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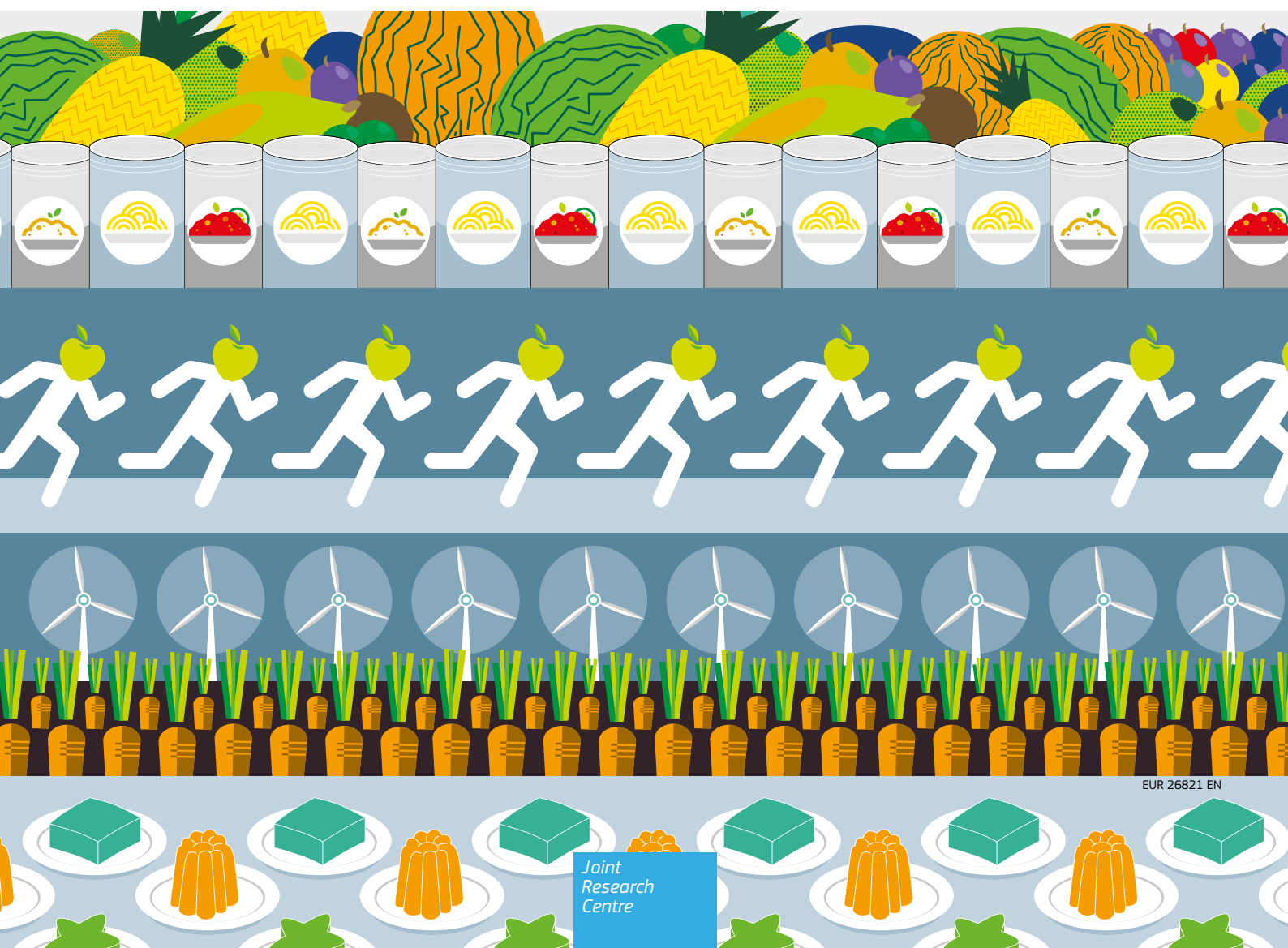
Tomorrow's Healthy Society

Research Priorities for Foods and Diets

Final Report

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

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Abstract

Healthy diets play a role in health promotion and disease prevention, and this is 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 that will 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). These 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; 2. Food, nutrients and health: cross-interactions and emerging risks; 3. Making individualised diets a reality; and 4. 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
• 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	• Deepening the understanding of human nutrition: facing the complexities • Anticipation of emerging risks	• Data needs: creation and management of necessary data for enabling individualised diets • Analysing feasibility and impacts of individualised, healthy diets	• 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.

