
- **Functional foods:** nano-sized delivery systems with controlled and targeted release properties (e.g. liposomes, nano-emulsions, micelles, solid lipid nanoparticles, encapsulation) for food additives, nutrients and bioactives are expected to have a high potential to add functionality to food. Other application areas will include texture engineering to improve 'mouth-feel' by using nanostructured components made from natural or synthetic polymers, and nanostructured edible coatings to protect perishable food from oxidation, moisture uptake and microbial attack.

4.8 Emerging technological developments in food packaging

Safety, logistics, sustainability, marketing and ergonomics are the main factors influencing the development of packaging technology (Table 4.3).

Changing lifestyles and growing demand for **convenience** are factors that continue to influence packaging design most significantly^{226, 227}. The resulting solutions cover packages that are easy to open and re-close, user-ready (microwave or oven-ready, containers enabling selective heating of certain foods in the same tray), easy to store, contain single-serving portions, are portable and easy to use 'on-the-go' (containers that are self-heating, based on the exothermic reaction of calcium oxide with water, or self-cooling thanks to zeolite technology)^{228, 229, 230}.

Packaging is a critical factor in the consumer decision-making process, both at the point of sale²²⁶ and while shopping online²³¹. Therefore, it is becoming more and more **customised** to reach many target audiences²³². The development of high-speed packaging machinery, print-on-demand technology and printed electronics enables the production of a short series of packages containing, for example, scratch-off labels with tickets for sports events, programmable messaging labels, write-on labels, labels containing most popular names, etc. Technological advances, such as 2D barcodes, digital watermarks, image recognition, and radio-frequency identification tags (RFID) facilitate the equipment of packages with elements that are **linked to electronic information and traceability systems**²³³. These enable better supply-chain efficiency and product traceability (automatic identification for inventories) and also extend the communication function of packages beyond printed messages to reach consumers' smart phones. Examples of information that can be transferred in this way include shopping lists, recipes, recommendations of healthier choices, daily nutrient requirements, and detailed information on the foodstuff, such as the origin of each component or manufacturing process²²⁹ (see Sections 3.3 and 3.4).

Table 4.3: Main factors influencing the development of packaging technology and design (based on²²⁶)

Safety	Preservation of package content and extension of shelf-life through packaging in modified atmosphere Preservation of package, tamper indication Safety of packaging components
Logistics	Traceability, inventory control, supply-chain efficiency, handling Disposal, reuse, recycle E-business, home shopping
Sustainability	Environmental impact, costs related to packaging life cycle Needs of various categories of users (disabled, seniors, children) Honest information
Marketing	Health awareness (demand for fresh produce without artificial additives; portion control) Demand for convenience, demand for small/individual portions (smaller households) Communication, branding, differentiation, product image and visibility
Ergonomics	Functionality, handling (e.g. easy grip) Accessibility of packaging content (easy to open)

²²⁵ Robinson et al. (2009) Nanotechnology developments for the agrifood sector - report by the Observatory NANO.

²²⁶ Azzi et al. (2012) Packag Tech & Sci 25:435-436

²²⁷ World Packaging Organisation (2008) Market statistics and future trends in global packaging

²²⁸ Brody, A. (2012) Food Technol 66 (7):72-74

²²⁹ Brody et al. (2008) J Food Sci 73 (8):107-116

²³⁰ Mahalik et al. (2010) Trends in Food Sci Tech 21:117-128

²³¹ Packaging Europe News (2012) Packaging: a medium with considerable power (accessed in July 2012)

²³² Brody A. (2012) Food Technol 66 (6):120-122

²³³ Lindqvist et al. (2012) Packag Technol & Sci 25:1-6

The trend towards environmentally friendly packaging is driving the development of lightweight materials and bioplastics (**biodegradable/compostable** or **biobased** materials)²³⁴. There is growing interest in innovative feedstocks and waste-conversion technologies to use recycled materials from organic waste, agricultural by-products, food or wood processing (e.g. technology to convert CO₂ emissions into polylactic acid)^{232,235}. Currently, the most significant tendency is to advance technologies to produce **biobased conventional plastics** (chemically identical to petrochemicals), such as plant-based polyethylene (e.g. made from sugarcane ethanol) and polypropylene (e.g. produced by genetically modified bacteria)^{232,234}. In parallel, the research is ongoing into improving the functional properties (heat and tear resistance, permeability, clarity, durability, etc.) of biopolymers so that they can compete with conventional plastics^{232,234}.

The trend towards improving **barrier properties** continues to drive innovation in packaging materials. Packaging should protect the food from a variety of destructive or harmful substances and factors while, at the same time, preventing the loss of volatile flavours and aromas. No material is completely impermeable and in some applications high barriers are undesirable (e.g. fresh fruits require continual access to oxygen)²³⁶. Ways to enhance packaging barrier properties include development of new polymers, polymer blending (barrier and standard), coating, lamination, metallisation, using complex multi-layer films, and nanomaterials²³⁶.

Research is increasing into the application of **nanotechnologies** in packaging^{230,237}. Polymer nanocomposites, for example, improve barrier properties (gas, solvent permeability), mechanical and oxidation stability, temperature control, flexibility, flame resistance, etc.^{236,237}. In addition, some nanomaterials have positive effects on shelf-life (and thus on food quality and safety) owing to their antimicrobial properties and/or, particularly for fruit and vegetables, their ability to adsorb and decompose ethylene (e.g. commercially available materials with embedded silver nanoparticles)²³⁷. Nanotechnology also offers the possibility to retain or encapsulate bioactive molecules and to release them slowly and steadily.

Advances in nanotechnologies contribute to the development of **active packaging** (designed to interact with the content and/or environment) and **intelligent/smart packaging** (capable of monitoring the condition of the content and/or environment)²³⁸. Examples of active packaging include oxygen scavengers or antioxidants (e.g. to inhibit the degradation of ascorbic acid, oxidation of fat, growth of aerobic micro-organisms), moisture

adsorbers, ethylene scavengers (to prolong the post-harvest life of fruits and vegetables), flavour and odour absorbers/releasers (quality improvement), antimicrobials (e.g. ethanol releasers)²³⁸. Intelligent packaging solutions include time-temperature indicators (which change colour after exposure to temperature, and RFID tags), seal and leak indicators (colour-changing gas/moisture detectors), freshness and/or ripening indicators (colour-changing indicators of volatile metabolites (diacetyl, amines) produced during ageing of foods), and biosensors (enzyme, conductivity, bioluminescence sensors, immunosensors) to detect, for example, the presence of harmful organisms, toxins, chemicals or genetic modifications^{237,238}.

5. Relevant aspects of primary production

Primary production provides the raw material for the food chain and thus influences diets to a certain extent. It is determined by a variety of social, economic, physical and biological factors, as well as policy measures. European consumers expect a continuous and secure supply of safe, healthy and affordable food, plus an increasing awareness of environmental and animal welfare aspects in food production (see Section 2.4). To meet these expectations, strict European standards^{239,240} are in place to regulate agricultural management practices, with particular attention to product quality.

5.1 Food availability

Food availability is determined by the combination of: (i) food production, (ii) food distribution, and (iii) food exchange (food trade)²⁴¹. Current food-retail systems ensure that practically any type of food is made available to European consumers. Given the uninterrupted functioning of food distribution and exchange, food availability in the EU is mostly dependent on **global and European primary production**. Considering the expected increase in the global population in the coming decades, mainly in Asia and Africa, food production needs to increase by an estimated 60 % until 2050²⁴². EU agriculture, which accounts for 18 % of world food exports and about 40 % of total food production in the OECD²⁴³,

²³⁹ Council Regulation (EC) No 73/2009 establishing common rules for direct support schemes for farmers under the common agricultural policy and establishing certain support schemes for farmers

²⁴⁰ Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety

²⁴¹ ESF & COST (2009) Forward Look: European Food Systems in a Changing World

²⁴² OECD & FAO (2012) Agricultural Outlook 2012-2021

²⁴³ European Commission (2012) Communication on the European Innovation Partnership 'Agricultural Productivity and Sustainability' COM(2012)79

²³⁴ Grushkin, D. (2011) Nature Biotechnol 29 (1):16-18

²³⁵ Hattersley V. (2011) Packaging Europe 6 (2):28-33

²³⁶ Duncan, T. V. (2011) J Colloid Interf Sci 363:1-24

²³⁷ Cushen et al. (2012) Trends in Food Sci Techn 24:30-46

²³⁸ Pereira de Abreu et al. (2012) Food Rev Int 28:146-187

will also have to increase its output. Several recent foresight studies have dealt with the issue of **global food security**^{244,245,246}. All stressed the urgent need to find a way to **increase production globally**, while reducing the environmental impact of primary production, also with a view to alternative uses of biomass, for example to replace fossil fuels, dealing with scarcities of essential production factors, as well as the adaptation to and mitigation of climate change.

In general, it can be assumed that EU citizens will not face future food insecurity, considering the overall comparatively high economic levels and the rather modest population growth in the Union. However, food insecurity elsewhere could also have repercussions for the EU food market, e.g. via **disturbances in food trade and price increases**. The latter might have a greater effect on economically weak population groups, potentially leading to the consumption of poor diets (see Sections 1.4 and 2.4). Food security is therefore one of the core objectives of the post-2013 EU common agricultural policy, fostering global market stabilisation, thus ensuring continuous and secure food supplies to EU consumers at a reasonable price²⁴⁷.

Environmentally sustainable agriculture

Climate change will also influence EU agriculture. Current models predict that **Europe will be 1.5° C warmer** in the 2021-2050 period, compared to the 1960-1990 period, and the most **pronounced changes** will be seen in the Scandinavian and Mediterranean regions²⁴⁸. One major effect of climate change is the **desertification of soils**. In Europe, extensive soil- and land-degradation processes are occurring, mainly in Southern Europe²⁴⁹, which is the major fruit and vegetable producing region. This, coupled with **drought** periods of increased frequency and intensity and the predicted rise in temperature, may impact **European fresh food produce** and, as a result, reduce both its availability and accessibility. Climate change might also have implications for food safety²⁵⁰.

EU primary production needs to become more **environmentally sustainable**. Studies show that human activities on a global scale, including food production, use more resources than our planet's capacity to recover can tackle²⁵¹. Agriculture and food production are associated with a range of environmental externalities and contribute significantly to greenhouse gas emissions, fossil energy use, loss of biodiversity, soil erosion and water pollution, thereby raising concerns in terms of sustainability^{252,253,254}. One important driver towards a more sustainable primary production could be changing **consumer demand** (see Section 2.4). In this context, organic farming is experiencing growing demand (between 2000 and 2008, the cultivation area increased by an average annual growth of 6.7 % (EU-15) and 20 % (EU-12). Consumption in this sector is increasing with an average annual growth rate of up to 18.1 % in the four largest markets – France, Germany, Italy and

the UK²⁵⁵ – although the overall environmental impact compared to conventional agriculture is still under discussion²⁵⁶.

In the context of future food security, the **Western-type diet**, with its large share of animal-based products, also plays a role. Several studies suggest that sustainably feeding a world population of 9 billion in 2050 will be impossible without **significant changes** in animal production and consumption. Increased resource and energy efficiency of intensive production systems, shifting meat production patterns from ruminants to monogastric animals (e.g. pigs and poultry) or changing consumption patterns towards diets with less meat are possible approaches to reducing the environmental impact of animal livestock^{257,258}.

Livestock is a significant contributor to the serious environmental problems we face today²⁵⁹. Animal livestock production is estimated to be responsible for 9 % to 18 % of the overall anthropogenic greenhouse gas emissions²⁶⁰. Furthermore, animal production systems have a negative energy balance, and need intensive energy input while returning a disproportionately low output in calories²⁶¹. Around 33 % of global arable land (ca. 30 % of the Earth's entire land surface) is devoted to producing feed for livestock, while 39.8 % of the EU's total agricultural input costs are associated with animal production¹⁵⁶.

5.2 Affordability of food

Affordability of food refers to the purchasing power of households or communities relative to the price of food²⁴¹. As such, it is one of the main contributing factors to the access to food, and determines the amount and composition of food that the consumer can purchase. **Agricultural commodity prices** increased sharply in 2006-2008, and are expected to remain at relatively high levels in the mid-term future. Influencing factors include, among others, unfavourable weather conditions, increased demand, trade policies, and changes in oil and fertiliser prices.

²⁴⁴ UK Government Office for Science (2011) Foresight: Future of food and farming

²⁴⁵ INRA & CIRAD (2009) Agrimonde foresight study

²⁴⁶ European Commission (2011). Sustainable food consumption and production in a resource-constrained world – The 3rd SCAR Foresight Exercise

²⁴⁷ European Commission (2010) The CAP towards 2020: Meeting the food, natural resources and territorial challenges of the future; COM(2010)672

²⁴⁸ European Environmental Agency (2012) Climate change models for Europe

²⁴⁹ European Commission Joint Research Centre: European Soil Portal: <http://eu-soils.jrc.ec.europa.eu/> (accessed in July 2012)

²⁵⁰ FAO (2008) Climate change: Implications for Food Safety

²⁵¹ Rockström et al. (2009) Ecology and Society 14:32

²⁵² OECD (2002): Towards Sustainable Household Consumption? Trends and Policies in OECD countries

²⁵³ ETP (European Technology Platform) 2008: Food for Life - Implementation Action Plan

²⁵⁴ McIntyre et al. (2008) Agriculture at a Crossroads: The IAASTD Global Report

²⁵⁵ European Commission (2010) An analysis of the EU organic sector

²⁵⁶ Tuomisto et al. (2012) J Env Man 112: 309-320

²⁵⁷ PBL Netherlands Environmental Assessment Agency (2011) The Protein Puzzle

²⁵⁸ Steinfeld, H. and Gerber, P. (2010) PNAS 43:18237-18238

²⁵⁹ FAO (2006) Livestock's Long Shadow

²⁶⁰ European Commission, Joint Research Centre (2010): Evaluation of the livestock sector's contribution to the EU greenhouse gas emissions (GGELS) – final report

²⁶¹ Kastner et al. (2012) PNAS 109 (18): 6868-6872

Price volatility has also increased, to its highest level in the period 1997–2008 since the 1960s for most agricultural products, and is likely to remain high²⁶². The recent effects of drought in the US and Canada, as well as in Russia, Ukraine and Kazakhstan, on corn and wheat harvests and the resulting price increases are a case in point. Given that price fluctuations cannot be eliminated completely, policy mechanisms are needed to constrain their harmful impacts^{263, 264}. A report by international organisations highlighted a number of weaknesses in relation to the provision of market information at the global level and the coordination of policy responses to food-price volatility. The primary recommendation of this report is to develop **market-information-share** mechanisms, **price-monitoring** instruments and appropriate **early-warning** systems to tackle food-price volatility²⁶⁵. The EU is introducing instruments for sharing market information and price monitoring²⁶⁶.

5.3 Quality of agricultural products

Since its reform in 2003, and as subsidies have been decoupled from production activities, the direct effect of the EU common agricultural policy on production levels has decreased progressively. In the past, agricultural subsidies were key production incentives worldwide –this trend may have shaped European diets to a certain extent. Over the second half of the 20th century, technological developments and policy changes resulted in a substantial increase in agricultural production. Subsidies were primarily designed to support farmers' competitiveness and have never been designed to affect people's diet. Yet, food price, availability and quality affect food choices.

Therefore, one could ask the question whether past agricultural policies have **contributed to the current obesity trend in Western Countries**²⁶⁷; in other words, has the promotion of basic cereals (corn) and soybeans contributed to the growth of, for example, **processed food and meat production**? Together with other factors related to consumption patterns, affluence and life style, such trends in production could have contributed to higher animal protein diets or to the growing consumption of energy-dense, sugar-rich, more salty and fatty food.

There is a wide range of risk factors related to agricultural production can have a significant impact on **food safety**. In agricultural production, there are several possible **chemical and biological hazards**, including residues of synthetic agrochemicals, environmental pollutants, nitrates, animal-feed contaminants, veterinary drugs or animal disease patterns, natural plant toxins, biological pesticides, pathogenic microbes with increased antibiotic resistance, and fungal mycotoxins which can all cause chronic or acute diseases²⁶⁸. Strict European food standards^{239, 240} are in place to ensure the highest quality and hygiene of agricultural food products. However, changes in environmental conditions, e.g. through **climate change**, or **agricultural practices**

(as in the case of bovine spongiform encephalopathy, BSE) and **new technologies** can lead to new risks. For this reason, the EFSA has initiated the development of procedures to monitor, collect and analyse information and data for the identification of emerging risks in the field of food and feed safety²⁶⁹.

5.4 Emerging technologies and applications

Sustainable intensification through new technologies has the potential to increase food production yields while minimising the negative impacts of agricultural activities. **Biotechnology** (e.g. marker-assisted selection (MAS), genetic modification, cloning, synthetic biology) might be used in the future to support plant and animal breeding processes towards improved efficiency, but also towards the development of products with an enhanced nutrient profile or other health-promoting characteristics^{270, 271}.

Another approach to decrease the environmental impact of meat production is to grow animal muscle tissue *in vitro*, rather than rearing whole animals^{272, 273}. This technology is called '**cultured-meat**' (or *in vitro* meat) production and is currently being researched. In addition, cultured meat could have a lower risk of animal-borne diseases and epidemic zoonoses, and potentially facilitate the manipulation of nutritional, textural and taste profiles, such as the quantity and quality of fat, with possible positive health effects.

The concept of '**vertical farming**' brings together traditional indoor farming with cutting-edge technologies to meet the increasing food demand without additional land use. This approach includes the use of a vertical, multi-storey greenhouse equipped with hydroponic plant cultivation, using recycled, nutrient-rich urban wastewater. It could offer the sustainable production of a safe and varied food supply (year-round crop production), including local production of fresh products for urban consumers, and could offer solutions to the restoration of ecosystems that have been sacrificed in horizontal farming. Related technology is currently under development, since a major limitation of the concept (artificial light demand) is still unsolved²⁷⁴.

²⁶² European Commission (2011) Agricultural Market Briefs, 1:1–11

²⁶³ UK Government Office for Science (2011) Foresight Project on Global Food and Farming Futures. Synthesis Report C10: Volatility in food prices

²⁶⁴ Gilbert, C.L. & Morgan, C.W. (2010) Phil Trans R Soc 365:3023–3034

²⁶⁵ G20 (2011) Price Volatility in Food and Agricultural Markets: Policy Responses (Interagency report)

²⁶⁶ European Commission (2012) Short-term outlook for arable crop, meat and dairy markets

²⁶⁷ United Nations Human Rights Council (2011) Report submitted by the Special Rapporteur on the right to food, Olivier De Schutter. A/HRC/19/59

²⁶⁸ Magkos et al. (2006) Crit Rev Food Sci Nutr 46:23–56

²⁶⁹ EFSA technical report (2012) Piloting a process for Emerging Risks Identification: Lessons learnt and next steps

²⁷⁰ European Commission Joint Research Centre (2009) The global pipeline of new GM crops. EUR23846EN

²⁷¹ Newell-McGloughlin (2008) Plant Phys 147:939–953

²⁷² Post, M.J. (2012) Meat Sci 92:297–301

²⁷³ Tuomisto, H.L. & de Mattos, M.J. (2011) Environ. Sci. Technol. 45:6117–6123

²⁷⁴ Despommier, D. (2009) Scientific American Magazine, November: Growing skyscrapers: The Rise of Vertical Farms

6. Food and health policy measures

Food safety, as the precondition for a healthy diet, is targeted by a comprehensive regulatory framework at the EU level to protect consumer safety and interests. A 'farm-to-fork' approach is being followed, including feed production, primary production, food processing, storage, transport, and retail sale, enabling comprehensive and effective regulation and control of the food chain.

Health-related aspects of foods and diets other than food safety are largely addressed at national level in the EU, following the Member States' responsibility for public health. In its White Paper – A strategy for Europe on nutrition, overweight and obesity related health issues²⁷⁵, the European Commission set out to increase coherence and consistency of Community policies and to coordinate and support Member States in their efforts to promote a healthy and balanced diet. Initiatives envisaged in the Commission strategy include **regulatory approaches**, for example, on labelling and health claims, as well as a **partnership approach** between relevant stakeholders (e.g. Member States, private actors) on an international, European and local level with continued support to existing networks (such as the EU Platform for Action on Diet, Physical Activity and Health), and the creation of new networks such as the High Level Group on Nutrition and Physical Activity. Cooperation with the WHO also takes place, against the background of the WHO European Action Plan for Food and Nutrition Policy 2007–2012²⁷⁶, to facilitate data collection and monitoring the implementation of these strategic documents.

Indeed, the presence of food and health is increasing on the agendas of policy-makers and regulators worldwide, and there is a rise in the number of **initiatives to promote healthier nutrition** of European citizens²⁷⁷. Capacci et al. classify the initiatives into four broad categories: interventions supporting more informed choice; interventions changing the market environment; interventions not explicitly targeted at healthy eating; and generic interventions. Overall, 129 initiatives were identified and, as far as possible, evaluated²⁷⁸. Most initiatives are related to supporting an **informed choice**, including public information campaigns and school education programmes. Initiatives targeting the **market environment** mainly focus on the regulation of school meals and promotion of private-sector actions. For actions other than information campaigns, a geographical focus on Scandinavian countries, the UK, and France was detected.

According to Capacci et al., current evidence suggests that **nutrition labelling** policies and **regulation of advertising** to children generate positive behavioural responses. Product reformulations have not yet been evaluated but are considered to be potentially effective²⁷⁸. Furthermore, a recent OECD analysis concluded that **health education and promotion, regulation and fiscal measures and counselling in primary care** are cost-effective measures for tackling obesity, with a combination of measures having the potential to increase impact via synergistic effects²⁷⁹. However, overall, **more empirical evidence is needed** to fully evaluate the efficiency of policy measures^{277, 278, 280, 281}.

Some selected measures are detailed below:

Informed choice

Food labels

Consumer information on food labels is subject to EU regulation. The aim is to provide consumers with the **necessary and accurate information** on the products they buy. So-called **health claims** play a specific role in increasing the consumer attention towards food products with a particular health benefit, on the one hand to providing information, being a strong marketing tool on the other. The health claims regulation²⁸² provides the framework for harmonised rules for nutrition (such as "low fat" or "high in fibre") and health claims (suggesting a health benefit). For the latter, this involves an evaluation by the EFSA of the scientific evidence for proposed food-health or food-compound-health effects and their legal approval according to the regulation, as well as a risk-benefit assessment of foods where necessary²⁸³. The European Commission recently approved a list of 222 health claims which have been evaluated by the EFSA based on scientific evidence supporting these claims²⁸⁴.

There are various approaches in Europe and beyond which aim to guide the consumer towards more healthy choices between or within food categories linked to their nutrient composition. These are based either on **national initiatives**, such as the keyhole symbol in Nordic countries²⁸⁵, or on **private initiatives**, such as the choices programme in Europe²⁸⁶ or NuVal® in the US²⁸⁷, or on participating retail sectors, such as the traffic-light system in the UK²⁸⁸. No such system has been agreed for the EU in the recently adopted **Regulation on the provision of food information to consumers**²⁸⁹. This aims

²⁷⁹ OECD (2010) Obesity and the Economics of Prevention: Fit not Fat

²⁸⁰ Thow et al. (2010) Bulletin of the World Health Organisation 88:609

²⁸¹ European Commission, Joint Research Centre (2012) How can science support policy makers in addressing the nutritional challenges of Europe? Workshop report EUR 25165 EN

²⁸² Regulation (EC) No 1924/2006 of the European Parliament and of the Council of 20 December 2006 on nutrition and health claims made on foods

²⁸³ EFSA Journal 2010; 8(7):1673

²⁸⁴ European Commission press release 16 May 2012 IP/12/479

²⁸⁵ Nordic Council of Ministers – About the Keyhole (accessed in July 2012)

²⁸⁶ Choices Programme website (accessed in July 2012)

²⁸⁷ NuVal website (accessed in July 2012)

²⁸⁸ National Health System UK – Food Labels website (accessed in July 2012)

²⁸⁹ Regulation (EC) No 1169/2011 on the provision of food information to consumers

²⁷⁵ European Commission (2007) White paper on: 'A strategy for Europe on Nutrition, Overweight and Obesity-related Health Issues' COM(2007)279

²⁷⁶ WHO Europe (2008) European Action Plan for Food and Nutrition Policy 2007–2012

²⁷⁷ OECD (2009) Policy Initiatives Concerning Diet, Health and Nutrition (Food, Agriculture and Fisheries Working Papers No. 14)

²⁷⁸ Capacci et al. (2012) Nutr Rev 70:188–200

to further harmonise labelling and calls for mandatory nutritional information on energy, fat, saturated fat, carbohydrates, sugars, protein, and salt (per 100g or ml). It also improves the legibility of labels and adds requirements for the labelling of vegetable fat/oil origin, or the highlighted labelling of allergens, for example.

Various scientific initiatives recommend more consumer guidance using **front-of-pack signposting systems**^{290,291,292,293}, following the revelation that the average attention paid to nutrition labels when consumers are shopping lasts between 25 and 100 milliseconds, which does not allow for a conscious processing of information. The wider introduction of such systems may also be facilitated through the WHO-initiated process to harmonise nutrient profiling²⁹⁴ (classifying or ranking foods according to their nutritional composition for reasons related to preventing disease and promoting health).

Caloric information in menus

In the US, the provision of caloric information is required from major chain restaurants with 20 or more outlets nationwide, taking full effect in 2012, and complementing and superseding initiatives at the state and municipal level. A recent study found that restaurants that currently make caloric information less readily available have menus with a higher fat, salt and energy content²⁹⁵.

Advertising control

The European Parliament recently called for a check as to whether stricter rules are needed for advertising aimed at children and young people, in particular regarding food²⁹⁶. In addition, in his report the UN Special Rapporteur on the right to food recommends taking **stricter actions** to limit/abolish the advertising of foods with known detrimental health effects²⁹⁷. Currently in the EU, the Audiovisual Media Services Directive obliges Member States and the Commission to encourage media service providers to develop codes of conduct regarding advertising food high in fat, sugar and salt (HFSS) to children. Experience from the UK indicates a significant reduction (37 %) in the exposure of children to advertising for HFSS²⁷⁹. Many Member States have agreed a **code of conduct** with the relevant media service providers²⁹⁸.

Fiscal measures

Purchase decisions in the area of food are sensitive to **product price** (e.g. the price elasticity is between 0.27 and 0.81 (absolute values) for foods and non-alcoholic beverages in the US; out-of-home food, soft drinks, juice and meats are most responsive to price changes (0.7-0.8, i.e. a 10 % price increase would lead to a reduction of 8 %-10 % in demand²⁹⁹). Against this background, fiscal measures to direct food consumption towards a more healthy choice have gained more and more attention in recent months. Also, the WHO recommended the use of fiscal measures to influence food prices towards promoting healthier diets^{300,301}. This recommendation was recently taken up by the UN Special Rapporteur on the right to food²⁹⁷. There is some evidence that increasing the price of selected foods could be an effective approach to reducing consumption. However, these price increases need to be sufficiently large to have any real effect^{302,303}.

In the EU, **food taxes** are not subject to European Union legislation. However, **national initiatives** need to comply with the functioning of the EU's internal market. Some Member States already have taxes in place: Denmark has taxation on chocolate and confectionary and soft drinks. The tax on saturated fat introduced in October 2011 was abolished about one year later due to implementation costs. In September 2011, Hungary introduced a health food tax targeting packaged products with high sugar, salt or caffeine levels. France recently introduced a soft drink tax, with effect from January 2012³⁰⁴. However, these measures are too recent to be able to evaluate their impact on diets.

Apart from possible health effects, food taxes could create revenues which, in turn, could be used to support public health initiatives. However, since taxes also affect the economically more vulnerable societal groups, it is recommended to combine them with price reductions/subsidies for healthier alternatives³⁰⁵. Substitution effects must also be taken into consideration when developing fiscal measures. Consumer reaction to price changes still seems difficult to predict, and substitutes chosen to replace the taxed products might not necessarily present a healthier food choice³⁰⁶.

²⁹⁰ RInstitute of Medicine (2011): Front-of-Package Nutrition Rating Systems and Symbols: Promoting Healthier Choices

²⁹¹ Food Standards Agency news (10/03/2010) – Board agrees single front-of-pack label plan (accessed in July 2012)

²⁹² Bialkova, S. & van Trijp, H. (2010) Food Qual Prefer 21:1042-1051

²⁹³ van Herpen, E. & van Trijp, H. (2011) Appetite 57:148-160

²⁹⁴ WHO (2011) Nutrient profiling. Report of a WHO/IASO technical meeting, 4-6 October 2010

²⁹⁵ Wu, H.W. & Sturm, R. (2012) Pub Health Nutr (published online on 11 May 2012)

²⁹⁶ European Parliament resolution of 22 May 2012 on a strategy for strengthening the rights of vulnerable consumers (2011/2272(INI))

²⁹⁷ United Nations (2011) Report submitted by the Special Rapporteur on the right to food, Olivier De Schutter A/HRC/19/59

²⁹⁸ European Commission (2010) Strategy for Europe on nutrition, overweight and obesity-related health issues (Implementation progress report)

²⁹⁹ Andreyeva et al. (2010) Am J Public Health 2:216

³⁰⁰ WHO (2004) Global Strategy on Diet, Physical Activity and Health

³⁰¹ WHO (2008) 2008-2013 Action Plan for the Global Strategy for the Prevention and Control of Non-communicable Diseases

³⁰² Duffey et al. (2010) Arch Intern Med 170:420

³⁰³ Sturm et al. (2010) Health Aff (Millwood) 29:1052

³⁰⁴ Flash Report of High Level Group on Nutrition and Physical Activity, 2 February 2012

³⁰⁵ Epstein et al. (2012) Am J Clin Nutr 95:789

³⁰⁶ OECD (2012) Obesity Update 2012

Making the healthy option available

Apart from promoting the consumption of fruits and milk via the **School Fruit Scheme**³⁰⁷ and the **School Milk Scheme**³⁰⁸, initiatives targeting **reformulation** are ongoing to reduce salt, sugar and fat consumption via the **EU Salt Reduction Framework**³⁰⁹, as is a new framework for a holistic approach to all nutrients as well as portion sizes and frequency of consumption. As regards the latter, the European Commission is currently working towards a common framework for the **reduction of saturated fat** within the holistic approach³¹⁰. For removing trans fats in diets, a variety of successful initiatives exist in different countries worldwide (e.g. voluntary or mandatory reformulation of food products as well as nutrition recommendations, awareness campaigns and labelling). A common prerequisite for success seems to be the **collaboration** between governments, industry, public health sectors and academia, while the media play an important role in increasing consumer awareness. Adaptation of measures to the local environment is also considered necessary. For example, in Denmark, since 1994, a combination of high media and consumer awareness, agreement with relevant industries, followed by legislation in force since 2003 has resulted in nearly zero intake of trans fats, at the individual as well as population level³¹¹.

³⁰⁷ European Commission, School Fruit Scheme

³⁰⁸ European Commission, The European School Milk Programme

³⁰⁹ European Commission DG Health and Consumers (2012) Implementation of the EU Salt Reduction Framework (Results of Member States survey)

³¹⁰ European Commission (2012) High Level Group on Nutrition and Physical Activity, Flash Reports of meetings on 2 February 2012 and 14 June 2012

³¹¹ L'Abbé et al. (2009) Eur J Clin Nutr 63:50-67

Tomorrow's healthy society

Research priorities for foods and diets

ANNEX II

BRIEF OVERVIEW OF RELEVANT DRIVERS FOR FUTURE FOOD PRODUCTION AND CONSUMPTION

LITERATURE REVIEW

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I. Introduction

The scope of the present document is to give a brief literature overview of relevant drivers potentially impacting future food production and consumption as well as consumer behaviour.

This review is mainly focused on the European Union (EU); however, where relevant, global trends are presented. In some cases, aspects of the described drivers have already been covered adequately by the background document (Annex I). In these cases, this review will only present additional elements that complement the background document.

This review does not aim to provide an exhaustive description of each of the drivers; rather, it aims to give a food-, diet- and (where applicable) health-related snapshot of the current situation and a glimpse of future developments, which will allow for a better understanding of the four scenarios.

II. Review

1. Climate change and natural resources

Climate change has the capacity to influence, either directly or indirectly, food and freshwater availability and access, and health. Apart from its direct impact on food and health, climate change effects could also result in significant economic damage, leading to a permanent loss of over 14 % on average of global consumption per capita¹. The magnitude and rate of climate change depends on the rate of increase of greenhouse gas concentrations, the extent of the effect greenhouse gases can have on temperatures, precipitation and sea level, and on natural influences on climate (volcanic activity, sun intensity, ocean circulation patterns)².

According to the Organisation for Economic Co-operation and Development (OECD), in 2050 the world economy will be four times larger and will consume about 80 % more energy than today.

About 85 % of that energy would come from fossil fuels, while only 10 % would come from renewable sources (including biofuels) and about 5 % from nuclear power. The major energy users would be the emerging economies of Brazil, Russia, India, Indonesia, China and South Africa (BRIICS)¹. Agricultural land use in BRIICS and OECD countries is expected to peak before 2030 and then decline, due to population growth slowdown and improvements in crop yield, while in the rest of the world a further increase is foreseen in the use of agricultural land¹. The size of mature forests is projected to decrease by 13 %, due to increased agriculture, commercial forestry and human encroachment. This reduction will also lead to a 10 % decrease³ in biodiversity by 2050. The biodiversity of water habitats is also under threat.

Freshwater availability will be reduced across many regions; 2.3 billion more people are expected to be living in areas of water stress by 2050; and groundwater depletion could well become the main problem in urban and agricultural water supply¹.

Although air pollution is also expected to be a threat to ecosystems and human health (premature deaths due to exposure to particulate matter are expected to double by 2050), knowledge is still limited on the possible future impacts of air pollution¹.

1.1 Past and future trends

Global warming is a certainty: the earth's atmosphere has become successively warmer in the last three decades, compared to any preceding decade since 1850, and it is considered likely that the period 1983-2012 was the warmest since 600 AD⁴. The total temperature rise between the 1850-1900 average and the 2003-2012 average is 0.78 °C⁴. This warming is also reflected in an increase in ocean (upper 75 metres) temperature by 0.09-0.13 °C per decade in the period 1971-2010. Ice sheets have been losing mass in Greenland and the Antarctic, while glaciers have continued to shrink around the globe. Arctic ice and northern hemisphere spring snow cover have also continued to decrease⁴. The rate of sea-level rise has been higher in the last 50 years than the mean rate during the previous 2000 years; in the period 1971-

¹ OECD (2012) - Environmental Outlook to 2050. The consequences of inaction

² U.S. Environmental Protection Agency - Future Climate Change website (accessed in December 2013)

³ Measured as Mean Species Abundance (MSA), an indicator of the intactness of a natural ecosystem

⁴ Intergovernmental Panel on Climate Change (2013) - Fifth Assessment Report, Summary for Policymakers

Fig. 1.1: Long-run temperature increase (baseline, 1970-2100), IMAGE model output; grey area represents range of uncertainty (Source: OECD 2012⁵, page 2)

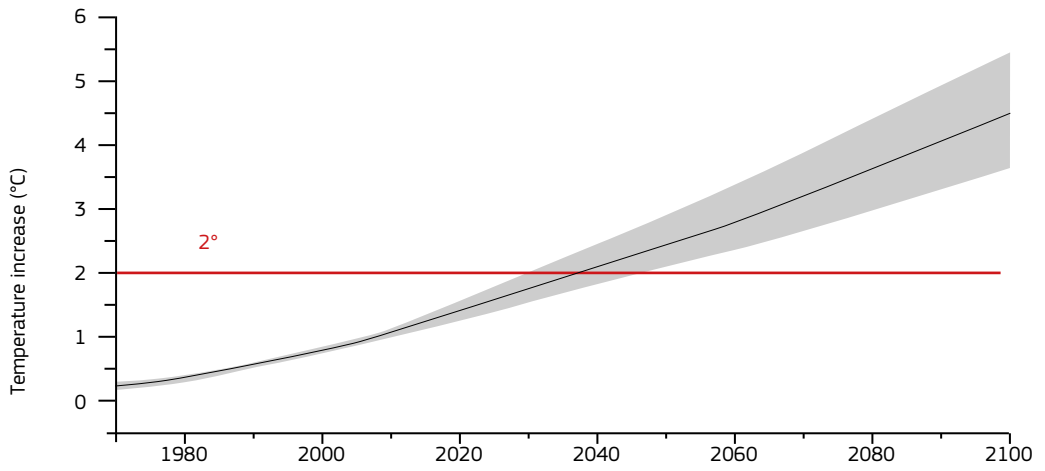
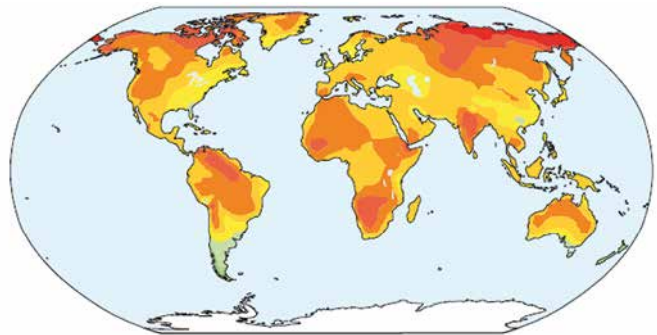
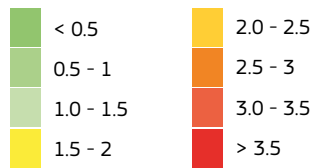


Fig. 1.2: Change in annual temperature by geographical area (baseline scenario, 1990-2050), IMAGE model output (Source: OECD 2012⁵, page 2)

degree C
(change relative to 1990)



Source: The OECD Environmental Outlook Baseline projections; IMAGE model

2010, mean sea level rose by 0.19 metres, mainly due to glacier mass loss and ocean thermal expansion.

The continually increasing emissions of greenhouse gases are expected to cause further global warming and, subsequently, changes in the specific components of the climate system. Compared to the period 1986-2005, the global mean surface temperature is likely to increase by 0.3-0.7 °C in the period 2016-2035. In the periods 2046-2065 and 2086-2100, the average mean increase could range between 1.0-2.0 °C and 1.0-3.7 °C, respectively⁴ (Figs. 1.1, 1.2). In general, more hot temperature extremes are expected, in parallel with fewer cold extremes, as well as a greater contrast in precipitation between wet and dry regions and seasons. The Arctic region is expected to warm more rapidly than the global mean, and the mean warming over land surface is predicted to be larger than over the oceans. Finally, arctic sea-ice covers, spring snow cover in the northern hemisphere, as well as global glacier volume are all expected to decrease, while global sea levels are expected to continue to rise during the 21st century⁴.

The 2009 Copenhagen Agreement⁶ established that, to combat climate change and its effects, the increase in global temperature should be held below 2 °C, compared to the pre-industrial (before 1850) global mean temperature, and that to achieve this deep cuts in global emissions are required. This was further recognised and confirmed in the Cancun Agreement⁷, which also introduced a set of agreements that represent key steps forward in implementing plans to reduce greenhouse gas emissions, including the development and transfer of clean technology, the scaling up of funds to enable developing countries to take greater and effective action, encouraging the participation of all countries and creating networks and assisting vulnerable people in particular to adapt to climate change effects⁸. According to an OECD¹ report, by 2050, and in the absence of additional policy interventions, an increase of 50 % is expected in greenhouse gas emissions, due to a 70 % increase of CO₂ emissions from energy use. Under these conditions, compared to pre-industrial years, the increase in global surface temperature is likely to exceed 2 °C by 2050; in 2009, it was already 0.7-0.9 °C higher. Even if the Cancun Agreements

⁵ OECD (2012) The OECD Environmental Outlook to 2050 – Key findings on climate change

⁶ Copenhagen Accord (2009) - U.N. Framework convention on climate change
⁷ Cancun Agreement (2011) - U.N. Framework convention on climate change
⁸ United Nations - The Cancun Agreements website (accessed in November 2013)

were to be fully implemented, they would not be sufficient to prevent a global average temperature increase above the 2 °C threshold by 2050, unless very rapid and costly emission reduction measures were realised after 2020 (Figs. 1.1, 1.2). In almost all future scenarios, global warming will certainly exceed 1.5 °C by 2100 (compared to 2010)⁴, which is a more than 2 °C increase from pre-industrial temperatures^{9,10}, ranging from 1.5 °C to 8.6 °C, depending on future greenhouse gas emissions and on different climate models. The likelihood of experiencing a warming of 4 °C by 2100 is around 20 %, even if current mitigation commitments and pledges are fully implemented. If these mitigation goals are not met, a warming of 4 °C could occur as early as 2060¹⁰.

1.2 Climate change in Europe

The average temperature of EU land area in the decade 2002-2012 was 1.3 °C higher than pre-industrial levels¹¹, being the warmest decade on record. In the period 2021-2050, a 1.0-2.5 °C temperature increase (compared to 1961-1990) is predicted for Europe, while for the period 2071-2100 the increase could range between 2.5 °C and 4.0 °C. Under all scenarios examined by the European Environmental Agency (EEA), the EU target of limiting global average temperature increase to less than 2 °C, compared to the pre-industrial period, will be exceeded¹¹.

Overall, in the 21st century the largest temperature increases are projected to occur over eastern and northern Europe in winter and over southern Europe during summer, during which heatwaves are expected to become more frequent and to last longer. Widespread reduction in snow cover in Europe, as well as a 22-66 % decline in the volume of European glaciers is also predicted by 2100¹¹. Average surface-water pH is projected to decline further, to 7.7-7.8 by 2100, which is a 100-150% increase in acidity relative to present conditions, with possible consequences for ocean organisms, including marine ecosystems and fisheries. Global and European sea-level rise in the 21st century is more likely to be less than 1 metre than more than 1 metre.

1.3 Global climate change - future impact

A 2 °C warming (compared to pre-industrial levels) is expected to have significant impact on food production and freshwater availability¹⁰. Food availability in particular may be threatened either directly by a short-term lack in supply, threatening geographical areas that are already vulnerable to hunger and under-nutrition, or in-

directly by affecting food access and utilisation due to collateral effects on household incomes¹².

The predicted 2 °C rise in temperature would alter rainfall patterns, increase glacier melting and mean sea level, worsen the intensity of extreme weather phenomena (heatwaves, droughts, storms, floods), and result in significant loss in biodiversity. A 4 °C increase could lead to a sea-level rise of 0.5-1.0 m by 2060, as well as an increase in the intensity and frequency of high temperature extremes¹⁰. Heatwaves and droughts could also affect freshwater availability, which could be a serious issue in 2050, since a 55 % increase in global demand for water is expected due to manufacturing, domestic and electricity needs. In addition, in 2050, nearly half of the global population is expected to live under conditions of water scarcity¹³.

1.4 Climate change - future impact in Europe

The main climate change effects in Europe are expected to be: a) increases in heatwaves and droughts in Southern Europe and the Mediterranean basin; b) melting of ice and snow in its numerous mountains; c) sea-level rises, intense rainfall and floods threatening coastal regions, river deltas and flood plains; and d) increasing temperatures and melting ice in the Arctic and far Northern European regions¹¹. According to a study of the physical and economic impacts of climate change in Europe, if the climate conditions of 2080 were to be applied today, the EU would lose between 0.2-1.0 % of household welfare, based on the effects of river flooding and rising sea levels in coastal areas on agriculture and tourism. Regions such as Southern Europe, the British Isles and Central-North Europe will be more affected by climate change due to higher temperatures, while Northern Europe may experience positive effects on agriculture and may even enjoy net economic benefits¹⁴.

Climate change effects on plant life and, as a consequence on agriculture, will be of particular importance. It is predicted that, by 2100, European plant species will shift several hundred kilometres to the north, while forests will contract in the south. In the agricultural sector, the length of the growing season is expected to increase further enabling a northward expansion of warm-season crops, while the expected shortening of crop-growth phases could be particularly detrimental to the yield of cereals and oilseed crops, due to the shortening of the grain-filling phase¹¹. As a result, climate change is projected to improve the suitability for growing crops in Northern Europe and to reduce crop productivity in large parts of Southern Europe. Most models predict an increase in precipitation

⁹ European Environmental Agency - Climate Change website (accessed in December 2013)

¹⁰ World Bank (2012) - Turn Down the Heat

¹¹ European Environmental Agency Report (No12/2012) - Climate change, impacts and vulnerability in Europe 2012

¹² Wheeler, T. & von Braun, J. (2013) *Science* 341:508-513

¹³ Water: The environmental outlook to 2050 - Presentation by Helen Mountford, OECD Global Forum on Environment: Making Water Reform Happen, 25-26 October 2011, Paris

¹⁴ Ciscar et al. (2011) *PNAS* 108:2678-2683

in Northern Europe during winter and a decrease in Southern Europe during summer, as well as a decline in river flows in Southern and Eastern Europe (particularly in summer) and an increase in the rest of Europe (particularly in winter)¹¹.

Another effect of climate change is the desertification of soils. In Europe, extensive soil- and land-degradation processes are already occurring, mainly in Southern Europe. Coupled with drought periods of increased frequency and intensity and the predicted temperature rise, this is likely to impact European fruit and vegetable production and, as a result, reduce both their availability and accessibility¹⁵. Rain-fed agriculture might also be affected in Southern Europe, resulting in the development of more irrigation infrastructure to cope with water scarcity¹¹.

Although the effects of climate change on wild fish distributions are difficult to pinpoint, due to high fishing rates, future climate change is likely to increase fishing-catch rates in the Arctic region and to decrease (or not increase) catch rates in all other European seas. Although aquaculture has the means to adapt to climate change, specific aspects such as the optimal location for growing, the appropriate choice of species, and the efficiency of the production could all be affected¹¹.

Human health effects are also to be expected and, depending on the geographical area, climate-change effects on existing health risks could be either positive or negative. In addition, health risks may emerge that are new to specific regions. In general, potential health benefits from favourable outcomes, for example, milder winters and a reduction in cold-related mortality, are not expected to outweigh the impact of negative outcomes, such as heatwaves and floods. Specifically, it is predicted that cold-related mortality will decline, also allowing for better socio-economic and housing conditions in those areas currently affected by low temperatures during winter. In contrast, the length, frequency and intensity of heatwaves are expected to lead to an increase in mortality, especially among vulnerable population groups. In addition, the higher temperatures are expected to increase the risk of food-borne diseases, such as salmonellosis, and coupled with intense floods, could also increase the risk of campylobacteriosis, and cryptosporidiosis as well as norovirus and non-cholera *Vibrio* infections¹¹.

2. Agricultural commodity and food prices

In the present foresight study, agricultural commodity price is one of the two major drivers behind the scenarios. Agricultural commodity prices have an impact on consumer food prices and thus on food choice and diets. In the following chapter, past, current and future trends for agricultural commodity prices and the main factors driving commodity price rises and affecting price volatility are summarised, and the relationships and price transmission from commodity to consumer (retail prices) are presented.

2.1 Past trends and current situation

Between 1960 and the early 2000s, the Food and Agriculture Organization (FAO) food price index¹⁶ showed a substantial fall in global food commodity prices. From 2003 to 2006, a slow increase was followed by a rapid increase up to mid-2008, before a decline in the second half of that year (Fig. 2.1). Once again, food price indices have risen rapidly since the second half of 2010. During July 2010 to February 2011, the FAO food price index rose by approximately 40 %, higher than the peak recorded during the 2008 food price increase, while the price index of cereals alone rose by 70 % in the course of 12 months, from June 2010 to June 2011¹⁷. In addition, there is a worrying increase in price volatility, as attested by the increase in the standard deviation of agricultural commodity prices, which was more than twice as high in the last five years compared to the previous 15-year period (29.3 compared to 13.5)¹⁷.

In the short term, higher food prices directly raise poverty in developing countries; the 2008 food price increase was estimated to push 105 million people into poverty in low-income countries, while the 2010 price surge resulted in 44 million people driven into poverty in low- and middle-income countries¹⁹. The 2008 price surge was the fifth since the 1973 oil crisis. Even though food prices are expected to rise in the foreseeable future, there is no clear pattern in their timing and duration²⁰.

Between 2005 and 2012, the EU food price index²¹ increased by an average of 3.6 %, ranging from 1.6 % in milk, cheese and eggs to 4.0 % in meat. From November 2011–December 2012, agricultural commodity prices in the EU rose for maize, soft

¹⁵ European Commission Joint Research Centre - European Soil Portal website (accessed in December 2013)

¹⁶ FAO consumer food price index is a measure of the monthly (and annual) change of specific food commodity prices: cereals, vegetable oil, dairy, meat and sugar

¹⁷ Barilla Center for Food & Nutrition (2011) - Food prices and market volatility: the variables involved

¹⁸ FAO Food Price Index (accessed in March 2014)

¹⁹ World Bank (2012) Global monitoring report - Food Prices, Nutrition, and the Millennium Development Goals

²⁰ European Commission (2008) Directorate-General for Agriculture and Rural Development, Note to the File TH/14147- What caused the present boom in agricultural prices?

²¹ EU consumer food price index is a measure of the monthly (and annual) change of specific food commodity prices: bread and cereals, meat, milk, cheese and eggs, fats and oils and sugar

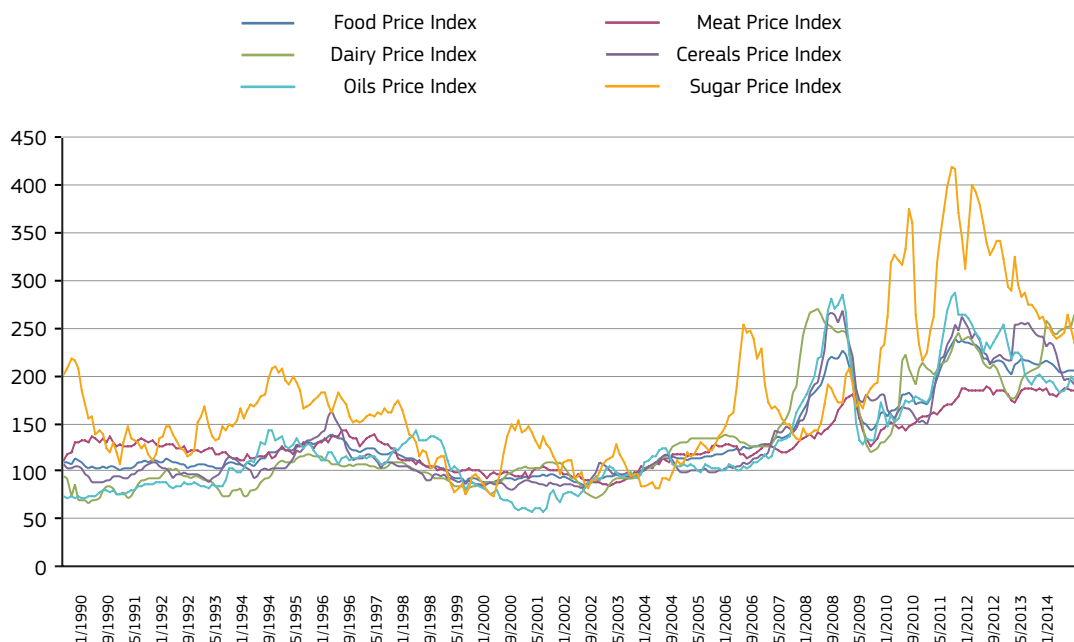


Fig. 2.1: FAO food commodity prices over the period 1990-2014 (based on FAO food price index data¹⁸⁾)

wheat, barley, butter and beef, ranging from 1.3 % to 3.4 %, while a fall in prices was observed for durum wheat, pork and poultry (-1.1 %, -3.4 % and -0.5 %, respectively). The average increase in consumer (retail) food prices in the EU was 3.6 %, between December 2011 and December 2012, ranging from 1.6 % for milk and eggs, 1.7 % in fish/seafood, and 2.2 % in bread and cereals to 4 %, 6 % and 8.3 % in meat, fruits and vegetables, respectively²².

2.2 A summary of factors affecting food commodity prices

Various factors have influenced the increase of prices which began in 2003 (Figs. 2.2, 2.3). In general, the reasons lie on the supply side of the food chain²⁰. Thus, weather extremes, such as droughts that affect world crop production and trade, can greatly affect food prices. It has been estimated that, barring other factors, the effects of rising temperatures and changes in rainfall since the 1980s account for a ~19 % increase in cereal prices¹⁷.

Energy costs also directly influence operating costs in the agricultural sector, ranging from cultivation to transport, including machinery, fertilisers, heating etc. Other factors include policies that promote biofuel use, which increase demand for maize and vegetable oils for non-food uses, as well as the depreciation of the United States (US) dollar. Slower growth in cereal yields over the last 30 years due to low investment, and trade policies, such as export bans or massive purchases in response to supply emergencies (droughts, crop failures), and stock market effects are also factors affecting food price^{17, 19, 20, 23, 24}.

²² European Commission (2013) Directorate-General for Agriculture and Rural Development - Commodity Price Data Dashboard No.7

²³ Chatham House (2008) Briefing Paper - Rising Food Prices: Drivers and Implications for Development

²⁴ Forbes online article (15/03/2012) - Why Are Food Prices So High? (accessed in April 2014)

On the demand side of the food chain, the growing world population and its continuous urbanisation, economic growth in developing countries with large populations, as well as the observed shift towards a Western-style diet (rich in meat and dairy protein and fats) lead to greater demand for resources such as grazing land, water, petrol and fertilisers, further driving up the agricultural cost of food. For example, the Westernisation of dietary habits in certain developing countries with very large populations, such as China and India, has increased the demand for meat, and hence animal feed and farmland to be used for grazing, indirectly affecting food prices¹⁷.

It is clear that commodity food prices depend on multiple variables and it seems that, due to the complexity of the factors involved and often relationships between the variables which are not precisely quantifiable, it is currently not possible to distinguish between the factors that have either major or minor impacts¹⁷.

2.3 Consumer (retail) food prices and price transmission

Wide price variations exist between EU Member States in various food and beverage groups. In 2012, the prices for food and non-alcoholic beverages in Denmark were 143 % of the EU average, while in Poland they were 61 % of the EU average. Denmark, along with Austria, were the most expensive EU countries for meat, fish, bread and cereals, while Cyprus was the most expensive country for milk, cheese and eggs. On the other hand, the lowest prices for the above-mentioned food categories were observed in Poland, except for bread and cereals, which were cheapest in Bulgaria²⁵. As regards oils and fats, the most expensive EU country is Denmark,

²⁵ Eurostat - Comparative price levels for food, beverages and tobacco [in 2012] (website accessed in December 2013)

Fig. 2.2: The complex interaction of factors affecting food price
(Source: Barilla Center for Food and Nutrition 2011¹⁷, page 18)

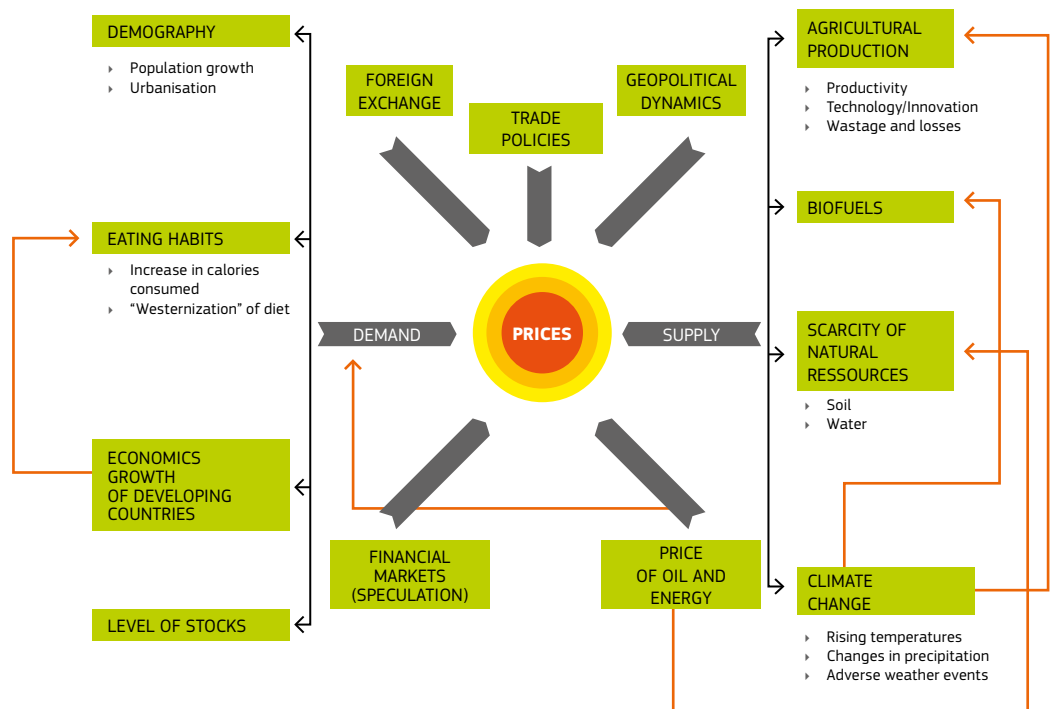


Fig. 2.3: Major drivers of world cereal prices
(Source: World Bank 2012¹⁹, page 41)

Average price levels		Price volatility	
Dependent on:		Dependent on:	
Long-term change in demand <ul style="list-style-type: none"> Population Income Biofuels 	Long-term demand responsiveness/elasticity to prices <ul style="list-style-type: none"> Share of food in consumption Biofuels mandates Oil/maize price ratio 	Short-term change in demand <ul style="list-style-type: none"> Oil prices volatility Exchange rate volatility Precautionary hoarding Food reserves 	Short-term demand responsiveness/elasticity to prices <ul style="list-style-type: none"> Stock release policies Oil/maize price ratio
Long-term change in supply <ul style="list-style-type: none"> Area planted Yield changes 	Long-term supply responsiveness/elasticity to prices <ul style="list-style-type: none"> Output and input market integration Price risk management 	Short-term change in supply <ul style="list-style-type: none"> Droughts and floods Share of production in more volatile production regions Trade policy responses (export bans and sharp reductions in import tariffs) 	Short-term supply responsiveness/elasticity to prices <ul style="list-style-type: none"> Trade openness

whereas fruits, vegetables and potatoes are the most expensive in Sweden. The lowest prices for this category can be found in Poland. When comparing the price dispersion within the EU between 2003 and 2012, the conclusion is that food prices have converged for each of the main group of the above-mentioned food categories.

The share of household consumption expenditure for food and non-alcoholic drinks can be seen in Fig. 2.4. In 2013, EU households spent on average 12.6 % of their expenditure on food and drinks, slightly less than 2010 (at 13 %). In 2010, after “housing, water and energy”, expenditure on food and drinks is ranked second, along with transport in the consumption expenditure of EU households²⁶. The highest proportions of household budget dedicated to food and beverages were in Romania, Lithuania, Bulgaria and Estonia, while the lowest proportions were observed in Germany, Austria, Ireland, the UK and Luxembourg.

According to a US report²⁷, the “farm value” of commodity raw materials used in food production (including what is necessary for their production in terms of agricultural expenses, energy, etc.) accounts for 19 % of total consumer food price (in 2007), down from 37 % in 1973. The remaining share of final retail price was due to the so-called marketing bill, which includes the cost of labour, packaging, energy requirements, transportation, advertising, interest, business taxes, and profits; all of the above are not attributed to basic agricultural commodity prices. Other interesting observations from the same report include the fact that historically there has been very little relationship between corn prices and consumer food prices, and growth in the bio-ethanol industry in the US has not contributed to the rise in consumer food prices. Similar findings²⁸ from the US show that retail food prices are driven more by consumer demand than by price changes in raw commodity markets, although this varies according to the share of raw food commodity in the retail product.

²⁷ Informa economics (2007) - Analysis of Potential Causes of Consumer Food Price Inflation

²⁸ Schnepf, R. (2013) Congressional Research Service - Consumers and Food Price Inflation

²⁶ Food and Drink Europe (2011) - Data & Trends of the European Food and Drink Industry

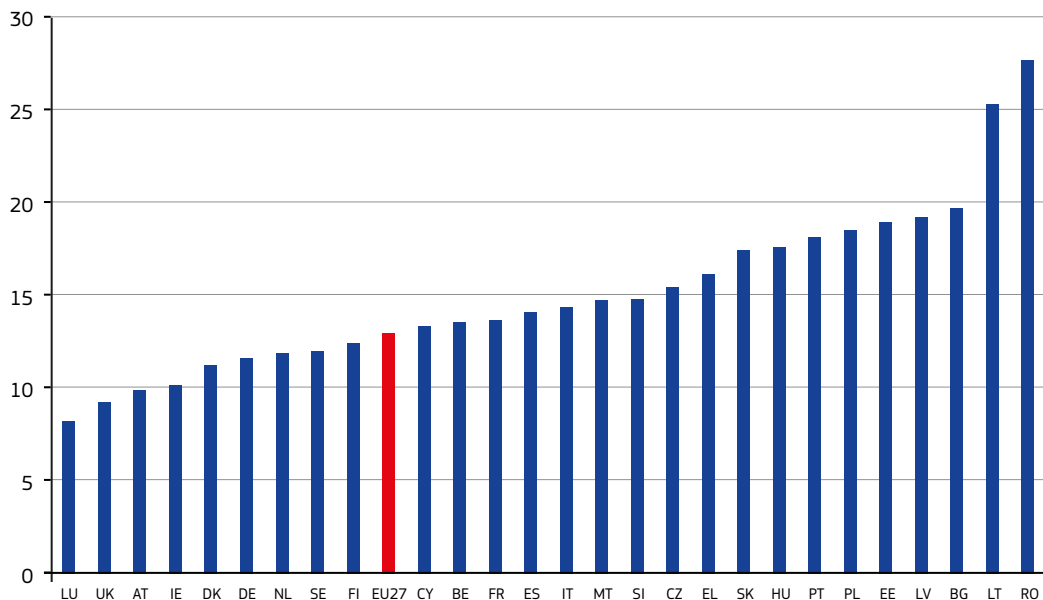


Fig. 2.4: Average EU household consumption expenditure on food and non-alcoholic beverages (% of total); based on Eurostat data for 2012, except: EL, BG (2011), RO (2010) and LT (2009); data for HR not available

The agricultural commodity price peak in the second half of 2007 generated a rapid increase in producer and consumer food prices (Fig. 2.5)²⁹. The situation differed across the various EU Member States (MS); among those MS who are more recent EU members, such as Bulgaria, Latvia and Lithuania, consumer prices increased by more than 15 %, while in older MS, such as Austria, Denmark and Ireland, consumer prices rose by approximately 6 %. These differences could be explained by the generally higher levels of wage and price inflation in the former, and because the share of agricultural commodities price in the final retail food price is higher. Therefore, consumer food prices were more sensitive in those countries, while the share of household consumption was typically higher in the countries joining the EU after 2007 (Fig. 2.4). The state of the food industry in the different MS also plays a major role in the degree to which increases in agricultural commodity prices are transmitted to consumer food prices. For example, more-developed food industries tend to be less affected by raised commodity prices, and in less-developed food industries, the input share of the agricultural sector and the food process itself tends to be higher.

This may not always be the case, however, as demonstrated by the food price increase in the UK in the period 2005-2011 – an old MS with a developed food industry. Food price indices from 2011 show an increase in food prices ranging from 3 % (Ireland) to 20 % (Denmark) for most EU MS (baseline = 2005), including the southern European ones that were hit harder by the recent financial crisis. The highest increases were observed in Poland (25.8 %), Slovenia (28.6 %), UK (34.3 %), Estonia (42.3 %) and Hungary (53.1 %)³⁰.