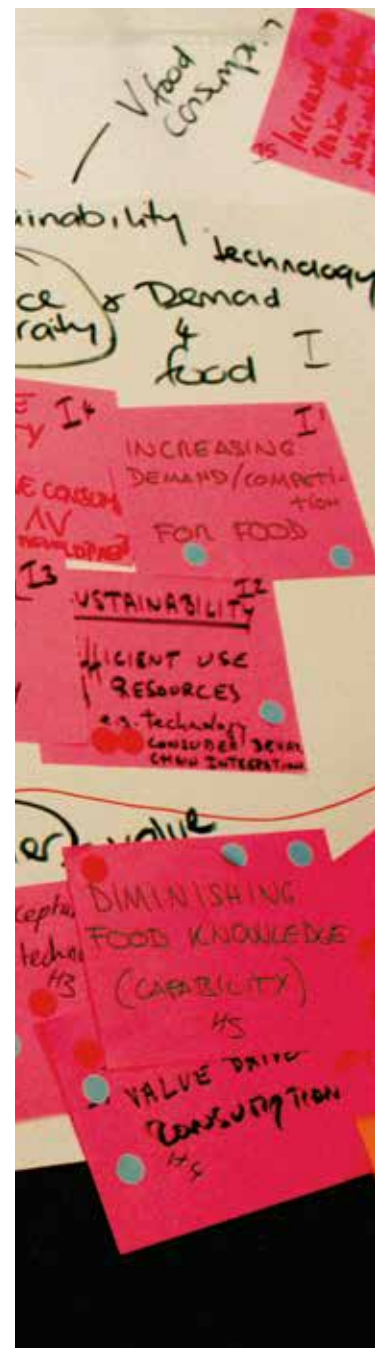
Foresight thus provides a different approach to identifying research priorities in the field of foods and diets for health in Horizon 2020, complementing other initiatives such as conventional expert workshops, or approaches and processes used by the Joint Programming Initiative 'A healthy diet for a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

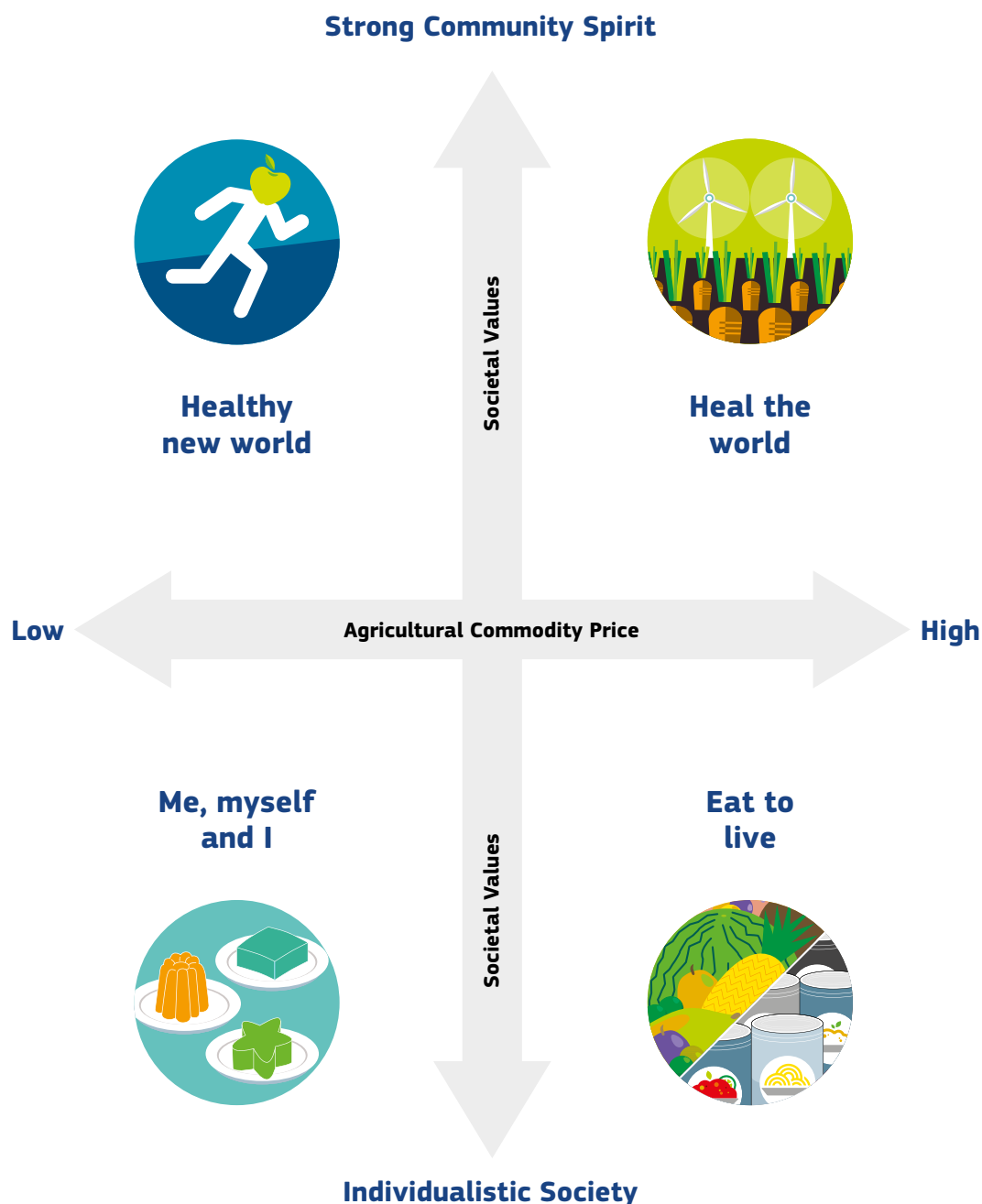
- plausibility, i.e. the scenario falls within the limits of what might conceivably happen;
- consistency, i.e. the various elements and factors in a scenario should not conflict and threaten its credibility; and
- decision-making utility, i.e. scenarios should contribute insights into the future, facilitating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