The transmission of prices from the food production sector to consumers could also be buffered by a reduction of profit margins in the retail sector. In most of the euro-zone countries, from mid-2007, consumer food prices started to rise much slower than producer food prices, whereas the opposite was true in the five-year period before the food price peaks. Again, in most of the new MS the increase in consumer food prices from July 2007-July 2008 exceeded the producer price increase. The status of market competition may also play a role; the more competitive the food market, the lower the final price levels are likely to be, as firms are compelled to lower their costs or profit margins and bring prices down. Finally, there are some indications that the consolidation of the EU retail sector can have a beneficial effect, leading to improved efficiency and lower prices²⁹. The above details indicate that factors that lie upstream from agricultural production can affect the consumer food prices and explain the differences seen in various MS during the agricultural price peaks of 2007 and 2008²⁹.

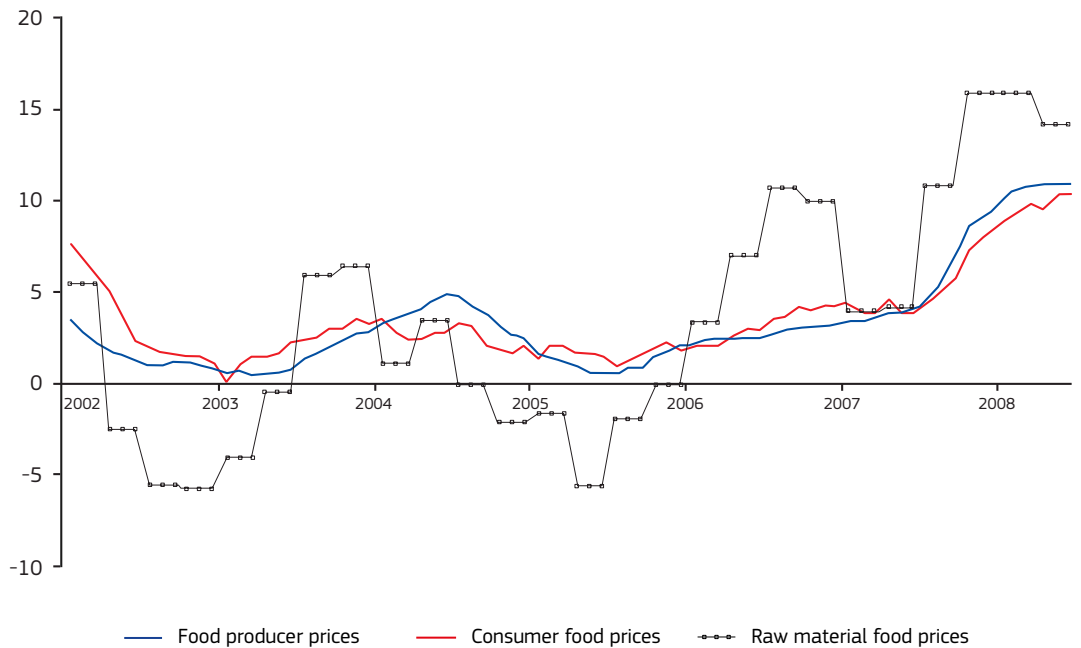
In general, fluctuations in agricultural commodity prices tend to be transmitted to producer prices at rates that vary across both product groups and EU MS³¹. Low transmission rates indicate that changes in agricultural commodity prices tend to be absorbed during pass-through to the food production sector, via a reduction in profit margins. Food markets in developed countries offer many alternatives for a single product, and therefore consumers can respond to changes in food prices by shifting their purchases among different food products. However, this may affect the quality of their diets, via the so-called ‘substitution effect’, whereby the alternative product is low cost but also of lower dietary quality³¹. In addition, in developed countries, the average share of household budget spent on food is relatively low,

²⁹ European Commission (2009) Directorate-General for Economic and Financial Affairs, Occasional Papers No 49 - The functioning of the food supply chain and its effect on food prices in the European Union

³⁰ TRANSFOP EU funded project (2012) - Food Inflation and the Cumulative Effects of Commodity Price Shocks

³¹ Garcia-Germán et al. (2013) Working Paper No. 2 ULYSSES FP7 Project

Fig. 2.5: Different food price increases in the EU (2001-2008, year-to-year growth rates)
(Source: ²⁹, page 9)



so the impact of increased food prices could be limited, although more vulnerable EU households may still feel the pressure.

As food expenditure rises, other household expenditures might have to be lowered in response, such as health or education. This can have serious consequences for the quality of life among lower socio-economic status households and could increase their vulnerability³¹. In 2011, 24.2 % of people were at risk of poverty and social exclusion in the EU, and on average approximately 10 % of the population could not afford a meal including meat, chicken, fish (or vegetarian equivalent) every second day; the highest rates were observed in Bulgaria (85.5 % of the population). Over the period 2004-2008, a growing disparity in price was observed between nutrient-dense and energy-rich foods, implying that food prices may inhibit consumers' adherence to healthy dietary habits³². In the UK, from 2007-2012³³, consumer food prices rose by 32 %, which is twice the EU average price increase. Compared with the years prior to the crisis (2005-2007), in 2010-2012 British households reduced real expenditure on food purchases by 8.5 % and spent 5.2 % less per calorie; the reduction was highest in families with young children³⁴, where the largest decrease in nutritional quality occurred. On average, all households moved away from calories obtained from fruit and vegetables (the worst effect seen in single-parent households with young children); instead, processed sweet and savoury foods were used as substitutes³⁴.

2.4 Future projections

The general consensus is that food commodity prices are likely to remain high and volatile³⁵ although some believe that volatility levels could drop to historical levels over the coming years³⁶. According to various projections, price levels will remain moderately high in the decade 2010-2020. World prices for rice, wheat, maize and oilseeds in the five-year period 2015-2020 will rise by 40 %, 27 % and 48 %, respectively, compared to the five-year period from 1998-2003³⁷. Inflation-adjusted prices will remain flat compared to the previous decade, which saw several years of record high prices. For the period 2013-2022, average real prices for most agricultural commodities will remain above the 2003-2012 average³⁷.

Long-term projections (2050) foresee modest increases in food commodity market prices, according to an FAO baseline scenario³⁸. Taking into account a base 100 % price index in 1990, cereal prices will to 94 % at 2020, return to the 1990 status in 2030 (99 %), increase towards 2040 (107 %) and further increase to 113 % in 2050. Livestock product prices follow a continuous increase, from 110 % in 2030 to 119 % in 2050. In general, and taking into account other scenario models, by 2030 prices will tend to revert to pre-surge levels (1990), but by 2050, cereal prices in the baseline would be higher than in 1990, but much lower than those during the period of price surges. Prices would not revert to a path of decline³⁸.

Food commodity prices are expected to rise in the future, due to the factors mentioned in Section 2.2, including the continued growth of both the emerging economies and world population, which will exert

³² Monsivais et al. (2010) Food Policy 35:514-520

³³ UK Department for Environment, Food and Rural Affairs (2012) - Food Statistics Pocketbook

³⁴ Institute for Fiscal Studies (2013) Briefing Note BN143 - Food expenditure and nutritional quality over the Great Recession

³⁵ European Commission (2011) Directorate-General for Agriculture and Rural Development, Agricultural Markets Brief No.1 June 2011 - High commodity prices and volatility

³⁶ Gilbert, C.L. & Morgan, C.W. (2010) Phil. Trans. R. Soc. B. 365:3023-3034

³⁷ OECD-FAO (2013) - Agricultural outlook 2013-2022

³⁸ FAO (2011) - Looking ahead in world food and agriculture, Perspectives to 2050

upward pressure on demand. The anticipated increased use of biofuels will also drive high prices in food. In addition, agricultural production costs are tightly tied to oil prices – the expected increase in the latter will contribute to higher agricultural production costs and higher food prices. Another factor that will drive the increase of food prices is natural resource constraints in farmland and water availability, linked in particular to climate change^{39,35}. Apart from being higher, over the longer term prices are also expected to become more volatile. This is due to increasing demand in developing countries as well as the greater frequency of extreme weather events, leading to frequent production disruption accompanied by higher price volatility⁴⁰. Poor countries that have to import most of their food are expected to fare worst.

The link between food prices and oil prices via biofuels has made the issue of volatility more complex: an increase in oil prices would lead to greater demand for biofuels, which would raise food prices. Historically, oil prices have been quite volatile and particularly affected by geopolitical developments in the less stable parts of the world; their linkage to food prices would add to the volatility of the latter.

3. The macroeconomy

In recent decades, globalisation has introduced interdependencies among global economies. In addition, the world economy has grown substantially; a significant part of this may be due to the growth seen in the so-called BRIC (Brazil, Russia, India and China) countries⁴¹ (Figs. 3.1 and 3.2), although the US, the EU and Japan are still the major economic powers globally. BRIC economies are continuing to grow, with increased internal demand that was only slowed temporarily by the 2008 financial crisis (Fig. 3.2). However, the crisis did accelerate the trend of shifting power from the mature, developed economies of the US, EU and Japan to the emerging economies of the BRIC countries⁴¹.

China had the highest GDP (4.300 billion euro, 9 % of global GDP) among the BRIC bloc, followed by Brazil (1.600 billion, 3 %), India (1.300 billion, 3 %) and Russia (1.100 billion, 2 %), while at the same time the EU had a GDP of 12.300 billion (27 % of global). As regards GDP per capita in the BRIC countries, Russia had the highest (61 % of EU-27 average), followed by Brazil (33 %), China (22 %) and India (10 %).

In comparison, the EU-27 average GDP is almost twice as high as the BRIC average, while the GDP per capita is three times higher. Finally, the EU-27 was the dominant power in world trade (17 % of global), followed by the US (14 %) and China (12 %)⁴².

3.1 Global future projections

It is predicted that the average global GDP will nearly quadruple by 2050. The international system of power, established after the Second World War, is expected to change significantly by 2025, due to the rise of emerging powers, an increasingly globalised economy, and the transfer of economic power and relative wealth from the West to the East. In general, it is assumed that BRIC countries will match the G7 share of global GDP in the period 2040-2050⁴³ and surpass it by 2050. The OECD countries' global GDP share is expected to decline from the current 54 % (2010) to less than 32 % in 2050, while the BRIC countries' share will increase to over 40 %.

By 2030, Asia might be well on its way to becoming the world's powerhouse, while the US would probably still be "first among equals", because of the multifaceted nature of its power⁴⁴. For the first time in history, most of the world's citizens would be middle class and not poor.

In the coming decades, average GDP growth rates are expected to slow down in China and India. Nevertheless, according to a 2013 report, in terms of purchasing power parity (PPP), China is expected to overtake the US by 2017, while India could become the third power by 2050⁴⁵. In addition, by 2050, the Brazilian economy could be larger than that of Japan, the Russian economy could overtake the German one and become the largest in Europe; Mexican and Indonesian economies could be larger than the French and UK economies together; and the Turkish economy could be larger than the Italian economy. However, such projections are prone to change, depending on regional or global developments. For example, the trend in shifting economic power to emerging economies has been further accelerated by the global financial crisis.

Other emerging economies, beyond BRIC or the E7⁴⁶, have the potential to grow significantly, including countries such as Vietnam, Nigeria, Egypt, Pakistan, Thailand, Iran, Argentina, Saudi Arabia and South Africa⁴⁵. The foreseen shift of economic power to emerging countries will undoubtedly impact their lifestyles, consumption patterns and dietary preferences, which could lead to increased pressure on both resources and the environment (e.g. land, water, energy, minerals and biodiversity)⁴⁷.

³⁹ FAO (2011) - The State of Food Insecurity in the World

⁴⁰ European Commission (2011) Directorate General for Agriculture and Rural Development, Agricultural Market Brief No.1 June 2011 - High commodity prices and volatility

⁴¹ Eurostat Pocketbooks (2012) - The European Union and the BRIC countries

⁴² Eurostat News Release (80/2012) - The European Union and the BRIC countries

⁴³ US National Intelligence Council US (2008) - Global Trends 2025: A Transformed World

⁴⁴ US National Intelligence Council US (2012) - Global Trends 2030: Alternative Worlds

⁴⁵ PriceWaterhouseCoopers Report (2013) - The world in 2050 - The Brics and Beyond: Prospects, Challenges and Opportunities

⁴⁶ The E7 comprises the seven major emerging economies: China, India, Brazil, Mexico, Russia, Indonesia and Turkey

⁴⁷ OECD (2008) - Environmental Outlook to 2030 summary

Fig. 3.1: Evolution of GDP (at current prices) in EU and BRIC countries, 2001-2010 (Source: ⁴¹, page 32)

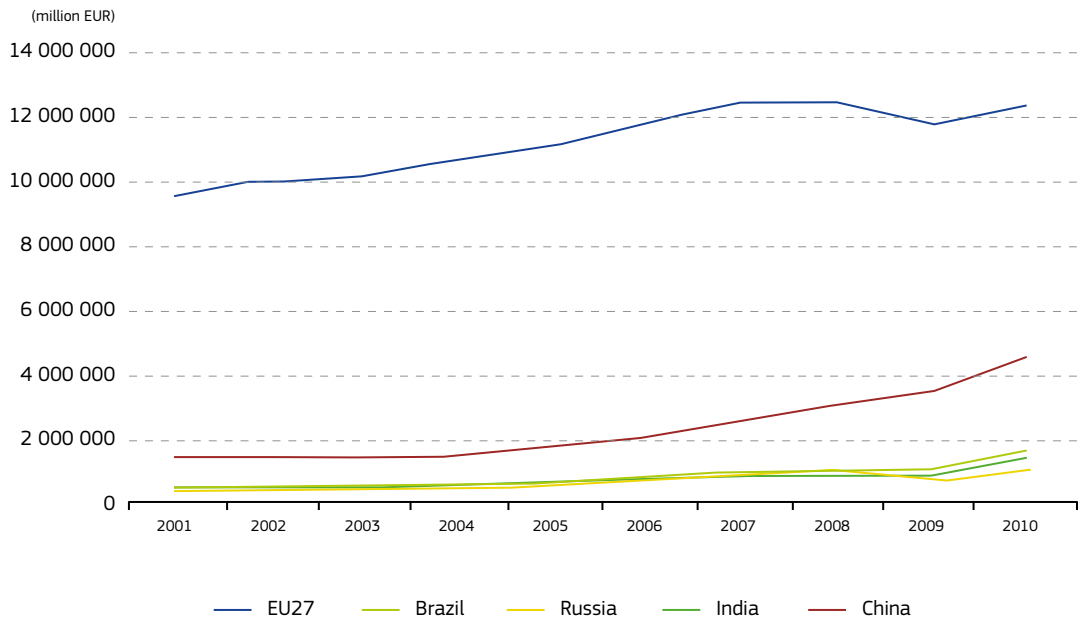


Fig. 3.2: GDP growth rate (% change, compared to previous year) (Source: ⁴¹, page 33)

%	2005	2006	2007	2008	2009	2010
EU27	2.0	3.3	3.2	0.3	-4.3	1.9
Brazil	3.2	3.9	6.1	5.1	-0.6	7.4
Russia	6.3	8.2	8.5	5.2	-7.8	4.0
India	9.3	9.2	9.8	4.9	9.1	8.8
China	11.3	12.7	14.2	9.6	9.2	10.4

3.2 Urbanisation and its impact on future global economy

With few exceptions, OECD member countries will experience slower rates of urban growth from 2005-2030, compared to previous decades. However, even if urban growth is slowing, suburban growth continues to increase in some countries⁴⁷. Switzerland and the north of Italy are examples where small and dispersed urban centres are gradually integrating into large urban agglomerations. Notwithstanding the slow growth of urban centres, cities are still likely to absorb the total population growth between 2010 and 2050, when it is predicted that approximately 70 % of the global population will live in urban areas¹. In the period 2010-2025, the GDP of the 600 largest world cities will account for nearly 65 % of global growth. The move to urban settings is expected to raise the incomes of millions of people worldwide; in cities, by 2025, 1 billion of people will enter the “consuming class”, earning high enough incomes to become significant consumers of goods and services. Around 60 % of them will live in 440 cities in emerging markets, generating almost half of global GDP growth between 2010 and 2025⁴⁸. According to these projections, by 2025, cities would need to expand their commercial and residential

floor space by 85 % – an area the size of Austria – and would need 80 billion cubic metres of water supply per year and over 2.5 times greater port infrastructure to meet rising demand for shipping.

3.3 European projections

In the long term, the average annual GDP growth rate is projected to remain stable, with an average potential growth of 1.5 % up to 2020, a rebound to 1.6 % from 2021-2030, slowing down to 1.3 % from 2031-2060⁴⁹.

The emerging multi-polar world, already expected for 2025, will change the global economic and political landscape, with a probable decline in the EU’s economic and political influence⁵⁰. However, the EU is expected to remain a major importer of goods and services, providing the possibility to exert influence on production standards outside its geographical boundaries⁵¹.

⁴⁸ McKinsey & Company (2012) - Urban world: Cities and the rise of the consuming class

⁴⁹ European Commission (2012) Directorate General for Economic and Financial Affairs, European Economy 2/2012 - The 2012 Ageing Report

⁵⁰ European Commission (2009) Directorate-General for Research and Innovation, European Research Area -The World in 2025: Rising Asia and Socio-ecological Transition

⁵¹ Netherlands Environmental Assessment Agency (2009)- Getting into the Right Lane for 2050

3.4 Inequalities

Prior to the onset of the economic crisis, household incomes in OECD countries rose by an average of 1.7 % per year. However, the household incomes of the richest 10 OECD countries grew faster than those of the poorest 10. In 2011, the average OECD country household income of the richest 10 % of the population was about nine times higher than the income of the poorest 10 %. However, figures differ considerably from country to country: the ratio was lower than 9:1 in Nordic or continental EU countries (e.g. 6:1 in Germany, Denmark and Sweden), but reached 10:1 in Italy, Japan and the UK, 14:1 in the US, and 27:1 in Mexico and Chile⁵². The sustained period of strong economic growth in BRIC countries has resulted in higher living standards and incomes for millions of people, although the uneven distribution has increased inequalities. Brazil has managed to reduce inequality somewhat, but the gap between rich and poor still stands at a ratio of 50:1⁵².

Not surprisingly, the most important factor driving inequalities concerns differences in salaries, since salaries represent about 75 % of total household income. Data from the US suggest that the share of net household income for the top 1 % of the population doubled over the period 1979-2007, from 8 % to 17 %, while the share of net household income of the bottom 20 % of the population fell from 7 % to 5 %⁵².

According to the OECD, globalisation and free trade have had little effect on wages and employment inequalities; the earning gap between high-tech skilled workers and low-skilled workers is growing in an age where technological progress demands high labour skills. Although regulatory reforms have managed to create employment for many people, these have been in the low-paid category and, as a result, inequalities are widening. Similarly, atypical employment (part-time, casual, fixed-term, teleworking, short assignments, etc.) has increased whereas collective trade union contracts have decreased, giving rise to unequal working conditions. Changing family structures have made household incomes more diverse (e.g. single parents), thereby contributing to inequality. Tax and benefit systems have become less redistributive in the last 20 years, and cash transfers and income taxes are currently reducing inequality among 25 % of the working population⁵².

Salary inequalities leading to household budget inequalities can be a source of social tension, creating a vicious circle covering crucial aspects of life. In the context of generic financial crisis and instability, where state healthcare budgets may need to be constrained (see Section 8.4), household budget inequalities can also give rise to inequalities in access to healthcare. Unequal

household budgets may also mean differences in the accessibility of healthy dietary components (see Section 2.3), fuelling inequalities in diets. In turn, low-quality diets further contribute to health inequalities.

4. Demographics

This driver refers to the structure and characteristics of the population, and includes topics such as population growth, fertility rates, ageing, life expectancy, household structure, and migration. The impact of demographic characteristics on the future of food and health is significant and is reflected in both the scenario descriptions and narratives of the foresight study. For example, an increased proportion of older people are expected to require a larger share of the healthcare budget as well as specialised foods to meet their specific needs, while smaller households may change dietary habits and the need for cooking skills. Immigration also has the potential to diversify the demands of European consumers as regards, for example, the demand for ethnic foods or exotic products, as well as specialised health treatment.

4.1 Population growth and fertility rates

According to the 2012 revision⁵³, the United Nations (UN) estimates the world population to be 7.2 billion in mid-2013, and forecasts that it will increase by 1 billion people until 2025, reaching 8.1 billion. Further increases of up to 9.6 billion and 10.9 billion are foreseen for 2050 and 2100, respectively. These projections are based on a medium-variant scenario which assumes a drop in fertility rates in countries where large families are still prevalent, as well as a slight rise in fertility rates in countries that currently average fewer than two children per woman⁵³. The effects of different scenario variants on future global population can be seen in Fig. 4.1. Almost all of the population growth is expected to occur in developing countries.

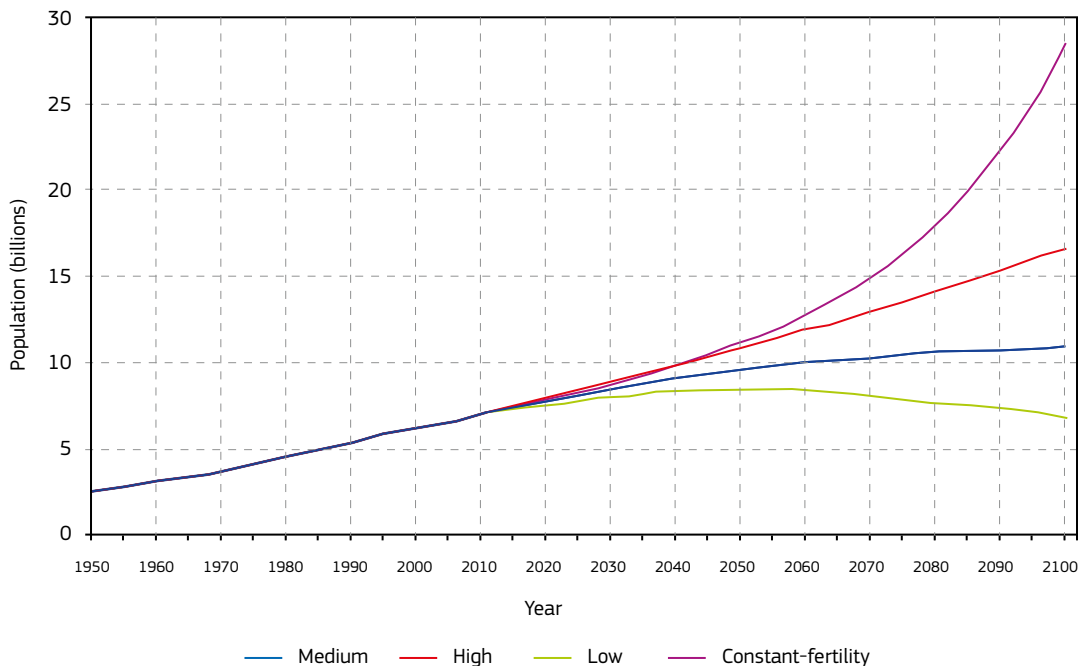
The highest total fertility rates are observed in South-Saharan and Central Africa, ranging from four to eight children per woman⁵⁴. However, total fertility rates ranging from four to six children per woman are expected to decline to an average of 2.85 by 2045-2050, and even lower (2.1) in 2100⁵³. It should be noted that China recently eased the decades-long one-child policy – introduced to curb population growth that might have resulted in consuming too many resources and suffocating

⁵³ United Nations (2013) – World Population Prospects, The 2012 Revision (Highlights and Advance Tables)

⁵⁴ US Central Intelligence Agency, The world factbook – total fertility rates website (accessed November 2013)

⁵² OECD (2011) – Divided We Stand. Why Inequality Keeps Rising

Fig. 4.1: World population in the period 1950-2012 and projections up to 2100 in four different fertility scenarios (Source: United Nations 2013⁵³, page XV)



growth⁵⁵ with potentially significant long-term impacts on global demographics.

The population of the EU reached 502 million in 2010, and is expected to increase slightly to 526 million in 2040 before falling back to 517 million by 2060⁴⁹. For the EU as a whole, the total fertility rate is projected to rise from 1.59 children per woman in 2010 to 1.64 by 2030 and up to 1.71 by 2060. Approximately half of the EU-27 MS will experience a fall in total population until 2060 (BG, CZ, DE, EE, EL, LV, LT, HU, MT, PL, PT, RO and SK), while an increase is projected for the rest (BE, DK, IE, ES, FR, IT, CY, LU, NL, AT, SI, FI, SE and UK). The strongest population growth is predicted in Ireland (+46 %), Luxembourg (+45 %), Cyprus (+41 %), the United Kingdom (+27 %), Belgium (+24 %) and Sweden (+23 %), and the sharpest decline in Bulgaria (-27 %), Latvia (-26 %), Lithuania (-20 %), Romania and Germany (both -19 %). In 2060, the UK is expected to be the most populous MS (79 million), followed by France (74 million), Germany (66 million) and Italy (65 million). In contrast, in 2010, Germany was the EU MS with the largest population (82 million), followed by France (65 million), the UK (62 million) and Italy (60 million)⁴⁹. It should be noted that in all EU MS the fertility rates are expected to remain below the natural replacement rate of 2.1 children per woman in the period up to 2060⁴⁹.

4.2 Ageing and life expectancy

The EU population is ageing, and it is assumed that the number of people aged 65 and over will rise from 17 % to 30 % in 2060⁴⁹ – i.e. almost doubling in the next 50 years (to over 150 million in 2060) – with those aged 80 and over nearly tripling (from 23.7 million in 2010

to 62.4 million in 2060), thus becoming as numerous as those in the 0-14 years age group (12 % and 14 %, respectively). This can have serious repercussions, for example, for pension systems, public healthcare, workforce composition, etc. The 14-64 years age group will decline to 56 % of the total population, compared to 65 % in 2010. On the other hand, the proportion of young people (0-14 years) is projected to remain fairly constant (around 14 %). This will result in demographic old-age dependency of 52.5 % by 2060, up from current 26 %⁴⁹.

Life expectancy is forecast to increase from 76.7 years for males and 82.5 years for females in 2010 to 84.6 and 89.1 years, respectively, in 2060, implying a possible convergence of life expectancy in the future. In 2010, life expectancy for males was lowest in Bulgaria, Estonia, Latvia, Hungary and Romania, ranging from 67 to 71 years old, while for females the lowest life expectancies (below 80 years) were in Bulgaria, Latvia, Lithuania, Hungary, Romania and Slovakia. In general, it is assumed that, in 2010, countries with lower life expectancies will experience proportionally greater gains than countries with higher life expectancies.

4.3 Migration

From an historical perspective, immigration towards Europe is a rather new phenomenon, since most European countries have traditionally been a source of immigrants rather than a destination. European countries first became an immigrant destination in the 1950s: in Germany, post-war labour recruitment was needed for reconstruction, attracting immigrants from Southern Europe, or in countries with a colonial past, which attracted immigrants from overseas ex-colonial territories in Africa and Asia (UK, France and the Netherlands). In the early 1990s, Southern European countries (Italy, Spain and Greece) became

⁵⁵ New York Times Article (15/11/2013) - China to Ease Longtime Policy of 1-Child Limit

destinations for immigrants from (at the time) non-EU Central and Eastern European countries as well as from Asia and Africa; currently, Central and Eastern European countries are both sources of and destinations for immigrants⁵⁶. Before the economic crisis, the EU had a net migration of 1.5 million people, with 55 % originating from outside the EU and 44 % moving from one EU country to another⁵⁷. At the moment, the EU-27 hosts about 20 million non-EU nationals, and about 5 million non-EU nationals have received European Union citizenship since 2001. The movement of EU citizens between MS accounts for 2.5 % of the Union's total population, while immigrants coming from countries outside the EU account for 4.0 % of the EU population⁵⁸. Figures for 2008 indicate Morocco, China, India, Albania and Ukraine as the main countries of origin, but any political and environmental crisis could easily change that picture⁵⁹.

For the EU, annual net migrant inflows are projected to increase from approximately 1 million in 2010 to 1.3 million in 2020 and thereafter decline to 0.95 million people by 2060. It is predicted that, until 2060, net immigration will be concentrated in a few destination countries: Italy (15.9 million), Spain (11.2 million) and the United Kingdom (8.6 million). By 2060, 33 % of the EU-27 population is expected to comprise people with at least one foreign-born parent⁶⁰.

A study by the Oxford University in the UK explored the drivers that could have a significant impact on the future of migration in Europe. The most uncertain and important drivers identified include economic growth in the EU, the economic fragmentation of EU into sub-regional blocs, as well as labour market regulations. While it is unlikely that the EU and the euro zone will entirely fragment by 2035, its future cohesion, the status of the less-prosperous MS and the future of EU expansion remain highly uncertain. EU economic cohesion is also very important for immigration; high EU economic cohesion may mean expansion of the Union and new sources of labour migration; on the other hand, a weak economic cohesion may result in divergence in growth within the EU, fuelling intra-regional migration⁶¹.

4.4 Household structure

The EU consumer is mainly a city dweller, as 75 % live in urban environments – a figure which is

predicted to rise to 80 % by 2020⁶². According to Eurostat data⁶³, in 2013, each household in the EU-28 comprised 2.3 people on average. In the US, the average household size fell from 3.3 in 1960 to 2.6 in 2000. Similar trends are evident from OECD data: in OECD countries, average household size fell from 2.8 in the mid-1980s to 2.6 in the mid-2000s⁶⁴.

In the US, single-person households rose from 13 % (of total households) in 1960 to 26 % in 2000, while in the EU, 12 % of the population lived in single-person households, and over 4 % were single parents in 2008⁶⁰. Eurostat reports⁶⁵ the single adult (below 65 years old) households at 17.6 % of all households in 2007, ranging from 6 % in Portugal to 30 % in Denmark, and generally being lower in Southern Europe, higher in Eastern Europe, even higher in the North-West, and highest in the Nordic countries. A similar pattern is seen in the share of couple-only (no children) households, where at least one adult is less than 65 years old (14 %).

The percentage of childless women in the 33-37 years age group is 27 %, being lowest in Lithuania (7 %) and Eastern Europe and highest in Italy and Spain (over 33 %). Today, there are no children in over half of the households in almost all OECD member countries⁶⁴. On the other hand, the largest families are found in Ireland, where 21 % have three or more children, followed by Belgium and the Netherlands. The smallest percentage of large families is found in Spain, Portugal, Greece and Italy (under 7 %). The number of children born outside marriage has tripled in OECD countries, from 11 % in 1980 to nearly 33 % in 2007. Almost 10 % of all children now live in reconstituted households (adults in any form of partnership who have children from previous relationships), and nearly 15 % in single-parent households, while one in 15 children live with their grandparents⁶⁴.

Similarly, between 1950 and 2000, the number of single-parent households rose from 1.5 million to 9.5 million, reflecting declining marriage rates across Europe, but with marked differences across geographical areas. In 2008, in Sweden, unmarried couples living together represented 20 % of the total, while children born to unmarried parents made up 50 % of the total number of births. Between 1970 and 2009, marriage rates fell from over 8/1000 people in 1970 to 5/1000 in 2009, while the average divorce rate doubled to 2.4/1000 people. In Southern Europe, the percentage of unmarried couples living together ranged from 1-5 % of couples, while children born to unmarried parents were below 10 % (of the total number of births) in Italy and Greece⁶⁴. Almost all OECD member countries for which projections

⁵⁶ European Commission (2006) Directorate-General for Economic and Financial Affairs, European Economy, Economic Papers No. 256 - Labour Migration Patterns in Europe: Recent Trends, Future Challenges

⁵⁷ European Commission - Digital Agenda for Europe/Futurium website: Evolving trends in migration and multiculturalism (accessed in November 2013)

⁵⁸ Eurostat - Migration and migrant population statistics website (accessed in October 2013)

⁵⁹ Eurostat Statistical Books (2011) - Migrants in Europe, A statistical portrait of the first and second generation

⁶⁰ Eurostat Demography report (2010) - Older, more numerous and diverse Europeans

⁶¹ University of Oxford, International Migration Institute (2011) Policy Briefing - Exploring the Future of Migration in Europe

⁶² European Environmental Agency (2006) - Urban Sprawl in Europe: The ignored challenge

⁶³ Eurostat - Number of persons in households website (accessed in April 2014)

⁶⁴ OECD International Futures Programme (2012) The Future of the Family to 2030: A Scoping Report

⁶⁵ Eurostat Methodologies and Working papers (2010) - Household structure in the EU

exist expect significant increases in the numbers of childless couples by 2025-2030, with a parallel decline in the number of couples with children⁶⁴.