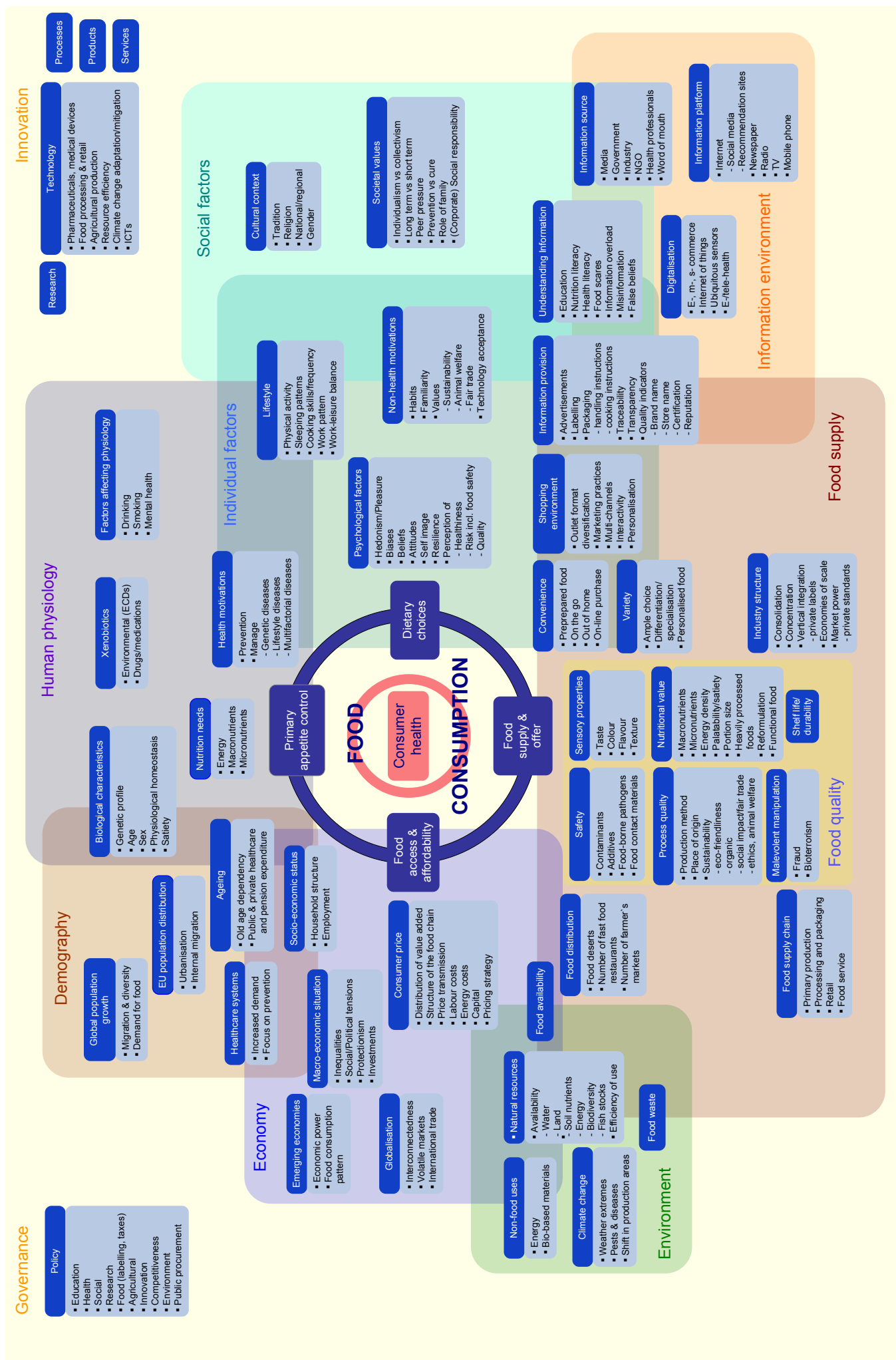


²⁵ An interesting approach to visualising interactions is the 'Obesity System Atlas' developed in the context of the UK Foresight study 'Tackling Obesity', UK Government's Foresight Programme (2007).

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	• Low	• High
Societal values	• Importance of common goods, rights and social justice	• Importance of common goods, rights and social justice
Climate change	• Leads to temperature increases of about 2 °C, moderate effects on the EU	
Global population	• 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	• Growing slightly	
Digitalisation	• Enables online shopping, information exchange, sophisticated marketing and (self-)monitoring applications	
Working patterns & Work/leisure balance	• Clear distinction between work and leisure, with flexible individual work patterns	• Long working days and teleworking common; flexibility required
Individual values	• Diets and physical activity valued as essential for healthy lifestyle	• Environmental protection and environmentally sustainable food chain
Acceptance of technology	• Positive but careful assessment and regulation	• Positive for enabling a sustainable food chain, preserving biodiversity, and cost reduction
Technological innovation	• Food technology combining health and nutrition standards with convenience and taste	• Food technology focuses on environmentally sustainable production and distribution
Food chain business models	• 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	• Concentrated agro-food chain focus on sustainable European products, main production in the EU • Online shopping dominant
Food-related governance (nutrition, environment)	• 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	• 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	• Health is a right - state-funded healthcare system, including provision of care • Focus on prevention, support given to foster healthy behaviour	• 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	
• High	• Low	Agricultural commodity prices³⁰
• Individual rights and initiative valued, self-interest before the common good	• Individual rights and initiative valued, self-interest before the common good	Societal values
• Leads to temperature increases of about 2 °C, moderate effects on the EU		Climate change
• 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
• Growing slightly		EU economy
• Enables online shopping, information exchange, sophisticated marketing and (self-)monitoring applications		Digitalisation
• High flexibility required, high pressure	• Highly flexible individual work patterns, work/leisure boundaries blurred	Working patterns & Work/leisure balance
• Different food-related values, but food price is decisive	• Broad variety of different values; food is subjected to trends	Individual values
• Considered necessary to keep food prices from rising further	• High until proven unsafe, enabler of different lifestyles	Acceptance of technology
• Food technology focuses on cost-efficient convenience production	• Technological innovations are taken up as they become available	Technological innovation
• Economies of scale are priority, concentration and integration, dominance of multinational companies with global resourcing • Emerging peer to peer food businesses • Online shopping dominant	• 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
• Measures taken to facilitate a working market, minimal regulation • Nutrition and health education not considered a public task	• 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)
• State funds basic services³¹, other services are paid by extra insurance or out of pocket • Policy limited to provision of information on nutrition	• 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)