Household size depends on changes in population age, fertility rates, and the rate of household formation and dissolution. Although few projections exist, all of the three factors mentioned above point towards smaller household sizes, assuming that the average future household size will not exceed 1.9 members per family⁶⁴. Such trends are seen in the forecasts for specific OECD countries: in the UK, single-person households are expected to increase by 2026 for all age groups, while it is forecast that average household size will fall from 2.11 in 2004 to 2.09 in 2029. Similarly, in Australia, a decrease is expected from 2.6 people per household in 2001 to 2.2-2.3 in 2026, while in Japan a fall from 2.56 in 2005 to 2.27 in 2030 is expected⁶⁴.

'Statistics Netherlands' has envisaged three different future household scenarios for the EU-15 in 2025⁶⁶: individualisation, family, and a baseline scenario which is an average of the two. All scenarios predict for 2025 an increase in people living in non-private, institutional households ranging from 6 to 7.5 million. The individualisation scenario (in which long-term trends of individualisation, secularisation and emancipation continue) predicts a decline in the number of private households (non-institutionalised), in the number of couples, and in the number of children living with their parents, and an increase in single-person households, up to 20 % of the total in 2025. The average number of people per household for 2025 was foreseen at 2.1. In the family scenario (in which trends in individualisation, secularisation and emancipation slow down), the proportion of people living alone also increases, although here numbers of private (non-institutionalised) households are expected to rise. Average household structure falls slightly to 2.4 (from 2.5 in 1995). When compared to the baseline scenario, the number of people per household drops to 2.2.

Currently, all projections for future household structures for developed countries foresee a drop in the average number of persons per household and an increase in the percentage of single parents. As a result, changing household structures⁶⁷ might lead to different eating habits and lifestyles.

4.5 Individualisation in Western societies

Over the last few decades, Western societies have become more individualistic. This, it is claimed, has created a difficult environment to live in – based on the lack of communitarianism, moral bonds and welfare – where we have less interaction with our social peers, due to changes in working conditions,

family structure, city life, television, computers etc., leading to a decline in the "social capital"⁶⁸. In advanced economies, and once living standards rise above the poverty level, it is claimed that income becomes irrelevant to well-being and happiness; rather, it is social relationships and good family life that are the main sources of well-being⁶⁹. In addition, it has been claimed that rising inequalities come from the long allegiance to "individualism", especially in countries like the US⁷⁰. However, the opposite has also been proposed: a study measuring the quality of life in 43 nations in the early 1990s reported that the more individualised the nation, the more citizens enjoy their life, and that the benefits of individualisation are greater than the costs⁷¹.

5. Food consumption⁷²

5.1 Trends and projections for food consumption

Globally, between 1969-1971 and 1999-2001, the daily energy consumption per person increased by about 300 kcal, from 2411 to 2725, reaching 2771 kcal in the 2003-2005 period^{73,74}. However, there are still areas (such as sub-Saharan Africa) where the per-capita energy consumption has declined. Before the 2008 food price spikes, approximately 850 million people worldwide were undernourished. The 2008 food price spikes increased this number to more than a billion, reverting to 925 million in 2010⁷⁵.

In the period 1963-2003, developing countries increased the available calorie consumption from meat (by 119 %), sugar (127 %) and vegetable oils (199 %), while in the developed world only vegetable oil consumption increased significantly (105 %). China displayed a complete change in diets between 1963 and 2003, massively increasing calorie consumption from vegetable oil (683 %), meat (349 %) and sugar (305 %)⁷³. In the 1960s, in Europe and Oceania, animal fats were consumed at higher level than vegetable oils. However, in recent decades, a decline has been observed in animal fat and an increase in vegetable oil consumption, trends which are also expected to continue in the same fashion in

⁶⁷ German Institute for Economic Research (2007) Research Note: Household Patterns

⁶⁸ Putnam, R. (2000) - Bowling Alone: The Collapse and Revival of American Community. Simon & Schuster

⁶⁹ Lane, R. (2001) - The Loss of Happiness in Marked Democracies. Yale University Press

⁷⁰ Santa Clara University website article - Creating the Good Society (accessed in December 2013)

⁷¹ Veenhoven, R. (1999). Social Indic Res 2:159-188

⁷² This chapter complements the respective parts of the background document (Annex I), especially on the topics of European eating habits and dietary patterns, presenting mainly future trends and projections on food consumption

⁷³ Kearney, J. (2010) Phil. Trans. R. Soc. B. 365:2793-2807

⁷⁴ FAO (2009) - World Food and Agriculture to 2030/2050: Highlights and Views from Mid-2009

⁷⁵ The UK Government Office For Science - Foresight: The future of Food and Farming (2011): Synthesis Report C1: Trends in Food Demand and Production

⁶⁶ Statistics Netherlands (1999) - Household Scenarios for the European Union, 1995-2025

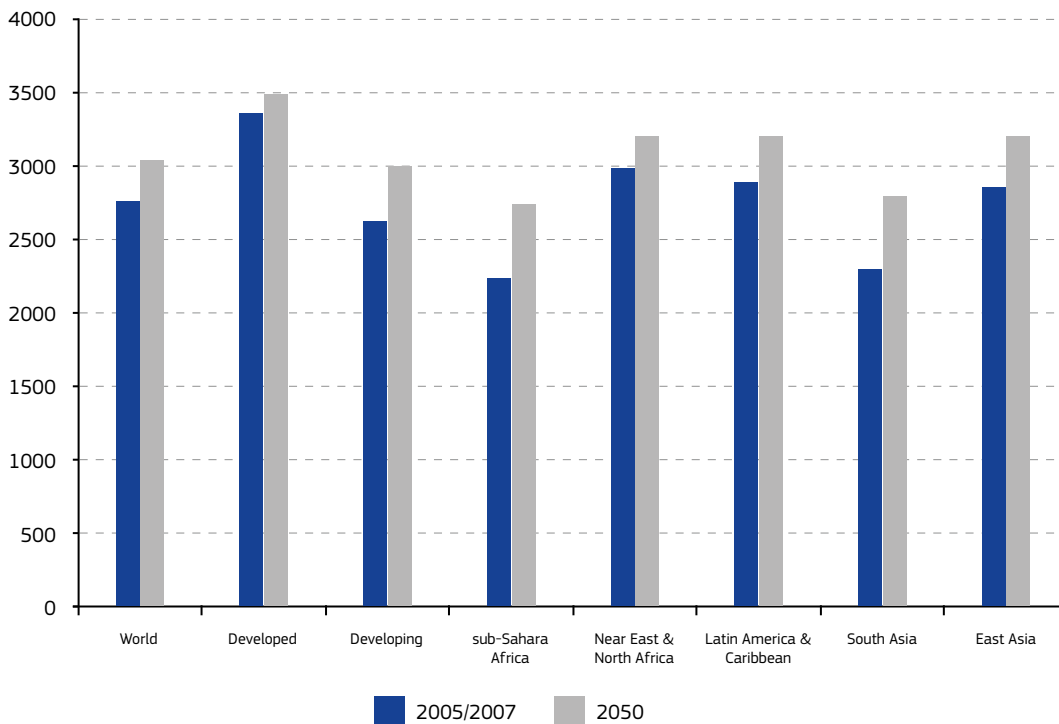


Fig. 5.1: Global and regional daily average food consumption (in kcal) per capita; 2005-2007 and 2050 outlook (Source: FAO 2012⁷⁶, page 4)

the future. Sugar consumption rose in the developed countries in general as well as modestly in Europe (especially the eastern part), while it declined in North America and Oceania⁷³.

The FAO has calculated that by 2050 the global average daily consumption could rise to more than 3100 kcal per person, which is approximately an 11 % increase from 2003, which means that agricultural production would need to increase by 60 % from 2005-2007 to 2050⁷⁶. In developed countries, daily consumption could increase slightly to reach around 3500 kcal per person, while in developing countries daily consumption could increase from 2600 to approximately 3000 kcal (Fig. 5.1). In parallel, the number of people living in countries with an average consumption of below 2500 kcal may decrease ten-fold, from 2.3 billion to 240 million⁷⁶.

The 'Agrimonde' foresight study has also explored future food availability (in terms of calorie availability per capita per day), under two scenarios: Agrimonde GO and Agrimonde 1⁷⁷. The first scenario uses projections of current trends in food consumption and involves investments in research and infrastructure, with intense economic growth, low trade barriers, rapid diffusion of new technologies and a steep rise in energy demands. The Agrimonde GO mindset is to provide employment and food for a growing world population. It foresees a mean global availability of around 3600 kcal/cap/day by 2050, ranging from approximately 4100 kcal (of which ~2400 kcal come from plant sources) per capita per day for OECD countries to 2970 kcal (of which ~2700 kcal come from plant sources) per capita per day in sub-Saharan Africa. On a global level, 75 % of calorie

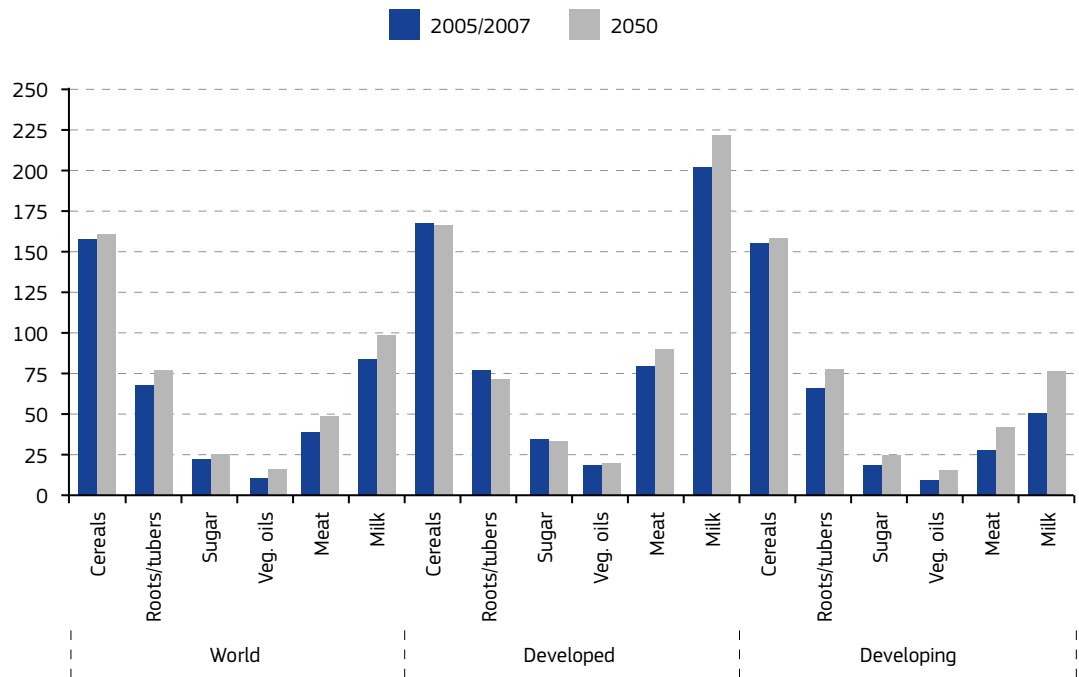
availability per capita per day comes from plant sources. It is interesting to note the different share of calorie availability from plant sources between OECD and sub-Saharan African countries – i.e. approximately 59 % and 91 %, respectively. Overall, the Agrimonde GO scenario foresees a general increase in calorie availability (e.g. up to 30 % in Asia), driven by growing income, global convergence and the urbanisation of eating habits, as well as a greater share of animal proteins in diets and obesity rates. As a result, the future double challenge of the health and environmental sustainability of diets is of the utmost importance in Agrimonde GO⁷⁷.

The Agrimonde 1 scenario, on the other hand, involves sustainable food systems, protected ecosystems, regulated global trade, and fewer inequalities in access to food. In this scenario, the average global food availability is foreseen at 3000 kcal/cap/day, which includes approximately 500 kcal/cap/day of animal protein (~17 %) and 2500 from plant products (~83 %)⁷⁷. Due to the nature of this scenario (i.e. regulated trade and fewer inequalities) there are no large differences in calorie availability between the world regions. Compared to the baseline (year 2000), for OECD countries this implies a reduction of 25 % of calorie availability per capita per day. The 3000 kcal per capita per day availability foreseen for Agrimonde 1 could have a positive impact not only on alleviating pressure on natural resources for food production, but also on public health, by reducing malnutrition in developing countries while, at the same time, limiting overconsumption (and nutrition-related NCDs) in developed countries⁷⁷.

⁷⁶ Alexandratos, N. and Bruinsma, J. (2012) World Agriculture Towards 2030/2050; The 2012 Revision ESA Working Paper No 12-03, Rome, FAO

⁷⁷ INRA & CIRAD (2009) – Agrimonde: Scenarios and Challenges for Feeding the World in 2050. Summary Report

Fig. 5.2: World consumption (kg/capita/year) of major food commodities: 2005-2007 average and 2050 projections (Source: FAO 2012⁷⁶, page 5)



5.2 Trends and projections for main dietary constituents

Cereals still remain the most important food source in the world, contributing 50 % of calories. Current global projections foresee a decline in consumption (in terms of calories) from cereals to around 46 % in 2050. In developing countries, such as parts of Africa and Asia, the contribution of cereals to energy intake can be as high as 70 %, while in developed countries it can be as low as 30 %. Wheat consumption will continue to be of major importance in developing countries, together with maize, the consumption of which is set to rise modestly up to 2050⁷³.

The consumption of roots and tubers (including cassava and potatoes) has fallen moderately worldwide, particularly in China and sub-Saharan Africa. Generally speaking, potato consumption is falling in developed countries but rising in developing countries. Fruit and vegetable production has been increasing worldwide, although inadequate consumption remains an issue⁷³.

In the developing world, non-animal-based protein sources are still dominant, while in developed countries, the most prominent meat sources are pigs, sheep and cattle. In developed countries, half of all meat products consumed comprise non-muscle meat, like sausages, burgers, salami, etc. Developing countries have increased their total meat consumption three-fold since 1963, while in China the increase has been nine-fold.

Future projections foresee that higher consumption of specific food groups is expected for vegetable oils (33 %), meat (26 %), and milk and dairy products (excluding butter) (19 %) (Fig. 5.2).

In recent decades, other livestock products have shown variable consumption trends. For example, egg consumption has doubled globally, mainly due to increased consumption in developing countries. Further variation also exists in the developing world, where the greater consumption of eggs is due to changes in dietary habits in Brazil and China, but not in areas like India or Africa. Similar variations exist in the developed world: for example, egg consumption has risen modestly in Europe, especially in the eastern part, while it has declined modestly in North America and Oceania. Milk consumption has risen in developing countries, while in the US, for example, it has declined sharply, in parallel with a rise in the consumption of carbonated beverages and juices⁷³. Projections for 2050 suggest that the current trends will continue, i.e. egg consumption will rise and milk consumption will decline (in developed countries). No changes are foreseen in butter and cheese consumption globally⁷³.

Fish catches are increasing globally while fish stocks continue to be depleted. In the period 1963-2003, there was little increase in the consumption of marine fish but, at the same time, more freshwater fish and seafood were eaten. Highest increases were seen in Oceania and China, where freshwater fish consumption increased 10-fold over the same period. Global projections for 2050 foresee a modest increase in marine fish consumption, as well as a higher rise in seafood consumption that will surpass all other fish categories⁷³.

6. Employment and working patterns

Working patterns, unemployment, and the balance between private and working life are important elements in the four different scenarios of this foresight study on diets and health, and vary according to the conditions in each society, from high employment rates, well-being at work, and a clear distinction between working and private life to increased demand for mobility and flexibility, hectic working schedules, and a blurring of personal and professional life. This chapter aims to examine the current and future trends in employment, the composition of labour sectors, and the private and working life balance.

6.1 Employment and workforce in the EU

In 2012, the EU employment rate among working age people (15-64 years) dropped slightly to 64.2 %, with 11 MS registering higher employment rates than the average, and ten MS with employment rates below 60 % of the EU-27 average. The highest rates (72.5-75.0 %) were observed in the Netherlands, Sweden, Germany, Denmark and Austria, while the lowest rates were recorded in Greece, Spain, Italy and Hungary (51.3-57.2 %). In 2012, the EU workforce comprised approximately 241 million people, an increase of 0.4 % compared to 2011⁷⁹. Of those, 216 million were employed. While youth unemployment remains a major issue in the EU, the employment rate for those aged 60-64 years increased from 23 % in 2000 to 31 % in 2010. In the same period, the employment rate for people aged 55-59 years rose from 50 % to 61 %, reflecting the trend in active ageing in the EU⁷⁸. In 2012, employment rates for the 55-64 years age category increased to 49 %, ranging from 33 % in Slovenia to 73 % in Sweden⁷⁹.

The service sector employed 70.1 % of the working people in the EU-27; 39.6 % were involved in market-oriented services, such as trade, transportation, accommodation and food services, information, financial activities and real-estate, while 30.5 % were employed in non-market services, such as public administration, education, human health, arts, entertainment and recreation. Almost 25 % of employed people worked in industry, while only 5 % were employed in agriculture. The skill level and qualification of those employed also varied across the EU, with skilled non-manual workers accounting for 57.8 % in Luxembourg, while skilled manual workers accounted for 49.5 % in Romania and 36.9 % in Poland. Employees accounted for approximately 83.3 % of total EU employment in 2012, of whom 15.2 % were self-employed. Foreign citizens accounted for 7 % of employed personnel,

with the highest percentages observed in Luxembourg (49.9 %) and Cyprus (22.7 %). The majority of foreign citizens were nationals of another EU MS⁷⁹.

6.2 Current unemployment

In September 2013, the average (seasonally adjusted) unemployment rate was 12.2 % in the euro-zone area and 11 % in the EU. Both figures had increased compared to September 2012 (11.6 % and 10.6 %, respectively). The total number of unemployed EU citizens was almost 27 million, almost 20 million of whom were in the euro zone. The lowest unemployment rates were recorded in Austria, Germany and Luxembourg (4.9 %, 5.2 % and 5.9 %, respectively), whilst the highest rates were observed in Greece and Spain (27.6 % and 26.6 %, respectively). In comparison, the unemployment rate in the US was 7.2 % in August 2013⁸⁰. In September 2013, ca. 5.6 million young people (under 25 years) were unemployed in the EU, registering a slight fall in the Union but a slight rise in the euro zone. Youth unemployment rates for the EU reached 23.5 %, ranging from 7.7 % in Germany and 8.7 % in Austria to 52.8 % in Croatia, 56.5 % in Spain and 57.3 % in Greece⁸⁰.

6.3 Employment projections

Demographic change can have many impacts on future European labour, the most significant being the changing composition of the workforce (with respect to age, gender and nationality), as well as effects on health, safety and lifelong learning⁸¹. For the period 2018-2050, the ageing effect is expected to lead to a decline in total employment in Europe, which could translate into shortages in the labour market. Older workers (over 55 years) provided 10 % of the global workforce in 1990, and 14 % in 2010. By 2030, this proportion could reach 22 %⁸³, increasing to 40 % by 2060⁷⁸.

The overall participation rate (employed people plus those actively looking for employment) in the EU is expected to increase from 75.6 % in 2010 to 78.8 % in 2060, although the increase in the rate of participation in the 15-64 years age group is expected to be smaller and to occur mainly before 2020. The biggest increase in participation rate is expected among workers in the 55-64 years age group (ca. 22 % increase for women and ca. 11 % increase for men), leading to a narrowing of the gender gap in participation rates by 2060⁴⁹. Unemployment, on the other hand, is predicted to fall in the EU-27 from 9.7 % in 2010 to 6.5 % in 2060. A similar trend is expected for the euro zone (falling from 10.1 % in 2010 to 6.7 % in 2060). In parallel, employment is expected to rise from 68.5 % in 2010 to 71.5 % in 2020 and 74 % in 2060 (EU-27), with similar trends also foreseen for the euro zone⁴⁹.

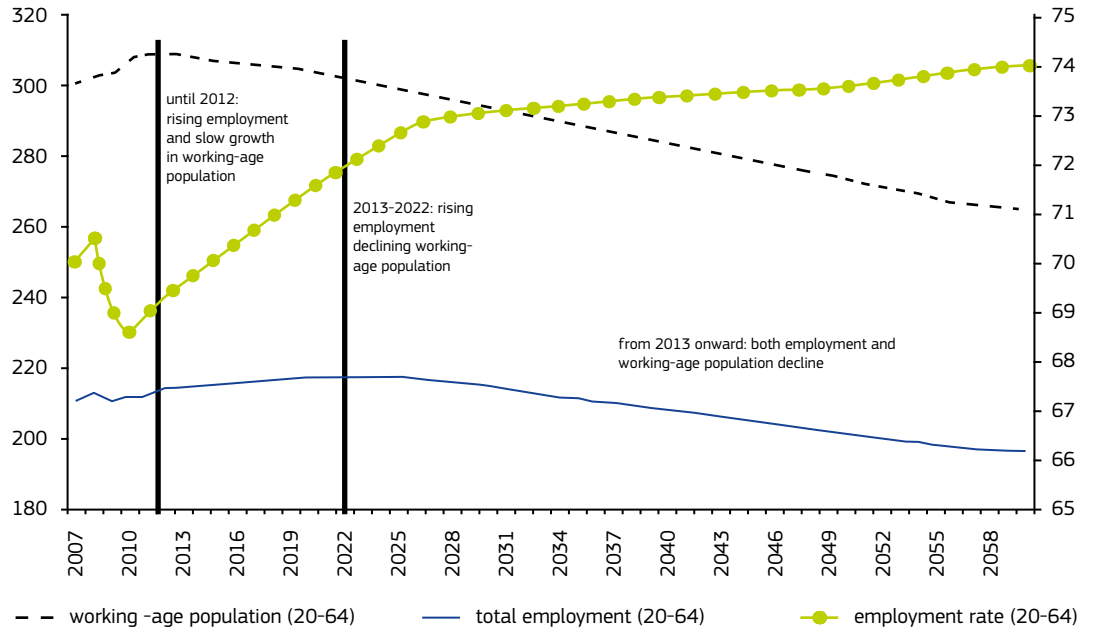
⁷⁸ Eurostat News release (8/2012) - Active ageing in the EU: The employment rate for persons aged 60-64

⁷⁹ Eurostat - Labour force survey overview 2012 website (accessed in April 2014)

⁸⁰ Eurostat News release (159/2013) - Euro area unemployment rate at 12.2 %

⁸¹ European Foundation for the Improvement of Living and Working Conditions (2010) Demographic change and work in Europe

Fig. 6.1: Population and employment developments in the EU
(Source: ⁴⁹, page 29)



In the period 2007-2012, the working-age population and the number of employed persons increased, since demographic developments are still supportive of growth. According to projections, in the period 2013-2021, the decline of the working-age population is countered by rising employment rates, while in the period 2021-2060 the ageing effect becomes more pronounced, and, in the absence of interventions, the working-age population and the number of people employed are expected to decline (Fig 6.1)⁴⁹.

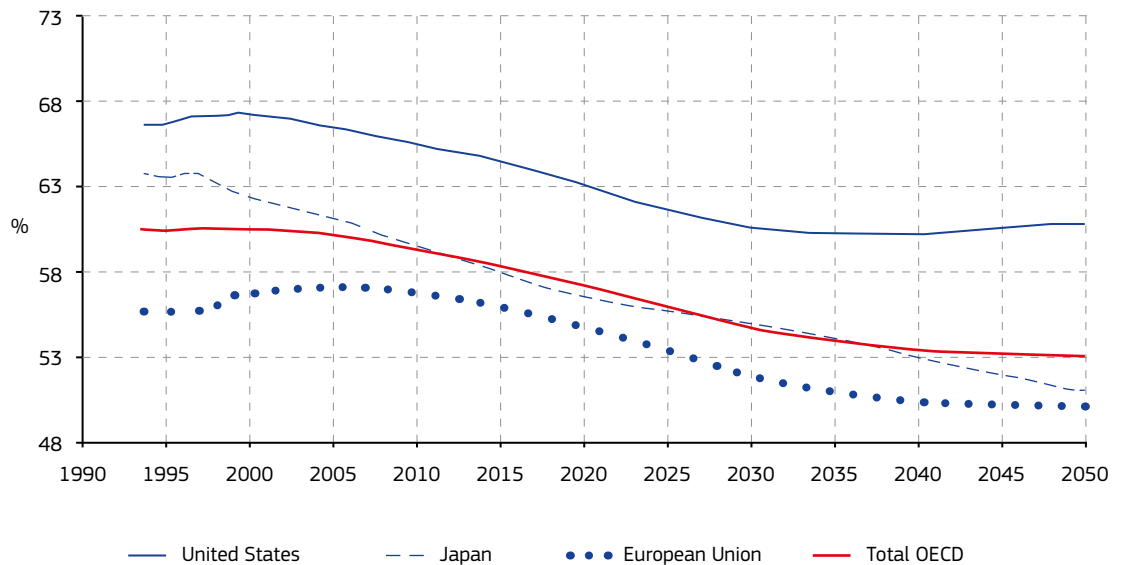
the OECD area might fall from 60 % to less than 53 % in 2050, with the drop more pronounced in the EU⁸² (Fig. 6.2). Substantial falls in labour participation rates are expected in countries such as Austria, Italy, Eastern European countries, Japan, Korea and, to a lesser extent, Germany, due to weak population growth, rapid ageing, and the low participation of workers aged 50 years or more.

However, OECD projections yield somewhat different messages. According to OECD pre-crisis projections, the total labour force for the OECD area will remain roughly the same, or decline slightly by 2050. Without policy interventions, the participation rate in

6.4 Careers in the future

Over the next few decades, jobs in advanced economies are unlikely to resemble either jobs of the past, or those recently lost due to the recession⁸³. Technology and demography have changed working conditions. As a result, the notion of full-time, exclusive

Fig. 6.2: Aggregate labour-force participation rates (15 years and over) in OECD countries, 1994-2050 (Source: OECD 2006⁸², page 43)



⁸² OECD (2006) - Employment Outlook: Chapter 2, Labour Market Performance since 1994 and Future Challenges
⁸³ McKinsey & Company (2012) Help wanted: The future of work in advanced economies

employment (full-time employment by a single employer), permanent jobs, where people are paid according to the time they accumulate at work and are evaluated by their hierarchical superiors, may be a characteristic of the 20th century, but not necessarily one of the 21st century workplace⁸⁴. In the EU, for example, part-time work patterns were high in some countries (e.g. the Netherlands, 49.2 % of employed people) but low in others (Bulgaria and Slovakia, 2.2 % and 4.0 %, respectively)⁷⁹. In the medium to long term, the expected rising share of part-time employment will result in a slight reduction in the total number of working hours, especially from 2020 onwards.

The concept of full-time exclusive employment has already been challenged, either by financial constraints or by adopting crowd-sourcing techniques and part-time schemes, using digital online platforms. Teleworking and video- or web-conferences are increasingly used in private and governmental settings, while outsourcing complete projects or parts of them results in non-standard hierarchies⁸⁴.

In 2011, and notwithstanding the economic crisis, 26 % of employers in Europe reported difficulties in filling jobs due to the lack of qualified candidates with the required skills, while 66 % of European managers said that finding candidates with the right skills was a key challenge for the near future⁸³. In the US, during 2000–2009, nearly all newly created jobs involved occupations characterised by complex interactions rather than simple two-way transactions, direct services or production, which is in line with a trend towards jobs that require more education and skills. Most of these interaction jobs were in ‘non-tradable’ sectors, not affected by global competition, such as in healthcare and education, and therefore their nature has changed less dramatically. In contrast, globalisation and technology had a significant impact in transactions and production-related work⁸³.

By 2020, it is foreseen that the US may lack 1.5 million workers with college or graduate degrees but may have an excess of 6 million workers who have not completed high school. Similarly, France could lack 2.2 million baccalaureate holders while, at the same time, having a surplus of 2.3 million workers without a degree. Geographical mismatches could also come into play in the future – i.e. high job offer and high job demand do not coexist geographically, as is already the case in North/South Europe. Finally, growing income polarisation, coupled with changing household structures and lower household income, is another factor to be considered in future⁸³.

In 2050, the labour market could be divided into two major dimensions: highly mobile, globally connected and specialised workers, on the one hand, and people working in the service and high automation sectors, relatively disconnected globally, with lower mobility options and opportunities, on the other. In the latter, effi-

ciency, productivity, high quality and customer relations will become another form of specialisation. In future, highly specialised markets will require solutions for highly complex tasks, thus more collaboration between various areas of expertise will be needed⁸⁵.

According to the US Bureau of Labour Statistics⁸⁶, in the period 2008–2018, employment in healthcare-support occupations is expected to grow most rapidly (35 %), followed by personal care and services professions (27 %), as well as healthcare practitioners and technical occupations (26 %). As regards specific professions, registered nurses, home health aides and personal care aides are expected to add the most employment, reflecting ageing population needs as well as an individualised society. In total, around one-third of the fastest growing occupations will be related to healthcare⁸⁶.

Of course, apart from already-known occupations that are expected to be in demand in the future, completely new functions may also be created as the result of technological and scientific developments. Table 6.1 presents some novel jobs that may be in demand in the future.

6.5 Work-leisure balance

The work-leisure balance is considered to be one of the major indicators of well-being. Too little work means that the individual may not earn enough to afford their desired standards of living, while working too much can have a negative impact on an individual's health, personal and family life⁸⁷. According to a recent literature review on work-leisure balance, an increase in economic growth (expressed as GDP) does not necessarily result in an increased feeling of well-being, since people tend to evaluate their income in relation to changing life standards⁸⁸. Balancing work and leisure is a common challenge for the average working person in the 21st century. In the 1960s and 1970s, a common belief was that technology would shift the balance towards leisure, by cutting down on hours of work⁸⁹. However, advances in information and communication technologies and digitalisation of the social and working environments have resulted in much easier access to work material, not only from home, but from virtually anywhere. A common example is checking emails from home or while travelling, or working late at night having access to office servers, etc. In effect, digitalisation has enabled increased availability outside normal working hours, as well as the expectations of being available; expanding the boundaries from work well into what is considered private life⁸⁹.

⁸⁵ European Commission Digital Agenda For Europe/Futurium website - Julie Kronstrøm Carton interview (accessed in February 2014)

⁸⁶ US Department of Labor (2012) Bureau of Labor Statistics - Economic and Employment Projections

⁸⁷ OECD (2011) - Compendium of OECD well-being indicators

⁸⁸ Haworth, J.T. (2010) Manchester Metropolitan University working paper

⁸⁹ The Conversation website article (30/072012) - Tool or time thief? Technology and the work-life balance (accessed in February 2014)

⁸⁴ The Aspen Institute (2011) The Future of Work

Table 6.1: Future professions⁹⁰

Job	Description
Productivity councillor	Helps people put emphasis on productivity and cost efficiency in their personal and professional lives
Personal digital curator	A specialist who recommends and maintains your unique suit of apps, software and hardware for your personal and business life
Microbial balancer	A trained expert who assesses the microflora of an environment or individual and provides recommendations for improving the ecosystem or personal diets and health
Corporate disorganiser	An expert who shuffles hierarchies in companies to create newness, start-up culture and organised chaos
Alternative currency speculator	Investment opportunities in virtual currencies such as Bitcoin
Urban shepherd	A micro-farmer specialised in plant care in small-scale urban gardens
3D handyman	A local 3D printing specialist, a 'do-it-all' repairman to fulfil everyday micro-manufacturing needs
Personal life logger	A need for experts to organise, catalogue and make sense of the volumes of personal information available
Digital detox therapist	A specialist in separating technology-obsessed individuals from their devices
Crowd-funding specialist	An expert of the 'kick-starter' system who understands how to promote and acquire funds for a project
Personal diet-trainer	A health trainer who not only recommends and looks after diets but also analyses personal and fitness data to create optimal life choices in food and health
Privacy consultant	This specialist reveals vulnerabilities in an individual's personal, physical, and most importantly, virtual habits
Remote staging	Hired career advisors and trainers who prepare and school people in the use of remote interviews, holo-conferences, including acronyms, 'webtiquette' and conversational skills
Internet meme agent	An agent who, instead of talents or celebrities, represents and maximises intellectual property in internet crazes
Drone driver	Expanding out of the military and into social life, be it taxis or bulldozers, remote drone operators with urban experience will be highly sought after

However, the opposite can also be true. A study revealed that the internet was being used for personal purposes during work time to a greater extent than for work-related purposes during non-work time, and found that internet used for work purposes outside of traditional working hours could assist work-leisure balance⁹¹. Finally, the notion of increased balance between work and leisure is not necessarily the only model of managing the relationship between working and private time. The 'work-leisure balance' that is sought after in the Western world will be in competition with the 'work hard - get rich' model that is emerging in Asia⁹².