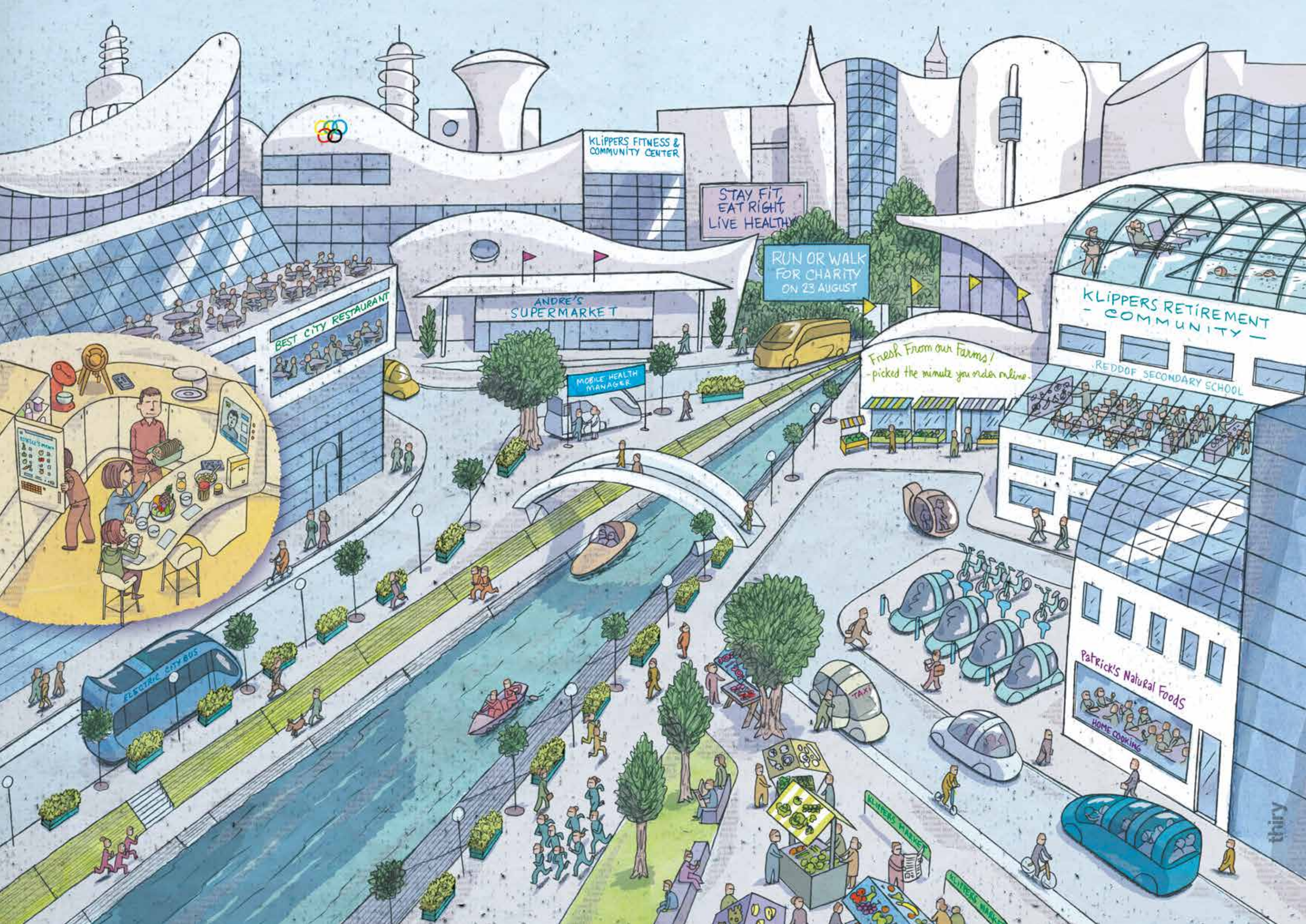
"...on my way home my glasses warned me that my blood glucose levels were low. Hmmm, what a coincidence! I guess my implanted blood glucose balancer needs to be adjusted again, but what better excuse to turn off the navi-tracker in the car (thanks to my flatmate I know how to do it) and sneak to the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





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 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)