In the end, technology is a tool and the shift in work-leisure balance might ultimately depend on the use made of it. Some companies have recognised that there are advantages, in terms of productivity and creativity, in 'switching-off' completely from work when not working, as in the case of a well-known European car manufacturer which only allows the receipt of work emails 30 minutes before and after the normal working period; outside normal working hours, email accounts are deactivated⁸⁹.

One of the greatest impacts of work-life imbalances relates to the time available for caring for and staying

with children. In some cases, parents and companies employ schemes, such as part-time employment, continued wage payments during maternity leave, flexible working hours, childcare facilities and similar family-friendly practices. However, most of those are observed in the public sector or large private entities and are most commonly associated with highly educated and highly skilled employees. Often, less-skilled employees do not have access to similar opportunities, and smaller firms find the cost of family-friendly practices too high⁹³. In parallel, governments are reluctant to intervene and impose family-friendly practices due to the fear of increasing labour costs along with the belief that this issue should be handled at employer-employee level. However, some countries, such as the Netherlands and the UK⁹³, have begun to regulate flexible workplace practices.

The OECD reports⁹⁴ that the best country for work-leisure balance is Denmark, followed by the Netherlands, Norway and Belgium, with Japan, Mexico and Turkey being the worst. In Denmark, people devote 69 % of their day to personal care (sleeping, eating) and leisure (socialising with friends, family, games, computer, television), which amounts to 16.1 hours. In addition, less than 2 % of employees work very long hours. In comparison, the OECD average is 14.9 hours, accounting for

⁹⁰ Adapted (2013) from Innovation Excellence website (accessed in November 2013) and sparks & honey website (accessed in November 2013)

⁹¹ Wajcman et al. (2010) *J Sociol* 46:257-275

⁹² IMD World Competitiveness Yearbook (2014) -The Competitiveness Roadmap 2014-2050

⁹³ OECD (2008) Policy Brief - Babies and Bosses: Balancing Work and Family Life

⁹⁴ OECD website on Work-Life Balance (accessed in November 2013)

62 % of the day. The share of employees in OECD countries working more than 50 hours per week is 12 % for men and 5 % for women; Turkey (46 %) Mexico (29 %) and Israel (20 %) display the highest shares of employees working more than 50 hours/week compared to the total⁹⁴.

In the absence of policy interventions to reduce working hours, the global trend towards a US-style model of more work (more working hours, blurring of boundaries between work and private life) will continue. In the US, this trend is due to the growing participation of married women in employment, growing inequalities in income, new technologies and the desire for increased profits; similar factors apply in the UK⁹⁸.

Apart from the increasing number of working hours and the blurring of work and private life, the type of leisure activity is also important. For many, leisure is used for relaxing and recuperating from the stress of work, potentially resulting in a passive leisure lifestyle. On the other hand, active leisure, such as trying and mastering novel challenges (new hobbies or leisure activities), is rendered difficult by our social system and environment. However, it is this active leisure that is most important for health and well-being, as participation in both physical and non-physical leisure activities has been shown to reduce depression and anxiety, and to promote positive moods, self-esteem and social interactions⁹⁸.

7. Non-communicable diseases and obesity⁹⁵

Non-communicable diseases (NCDs) are responsible for about 63 % of all deaths worldwide (ca. 36 million out of 56 million deaths in 2008), with cardiovascular diseases, cancer, diabetes, and chronic respiratory diseases playing the major role. They represent a burden for the affected individuals but also put substantial economic strain on the healthcare system⁹⁶.

7.1 Current NCD trends

Among NCDs, cardiovascular diseases were responsible for most deaths in 2010 (17.3 million), followed by cancers (7.6 million), respiratory diseases (4.2 million) and diabetes (1.3 million). Major NCD risk factors (tobacco use, physical inactivity, alcohol abuse and unhealthy diets) are lifestyle-related and thus can be influenced⁹⁷. Even in Africa, NCDs are

rising rapidly (with the double burden of hunger and obesity considered to contribute to this development), and are expected to exceed communicable, maternal, perinatal and nutritional diseases by 2030⁹⁷ as the leading cause of death. Susceptibility to NCDs increases with age, so the ageing population is expected to experience an increase in the burden of mortality due to NCDs⁹⁸.

The global prevalence of diabetes rose worldwide from an average of 8.3 % in men (range: 6.5-10.4 %) in 1980 to 9.8 % (range: 8.6-11.2 %) in 2008. Similarly, in women, diabetes prevalence increased from 7.5 % (8.1-10.5 %) to 9.2 % (8.0-10.5 %) in the same period⁹⁹. In 2013, 382 million people had diabetes; this number is expected to increase by almost 55 % to 592 million in 2035¹⁰⁰. Most people with diabetes are aged between 40 and 59 years, and 80 % of diabetics live in low- and middle-income countries.

High blood pressure, a major risk factor for coronary heart disease and stroke, is estimated to have caused 7.5 million deaths annually (2004), which was about 13 % of the total deaths. The prevalence of high blood pressure is slightly lower in high-income countries (35 %) compared to 40 % in all other income groups¹⁰¹.

In 2008, 2.4 million new cases of cancers were diagnosed in the EU¹⁰², while 1 million deaths were related to cancer in 2006¹⁰³. The most common cancer types for women were breast cancer, for men prostate cancer, followed by colon and rectum cancers, as well as lung cancer, amounting to more than 50 % of total cancer incidence in 2006. In general, cancer rates tend to be low in Southern and Western Europe, with some exceptions (Belgium, France, Luxembourg), and higher in Central and Eastern European countries (e.g. Slovakia and the Czech Republic). Projections show that by 2020, without any policy intervention on risks factors, there would be about 3.4 million new cases of cancer each year in Europe, a 20 % increase from 2002, and that much of this rise in the total cancer burden will occur among men and women aged 65 or over¹⁰³.

It has been estimated that approximately 30-35 % of cancer deaths in the US are linked to dietary factors¹⁰⁴. According to the diet and cancer report¹⁰⁵ by the World Cancer Research Fund and the American Institute for Cancer Research, 70 % of endometrium cancer cases and almost half of stomach and colorectal cancer cases (47 % and 45 % of cases, respectively) could be prevented by the appropriate diet and body-fat levels, as well as

⁹⁵ UN Population Facts (No.2012/1) - Population Ageing and the Non-communicable Diseases

⁹⁶ Danaei et al. (2011) Lancet 377:568-577

⁹⁷ International Diabetes Federation (2013) - IDF Diabetes Atlas (sixth edition)

⁹⁸ WHO (2010) - Global status report on noncommunicable diseases

⁹⁹ OECD (2012) - Health at a Glance: Europe 2012

¹⁰⁰ Institute of Public Health of Slovenia (2008) - Responding to the challenge of cancer in Europe

¹⁰¹ Anand P et al. (2008) Pharm Res 25:2097-2116

¹⁰² World Cancer Research Fund & American Institute for Cancer Research (2010) - Policy & Action for Cancer Prevention: Food, Nutrition and Physical Activity (executive summary)

⁹⁵ This chapter complements Chapter 1 of the background document (Annex I)

⁹⁶ Harvard School of Public Health & World Economic Forum (2011) -The Global Economic Burden of Non-communicable Diseases

⁹⁷ WHO Noncommunicable diseases fact sheet website (March 2013 update, accessed in February 2014)

Fig. 7.1: Overweight and obesity (% of total population) in men, 2008 (Source: ¹¹¹)

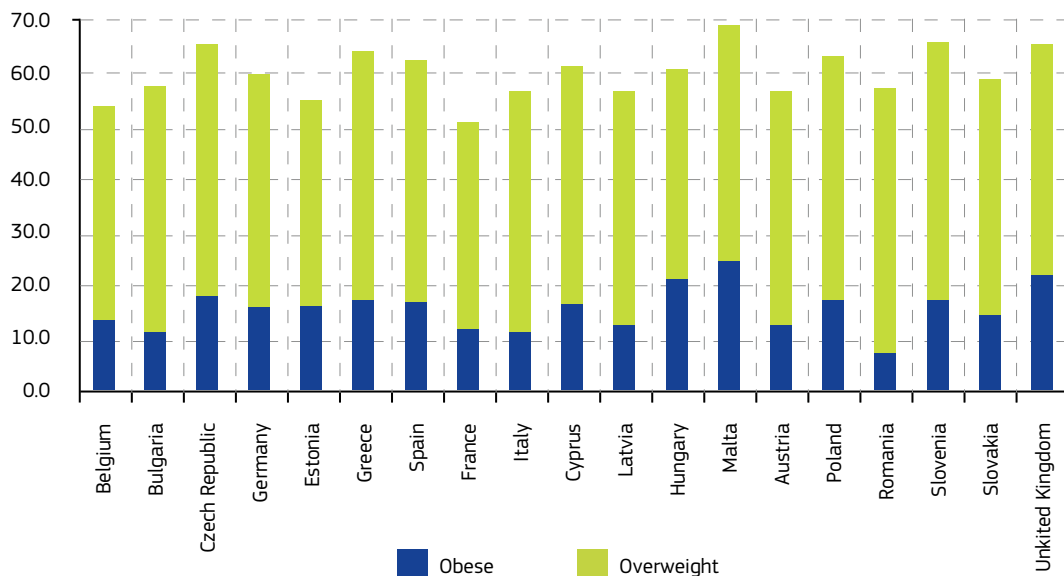
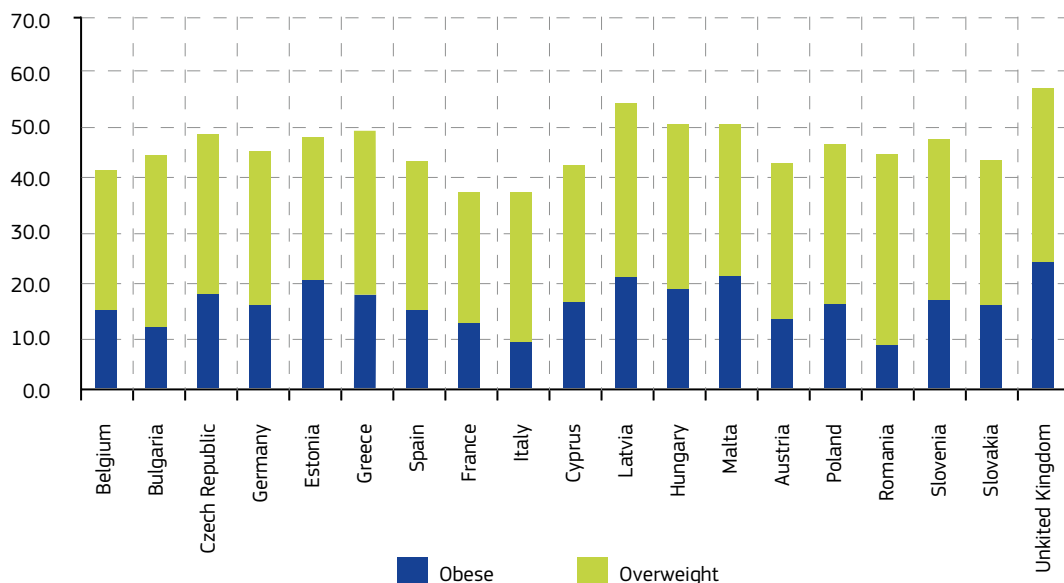


Fig. 7.2: Overweight and obesity (% of total population) in women, 2008 (Source: ¹¹¹)



physical activity. To a lesser extent, this also applies to pancreas (39 % of cases), breast (38 %), kidney (24 %), gall bladder (21 %), liver (15 %) and prostate cancer (11 %).

Apart from NCDs linked to lifestyle and diets, dementia is also a public health concern in both the developed and developing worlds, driven by increasing life expectancy. Approximately 36 million of people suffered from dementia in 2010, a number which is expected to double every 20 years, reaching 66 million by 2030 and 115 million by 2050. In addition, approximately 60 % of those afflicted currently live in low- to middle-income countries, where awareness is low and social and healthcare-protection mechanisms are limited. Since the bulk of the expected population increase will occur in those countries, so will the increased prevalence of dementia. In 2050, 71 % of dementia-affected people are expected to be living in low- to middle-income countries¹⁰⁶.

7.2 Obesity

(addendum to background document¹⁰⁷)

Obesity is considered by the WHO as one of the greatest public health challenges for the 21st century. Worldwide, obesity prevalence has doubled since 1980; in 2008, an alarming 1.46 billion adults were overweight, and one-third of those were obese¹⁰⁸. The body mass index (BMI) has increased worldwide by 0.4 kg/m² per decade from 1980 to 2008.

Obesity is a major contributor to the burden of NCDs and loss of quality-adjusted life years (QALYs). The burden of disease caused from obesity may be equal to, or even greater than that caused by smoking, due to the marked increase in the proportion of obese people.

Childhood obesity is a particularly challenging public health issue, because overweight and obese children are likely to stay obese into adulthood and develop NCDs such as diabetes and cardiovascular diseases

¹⁰⁶ Alzheimer Disease International (2013) - Policy Brief for Heads of Government - The Global impact of Dementia 2013-2050

¹⁰⁷ This section complements Section 1.1.2 of the background document (Annex 1)
¹⁰⁸ Finucane MM et al. (2011) The Lancet 9675:557-567

at a young age. In 2010, more than 40 million children under the age of five were overweight¹⁰⁹. The vast majority of those (35 million) are living in developing countries.

According to country estimates for 2008, over 50 % of men and women in the WHO European Region were overweight, while 23 % of women and 20 % of men were obese. In the EU (Figs. 7.1 and 7.2), overweight affects 30-70 % and obesity affects 10-30 % of adults¹¹⁰. For both women and men, the lowest obesity rates were observed in Romania (8.0 % and 7.6 %, respectively), Italy (9.3 % and 11.3 %, respectively) and Bulgaria (11.3 % and 11.6 %, respectively). The highest shares of obese men were recorded in Malta (24.7 %), the UK (22.1 %) and Hungary (21.4 %), while for women highest rates were observed in the UK (23.9 %), Malta (21.1 %) and Estonia (20.5 %)¹¹¹. Obesity increases with age, and a clear pattern is emerging among all MS: the older the age group, the higher the share of overweight and obese individuals. In contrast, the share of overweight and obese people falls with increasing levels of education.

According to global forecasts, by 2015, the number of overweight and obese people will rise to 2.3 billion, of whom 700 million will be obese¹¹². Currently, 35.7 % of adults and 16.9 % of children (aged 2-19) are obese in the US¹¹³. By 2020, 77.6 % of men are predicted to be overweight (including obese), and 40.6 % to be obese, while for women the corresponding figures are 71.1 % and 43.3 %, respectively¹¹⁴. By 2030, obesity rates for every US state are expected to be at least 44 %, while in 13 states it might exceed 60 %¹¹³. Another study confirms this forecast, with obesity prevalence predicted at 42 % for 2030¹¹⁵.

The UK obesity study¹¹⁶ projected that by 2015, 36 % of males and 28 % of females would be obese. By 2025, 47 % of men and 36 % of women would be obese, and by 2050 this would increase to 60 % and 50 % respectively, with less than 10 % of men and 15 % of women having a healthy body weight.

8. Healthcare expenditure

Public spending on pensions, healthcare, and long-term care is considered a “daunting challenge” for EU policy-makers⁴⁹ especially when trying to reduce health expenditure without reducing the quality of healthcare services. This chapter looks at healthcare expenditure in the EU, both currently and in the pre-crisis period, and presents how healthcare coverage can change where state funding is strained.

8.1 Health expenditure snapshot in 1998-2009

Health spending in OECD countries has risen more than GDP, resulting in an increasing share of GDP being spent on healthcare, amounting to 9.6 % in OECD countries in 2009¹¹⁷ and 8.3 % in the EU in 2008 (up from 7.3 % in 1998)¹¹⁸. On average, annual total health expenditure in Europe was around EUR 2200 per capita (both state and private insurance schemes), with the highest expenditure in Norway (about EUR 4300) and the lowest in Romania (around EUR 690). Most Northern and Western European countries spent between EUR 2500-3500, which is between 10-60 % more than the EU average, while those spending less than the EU average were mainly Central and Eastern European countries.

Across all EU MS, per capita spending on health grew by 4.6 % in the period 1998-2008. Highest increases were observed in countries which had low expenditures, while countries with high expenditures saw moderate increases¹¹⁸. Slovakia and Ireland experienced an average annual growth in real health expenditure per capita by 8.5 % and 7.8 %, respectively, while on the other hand, Switzerland, Germany and Norway experienced an increase of 1.9 %, 1.8 % and 0.8 %, respectively¹¹⁸. In general, there was a positive association between GDP and health expenditure per capita across European countries. However, situations arose where countries with similar GDP per capita devoted different funds to healthcare, for example in Spain and France, where Spanish spending on health was less than 80 % of the French expenditure¹¹⁸.

8.2 Health expenditure by function

Health spending also varies by function, and is influenced by factors such as hospital-bed availability, numbers of doctors, and access to new technologies. Across European countries, curative and rehabilitative care accounted for approximately 60 % of all health expenditure in 2008¹¹⁸.

The amount of curative and rehabilitative healthcare allocated to in-patient or out-patient spending

¹⁰⁹ WHO Obesity and Overweight Fact sheet No. 311 (updated March 2013, accessed in February 2014)

¹¹⁰ WHO Data and Statistics website - The challenge of obesity (accessed in February 2014)

¹¹¹ Eurostat - Overweight and obesity - BMI statistics website (accessed in February 2014)

¹¹² Berlin Institute Overweight website (accessed in February 2014)

¹¹³ Robert Wood Johnson Foundation (2013) - F as in Fat: How Obesity Threatens America's Future

¹¹⁴ US National Bureau of Economic Research (2007) - Current and Future Prevalence of Obesity and Severe Obesity in the US

¹¹⁵ Finkelstein et al. (2012). *Am J Prev Med* 42:563-570

¹¹⁶ UK Government Office for Science (2007) - Tackling Obesity: Future Choices - Project Report

¹¹⁷ OECD (2011) - Health at a Glance 2011: OECD Indicators

¹¹⁸ OECD & European Commission (2010) - Health at a Glance: Europe 2010

depends on the institutional arrangements for health-care provision. Austria and France had a high proportion of in-patient care – more than 33 % – associated with high hospital activity, whereas Spain and Portugal reported low levels of hospital activity and only allocated around a quarter of resources to in-patient care. Another major category of health expenditure is on medical material, including pharmaceuticals. Average European figures showed that about 25 % of health spending was used to cover medical material needs, ranging from a low of 13 % in Denmark to a high of 38 % in Bulgaria. Long-term care of the elderly also differed within the EU, with an average expenditure of around 8 % of the public health budget in 2008. Norway and Denmark had formal elderly-care systems, and allocated more than 20 % of public health spending to it. In Southern countries like Portugal and Cyprus, where elderly care was provided either within a family setting or informally, public funds were allocated at much lower percentages (1-2 %) ¹¹⁸. Average spending on public disease-prevention programmes across the Europe accounted for 2.9 % of total health expenditure in 2008, and included activities such as vaccination programmes and public campaigns against health-compromising behaviours. However, a wide variation has been observed across Europe concerning expenditure on public disease-prevention programmes, ranging from as low as 0.7 % in Cyprus and Italy, to highs of 5.7 % and 6 % in Finland and Romania, respectively. The percentage of public funds spent on prevention may not account for the true budget allocated and may be the reason for the wide variations observed. Some countries, such as Spain, carried out prevention campaigns at the primary care level and thus their costs may be included under the spending for curative care, while other countries with more centralised approaches may be more able to accurately identify their prevention programme spending ¹¹⁸.

8.3 Pharmaceutical expenses

Spending on pharmaceuticals is a significant proportion of the total health-care budget in the EU: increased consumption of drugs, due to the availability of new medications, and an ageing population have put a significant burden on state health-care systems. In the period 1998-2008, the total pharmaceutical expenditure in the EU rose by approximately 50 % and was estimated at approximately EUR 180 billion in 2008, accounting for an average of 18 % of total health spending. Spending across the EU was calculated at EUR 376 per capita. Greece and Ireland spent the most per capita for drugs (EUR 584 and EUR 563, respectively), whereas Romania (EUR 172) and Estonia (EUR 224) spent the least ¹¹⁸. In general, Central-Eastern European countries are among the lowest spenders on pharmaceuticals in the EU. On average, the public budget covers around 60 % of pharmaceutical expenditure in the EU, due to higher co-payment under public health insurance systems, or to a lack of cover for non-prescribed drugs.

Public budget expenses on pharmaceuticals were the lowest in Bulgaria (20 %), while countries like Germany, Luxembourg and Greece passed on only a small portion of the expenditure to the patient (approximately 80 % being covered by their health-care systems). On average, pharmaceutical spending accounted for 1.7 % of GDP across the EU, ranging from below 1 % (e.g. Luxembourg, Norway) to more than 2 % (e.g. Greece, Hungary, Portugal) ¹¹⁸.

8.4 Health expenditure after the crisis

In 2011, health expenditure fell from 9.6 % to 9.3 % (of GDP) across all OECD countries ¹¹⁹. The economic crisis affecting Europe has also hit the public health-care sector, especially in Southern Europe. In 2010 and 2011, the annual increase in public spending on health was minimal, around 0.5 % (compared to 5 % annually from 2000 to 2009) ¹¹⁹. Health spending fell sharply in 2010, and stagnated in 2011, due to the effects of the economic crisis, particularly in those EU countries most affected by it. For example, in Greece, overall health spending fell by 11 % in 2010 and 2011, mainly due to deep cuts in government spending, following annual growth rates of 5 % from 2000 to 2009. Other crisis-stricken countries, such as Portugal and Italy, delayed cuts in 2010 but reduced public spending in 2011. In Portugal, public spending decreased by 8 % in 2011 ¹¹⁹. Health spending has also slowed in Canada and the US.

These reductions in public expenditure on health have usually been made across the board, with a reduction in pharmaceutical spending, increased co-payment for the citizens, reduced prices and ranges in cover, as well as promoting the use of generic drugs. Portugal, Greece and Spain cut expenses on pharmaceutical prescriptions by 20 %, 13 % and 8 %, respectively, and in Spain the market share of generic drugs doubled between 2006 and 2011 ¹¹⁹. Some countries have also opted to cut funding for prevention measures, although prevention does not usually account for a large part of health expenditure. Public spending on hospitals has also been reduced, by lowering wages for doctors and hospital personnel, reducing staff and beds, increasing co-payment, and merging health structures, etc. As a result, for the first time since 2009, the percentage of GDP devoted to health spending has been reduced in many OECD countries.

A 2010 OECD report outlines priorities and strategies to be employed in the health system in times of reduced funding capability ¹²¹. In order to reduce health-care costs, bonus insurances schemes for a healthy lifestyle or significant reductions in insurance coverage could provide a way forward ¹²⁰. So far, EU countries have opted for the latter: reductions in healthcare coverage, in the percentage

¹¹⁹ OECD (2013) - Health at a Glance 2013: OECD Indicators

¹²⁰ The Federation of German Industries (BDI) & Z Punkt (2012) Germany 2030 – Future perspectives for value creation

of state coverage for pharmaceuticals, as well as reimbursements only for generic drugs are just some of the examples. In Germany, the health spending per capita increased by only 1.8 % per year in the decade 1999-2009, one of the lowest percentages in the EU, due to cost-containment policies such as those mentioned above. Growth in pharmaceutical spending is an area that has seen intervention by state policies, via a mix of price and volume controls directed at doctors and pharmacies, as well as policies such as lower drug prices (Ireland, Greece and Sweden) or state reimbursement of generic drugs only (which are cheaper than the original brands). Such measures can result in substantial savings in spending, such as those seen in Germany and the Netherlands¹²¹.

8.5 Healthcare expenditure projections

Long-term projections of spending on public healthcare are challenging, since they involve many uncertainties, including future spending and the complex situations surrounding national health-care systems⁴⁹. Nevertheless, according to the 2012 Ageing Report⁴⁹, the reference scenario¹²² projected an increase in health-care spending from 7.1 % of GDP to 8.3 % for the EU-27, with the lowest increases forecast for Belgium and Cyprus (0.4 % percentage points) and the highest for Malta (2.9 %). In particular, long-term care¹²³ costs in the EU could be affected and could almost double from 1.8 % of GDP in 2010 to 3.4 % in 2060, ranging from a rise of less than 0.5 % in Bulgaria, Estonia, Cyprus, Latvia, Portugal and Slovakia to more than 2.5 % in Belgium, the Netherlands, Finland and Sweden. Higher rises in public health expenditure are projected in the “risk scenario”¹²⁴, where the average EU public spending on healthcare is expected to rise to 8.9 % of GDP by 2060, 1.7 % higher than the 2010 expenditure and 0.6 % more than the reference scenario. On average, long-term care costs in the risk scenario for the EU are expected to increase by 1.7 %.

OECD projections suggest that as a result of the drivers that exert upward pressure on health spending, such as rising incomes, technological changes and demographic factors, health expenditure will continue to rise and become a major concern for most governments. Health expenditure and long-term care could increase by 50 % or even 100 % between 2005 and 2050 across OECD countries¹²¹. Even with the adoption of cost-containment policies, public health-care spending could still increase

by approximately 50 % over the same period¹²⁵. However, the recent economic crisis has shown that wild-card events like this could severely affect health-care spending and change decade-old trends. Current projections for OECD countries in 2060 place long-term care and public health expenditure at 9.5 % of GDP (8 % public healthcare and 1.5 % long-term care), under cost-containment scenarios, and assuming policy interventions will be made to rein in expenditure growth¹²⁶. In a cost-pressure scenario, which assumes no policy interventions, total spending could reach up to 14 % of GDP. Increases in health-care expenditure will be mainly driven by the combined effects of technology, relative prices and exogenous factors (institutions and policies).

9. Digitalisation and technology in food and health¹²⁷

We currently live in a highly digitalised world, accessible mainly by personal, mobile devices which, apart from being used in everyday transactions, also function as portals for virtual social life. Digitalisation and technological advances are already finding their way into health and food applications and are expected to have an even greater impact in the future. Therefore, this part of the review focuses on both the current status and future trends of digitalisation, with a special focus on digitalisation in healthcare and food.

The digital world is evolving at an astonishing speed, producing massive amounts of data, the volume of which is expected to grow even more with ever-more powerful computing¹²⁸. Data might increasingly be stored in a cloud-computing format rather than traditional storage devices (e.g. hard disks) and could become accessible from an expanding range of personal mobile devices. In future, free access to information will affect many aspects of private, social and political life. However, digitalisation can be a double-edged sword, offering extended freedom of information but also providing for extensive control.

Technological innovation in food and health through information and communication technologies (ICT), nanotechnology, biotechnology and synthetic biology has the potential to influence processes and products throughout the food and health sector, as well as consumer behaviour. Tight regulation in technological developments may benefit the careful

¹²¹ OECD Health Ministerial Meeting Session 1: Health System Priorities when Money Is Tight, Paris, 7-8 October 2010

¹²² Scenario that assumes that half of the increased life years (increased life expectancy) is spent in good health

¹²³ Defined (EU 2012 Ageing Report) as the organisation and delivery of a range of services and assistance to people who are limited in their ability to function independently on a daily basis for an extended period of time

¹²⁴ Same as the reference scenario but also includes the impact of non-demographic cost drivers, such as technological changes (i.e. new treatments and equipment) and institutions (i.e. universalisation of health coverage or breakdown to regional coverage) that may result in rises in expenditure beyond what might be expected from the demography

¹²⁵ OECD (2006) Economics Department Working Paper No. 477 - Projecting OECD Health and Long-term Care Expenditures: What are the Main Drivers?

¹²⁶ OECD (2013) Economic Policy Papers No.06 - Public spending on health and long-term care: a new set of projections

¹²⁷ Part of this topic has been covered in the background document (Annex I), in Chapters 1, 3, 4 and 5. Only additional information not covered in the background document is presented here

¹²⁸ Accenture (2013) Top Three Healthcare Technology Trends: Big, Personal, Social

assessment and safety of use but, on the other hand, it may slow down innovation, and there is a risk that technological developments will not be able to tackle future challenges. In contrast, the lower regulation of new technologies leaves room for innovation and the rapid development of novel techniques, with the risk of a lack of long-term assessment of their effects, which could potentially create issues in the provision of safe food and health services. In either case, consumer acceptance of new technologies is key.

9.1 Digitalisation: general trends and future impacts

The use of internet for personal and social communication has already substituted traditional forms of communication: 54 % of US internet users have posted original photos or videos they have produced themselves, while 47 % have shared photos or videos found while browsing online¹²⁹. Digitalisation has become an integral part of everyday life in the developed world, being involved in communications, financial transactions, business and governmental infrastructure, online shopping, etc. Although a wealth of information is readily available, there is no guarantee that such information is always of good quality.

The control of information provision through the internet, in both a political and commercial sense, is already of crucial importance and will continue to be so in the future. The importance of internet control was highlighted by the 2012 World Conference on International Telecommunications, organised by the International Telecommunication Union (a UN agency), to update a global treaty on technical standards for communications¹³⁰. The last such meeting was in 1988, when the internet was in its infancy, and communications were still of an analogue nature. Debate during the 2012 conference centred on who should control internet, and to what extent, and on how much control a state should exercise over its own internet, dividing the participant nations in those that broadly support internet freedom (e.g. US and EU) and those that advocated tighter controls, including monitoring, filtering and censoring content (e.g. emerging powers such as China and Russia)^{131, 132}. However, various groups, such as Google, the Internet Society, the International Trade Union Confederation and Greenpeace have already warned that such discussions by governments – even on a global scale – on internet communication standards, could set a bad precedent, introducing practices and opening up ways of controlling the internet¹³⁰.

In 2011, approximately 30 % of the global population had access to internet, 60 % of whom were users from the developed world (Europe, US, South Korea and Japan). In total, Asia accounted for 42 % of internet users in 2010¹²⁹. It is likely that towards 2030 there will be a shift of influence towards Asia, as a bigger share of its increasing population gains access to the internet. Following current trends, by 2020 most people would be connecting to the internet via mobile devices, which are expected to evolve into a small personal computer device with telecommunication capabilities. In fact, mobile device internet access is the only internet access available to the majority of people in the developing world, and is expected to remain so in 2030¹²⁹.

The emergence of internet users in countries such as China may result in new regional digital platforms and services that would challenge the current integrated state of the internet, and could result in fragmented or closed communities in future. Therefore, the digital world of the future may not be similar to the current, globalised state¹³³. The influx of new users from emerging nations may have other impacts in the global digital arena and could change the way the internet works. These new users are expected to be more innovative, more likely to produce and change rather than merely consume content, compared to users in the developed nations. Even so, it is unlikely that the technological supremacy and innovation of US companies will be challenged in the near future¹³³.