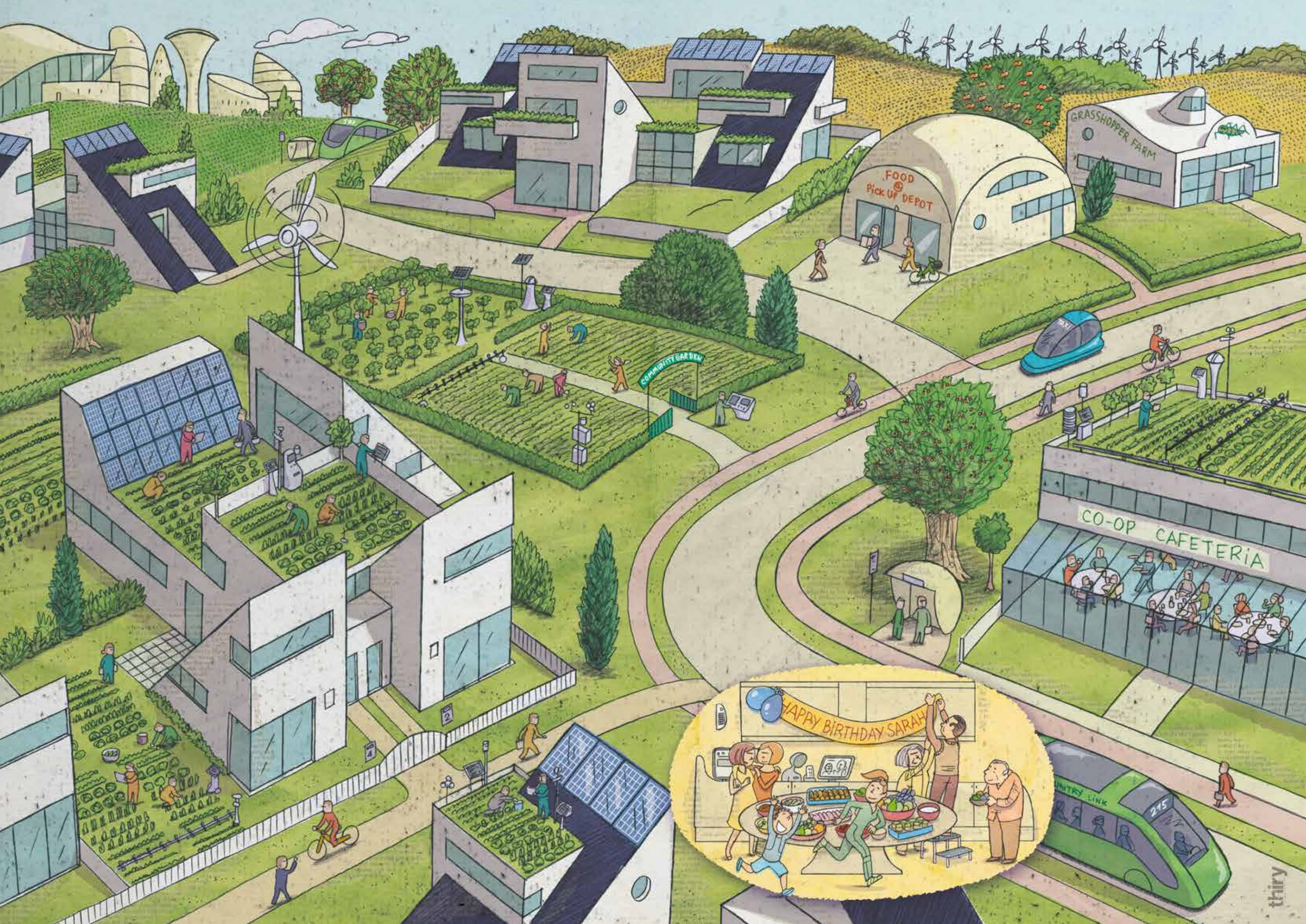
"...Helen will come home for dinner, hope she isn't late today. People work so many hours nowadays...Theoretically everybody should work 10 hours a day, but everybody knows that most people have to put in 2-3 extra hours or have two jobs. After the dinner party I will probably have to go through our 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.”





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...”





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)