Over the last decade, computer prices have fallen by 90 % – a trend which is expected to continue in the future¹³⁴. On the other hand, between 2000 and 2011, the number of global internet users rose by 480 %. Following a similar exponential growth rate, 99 % of the global population could have internet access by 2030, assuming that internet access is seen as a public good and is prioritised by governmental policies. As a result, it is expected that in the future the digital divide between developed and developing world will be reduced significantly, while not disappearing completely. Current electronic gadgets could be sold for very low prices, unimaginable today¹³⁴. In addition, the development of tools such as cloud computing would give small businesses and individuals in the developing world the chance to use the same tools as their competitors in the developed world, since no special or physical infrastructure is required. However, this enhanced availability of information in the developing world would not guarantee increased knowledge for the public, and the management of knowledge could be a further issue: a new divide may develop between companies, governments and regions that control strategic knowledge (in the political and commercial sense) and those that do not¹²⁹.

¹²⁹ EUISS-ESPAS (2012) Global Trends 2030 - Citizens in an Interconnected and Polycentric World

¹³⁰ NY times online article (27/11/2012) – Integrity of Internet is Crux of Global Conference (accessed in February 2014)

¹³¹ The Economist online article (6/4/2013) – To each their own: China's model for controlling the internet is being adopted elsewhere (accessed in January 2014)

¹³² The Guardian online article (22/08/2012) – The fight for control of the internet has become critical (accessed in January 2014)

¹³³ Foreign Policy article (15/08/2011) – The FP survey: The Internet (accessed in February 2014)

¹³⁴ Wall Street Pit online article (13/05/2009) – Computer Prices have Fallen by 90% over the Last Ten Years: is that Evidence of Monopoly Power?

The digital world offers huge opportunities for virtually unlimited access to information, potential empowerment of the individual, as well as peer-to-peer connections and knowledge exchange. Access to information would not be concentrated in the hands of a few and information could be spread easily and widely, challenging established channels¹²⁹. New informational tools enable citizens or small groups to double-check facts, using digital platforms to report in a rapid and wide manner on issues that might normally be hidden from the public (or inaccessible). This can give even small individual groups considerable power, and can support revolutions against totalitarian and oppressive regimes, potentially facilitating a move to more democratic forms of government. In future, controlling the digital world will be difficult, even for organised entities such as governments or corporations. Countries which limit/control internet access have already experienced how difficult this task can be¹³⁵.

Unlimited access to data and extensive digitalisation of private and social life can be a double-edged sword. Governments, corporations and organised interest groups could also exploit digitalisation to exert greater control over citizens' lifestyles and diets, violating their privacy. Digital surveillance, either of browsing habits for marketing purposes or of digital communications for political or military purposes, is already happening and will continue to do so in the future, possibly including new forms of digital propaganda, outright censorship, and banning internet access, etc. Cyber-attacks are also likely to increase in the future, as more and more critical aspects of life and work are conducted online. Cyber-crime by organised criminal groups, and cyber-attacks by activists or anarchists are likely to threaten business, individuals and governments as they rely increasingly on digital systems. Similarly, cyber-warfare could be used by states or other groups to gain strategic or even tactical battlefield advantage. In fact, digital platforms are perfectly suited for individuals or smaller and less powerful groups to challenge opponents with conventional/traditional power¹²⁹.

9.2 The changing face of healthcare

Three major technological trends that are currently evolving have the potential to impact the future of healthcare: size and scale of digital technologies and available information, the personalisation of all kinds of services for individual needs, and social networking creating interlinked communities of consumers. In general, the concept of healthcare is moving towards personalised preventive health maintenance and away from cure. However, to achieve this by 2050, various scientific and information technology developments are needed (e.g. better knowledge of effects of nutrition on health, ability to combine data

from multiple settings to construct health profiles), as well as mindset and policy and institutional changes (responsibility of health shifted in part from physician to empowered individuals, required legal and structural framework)^{136,137}. Currently, a proliferation of patient-focused health applications intended for use by the patient alone can be seen¹³⁸. By 2050, the individual/patient could become increasingly able to self-monitor his/her health status – via advanced medical devices – while acquiring the ability to understand and interpret basic data and patterns and receive early warnings. Peers with similar health interests, as well as health collaborators and advisors (health coaches, wellness instructors, etc.) could also assist in data interpretation and basic preventive measures. Finally, as a third layer, traditional public health-care systems and health professionals could provide specialised health-care services in diagnosis and treatment. All of the above would take place in an environment where various 'omics technologies (e.g. genomics, metabolomics) generate data on personalised health informatics platforms. An expanded concept of personalised preventive health and healthcare would include desirable health outcomes going beyond prevention, treatment and cure towards enhancement and longevity¹³⁷.

The above technological trends (size and scale, personalisation, and social networking) can already be seen in health technologies. Gaming consoles are being used for fitness, tele-health is offering patients remote access to specialised professionals, resulting in faster, cheaper as well as multiple medical advice, and health-care networks help practitioners deliver services better¹²⁸ or stay informed on developments within their profession. Currently, 60 % of US physicians use their smart phones to access health content online, and 44 % use tablet computers (so-called mobile or mHealth)¹³⁹.

Apart from better access to medical records, digitalisation also enables teleworking for certain functions within the medical profession, and helps reduce staff and space resources in the health-care system. Last, but not least, digitalisation offers immense opportunities for the remote and real-time monitoring of patients¹³⁶. Worldwide, 2.8 million patients are already using monitoring devices to measure and send alerts on issues such as sleep apnea, blood pressure or adherence to medication. Remote monitoring may not only provide faster intervention in healthcare, but may also help offset a shortage of doctors where this remains a major issue¹³⁹. Mobile devices are being turned into decision-making diagnostic tools; for example, specific products deliver foetal heartbeat and maternal contraction-pattern data in real time to a professional's mobile device, whereas other applications enable instant access to radiology diagnostic images and reports¹³⁹.

¹³⁶ Open Health News blog (06/11/2011) - Notes on the Future of Health Care in America (accessed in January 2014)

¹³⁷ Swan, M. (2012) *J. Pers Med* 2:93-118

¹³⁸ Lubick Goldzweig et al. (2009) *Health Affairs* 28:282-293

¹³⁹ Medical Economics online article (10/03/2013) – 5 tech trends that will affect the way you practice medicine in 2013

¹³⁵ NY Times online article (15/01/2010) - Scaling the Digital Wall in China (accessed in January 2014)

Table 9.1: Potential future health technologies (currently experimental)

Technology	Application
Anti-bleeding gel ¹⁴²	Rapid wound sealing and blood clotting
Magnetic levitation ¹⁴³	Artificial lung tissue grown in 3D
Artificial cell mimicry ¹⁴⁴	Artificial cell cytoskeleton replacing lost or damaged cells
Brain cells from urine ¹⁴⁵	Waste cells from urine modified with retroviruses to create progenitor cells
Electric underwear ¹⁴⁶	Delivering electrical charges mimicking movement against pressure sores
Pollen vaccines ¹⁴⁷	Pollen as robust delivery vehicles for vaccines for overseas military personnel
Bio-powered equipment ^{148, 149}	Powering pacemakers with energy generated from ear electrical gradient
Wi-Fi tooth sensors ¹⁵⁰	Oral activity sensors transmit data when smoking or overeating
eSkin ¹⁵¹	Biomedical sensors in the form of resilient, artificial, sensing skin
iKnife ¹⁵²	Intelligent scalpel tells doctor if tissue is cancerous
DNA Legos ¹⁵³	DNA used to build nanostructures applied in biophysics, medicine and electronics
Robotic tele-diagnosis ¹⁵⁴	Robot controlling a probe on a distant patient for remote examination and diagnosis
Silencing genes ¹⁵⁵	Silencing disease genes in clinical settings
Use of biobots ¹⁵⁶	Biobots for diagnosis, drug delivery, 'patrolling' and tele-operation
Breath analysis ¹⁵⁷	Identifying microbes or disease markers, e.g. cancer, heart diseases
In-vitro red blood cells ¹⁵⁸	Universal red blood cells derived from stem cells

A US study of more than 6500 people reported that, in 2005, for 62 % of participants, general practitioners were the most highly trusted source of information, followed by the internet (24 %), television (20 %), family and friends (19 %), magazines (16 %), newspapers (13 %) and radio (10 %). When asked how they would prefer to access specific health information, 50 % said they would want to go to their physicians. However, when asked where they actually went for this specific information, 49 % checked online sources first, whereas only 10 % went straight to their doctor¹⁴⁰. The potential of ICT applications in health has been recognised by the US Food and Drug Administration (FDA), which recently called for the implementation of balanced and transparent approaches in the development of health IT solutions while, at the same time, ensuring appropriate protection for the patient¹⁴¹.

In an age where doctors will no longer be the sole holders of medical information, the role of the basic, primary, family doctor might change to that of a 'medical curator', directing patients to appropriate applications and online sources of information. Patients going for medical visits having already gathered information on their potential diagnosis from online healthcare sources^{139, 140}. The numbers of health applications designed to be used by the patient alone are rising, including those to

increase efficiency (reminders, web-based cognitive behavioural therapy), improve quality, and provide more accessible care for difficult issues (alcohol abuse and eating disorders). However, there has not been any solid evaluation of the emerging apps¹³⁸.

Access to medical information will be less and less limited to practitioners, since an increasing number of patients can access their personal health records via websites or mobile phone applications. The nature of electronic records for doctors is also changing. A survey from the US Centers for Disease

¹⁴⁰ Hesse et al. (2005) Arch. Intern. Med. 165:2618-2624

¹⁴¹ US FDA (2013) Statement: Health Information Technologies: Administration Perspectives on Innovation and Regulation (accessed in January 2013)

¹⁴² Medical Daily online article (19/03/2013) - College Student Joe Landolina Creates Healing Gel (accessed in December 2013)

¹⁴³ University of Texas, Anderson, M.D. Cancer Center news (15/03/2010) - 3-D Cell Culture: Making Cells Feel Right at Home

¹⁴⁴ Fox News online article (24/01/2013) Artificial gel mimics living cells (accessed in December 2013)

¹⁴⁵ Nature website news (09/12/2012) - Brain cells made from urine (accessed in December 2013)

¹⁴⁶ CBS News article (17/10/2012) Underwear uses electric shock to prevent bed sores (accessed in December 2013)

¹⁴⁷ Nextgov Newsletter website (10/12/2012) - Pentagon, NIH fund pollen-based vaccine delivery research (accessed in December 2013)

¹⁴⁸ BBC News article (05/11/2012) - Heartbeat 'could power pacemaker' (accessed in December 2013)

¹⁴⁹ Mercier et al. (2012) Nat. Biotech. 30:1240-1243

¹⁵⁰ New Scientist article (25/07/2013) - Sensor knows when you're lying through your teeth (accessed in December 2013)

¹⁵¹ New Scientist article (24/07/2013) - Feather-light sensors are as comfy as a second skin (accessed in December 2013)

¹⁵² Imperial College news (17/07/2013) - "Intelligent knife" tells surgeon if tissue is cancerous (accessed in December 2013)

¹⁵³ Gothelf, K. (2012) Science 338, No. 6111:1159-1160

¹⁵⁴ Istepanian et al. (2004) IEEE Transact Informat Technol Biomed 8:405-414

¹⁵⁵ Watts, J.K. & Corey, D.R. (2011) J Pathol 226: 365-379

¹⁵⁶ Bhatt et al. (2013) Int J Pharm Res Bio-Sci 2:301-314

¹⁵⁷ Risby, T.H. & Pleil, J.D. (2013) J Breath Res 7:010201

¹⁵⁸ In vitro red blood cell website - An in vitro universal red cell product (accessed in December 2013)

Control and Prevention showed that, in 2011, 54 % of doctors had adopted an electronic health-record system, 85 % of whom reported being somewhat or very satisfied, and 75 % reported that this change had resulted in enhanced patient care¹⁵⁹.

However, accelerating the adoption and implementation of fully digitalised health services will require more public-private partnerships (e.g. between state health-care institutions, academic experts, private health-care services and insurances, and private providers of health IT systems), as well as a robust evidence base regarding their implementation. Solid cost-benefit calculations on information technology implementation in health-care seem to be lacking. A current indicator for cost efficiency is the fact that institutions that both pay for and deliver health-care services have adopted health IT at a greater rate than organisations that only deliver healthcare¹³⁸.

Various advances are foreseen in the field of medicine^{160,161} based either on projections of current scientific achievements and developing technologies¹⁶² or on the insight of futurologists¹⁶³. It is beyond the scope of this review to discuss and evaluate specific future technologies in medicine, although some of them are presented in Table 9.1 to enable a vision of future healthcare.

9.3 Digitalisation in the food sector

Even though consumer preferences are, to a large extent, still defined by geographical and cultural characteristics, the recent digital revolution is connecting billions of people around the globe, overcoming cultural and geographical boundaries and empowering choices in how, where, when and at what price to get their food¹⁶⁴. Mobile devices have made this even easier: smart phones are used for accessing the internet, transferring money, and researching and purchasing consumer goods. In the US, digital shopping is now commonplace, with 25 % of smart phone owners having used the device to shop during the 2010 holiday season¹⁶⁴. However, it is not only about shopping, since many consumers are using digital platforms to evaluate products bought physically and online, as well as to evaluate retail services. In the retail sector in particular, digital technologies have become a vital tool, evidenced by an increasing number of consumer shops online. In addition, there are significant opportunities for food manufacturers to exploit the

rise of digitalisation in emerging markets, to better understand consumer preferences, and thus to target demands accordingly¹⁶⁵.

As mobile technologies evolve, more and more consumers are expected to use their mobile devices for every kind of shopping interaction: locating products inside the store, adding products to their digital basket while walking up and down the aisles, mobile payments, loyalty programmes and price comparisons. In future, retail services might adapt their marketing strategies and concentrate on offer specialisation, including brand-offer alerts, personalised shopping lists, mobile checkouts, and product ratings and reviews¹⁶⁶. Further, digital technologies could also provide opportunities for consumers with specific needs, such as food allergies, to use mobile scanning to quickly identify any items not suitable for their diets. Short-term predictions foresee a continual annual rise of 12 % for e-commerce in the retail of food and consumables for the period 2012-2017¹⁶⁷. In addition, while robotically handled foods (with the option to choose fresh produce oneself), selected via mobile devices and home delivered might be a thing of the future, virtual food supermarkets, with “augmented reality” retail models, where only some products are displayed physically and all shopping transactions are done via mobile phone applications, along with home delivery, are already a reality in some countries¹⁶⁸.

Technological innovation for food in the home environment has also sparked interest and has led to appliances^{169,170} such as automated kitchens that suggest and cook your meals, can recycle food components and water, retractable and self-cleaning kitchens, portable kitchens, automated coffee machines guided by user movements on a touchscreen, multimedia kitchens serving as computers, hi-fi and radio to improve the cooking experience, and ‘liftmatic’ ovens with a movable base for convenient loading. These are just some of the food-related home-appliance technologies which, although rare and still considered odd today, give a glimpse of what we can (or cannot) expect in the future.

¹⁵⁹ US Centers for Disease Control and Prevention (2012) NCHS Data Brief No.98 - Physician Adoption of Electronic Health Record Systems: United States, 2011

¹⁶⁰ See also Section 1.5 of the background document (Annex I)

¹⁶¹ The New Atlantis online article (No.1 Spring 2003) The Future of Medical Technology (accessed in January 2014)

¹⁶² Listverse.com website online article (22/03/2013) - 10 Medical Technologies That Could Shape The Future (accessed in November 2013)

¹⁶³ RossDawson.com website online article - Six radical visions for the future of health (accessed in November 2013)

¹⁶⁴ PricewaterhouseCoopers & GMA (2011) - Financial Performance Report: Thriving in a Connected World

¹⁶⁵ Food Navigator article (22/06/2011) - Digital technologies driving food industry growth (accessed in December 2013)

¹⁶⁶ Strategy& online article (2013) - New Food Retail Industry Outlook is Personal, Digital and Virtual (accessed in December 2013)

¹⁶⁷ Sowka, H. (2013) The future of food retailing

¹⁶⁸ Retail Feedback Group article (16/09/2013) - Future Food Retailing Possibilities (accessed in December 2013)

¹⁶⁹ House Automator website - Futuristic Kitchen (accessed in November 2013)

¹⁷⁰ Trend Hunter website article (20/06/2013) - The 2D smart kitchen handles all of your cooking needs (accessed in November 2013)

10. Primary production: trends and future challenges¹⁷¹

10.1 Main characteristics of EU primary production

A large proportion of EU citizens still live and work in rural areas: around 24 % live in predominantly rural regions while 36 % live in intermediate regions (regions where the rural share of the population is between 20-50 %). More than half of EU land area is made up by rural regions, while about a third comprises intermediate regions; approximately 40 % of the EU land area is currently being farmed¹⁷².

Structure of the sector: In 2007, there were 13.7 million agricultural holdings in the EU, of which 7.3 million were commercial and around 6.4 million were small holdings. Almost 60 % of all commercial agricultural holdings were located in Italy, Poland, Spain and Romania. The average EU farm size of all types of holdings was 12.6 hectares. The average size of commercial holdings in particular was 22.0 hectares, varying widely between EU MS, ranging from less than 10 hectares in Italy, Greece, Cyprus and Malta to more than 100 hectares in Slovakia and the Czech Republic¹⁷².

Land use, holdings size and labour: The majority (60.5 %) of the agricultural area being utilised in the EU is devoted to arable land, rising to 90 % in Denmark and Finland. The largest share of arable area can be found in France (18 %), followed by Germany, Spain, Poland (11 %) and Romania (8 %). The largest permanent pasture land share was in Ireland (75 %) as well as the UK and Slovenia (60 %). UK, Spain and France were the countries with the largest areas in pasture land, accounting for 18 %, 15 % and 14 % of the EU total, respectively¹⁷². In 2007, across the EU, 16.4 million people worked on a regular basis in commercial agricultural holdings, the majority of whom (89 %) were farm holders or their family members. Half of the farm labour force worked in crop farming, 36 % worked in livestock farming, and 13 % worked in combined crop and livestock farming. Organic farming has a rather small share in the EU, with close to 200 000 holdings classified as organic in 2009¹⁷². In 2010, intermediate consumption within agriculture was about 60 % of the gross agricultural output, with items associated with livestock production taking a 40 % share, mainly feedstuff.

Livestock: In 2010, livestock production in the EU numbered 152 million pigs (largest shares in Germany (about 18 %) and Spain (around 17 %)), 88 million cattle (about 22 % in France), and more

than 87 million sheep (about 24 % in UK and about 21 % in Spain). In 2009, 148.5 million tonnes of milk were produced in the EU, 90.5 % of which was collected, the rest being consumed on farms (lowest in Romania, 21.3 % of milk collected, followed by 55.9 % in Bulgaria). Almost 70 % of total EU milk production took place in Germany, France, the UK, Poland, the Netherlands, and Italy¹⁷².

Agricultural products: Cereal production in the EU reached 296 million tonnes in 2009, the largest share coming from France (23.6 %); other major producers were Germany (16.8 %) and Poland (10 %). The production volume was relatively stable over the medium term (2000-2009). The main cereals were wheat (46.7 %), barley (20.9 %) and grain maize (19.5 %). Germany, France and the UK were the main wheat and barley producers, while grain maize was largely produced in France, Romania, Hungary and Germany¹⁷². One-third of the EU potato production of 62.5 million tonnes was produced by Germany and Poland; France and Germany produced more than half of the EU sugar-beet harvest in 2009 (about 114 million tonnes)¹⁷².

Fruit and vegetable production tended to be concentrated in a few EU MS. In 2009, tomatoes were largely produced in Italy and Spain, carrots in the UK and Italy. Orange production took place mainly in Spain and Italy, whereas more than 50 % of EU apple production occurred in Poland, Italy and France. Pears, with an overall much lower production volume than apples, were mainly produced in Italy, Spain, the Netherlands, Portugal and Belgium¹⁷².

Fisheries: The largest fish catches were made in the Netherlands and Spain (about 882 000 and 704 000 tonnes, respectively), while Denmark, France, Ireland, Italy and Germany all reported landings of over 200 000 tonnes. For comparison, the total fish catches of these seven MS were only slightly higher than the combined fish landings of Norway and Iceland. Aquaculture has continued to grow in recent years: the main species being produced are mussels, trout, salmon and oysters. In 2008, Norway, the largest European producer, together with Spain, France, Italy and the UK, provided 78 % of the production from 34 European countries¹⁷³.

10.2 Future outlook on global food production

The global food system will face major challenges until 2050, such as balancing future demand and supply while keeping food prices affordable; ensuring the sustainability of food supplies and protecting vulnerable groups when crises occur; achieving global access to food and ending hunger, by producing

¹⁷¹ This chapter complements Chapter 5 of the background document (Annex I)

¹⁷² Eurostat Pocketbooks (2011) - Food: from farm to fork statistics

¹⁷³ European Environmental Agency, Aquaculture production (CSI 033) - Assessment published Sep 2011 (accessed in February 2014)

enough food to potentially feed everyone; feeding the world in an environmentally sustainable way, protecting biodiversity; and reducing the contribution of the agri-food chain to climate change¹⁷⁴.

The major limiting factor for global food production is the cropland area needed for food and feed cultivation; the amount of land required depends mainly on population numbers, average food consumption, and yield per unit of land¹⁷⁵. In general, potential savings on the cropland area for food production, due to yield increases, are counteracted by a combination of population growth and dietary change. However, crop yield gains have been based mainly on practices such as the increased use of fertilisers, pesticides and energy, and irrigation infrastructure, with significant environmental impacts.

In addition, as socio-economic status improves, population growth falls but diets become richer in animal protein. Animal products alone represent almost 50% of the increase in cropland requirements since the 1960s¹⁷⁵. Much of future meat production will stem mainly from feeding cattle with grains, instead of grazing them on pasture¹⁷⁶; in a 'business as usual' (no dietary changes) scenario, grain production for feed purposes is forecast to grow by 77% by 2030¹⁷⁶. Taking into account the fact that the world population is predicted to stabilise at approximately 9 billion in 2050 (see Chapter 4.1), the shift towards diets rich in animal protein may become the major factor driving increased land requirements in future for growing food and feed¹⁷⁵.

10.3 Projections on natural resources needed for food production

In the coming decades, land resources are likely to remain an important concern in food production. Moreover, it is evident that it will be necessary to produce more food either by using more land or by improving yields. Currently, around 11% of the world's land surface is used to grow crops. Significant areas of unused land with agricultural potential could be exploited in parts of Eastern Europe and in the former Soviet Union, but most of the potentially usable land is located in sub-Saharan Africa and South America. However, much of this has low productivity potential, and its conversion to agricultural land would result in significant negative impacts on climate change and biodiversity¹⁷⁷. The projections for increases in future arable land vary: FAO projections estimate an increase of almost 5% (70 million hectares, an increase of 120 million

hectares in developing countries, and a decrease of 50 million hectares in developed countries), while others¹⁷⁸ foresee an increase ranging from 6% to more than 30% (average range 10-20%).

The above emphasises the need for novel approaches in food production so as to increase yield without impacting the environment¹⁷⁹. According to the FAO, 90% of the growth in crop production (80% in developing countries) will be due to higher yields and increased cropping intensity, (with the rest resulting from increased land use¹⁷⁷). As with future land use, projections for future yield growth vary widely. FAO projections⁷⁶ foresee that crop yields will continue to grow, albeit at a slower rate, with an annual growth of 0.8% (2005-2007 to 2050); cereal yield in particular would slow down to 0.7% annually, reaching approximately 3.94 tonnes/ha in 2050 (2.94 tonnes/ha in 2005-2007). However, there is room for improvement in certain geographical areas. In Africa, for example, cereal yields have grown slowly, and are approximately one-third (1.2 tonnes/ha) of developing world average yields¹⁷⁷.

Irrigated agricultural land is expected to expand by 17%, mainly in developing countries; the freshwater needed for irrigation is expected to increase by 11% by 2050¹⁸⁰. Total agricultural water demand could increase by as much as 30% by 2050, while global total water demand could almost double (by 2050), due to agricultural, industrial and domestic demands¹⁷⁴. Globally, there is more than enough freshwater available, but it is unevenly distributed. The problem is often more severe in countries that also suffer from arable land scarcity, i.e. in the Middle East, North Africa and South Asia¹⁸⁰. In Europe, freshwater is mainly used for agriculture (42%), industry (23%), as well as urban use and energy production (both 18%). However, these rates vary according to geographical areas. In Southern European countries, like Greece, Italy and Spain, water is mainly used for irrigation, while in Scandinavian countries, like Finland and Sweden, freshwater is mainly used in industry (cellulose and paper production). Future projections for Europe foresee no increase in the use of freshwater for irrigation, particularly in Southern Europe; in fact, it may even decrease under environmental pressures or due to urban demand¹⁷⁷.

The scarcity of nitrogen and phosphorous – two other natural resources – could impact food production in the future. Nitrogen is required for plant growth; its under-supply can be a constraint in crop yields in developing regions while, on the other hand, in high-intensity agricultural areas an excess of nitrogen fertiliser can cause eutrophication and environmental pollution. The current trends in agricultural production could lead to a more than twofold increase in the global consumption of

¹⁷⁴ Government Office for Science, UK (2011) - Foresight: The Future of Food and Farming Foresight Final Report

¹⁷⁵ Kastner et al. (2012) PNAS 109:6868-6872

¹⁷⁶ Overseas Development Institute (2014) Future diets - Implications for agriculture and food prices

¹⁷⁷ European Commission (2011) Standing Committee on Agricultural Research - Sustainable food consumption and production in a resource-constrained world (3rd SCAR Foresight Exercise)

¹⁷⁸ Smith et al. (2010). Phil Trans R Soc B 365:2941-2957

¹⁷⁹ Godfray et al. (2010). Phil Trans R Soc B 365:2769-2777

¹⁸⁰ FAO (2009) - The Resource Outlook to 2050: By how much do land, water and crop yields need to increase by 2050?

nitrogen fertilisers. Phosphorous is also an essential plant nutrient, and a major non-renewable and non-replaceable input for agricultural food production, having a significant effect on grain yields. Global demand for phosphorous is growing – at current rates of use, current global reserves could last almost until the end of the 21st century. Scarcity of phosphorous could have a major impact on food prices, food security and the widening of inequalities between countries¹⁷⁷.

Tomorrow's healthy society

Research priorities for foods and diets

ANNEX III

SCHEMATIC SCENARIO OVERVIEWS

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Schematic overview of the **HEALTHY NEW WORLD** scenario

- **Strong community spirit**
- **Low agricultural commodity price**

Demographics

- Ageing population, low fertility rates
- Active & independent elderly
- Pension age raised
- Low inequalities
- Social cohesion
- Limited immigration

Health Policies

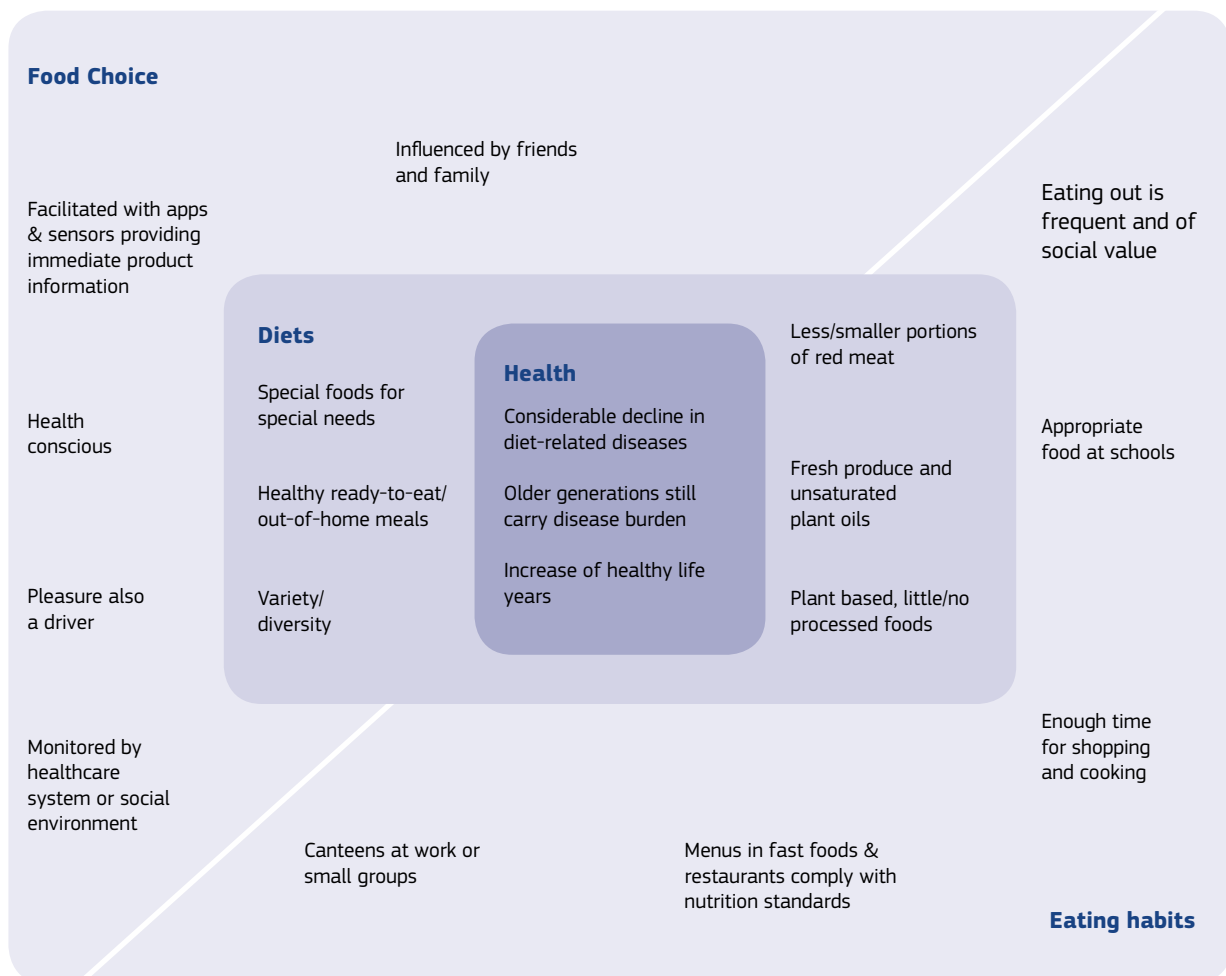
- State-funded healthcare
- Provision of care
- Focus on prevention/healthy lifestyles

Food Policies

- Strong governance on food quality & safety
- Authoritative nutrition guidelines
- Strong regulation of food sector
- Fiscal measures

Education

- Health consciousness & nutrition literacy
- Public awareness campaigns
- Nutrition in school curricula



Work

- Flexibility
- Jobs for all
- Distinction between work & leisure
- Health & well-being at work important

Technology

- Generally accepted
- Careful assessment and regulation
- Modern technologies support cooking
- Apps for health monitoring and behaviour tracking
- Combining health & nutrition with taste & convenience
- Apps provide info on nutrition, specific diets, labelling, references

Private Food Sector

- Online shopping
- Traditional supermarkets
- Concentration due to high regulation
- Niche markets for SMEs and co-operatives

Schematic overview of the **HEAL THE NEW WORLD** scenario

- **Strong community spirit**
- **High agricultural commodity price**

Demographics

- Ageing population, low fertility rates
- Extended family model
- Pension age raised
- Social cohesion
- Limited immigration

Health Policies

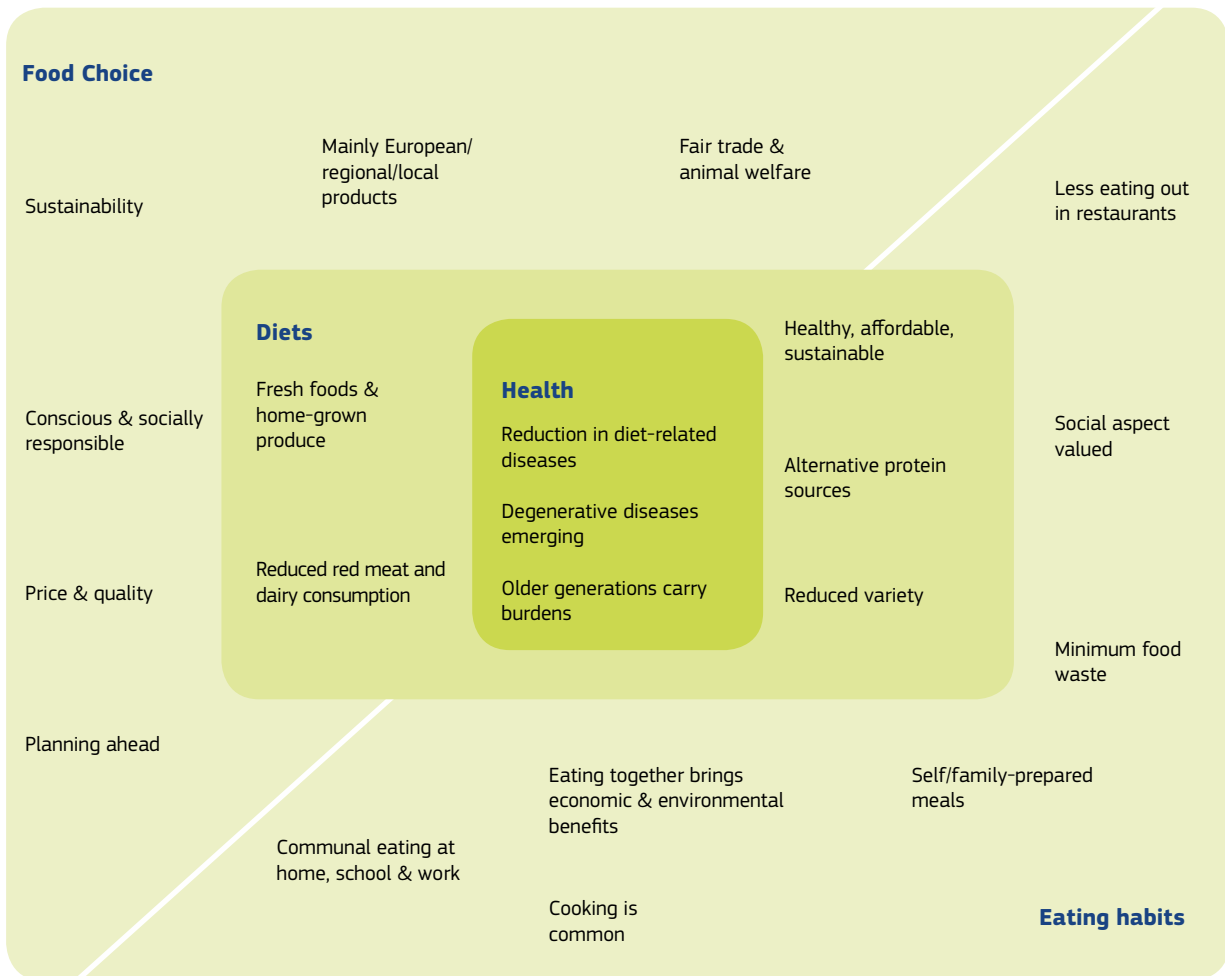
- Basic state-funded healthcare, co-payment necessary
- Transition period from treatment focus to prevention focus
- Limited support for vulnerable groups

Food Policies

- Strong governance on environmental sustainability
- Compulsory environmental labels
- Taxes on foods with high environmental footprint
- Focus on EU/regional/local products

Education

- Environmental & health effects of diets in school curricula
- Focus on cooking skills



Work

- Long hours
- Seniors also active
- Teleworking common
- Mobility & flexibility required

Technology

- Aim to increase cost-efficient production
- Acceptance after careful evaluation
- Government enforces framework
- Apps for healthcare, food
- GMOs, alternative & novel foods, nanotechnology
- Ready-to-use cooking ingredients

Private Food Sector

- Concentration of food chain
- Online shopping
- Less physical shopping
- Direct purchase from local producers

Schematic overview of the **EAT TO LIVE** scenario

- **Individualistic society**
- **High agricultural commodity price**

Demographics

- Ageing population, low fertility rates
- Social inequalities & tensions
- Poverty an issue
- Crime increasing
- Limited immigration

Health Policies

- Basic state-funded healthcare, co-payment necessary
- Private healthcare available (for those who can afford it)
- Long waiting lists in public health system
- Policies limited to provision of information
- Prevention in form of self medication/nutraceuticals

Food Policies

- Focus on market functioning
- Minimal regulation

Education

- Information from government, websites, industry, social circle
- Misconceptions, confusion & misinformation common
- Health & nutrition not taught at schools
- Poor cooking skills



Work

- Labour market insecurity
- More years & longer hours
- High flexibility & mobility required
- People often need two jobs

Technology

- High acceptance
- Aimed at cost-efficient food production
- Focus on longer shelf-life and packaging
- Low cost & common diet/health-monitoring sensors
- Reliable, science-based supportive apps expensive

Private Food Sector

- Concentration including primary production
- Multinationals mass produce limited variety of fortified foods
- Online shopping common
- Discount chains strong online
- Real shops reserved for special, high-end products
- Emergence of informal, non-regulated p2p businesses
- Vulnerable food system, compromised food safety

Schematic overview of the *ME, MYSELF AND I* scenario

- **Individualistic society**
- **Low agricultural commodity price**

Demographics

- Ageing population, low fertility rates
- Flexible pension age
- Limited immigration

Health Policies

- Basic state-funded healthcare
- Additional coverage self-paid
- Focus on treatment & self-management

Food Policies

- Focus on food safety
- Reliance on market mechanisms

Education

- Diet guidelines depending on app/device provider
- Health/nutrition not taught in schools

Food Choice

Food choice often automated by devices according to health-sensor data

Fashion & hedonics

Individualised eating schedules

Fair trade, animal welfare are niche markets

Diets

Nutraceuticals & supplements common

High variety, from local to exotic

Novel foods

Health

Improved general health status (due to progress in medicine)

Obesity and diabetes still prevalent

Junk foods

Fashion foods

Highly processed

Personalised foods & diets

No cooking skills

No efforts to reduce food waste

Means to individual identity

Origin of food irrelevant

Automated cooking & food preparation

Eating together uncommon/ not a social value

Various devices align diet to health

Eating habits

Work

- High flexibility required
- Blur between leisure and work
- Adaptation of working life according to needs
- Teleworking

Technology

- High acceptance
- Guarantees individualised lifestyles
- Personalised medicine and diets
- Considerable progress & innovation
- High penetration in all aspects of life

Private Food Sector

- Diversity, both multinationals and SMEs
- Pharma & cosmetics industry expand in food sector
- High share of food-services sector
- Shopping online or in physical shops
- Variety, customised products

Tomorrow's healthy society

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ANNEX IV

NARRATIVES

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Healthy new world

- **Strong community spirit**
- **Low agricultural commodity price**

The future 'Healthy new world' family is represented by François, 48 years old, and his wife, with their two children, Pierre and Estelle, 7 and 15 years old, respectively. The grandmother in the family, Margherita (84), is living in a community which takes care of the elderly.

Estelle

*An entry in her personal diary,
Wednesday 15/05/2050, 22:33*

This morning, as always, I woke up to the sound of my *Weecon* alarm. I let my eyes get accustomed to the morning light and then brought the *I-scan* sensor of the *Weecon* right in front of my eye to unlock the device. I checked the other side of the room and my brother Pierre was doing the same thing on his *Weecon*. He only has the simple version but calls it 'SuperWee' of course. It's not actually called *Weecon*, its real name is *We-connected* multifunctional personal device, but even dad calls it *Weecon*. Anyway, no new notifications or status updates from last night, although a holo-image of my friend Josephine is already blinking and waving on the screen. I haven't actually talked to Josephine face-to-face in quite some time, so I sent her a *wee-pointment* to meet later today. Apparently Pierre had finished chatting with his new pal Thomas in his *Weecon* because he was already up and nagging about breakfast... "Come on Estelle, let's get some breakfast, I bet it is ready by now!"

Mum and dad prepared the breakfast as always, checking the *smart fridge* to make sure that we each get what is necessary for our age. We have breakfast together every day before leaving for school, which is kind of nice. After breakfast we hopped on our bicycles and rode to school, where we started the day with exercises and meditation. Pierre then joined his class while I went to log into my study terminal and join my group. Each of these classes is not made up of children of the same age, the way it happened when grandmother went to school (imagine that!), but of children that have the same intellectual needs. After studying, I joined my cooking group and prepared our lunch. We often do this in school, because apart from lessons in diets and nutrition we have practical classes supervised by real cooks three times a week. As usual we prepared a plate with various cooked and raw vegetables, but today the recipe included a small piece of meat! Yummy...Then, of course, we had fruit for dessert, no surprises there...

In the afternoon, right after the daily sports practice and before heading for the showers I met some of my schoolmates and we jumped over the fence of the school next to the sport fields. As agreed last week, each of us brought a few sweets and candies that we got from our grandparents. Some kids didn't manage to get them but we shared what we had. Our parents and teachers would have a fit if they saw us stuffed with candies and sweets! We are only allowed a few of them each week. Plus, they are really expensive with all the government taxes on fat and sugar and we can't afford them with our own pocket money (apart from the fact that our parents would immediately find out if we bought them online), but hey, what are grandparents for anyway!

Back at home Pierre went to play virtual games on his *Weecon*, while I hooked up with my friends for a bit of MMOVGing (massive multiplayer online virtual gaming, as the teachers call it). At dinner time we ate with mum and dad and granny, who unexpectedly came to visit, taking time to enjoy dinner and discuss our days. Mum and dad have to work a lot, but their flexi-schedule allows them to have quite a bit of time to relax at home and chat with us.

The day after tomorrow is grandmother's visit day, which is actually quite cool. Yes, we saw her tonight as well but mum and dad were here. On visit day, we ride by ourselves to the community home where she is staying, and she might have some more sweets for us. Then we swim in the super-nice swimming pool there. Can you believe their swimming pool is actually better than the one at school. Anyway, grandmother Margherita will probably have another of her stories to tell us tomorrow. I wonder if she makes them up the day before or if they actually happened in the past. Like the time she told us about the water-wars, which happened before we were born. According to granny, not all countries always had enough water, because some countries kept it all for themselves. We haven't done history of the 2020s in school yet (next year maybe), so I'll have to check on my *Weecon* to see if it really happened. I keep forgetting though... Anyway, time to check with my friends online before going to bed...

François

Linking up with his uncle who lives on another city via holo-conference and describing his day

Today started as usual with a joint breakfast with the wife and kids, enjoying a wholemeal baguette, fresh fruit and vegetables, cheese, cereal and fruit jam. As we know, breakfast is the most important meal of the day so we always take great care to make sure it gives us a healthy and energetic start. I know I am going to need that for work...I don't know who invented the *smart fridge* all those years ago but the guy deserves an award – I don't know what we would do without it!

I caught the electric bus to work and had a look at the morning newspapers. Call me old-fashioned but I still like to buy the paper version, although it does mean I have to make a 10-minute detour every morning to buy it while walking to the bus stop. I read today that...hmm...apparently a group of senior citizens are organising junk-food events for kids. Honestly, sometimes, I don't know who is worse, the children or the grandparents. I hope my mother Margherita doesn't take part in these things. Pierre and Estelle would love to eat more sweets, and I know Margherita likes to spoil them. Anyway, I made a note on my PD (personal device) to have a chat with my mum next time I visit her.

Did you know I now work in the central offices of the FTAA (Food Technology Assessment Agency)? I have a customised and flexible working week, although sometimes I have to put in long hours, and so I am happy that both my kids and my mum are well taken care of by state services – in school and in the old people's home – and that their food is of high nutritional quality. Talking about food, today we ate with colleagues at the canteen, as usual. It was "easy Friday", so apart from our usual assortment of vegetable dishes we had some meat choices, too. Small portions and fat free of course. After lunch I checked my personal device to see when I last had meat, and to have a look at my health and diet monitors in general. Today, I ignored the "most appropriate dish for today" notification...

Before returning home after work I decided to go to the supermarket to buy some food. I like to visit the few remaining old-style supermarkets as I don't get the same feeling when choosing food using the online system. This means I had to take an agency bicycle to go to the supermarket before returning home, since the electric bus doesn't go near the store. While cycling home I was thinking how our world is and what we can do to make sure our kids grow up in a better place. The climate change indicators don't look so good... and on top of that we have our own senior citizens smuggling sweets to our kids. Bah! So, what about you, uncle?

Margherita

Explaining to her friends how she ended up in the black market

Tonight I am particularly happy because I visited my son and grandchildren! Not all of us in the 'community' (old people's home, officially) live as close to their family as I do. This thought immediately brightened up my day this morning, especially after the nightmare I had last night. I dreamed that I was young again and some children were bullying me because I was obese. I still am, of course, but in the community we all are. Same age, same problems, mainly due to being obese most of our lives. Back when I was just a young girl not so many kids were obese, at least not as many as later on, at the start of the new century. Fortunately my health monitors informed the nurse on duty about my stress levels and she arrived this morning to cheer me up, and of course to give me the medication I take for my diabetes.

As usual, breakfast was served in the garden and comprised a healthy and varied buffet prepared by the accredited chefs in the community, who also explained the breakfast ingredients and their impact on our health. These days, the information on food and its impact on health is quite easy to understand, even for us old people. My reading glasses can give me this kind of information immediately, as well as monitoring my health. I have a bit of a problem following all these little letters and numbers on my lenses while I am trying to eat though.

After breakfast I relaxed in the sun chair, enjoying the community garden while reading an Agatha Christie novel using my special glasses. I don't read real books anymore although I quite miss them. Later I met with friends and went for a dip in our pool on the roof of the community main building, and then we relaxed in the spa area on the top floor. And after all that hard work, we were served lunch by the poolside. The healthy food we ate was quite nice of course but I must admit that the desserts and sweets we get are not enough! My glasses keep telling me to eat more vegetables, but I don't really want any more. What I want is more sweets in my daily menu! I just ended up taking more sweets than I am allowed, they were so delicious. The chefs are to blame, really. I hope nobody noticed, because I promised the kids that I would have some for them, too, next time they come to visit alone. I hide the sweets in the cupboard in my room. My friend in the next room is a retired electronic engineer and he has installed a little script that can fool the sensors about what we have in the cupboards! Take that, healthcare system!

After lunch today I went back to the garden to rest, I get tired easily these days. Doctors tell me also that it's because of my weight, but what do they know? Later on I visited my family and had dinner with them. I picked up a community car, which is always convenient (and free of charge!) and drove to François' home where I had a great time with the family. The dinner was tailored to my needs; François would not have it any other way of course. Then I played some trans-generational games with Pierre; just lately Estelle has become bored of these games. That's teenagers for you!

On my way home my glasses warned me that my blood glucose levels were low. Hmmmm, what a coincidence! I guess my implanted blood glucose balancer needs to be adjusted again, but what better excuse to turn off the navi-tracker in the car (I know how to do it, thanks to my flatmate) and sneak off to the black market for more sweets? And here I am. Come on, Joan dear, let's see if we can find some full-fat, full-sugar chocolate tonight!



Heal the world

- **Strong community spirit**
- **High agricultural commodity price**

The future 'Heal the world' family comprises Ana and Helen, who have two children, Eric (5) and Sarah (10). Peter and Cristina (both 75) are Helen's parents and live in the same house with the rest of the family. Søren (100), Peter's father and the children's great-grandfather also lives with them.

Eric

'My Day', a video recording as a school assignment from Eric

Hello, my name is Eric, I am five years old, and I am going to school! Today, Spiderman was in my holo-clock to wake me up! I chose it the night before because he's my favourite hero! He said: "Good morning Eric, when you grow up you will be my assistant" and then he told me to get up and reminded me about Sarah's birthday. Sarah is my sister; she is older than me and is nice sometimes.

My two mums gave me a lot of kisses and prepared my breakfast. All the family was there and we all sang a birthday song for Sarah. Great-grandpa Søren forgot the words again! The table was really full of colourful food for Sarah's birthday; I want to have that many colourful fruits for my birthday as well. I told my granddad Peter and he said that he will see to it! Great! We also had more things to eat today than other days; I think we should have a birthday every day! I told granddad Peter and he smiled and gave me a kiss!

Sarah and I went to school on our bicycles, because my mums say it's cheap, quick and also healthy for us. Today, my friend Tomen's dad came with us. I think tomorrow it will be Karen's mum, she is really funny! We also took our digital lunch boxes with us in our school packs. I saw the holo-display and inside there were grilled vegetables and grilled grasshoppers with fat-free chocolate sauce. I love them! My great-grandpa Søren says that this "fat-free junk" that they give us tastes like water. Water doesn't taste like that; he is very old so maybe he forgot?

In the school canteen we ate a lot of fruit and other nice foods that are provided by the school. It's called a "school fruit scheme" and the teacher told us that it is a very old programme, as old as him. The teachers told us that fruit and veggies are healthy and "sus-tain-a-ble", which means they are good for the planet but also good for our tummies. My mums say they are also good for our pocket.

In the lunch break I played with my friends and then we had a nap. I wanted to play some more but the teacher said that taking a nap is obli-ga, obli-ga-to, - that we had to do it! Later we did our homework and I went home with Sarah and the other friends with the bicycles. My friends will come over later tonight because they are also invited to the party! It was my idea! Now I have to go because the grandparents are calling us to play some games in the communal garden. Bye!

Ana

Personal reflections during a five-minute break from work

I often sit and wonder how much things have changed in the last 16 years. I came from Spain and worked in Brussels, where I met Helen. We now live with our two children in northern Europe, together with Helen's parents and grandfather. Discussions about family structure ended a long time ago, and today our family is just like any other, living together in an extended household of four generations, because the cost of living and care, especially for children and the elderly, are just way too high.

Today I woke up early again. Three elderly people in the house can make a lot of noise. Søren got up first; I guess he went to the black market again. Was he with us at breakfast? Yes, he was back already, because he complained about the alternative dairy products not being "the real thing". What else did we eat, hmmm, nuts, apples, whole grain bread. The children are already off to school with the neighbourhood biking scheme, and Helen is off to work in the hospital. She is a doctor and needs to be physically present. I work as a remote taxi driver, doing my job in front of a holo-terminal at home. Once used in the military, remote piloting has become pretty much standard in the last 10 years. People still like to socialise and chat in the taxi, so I am what hairdressers used to be back at the beginning of the century – a sort of informal psychologist. I talk about the weather and politics a lot, of course, but I can't complain, I am always up to date.

Right now it is 11:00 and I am having a five-minute break and relaxing... In a bit I will meet Mogens, our neighbour, and run for 30 minutes. Mogens isn't the most athletic type out there, and he will probably lag behind as usual, but even he realises the need for daily physical activity. Later we will have lunch with the senior members of the family who are at home, and Mogens will join us. He is alone, so we share expenses and he comes every day to eat. He used to work as a cook in a nearby restaurant before they closed it down and he lost his job. He has some great ideas about cooking once in a while.

Anyway, after lunch I will have to sleep for half an hour, following government recommendations for a productive and healthy working life. I already have problems sleeping at night, worrying if we can make it to the end of the month, so I don't think I will actually sleep, but it's nice to just lie there a bit, I guess. At 14:30 I will have to start working again until the kids get home in the afternoon.

Today is Sarah's birthday – I can't believe she is ten already! We have invited some of her friends, and Eric's as well, for a small party. I went ahead and bought some real Spanish oranges for the party. I probably shouldn't have, since they are so expensive, because they are out of season right now. Kids love them, however, as do we. Fortunately the grandparents are taking care of the party organisation; there is no way me or Helen could have managed to spend any time on that. Helen will come home for dinner, hope she isn't late today. People work so many hours nowadays; I guess I should be lucky that I work from home. Theoretically everybody should work 10 hours a day, but everybody knows that most people have to put in 2-3 extra hours or have two jobs. Which reminds me, before I go running I should start the *in vitro* meat machine. I remember when we bought it that we had to explain to Søren that it's like the old domestic bread-making machines. Of course he was not happy with the taste at all. Can't say he isn't right, we had some real meat at Christmas and it was really something else.

I am also supposed to pick up the vegetables from our roof-top garden, but I won't make it. I'll ask Peter if he can do that. We have some more food we bought, the standardised industry stuff we eat every day. Maybe we can add it to our dinner, and perhaps Peter can prepare his special sauce to add a bit of taste and variety today since it is Sarah's birthday. After the dinner party I will probably have to go through the budget with Helen. I can't think what we would do if the grandparents weren't giving us a hand with the kids and the house. We don't want to spoil the mood after the party, but there are a lot of taxes to pay, food is expensive, and to make sure we make it to the end of the month we have to plan ahead. Even on our daughter's birthday.

Peter

First blog-diary entry on the Active Seniors web forum

Let me introduce myself in this very first attempt to blog in our forum: I am Peter, 75, and live with my wife Cristina, also 75, in an extended communal 'kangaroo' housing complex, together with my daughter Helen, her companion Ana, and our grandchildren Eric and Sarah. My father Søren, who has managed to make it to 100, also lives with us, being active and providing us with all sorts of memories (every single day) from life in the 1960s and 70s. Cristina and I are still working, still not retired. She is a patent lawyer and works part-time downtown, while I am an artificial intelligence programmer for robotic med-assistants in hospitals.

Today was Sarah's birthday, so we woke up early, a bit later than Søren who was already making his way down the back alleys to find his contact and buy a smoke. Old habits die hard even today now that smoking is practically banned, like many other items, due to ridiculously high taxes. Black markets are thriving, and since all monetary e-transactions are monitored, Søren and the other old coots now trade their memorabilia from the 1990s – like soccer cards or analogue calculators and wristwatches – for items like burgers or tobacco. I don't know how many times I've told him that he doesn't need to sneak down the stairs; we know where he is going, and that he makes more noise when he is trying to sneak ... At least he managed to remember to scan himself today as he left the house, so his digital vital signs will pass via the house register to the local hospital. This is an extra service we are paying for, but in this way I always know how he is doing. He is also supposed to monitor his daily nutritional intake to optimise his health, but I won't vouch for that – we didn't buy the auto-tracker, and I have a suspicion that he is intentionally reporting false data!

Today, while preparing breakfast with Cristina for the rest of the family we watched a bit of the early edition of the holo-news on our old 3DTV. There was a special report on food prices, which have spiked again to unprecedented heights. Droughts are quite common nowadays, and the report said that the climate conditions in Europe are getting drier. Commodity prices have risen 50 % since last year. Luckily, the government is now holding one year of staple food categories in stocks to smooth price volatility, but it's hard to stay ahead of the game. The coffee didn't taste so good, it was produced somewhere in Southern Europe. Our favourite coffee from Kenya is very expensive and considered a luxury; it's heavily taxed as it is environmentally unsustainable as well as not adhering to fair-trade criteria. At least some of these taxes go to support the poor.

Preparing food for the children at the birthday party might have seemed complex when I was younger, but nowadays it is quite a simple affair. Having the names of the children attending the party, we can access their health attributes and design snacks and food items to suit them all. Well, it's not us, actually it is our automated cooker that will do all that, and provide list of alternatives, taking into account the preferences found on each child's 'My Face' account. We had to order in some extra foods, which will arrive before the party and I will pick them up as I am at home.

Cristina has a very important patent case in court today, defending a new process for transforming insect bodies into "steak-type meat" (can't call them insect steaks due to legislation), burgers and sausages. It has been going on for several years now, since the government reviews everything so carefully to ensure the protection of public interests. Unfortunately, some companies have already given up investing in new processes because of the delays and strict regulations involved and have moved their research to other parts of the world. On the other hand, public research has gained momentum, especially since there is the need to find efficient sources of food.

I guess I should go check up on my dad Søren again and make sure he makes it home for the party. He has been spending so much time in his '100+ Club' recently. Yesterday I received a notification from the hospital that he needs to visit to check his muscle mass. His recent health data has raised some concerns, and he should increase his exercise and adapt his daily routine. I don't even want to think how much his hospital check-up will cost. But look at me – it's already time to prepare for the party and here I am still working on this blog. Well, more tomorrow, will let you know how the party went!

Have a nice evening fellow old-timers!
Peter, '75er. Posted on 05/04/2050



Eat to live

- **Individualistic society**
- **High agricultural commodity price**

This future family comprises Martina, her husband and her son Alexander (13). Maria (96) is Martina's mother-in-law but does not live with the family.

Alexander

Talking to a friend on a secure holo-chat

So yesterday I tried hacking into the Nescuisine using that worm-ware that you sent me. I didn't manage, but I got close. Next time I will do it, just you wait and see. I wanted to know what would turn up for breakfast this morning. I am bored of the usual fortified fruit salad and I wanted one of those foods I saw online. But my mum got upset when I told her, and she told me I shouldn't eat that stuff. Man, I wish she could just pop some chill-pills and relax like your mum does.

Apart from not hacking into Nescuisine, yesterday was a really fab day. To start with, it was the f2f day, the face-to-face day, where I can really meet all my schoolmates. It's about the only time we can relax and talk without any parental or teacher monitor drone hovering over us. You know, we spend most of our time with the nannies and we only see each other on-screen, like we are doing now. Thanks again for the secure-com software; really cool – my mum can't register our holo-chats anymore!

Anyway, something even more exciting happened. You know how we are always allowed to play some old-style games like soccer towards the end of the f2f day, right? And how the school is in the corner of the fortified complex where we all live, yeah? Well, we were kicking this real ball in the school field, when Adam kicked the ball too high, sending it over the school wall. So instead of waiting for Freddie, our bodyguard, to go outside and pick it up, I climbed on the tree next to the wall and meant to climb down on the other side and get the ball. I knew it would set off all kinds of alarms, but I have a clean track record in school and I am allowed two penalty points per year, so I said I would do it. Betty was also watching, so... you get the point.

I never got the chance to actually do it of course. As soon as I popped my head over the wall, I heard shouts and angry cries. Did you know that the soundproofed field that isolates the school and the complex extends only as high as the perimeter wall? Anyway, I saw some strange children, they must have been our age, but they were dirty and quite angry. In the beginning I didn't even realise they were actually kids like us! So, they were carrying some banners saying "Down with mega-corporations". They looked a bit scary as well. Anyway, at that point Fred came and pulled me down before I could ask them what their problem was. What's the problem with mega corps anyway? Why did they look so different? I want to ask my mum but she is always nervous and snaps back at me when I ask her things and never has time to just chat. Do you think your mum knows?

Martina

Thoughts while starting another work day

What time is it? 05:30... Half an hour more until the alarm goes off. I should get some sleep to face the tough day ahead...but I can't. My worries are keeping me awake again. If it's not about my job as a manager of the food distribution system at MultiFood downtown, it's about the rising tension in the city outside the fortified living complex. Anyway, I might as well voice-order the preparation of the breakfast for me and Alexander... the Nescauine voice terminal is right next to the bed. Today we will have some quite traditional items: probio-active yoghurt and some fruit and coffee.

A sharp beep in the sec-terminal – Jeeves, our house servant, is being cleared for entrance at the security point by the guards of the walled compound where our house is located.

Time to get up. I pass by my son's room and give him a kiss, he is still asleep. I eat breakfast in a rush and leave our spacious apartment, taking the gravi-lift to the parking area and enter one of the self-driven smart vehicles there. I confirm my destination towards downtown, choosing the C alternative route to avoid the demonstrations in the main avenues and already fire up the telecom terminal for the appointment with our suppliers in Africa. There is social unrest down there, much more than here in Europe, so I want to know whether they can deliver our primary resources of coffee beans and exotic fruits or if I need to start looking for it in another part of the globe.

While I wait for them to convene, I read flash-news items on the vehicle's multi-screen: one of our major competitors has announced a 20 % profit increase due to a novel waste-recovery system in their main food-processing plant. Oh, my boss will not be amused at all. Our profits have still to recover from the large outbreak of antibiotic-resistant listeria six months ago, which killed 160 people across the whole of the country. My boss will probably call a meeting with the crisis manager, and we will spend the whole morning and well into lunch discussing our strategies. Talking about lunch, I don't have a clue what they will bring us. I never do.

Maria

Thinking to herself and recollecting the day – doing short-term memory exercises

I miss my husband, Hans, and my family and my old life at home. I wish I could live near my daughter and grandson, but my pension is small and I can't afford an institution in my home country. No one can afford to cover part of my expenses either. Now I live in an institution for older people in another, remote country, which became a member of the EU some time ago, but prices are still much lower here than in the EU-38.

When I was younger, in my 50s, Hans kept telling me to lose weight and improve my diet, but I didn't take his advice. I was already obese and diabetic at that time, and now my institution care expenses are higher than normal because of that. As if this wasn't enough, the doctors here are telling me I have mild Alzheimer's disease and that I have begun to forget recent events and need to do memory exercises. Humph! I still remember the past quite well though.

The alarm rang, as usual, around 06:00 and the lights flashed. A few moments later the robot brought me my morning pills. I recollect the breakfasts of my past, with the taste of freshly baked bread and home-made marmalade. Now it's just nutrient-dense cookies and medication pills. The robot accompanied all of my dormitory mates to the bathroom. We always have to keep our bio-sensing monitors on as they track our heart rates, blood pressure as well as other biological parameters, and send any updates immediately to the robot so it can promptly intervene if we need help urgently. There are also some nurses and a doctor on duty, but we don't get to see them unless there are emergencies or we have a pre-set medical appointment.

In a few days my grandson Alexander will come to visit. Haven't seen him in over a year, I bet he is really grown up by now. How old is he now? Maybe we can connect later via the *Smart See* terminal? I am really proud of him and my daughter-in-law. She has a good job and Alexander is lucky to grow up in an environment where nothing is missing.

For lunch the food dispenser provided me with food and water. With very few exceptions, we eat an easy-to-chew cake with a high nutritional density – you should know that I still have good teeth however. I told the doctor that I can eat normal food, too, but he said that they can't afford to cater for personalised preferences, especially with the food prices these days. Every now and then we also get algae as a side dish. Easy to chew, and full of omega-3s which they say is good for our brains. I don't really believe them though. I still keep forgetting.

After lunch we watched the news on the terminal. The news is in English, and not all of the people here understand it. In this institution, you see, we come from all parts of Europe. There is the option to get a private terminal with news and programmes in your mother tongue, but it is an extra and most people can't afford it.

My mind drifts back to the time when I shared my meal with my two boys. They have also gone, like their dad, a few years ago. One died in a terrorist attack in the food megacorporation he was working for, and the other died from a deadly food-borne outbreak about five years ago. I keep going on...I can leave this world if I decide to, but I am not sure yet. My genetic profile and health status predict that, even with my obesity and diabetes, I could live up to 110 years, but I don't know if I really want that.



Me, myself and I

- **Individualistic society**
- **Low agricultural commodity price**

The future 'Me, myself and I' family comprises Daniel (48), his daughter Sophie (16) and his father Bruno (80).

Sophie

*Web-i-cast during registration
in the Global Girl Fashion Food
Forum - GGFFF*

Ok, Flint, are we on? Sure? OK, here goes... Hiya all, I'm Sophie, I turned 16 a month ago. I am attending high school now, although here in Europe we don't really go to school every day. We physically go to school just twice a week and today I am sending this message from home, during a break from my courses. Yeah, we still have to follow remote schooling courses the rest of the working week. Flint, do a holo-projection of yourself in front of the recording bio-iris: World, meet Flint! He is my social cyborg, he keeps me company, connects me to the rest of the world and advises me on many issues, like when to study and when not, when to go for a walk and to hang out with my friends, when to eat and, of course, on the moooost fashionable food to eat! Do you have social robots where you all come from? They are not so expensive anymore, are they?.

Anyway, I wear some sensors attached to my clothes and Flint can read my body needs concerning food. My dad Daniel has installed my genetic profile as a software add-on on Flint, and now Flint has access to my genetic make-up, age and dietary profile! The perfect mix to suggest what food would fit yours truly! The best thing though is that Flint can also sense my mood via my clothes sensors! We have a wireless connection all the time so he can sense my emotions and add emotional food to my diet as required – to cheer me up or slow me down if I get too excited!

Hey, right now, Flint activated the auto-cooker to prepare my lunch. But tonight I am going to put Flint in hibernation mode as I am going to have an actual dinner with my friends. I mean, social 'bots are cool but it's nice to meet face to face once in a while... Tonight we are going to eat with my real friends at the FIE-STA restaurant. I am sure you also have it in your countries; it's the No. 1 chain for fast, delicious, and most important, fashionable food! So I checked earlier with Flint what's on the menu today and he suggested the "positive mood dish for dinner", which will be perfect for my mood tonight but also for my dress! Its stratified pasta and a light orange chocolate mousse with 100% artificial cherry aroma! Yum Yum.

Oookaaaay, so I'll be waiting for your comments and ratings on my registration video! I can't wait to be part of the GGFFF community! See ya!

Daniel

*Personal memo,
12/11/2050, 08:27*

Today I read an article in the morning update of the hologram newspaper that made me wonder. The headline was "New restaurant serving food grown on Mars". I am thinking of how to get inspiration for my next designer food that has to be marketed quite soon when people are already serving food from Mars that was colonised just a few years ago. I have to stay ahead of the game and its getting quite tough lately. Maybe having dinner at this new restaurant could actually help...I'll have to talk to my assistant cyborg for a reservation after I complete this note. Speaking of which, I still need to finish my breakfast, most importantly those wonderful, real, and actually yellow bananas that were flown in overnight from Ecuador. This has given me an idea. Today will be my yellow day! I will programme my holo-assistant accordingly and order yellow-based natural or arti-coloured food for the rest of the day. I feel some inspiration coming on!

I also have to do my medical check-up later today. I am getting a bit worried as I am getting older; I wonder how long it will take them to invent a real anti-ageing pill, not of course the fake ones that they sell in those subscription holo-sites. You don't know who you can trust anymore on issues like health and food. I also have to check if my solar hover car is fully charged and if the autopilot has downloaded all the recent updates to take me to my health insurance agent appointment. He proposes a scheme which will cover every possible treatment I will ever need, plus some more treatments I never even knew existed. It costs quite a lot, but successful design food specialists, like me, earn enough.

Anyway, time to end this memo and get on with the day. I have to connect to my working team right now and propose them the idea I have just come up with. If someone can provide food grown on Mars, how about some water and soft drinks crafted in the vacuum of space???

Bruno

*Describing his day to a fellow
senior commuter on the train
returning home from work*

Pleased to meet you. I am Bruno, 80 years old, and I live with my son and his family in a nice house in the country with a garden and a personal gym area. Yes, I am indeed retired officially but I have kept this part-time job, it helps me stay sharp and connected, even though it is a bit far away from home. Although with these hover-trains a 50km ride to the city is not really an issue anymore. Do you remember the good old days with petrol-powered cars and traffic jams on the highway?

I usually get up at 06:00 every morning and have my complete health *Rap'O'Check*. You know the usual things, urine, exhale tests, blood from the thumb, etc. You have them too? I see. Then my health device suggests the most fitting breakfast, taking into account my age and physical status (it gets the data from *Rap'O'Check*). For the last few months, milk and eggs have been locked; I am only allowed to choose from fruit and some supplements. I complete my early morning with a fast session in the gym before I take this hover-train to work in the city centre.

Most days I eat my dinner while travelling back home from work, usually supplements and fruit, packed by the auto-kitchen in the morning. Although, sometimes I bump into my friend Bob – have you met him? We usually decide to eat together at his place, so we allow access to each other's device and our health apps communicate and find the best combination for both of us and suggest a shopping list. So when we get off the train together – we live near each other you see – we pick up our meals from the food-dispenser at the hover-train landing pad. We usually have the pleasure option enabled, with the “retro” style active as well, to spark those fond memories of when we were young and working as chefs. Yes, I was a chef, but I hardly cook now. We also let our families know when we are having dinner together, although they rarely manage to join us. We just end up talking about the good old times usually, before our devices tell us it's time to go to bed. Anyway, I have to hop off now; the next hover-pad station is mine. Have a nice evening!

Tomorrow's healthy society

Research priorities for foods and diets

ANNEX V

FP6 AND FP7 PROJECTS
RELATED TO THE
IDENTIFIED RESEARCH
PRIORITIES

(SELECTED PROJECTS)

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Towards healthier eating: integrated policy-making

Improve the evidence base for adoption of healthier dietary behaviour

Sixth Framework Programme (FP6)

EURECCA - *EUropean micronutrient RECommenda-tions Aligned*

The project targeted evidence-based methodologies and tools to help develop quality-assured and aligned micronutrient Dietary Reference Values (DRV) across Europe, with a special focus on vulnerable groups and consumer understanding.

Develop a scientific framework for a systems approach to food and nutrition policies

Seventh Framework Programme (FP7)

CONNECT4ACTION - *Strategies for improving communication between social and consumer scientists, food technology developers and consumers*

The project is focusing on communication and knowledge exchange between food technologists and consumer scientists in order to improve multidisciplinary dialogue and increase consumer acceptance of new food products.

Provide a framework to design, monitor and evaluate policies

FP6

HELENA - *Healthy Lifestyle in Europe by Nutrition in Adolescence*

The project developed harmonised and comparable European data about food intake among European male and female adolescents, taking advantage of computer-based dietary assessment tools.

IDEFICS - *Identification and prevention of Dietary- and lifestyle-induced health EFfects In Children and infantS*

The study explored the risks related to overweight and obesity in children, as well as the associated long-term consequences. IDEFICS also

developed, implemented, provided and evaluated health-promotion programmes in kindergartens and schools.

ISAFRUIT - *Live a long and fruitful life*

The strategic objective of this project was to increase fruit consumption to improve Europeans' health and well-being by taking a total-chain approach, identifying the bottlenecks and addressing them with consumer-driven preferences.

FP7

CHANCE - *Low cost technologies and traditional ingredients for the production of affordable, nutritionally correct foods improving health in population groups at risk of poverty*

The project aims to contribute to the better understanding of existing nutritional barriers to healthy nutrition among European sub-clusters with low purchasing power, limited education and the highest risk of diet-related diseases due to suboptimal nutrition. It is developing nutritional strategies and guidelines for the prevention of malnutrition in population groups at risk of poverty.

CLYMBOL - *Role of health-related claims and symbols in consumer behaviour*

The objectives of this project are to determine how health-related symbols and claims in their context are understood by consumers and how they affect purchasing and consumption.

EATWELL - *Interventions to Promote Healthy Eating Habits: Evaluation and Recommendations*

The project has assessed the efficacy of past policy initiatives, aiming to identify appropriate measures to improve dietary and health outcomes. It has developed procedures for assessing cost-effectiveness, cost-utility and cost-benefit analysis of policy initiatives, which take into account market interactions and agents' adaptive behaviour.

FLABEL - *Food Labelling to Advance Better Education for Life*

The project team is developing and applying a framework incorporating information on the characteristics of food labels and how consumers read them. Based on their findings, nutrition labelling guidelines will be developed. The project

is assessing which labels are most appealing and informative to the public and how best to strike a balance between 'simple' and 'complete' nutritional information.

FOODRISC - *Food Risk Communication Perceptions and communication of food risks/benefits across Europe: development of effective communication strategies*

Researchers in the project have compared the use of traditional and social media, and evaluated the public's information-seeking behaviour and perceptions of food risks and benefits. Based on their findings, an e-resource centre has been developed to help communicators to disseminate information on food risks and benefits.

HABEAT - *Determining factors and critical periods in food habit formation and breaking in early childhood: a multidisciplinary approach*

The project aims to understand how food habits are formed in infants and young children, including identifying the critical periods and the most-effective strategies for breaking habits.

I.FAMILY - *Determinants of eating behaviour in European children, adolescents and their parents*

This project will compare families who have developed and maintained a healthy diet with those whose diet has developed in an unfavourable direction, in order to study the impact of biological, behavioural, social and environmental factors on dietary behaviour over time. The focus will be on the family environment, socio-behavioural and genetic factors determining familial aggregation.

PREVIEW - *PREvention of diabetes through lifestyle Intervention and population studies in Europe and around the World*

The project's primary goal is to identify the most efficient lifestyle pattern for the prevention of type-2 diabetes in a population of pre-diabetic overweight or obese individuals, including children, adolescents, adults and the elderly, by conducting a multi-centre, randomised clinical trial and using data from large population studies.

TOYBOX - *Multifactorial evidence-based approach using behavioural models in understanding and promoting fun, healthy food, play and policy for the prevention of obesity in early childhood*

The project is identifying key behaviours related to early childhood obesity and their determinants, and evaluating behavioural models and educational strategies.

TRANSFOP - *Transparency of Food Pricing*

This work addresses the key aspects of the food chain, including different characteristics of the food sector throughout the EU Member States, and ongoing developments in the food chain with regard to its vertical coordination, consolidation and how the regulatory environment affects the overall functioning of food supply chains across the EU.

Food, nutrients and health: cross-interactions and emerging risks

Deepening the understanding of human nutrition: facing the complexities

FP6

FLAVO - *Focus on flavonoids in food quality and health*

The project team carried out research on how different production and processing methods can influence the flavonoid content of food products, and what kind of products are most appropriate for enhanced flavonoid content.

FLORA - *Bioactive protection for healthy living*

This project aimed to systematically analyse the health-promoting effects of plant flavonoids and related phenolics, and to identify the mechanisms by which bioactive nutrients protect against disease at the cellular level.

LYCOCARD - *Increase your tomato intake!*

The project investigated the role of lycopene, the compound in tomato which reduces the risks of both cardiovascular disease and cancer. The LYCOCARD consortium analysed lycopene bio-availability, the oxidative catabolism of lycopene, the physiologically relevant isomers and metabolites, modulation of endothelial functions, and the effects of lycopene and its derivatives on cell signalling pathways.

ZINCAGE - *Keep taking the zinc tablets?*

The work involved studying the behaviour of zinc and its related physiology in the immune cells of elderly, testing whether faults can be corrected with supplements, and generating advice on who could really benefit from zinc supplements and diets with zinc.

FP7

ATHENA - *AnThocyanin and polyphenol bioactives for Health Enhancement through Nutritional Advancement*

The overall objective of the project is to provide a robust scientific foundation for improved dietary recommendations that include foods with high levels of anthocyanins and related polyphenols to promote health and to protect against chronic diseases.

BACCHUS - *Beneficial effects of dietary bioactive peptides and polyphenols on cardiovascular health in humans*

The project team is developing tools and resources that can be used to support claims of a cause-and-effect relationship between consumption of bioactive peptides and polyphenols, and beneficial physiological effects related to cardiovascular health in humans.

EFRAIM - *Mechanisms of early protective exposures on allergy development*

This project has investigated protective factors and mechanisms, such as the maturation of immune responses, gut colonisation, mucosal barrier function, and genetic and epigenetic factors influencing the development of allergies.

ETHERPATHS - *Characterisation and modelling of dietary effects mediated by gut microbiota on lipid metabolism*

The work aimed to develop systems-biology tools that can facilitate studies of dietary interventions aiming to modulate lipid homeostasis. The plan was to optimise all models in the context of studies of dietary interventions, to be integrated into a sophisticated software platform.

EURO DISH - *Study on the need for food and health research infrastructures in Europe*

By building on available projects and systematically mapping existing research institutions, the research aims to provide feasible recommendations on the need to integrate existing, and to develop new food and health research institutions that are relevant to innovation in mechanistic research and public health nutrition strategies.

FIBEBIOTICS - *Dietary Fibres supporting Gut and Immune Function - From polysaccharide compound to health claim*

The goal of this project is to support the development of functional food ingredients and products that are beneficial for the human gut and immune system. Therefore, the team is studying the molecular, cellular and whole-organism effects of specific non-digestible polysaccharides.

FLAVIOLA - *Targeted delivery of dietary flavanols for optimal human cell function: Effect on cardiovascular health*

The researchers aim to explain the cellular and sub-cellular effects of flavanols and their main human metabolites, and to investigate the key parameters of dietary flavanol absorption, clearance and efficacy towards surrogate markers of cardiovascular function in humans. The goal is to develop evidence-based dietary recommendations and innovative new products that are nutritionally responsible and able to optimise nutrient delivery.

FULL4HEALTH - *Understanding food-gut-brain mechanisms across the lifespan in the regulation of hunger and satiety for health*

Here, laboratories are collaborating to investigate the mechanisms of hunger, satiety and feeding behaviour, the effects of dietary components and food structure on these processes, and their possible exploitation in addressing obesity, chronic disease and under-nutrition.

FUNCFOOD - *Impact of agents with potential use in functional foods on biomarkers for induction of age related diseases*

EU and Indian research centres are collaborating to investigate the protective actions of various non-toxic agents *in vitro* as well as in rodent models with respect to the induction of DNA lesions, tumours and biomarkers for the development of diabetes, diabetic retinopathy and atherosclerosis.

LIPIDIET - *Therapeutic and preventive impact of nutritional lipids on neuronal and cognitive performance in ageing, Alzheimer's disease and vascular dementia*

The project aims to develop a lipid-based diet that reduces the risk of Alzheimer's disease and related diseases and has a stabilising effect on cognitive performance in ageing.

MOODFOOD - *Multi-country collaborative project on the role of Diet, Food-related behaviour, and Obesity in the prevention of Depression*

The goal of the project consortium is to gain a better understanding of the psychological, lifestyle and environmental pathways underlying the links between food intake, nutrient status, food-related behaviour and obesity with depression, and to develop and disseminate evidence-based, feasible, effective and sustainable nutritional strategies for the prevention of clinical depression.

NEUROFAST - *The Integrated Neurobiology of Food Intake, Addiction and Stress*

This project is analysing the determinants of food addiction and substance abuse, the effect of mood, anxiety and stress on the development of diet-related diseases, and how risk factors like stress in the workplace are encouraging disadvantageous behaviour.

NUDGE-IT - *The Neurobiology of Decision-Making in Eating*

The project is seeking a better understanding of decision-making in food choice, and is building predictive models with strong explanatory power to contribute to improving public health policy.

NUTRIMENTHE - *Effect of diet on the mental performance of children*

Researchers are studying the role, mechanisms, risks and benefits of specific nutrients and food components on children's mental performance from the foetal stage to childhood. They are also addressing key issues in child mental health where diet could play a role, for example, cognitive development, cognition and anxiety/stress.

NUTRITECH - *Application of new technologies and methods in nutrition research - the example of phenotypic flexibility*

The work involves using cutting-edge analytical technologies and methods to evaluate the diet-health relationship, and to assess the underlying and related biological and genetic cell mechanisms and the physiological adaptation processes when homeostasis is challenged.

ODIN - *Food-based solutions for Optimal vitamin D Nutrition and Health through the life cycle (ODIN)*

The study aims to establish a standardised analytical platform for 25-hydroxycholecalciferol (25OHD) and to describe the prevalence of vitamin D deficiency in Europe. The team will carry out RCTs in pregnant women, children, teenagers and ethnic immigrant groups to provide experimental data to specify vitamin D intake requirements.

PATHWAY-27 - *Pivotal assessment of the effects of bioactives on health and wellbeing. From human genome to food industry – pathway*

This project is addressing the role and mechanism of three bioactives with known/claimed effectiveness in reducing some risk factors of metabolic syndrome, and determining their impact on the physiological-relevant end points of metabolic syndrome.

TORNADO - *Molecular Targets Open for Regulation by the gut flora – New Avenues for improved Diet to Optimise European health*

The project aims to determine the influence of diet on the gut flora, and the impact of gut flora on the immune system/other organ systems. It will deliver data that can be used to recommend biomarkers for evaluating the effects of diet or microbes.

Anticipation of emerging risks**FP6****BIOTRACER** - *Tracking microbes for improved food safety*

The work developed recommendations for controlling the risks of food contamination with microbes, through the integration of novel genomic and metabolic data on contaminating micro-organisms.

ECHAIN - *Developing a stakeholders' guide on the vulnerability of food and feed chains to dangerous agents and substances*

The objective of this project was to develop methodologies to optimise traceability and provide quantitative risk assessments of chain vulnerability.

GRACE - *Verification of GMO risk assessment elements and review and communication of evidence collected on the biosafety of GMO*

The project framework created quality reviewing processes for different fields of GMO impact assessment and addressed the need for a well-documented, transparent and sustainable representation of these reviewing processes.

HEALTHY-WATER - *Spring of life*

The study was designed to further scientists' understanding of pathogens in drinking water by building on previous work on the microbiological surveillance of water supplies. The major focus was on the development and validation of molecular-detection technologies.

MONIQA - *Monitoring and Quality Assurance in the Food Supply Chain*

This network is promoting the harmonisation of analytical methods for monitoring food quality and safety in the food supply chain by coordinating and combining research activities, infrastructure and personnel.

PATHOGENCOMBAT - *Fighting new pathogens in food chain*

The researchers studied eight new and emerging pathogens and developed molecular-based methods to detect, predict and characterise these pathogens along the food chain and at the time of consumption.

TRACE - *From fork back to farm*

This project set out to develop generic and sector-specific traceability systems for the food industry, including molecular biology methods, genetic markers and microarray technology specifications relating to the origin of food.

FP7**AQUAVALENS** - *Protecting the health of Europeans by improving methods for the detection of pathogens in drinking water and water used in food preparation*

The project aims to identify and characterise the genes of pathogens in drinking water and water used in food preparation, as well as to determine their virulence in humans. Based on this knowledge, new technologies are being developed that integrate sample preparation and detection into a single standardised platform.

COLLAB4SAFETY - *Towards sustainable global food safety collaboration*

The project team is setting up a global network on food safety for exchanging information on food safety related to research findings, capacity building and policies, and is facilitating the control and mitigation of existing and emerging food risks.

DREAM - *Design and development of REAListic food Models with well-characterised micro- and macro-structure and composition*

The study aimed to improve knowledge on the relationship between food compositions, processing and end-product structures on the molecular to macroscopic scale. To validate this approach, the team investigated the impact of structural changes in the food matrices on nutrient and toxicant bioavailability and the microbial food-borne population.

FOODINTEGRITY - *Ensuring the Integrity of the European food chain*

The researchers will establish processes for harmonising and exploiting existing databases, a methodology to address stakeholder needs, and will develop a self-sustaining food-fraud early-warning system.

FOODRISC - *Food Risk Communication. Perceptions and communication of food risks/benefits across Europe: development of effective communication strategies*

The project identified the barriers in communicating to consumers across Europe and key socio-psychological and socio-demographic characteristics, including gender, that affect food risk/benefit perceptions and processes as well as consumer preferences regarding communication channels.

OBELIX - *OBesogenic Endocrine disrupting chemicals: Linking prenatal eXposure to the development of obesity later in life*

The work involves assessing prenatal exposure to six major classes of endocrine disrupting chemicals (EDCs) found in food identified as potential inducers of obesity later in life, by using mother-child cohorts from various European regions.

PARASITE - *Parasite risk assessment with integrated tools in EU fish production value chains*

The project aims to provide new scientific evidence and technological developments to detect, monitor and mitigate impacts of zoonotic parasites occurring in fishery products.

STARTEC - *Decision Support Tools to ensure safe, tasty and nutritious Advanced Ready-To-Eat foods for healthy and vulnerable Consumers*

This project is developing tools based on scientific evidence and predictive and probabilistic models to enable food operators to estimate the quality and safety of their products (ready-to-eat foods). It is focusing on vulnerable consumers in situations where increased quality and safety levels are needed, e.g. patients in nursing homes, hospitals, and old and sick people living at home.

SYMBIOSIS-EU - *Scientific sYnergisM of nano-Bio-Info-cOgni Science for an Integrated system to monitor meat quality and Safety during production, storage, and distribution in EU*

The aim of the project was to identify and quantitatively evaluate practical and easy-to-use chemical, biochemical and molecular indices and to establish their applicability in monitoring the safety and quality of meat during inspections.

VITAL - *Integrated Monitoring and Control of Food-borne Viruses in European Food Supply Chains*

Researchers used standardised methods to detect viruses in and control contamination of the European food supply by pathogenic viruses throughout three food supply chains – salad vegetables, soft fruit, and pork – from farm to market.

Making individualised diets a reality

The projects mentioned below cover both research priorities in this thematic area: 'Data needs: creation and management of necessary data for enabling individualised diets', and 'Analysing the feasibility and impacts of individualised, healthy diets'.

FP6

DIOGENES - *Diet, Obesity and Genes*

The project set out to demonstrate prototypes of innovative products or advice regimes to help susceptible individuals to avoid weight gain and regain, and to link with implementers to facilitate commercialisation in the market place.

LIPGENE - *Diet, genomics and the metabolic syndrome: an integrated nutrition, agro-food, social and economic analysis*

The work examined how variations in the composition of dietary fats interact with common human genetic variations and influence the development of metabolic syndrome. It assessed consumer attitudes, economic barriers and the usefulness of the newly developed agro-food technologies and the cost of dietary versus pharmaceutical approaches in managing metabolic syndrome.

NUGO - *European NutriGenomics Organisation*

The project links genomics, nutrition and health and provides a network to develop and integrate genomic technologies, facilitate the application of these technologies, and train a new generation of European scientists to use them.

FP7

BIOCLAIMS - *BIOmarkers of Robustness of Metabolic Homeostasis for Nutrigenomics-derived Health CLAIMS Made on Food*

Researchers are developing new biomarkers predictive of a healthy metabolic phenotype during ageing, as well as characterising and evaluating them for practical application in human nutrition and comparing them to traditional biomarkers.

FOOD4ME - *Personalised nutrition: An integrated analysis of opportunities and challenges*

The goal of the project is to determine the application of personalised nutrition, by developing suitable business models, researching technological advances, and validating delivery methods for personalised nutrition advice. It will compile current scientific knowledge and consumer understanding of personalised nutrition to inform the EU institutions, the food industry, and other stakeholders.

NU-AGE - *New dietary strategies addressing the specific needs of elderly population for healthy ageing in Europe*

The project aims to counteract the physical/cognitive decline occurring in the elderly as a consequence of the progressive alteration of different organs/systems, using a one-year elderly-tailored whole diet intervention in healthy elderly study subjects. It is also assessing the effect of the newly designed food pyramid specifically for EU citizens aged 65 and over, using a large set of biomarkers related to nutrition and ageing.

Shaping and coping with the 2050 food system

Understanding the social role of food

No related FP6 or FP7 projects have been identified.

Towards a sustainable food system producing safe, affordable and healthy dietary components**FP6****HEALTHY STRUCTURING** - *Nutritional and structural design of natural foods for health and vitality*

The project focused on preserving the qualities of fruit and vegetables throughout the entire production process for ready-to-eat meals. The team used real food products and analysed plant characteristics from the early stages of production until their arrival on the consumer's table, as well as their impact during consumption. Ways of preserving the nutritional qualities of the raw materials were also explored.

FP7**FOODMANUFUTURE** - *Conceptual Design of a Food Manufacturing Research Infrastructure to boost innovation in Food Industry*

This project is investigating the main trends and challenges of the food and manufacturing sectors and defining four possible scenarios for the future of European food manufacturing.

FOODMETRES - *Food Planning and Innovation for Sustainable Metropolitan Regions*

The researchers are aiming to identify concepts and practical examples for food chain innovation in the context of small-scale urban, peri-urban and rural forms of agriculture and food production up to large-scale metropolitan production. They are also studying and comparing the technical, logistical, organisational and governance aspects of innovative food-chain system regimes and assessing their economic, environmental and social impacts.

FUSIONS - *Food Use for Social Innovation by Optimising waste prevention Strategies*

The overall aim of the project is to contribute to the harmonisation of food-waste monitoring, the feasibility of social innovative measures for optimised food use in the food chain, and the development of a common food waste policy across the EU.

GLAMUR - *Global and Local food chain Assessment: a Multidimensional performance-based approach*

The project goal is to integrate advancement in scientific knowledge concerning the impact of food chains with the application of knowledge to practice in order to increase the sustainability of food chains through public policies and private strategies.

SENSE - *HarmoniSed ENvironmental Sustainability in the European food and drink chain*

The objective is to deliver a harmonised system to assess the environmental impact of food and drink products and to validate the new system in the juice, meat, dairy and aquaculture chains.

SUSMILK - *Re-design of the dairy industry for sustainable milk processing*

The project aims to initialise a system change that will contribute to the sustainable processing of milk, quark and cheese and a redesign of the dairy industry via the products' existing infrastructures.

Supporting technologies to meet societal needs**FP6****NUTRA-SNACKS** - *ready-to-eat food for breakfast and sport activity with high content of nutraceuticals preventing disease and promoting public health*

The aim was to produce food with a high content of natural metabolites with the following recognised health activities: anticancer, antilipidemic, anti-cholesterol, antimicrobial, antibacterial, antifungal, antiviral, antihypertensive, anti-inflammatory and antioxidant activity, and the realization of bioreactor/sensors for innovative plant cell and *in-vitro* systems suitable for nutrient production.

FP7**CARODEL** - *Use of Microorganisms for Carotenoids Delivery: Next Generation of Probiotics for Cardiovascular Disease*

The project aims to valorise the results of the previous FP7 COLORSPORE project, in which initial isolation and characterisation work was performed on *Bacillus* strains producing gastric-stable carotenoids.

HEALTHBREAD - *HealthBread product innovation based on FP6 HealthGrain results and knowledge*

Based on an SME and consumer-oriented approach, the project is developing whole grain and white

bread with further improved nutritional and product quality by applying scientific and technological knowledge acquired from the FP6 HEALTHGRAIN project to the production and marketing of commercially viable, healthier bread.

NAMASTE - *New Advances in the integrated Management of food processing waste in India and Europe: use of Sustainable Technologies for the Exploitation of by-products into new foods and feeds*

Researchers are developing industry-relevant approaches for the valorisation of citrus, mango, pomegranates, wheat and rice bran by-products and waste into healthy food ingredients, foods and feeds. **NOSHAN** - *Sustainable Production of Functional and Safe Feed from Food Waste*

The project is investigating the process and technologies needed to stabilise food waste and convert it into suitable raw materials for bulk feed at low cost, low energy consumption and with maximum recovery.

PEGASUS - *Public Perception of Genetically modified Animals - Science, Utility and Society*

The work focuses on providing policy support for the development, implementation and commercialisation of GM animals, and derivative foods by integrating existing social, public perception, environmental and economic knowledge and conducting a foresight exercise.

PERFORMANCE - *Development of Personalised Food using Rapid Manufacturing for the Nutrition of elderly Consumers*

The project will develop and validate a holistic, personalised food supply chain for frail elderly people in nursing homes, ambient-assisted living facilities or at home (receiving nursing services). As a result, an overall concept will be made available enabling the automatic manufacturing and supply of personalised, specially textured food for frail elderly people.

PLEASURE - *Novel Processing approaches for the development of food products Low in fAt, Salt and sUgar*

The researchers aim to develop innovative processes and/or to implement novel technologies to allow for the development and production of food products with low fat (saturated and trans-fatty acids), salt and sugar content.

PROTEINSECT - *Enabling the exploitation of Insects as a Sustainable Source of Protein for Animal Feed and Human Nutrition*

The objective of the consortium is to facilitate the exploitation of insects as an alternative protein source for animal and human nutrition. It will set up pilot-scale production facilities in order to demonstrate the feasibility of using insect-derived proteins in animal feed.

ROBOYEAST - *Cellular, metabolic and genetic engineering for novel compounds*

This project aims to improve productivity and cellular robustness in the large-scale fermentation of novel-to-nature production of two health-promoting polyunsaturated fatty acids with market potential as nutraceuticals.

TERIFIQ - *Combining Technologies to achieve significant binary Reductions in Sodium, Fat and Sugar content in everyday foods whilst optimising their nutritional Quality*

The aim is to achieve significant binary (salt and fat or fat and sugar) reductions in selected cheese, meat, cakes and ready-made food products whilst maintaining and, where possible, enhancing the products' nutritional and sensorial qualities to ensure full consumer acceptance.

Tomorrow's healthy society

Research priorities for foods and diets

ANNEX VI

WORKSHOP PARTICIPANTS

Participants in the three study workshops

(not all participants attended all three workshops)

Name	Affiliation
Laura Alexandrescu	European Commission, Directorate-General for Research and Innovation
Cristina Andres-Lacueva	University of Barcelona, Spain
Pascale Barberger-Gateau	University of Bordeaux, France
Ellen Blaak	Maastricht University, The Netherlands (representing EASO)
John Blundell	University of Leeds, United Kingdom (representing EASO)
Jaume Biarnés Digón	Alicia Foundation, Spain
Joao Breda	World Health Organization
Camillo de Camillis	European Commission, Joint Research Centre
Margherita Caroli	ASL Brindisi, Italy
Jennifer Cassingena Harper	Malta Council for Science and Technology
Merritt Cluff	Food and Agriculture Organization
Maria Beatriz De La Calle Guntinas	European Commission, Joint Research Centre
Christophe Didion	European Commission, Directorate-General for Health and Consumers
Laurence Doughan	Ministry of Public Health, Belgium
John Dyson	HOTREC – Hospitality Europe
Catherine Esnouf	National Institute for Agricultural Research (INRA), France
Gerda Feunekes	Unilever N.V., The Netherlands
Lynn J. Frewer	Newcastle University, United Kingdom
Mojca Gabrijelčič Blenkuš	National Institute of Public Health, Slovenia
Silvia Gaiani	University of Bologna, Italy
Klaus G. Grunert	Aarhus University, Denmark
Xavier Gellynck	Ghent University, Belgium
Wencke Gwozdz	Copenhagen Business School, Denmark
Michael Hallsworth	Institute for Government, United Kingdom
Monika Hartmann	University of Bonn, Germany
Eva Hummel	Max Rubner-Institut, Germany
Robert S. H. Istepanian	Kingston University, United Kingdom
Raquel Izquierdo De Santiago	Freshfel Europe
Beate Kettlitz	FoodDrinkEurope
Gundula Kjaer	European Commission, Directorate-General for Health and Consumers

Mariusz Legowski	European Commission, Directorate-General for Agriculture and Rural Development
Jean-Paul Malingreau	European Commission, Joint Research Centre
Francesca Mancini	European Commission, Directorate-General for Enterprise and Industry
Eliza Markidou	Department of Medical & Public Health Services, Ministry of Health, Cyprus
Brian McKenna	University College Dublin, Ireland
Panagiota Mitrou	World Cancer Research Fund
Pablo Monsivais	University of Cambridge, United Kingdom
Thomas Ohlsson	ThOOhLS, Sweden
Jyri Ollila	European Commission, BEPA
Begoña Pérez-Villarreal	AZTI – Tecnalia, Bilbao, Spain
Agata Pieniadz	European Commission, Directorate-General for Research and Innovation
Monique Raats	University of Surrey, United Kingdom
Jutta Roosen	Technical University of Munich, Germany
Paolo Sckokai	Università Cattolica, Italy
Gebhard Seiwald	European Commission, Directorate-General for Agriculture and Rural Development
Richard Shepherd	University of Surrey, United Kingdom
Cornell Christian Sieber	Friedrich-Alexander-Universität, Germany
Kristine Sørensen	Maastricht University, The Netherlands
Francisco José Tinahones-Madueño	University of Malaga, Spain
Annette Toft	Danish Agriculture & Food Council (representing COPA-COGECA)
Bence Toth	European Commission, Directorate-General for Agriculture and Rural Development
Alexandra Tuijtelaars	European Commission, Directorate-General for Research and Innovation
Hanna Tuomisto	European Commission, Joint Research Centre
Yvonne van Duynhoven	National Institute of Public Health, The Netherlands
Robert van Gorcom	Wageningen University, The Netherlands
Joop van Raaij	National Institute for Public Health and the Environment, RIVM, The Netherlands
Ruth Veale	BEUC – The European Consumers' Organisation
Wim Verbeke	Ghent University, Belgium
Thommy Visscher	EASO (European Association for the Study of Obesity)
Iwona Wybranska	Jagiellonian University, Poland

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