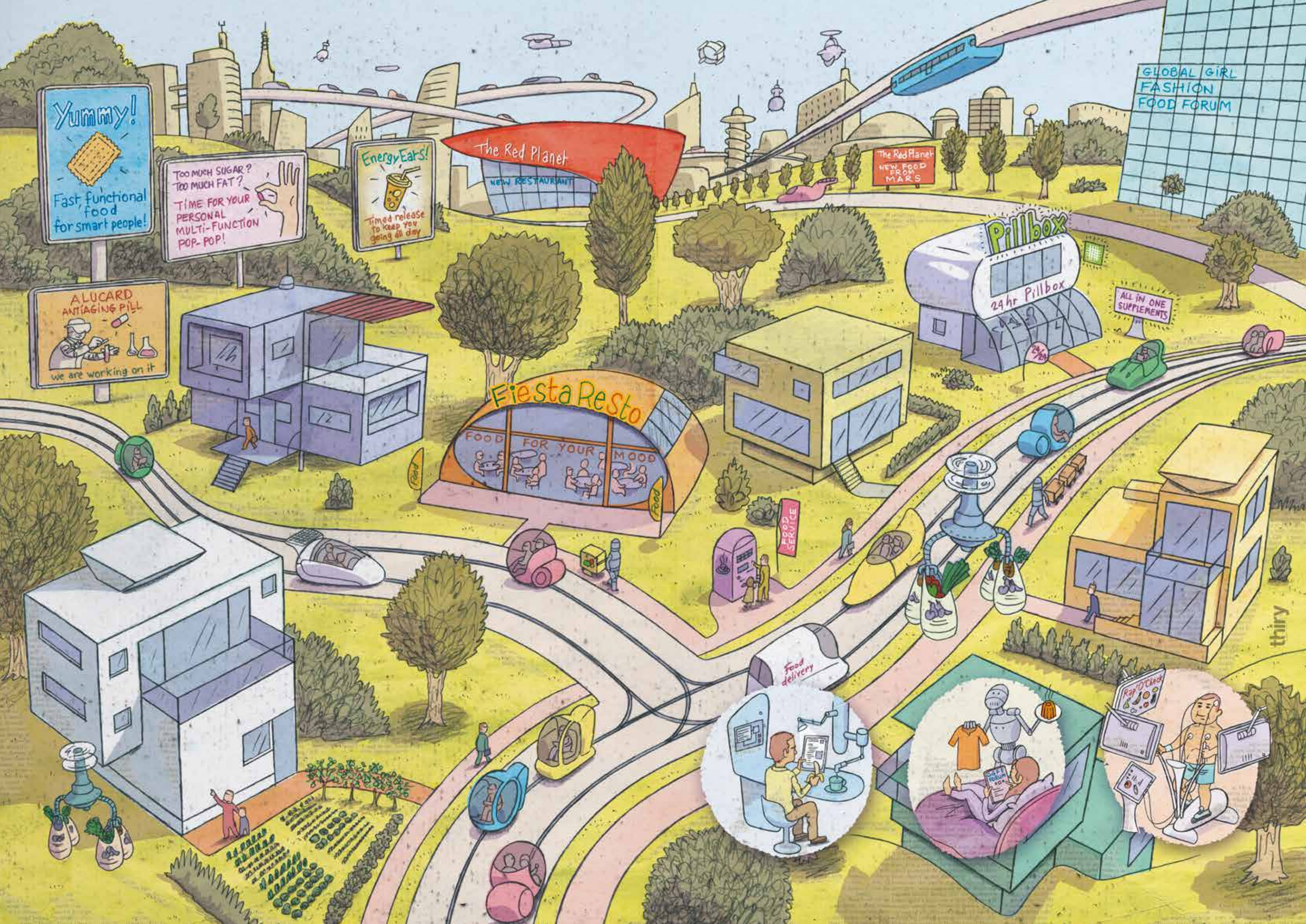
"...Flint is my social cyborg, he keeps me company, connects me to the rest of the world and advises me on many issues, like when to study and when not, when to go for a walk and to play with my friends, when to eat and, of course, on the moooost fashionable food to eat!... I wear some sensors attached 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

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

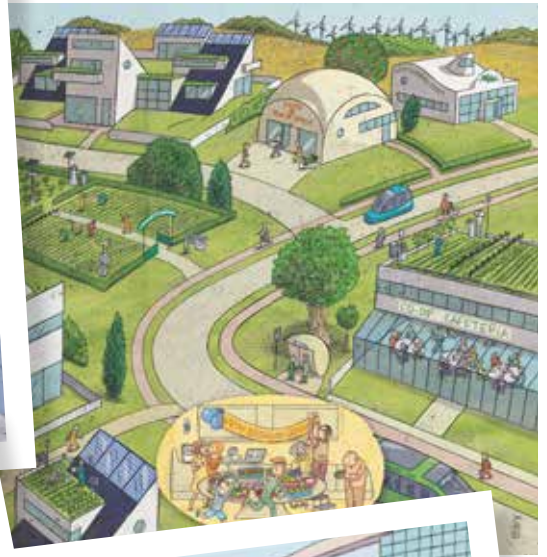
FOOD FOR YOUR MOOD

ALUCARD ANTIAGING PILL we are working on it

Food delivery

Pop O'Clock

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.

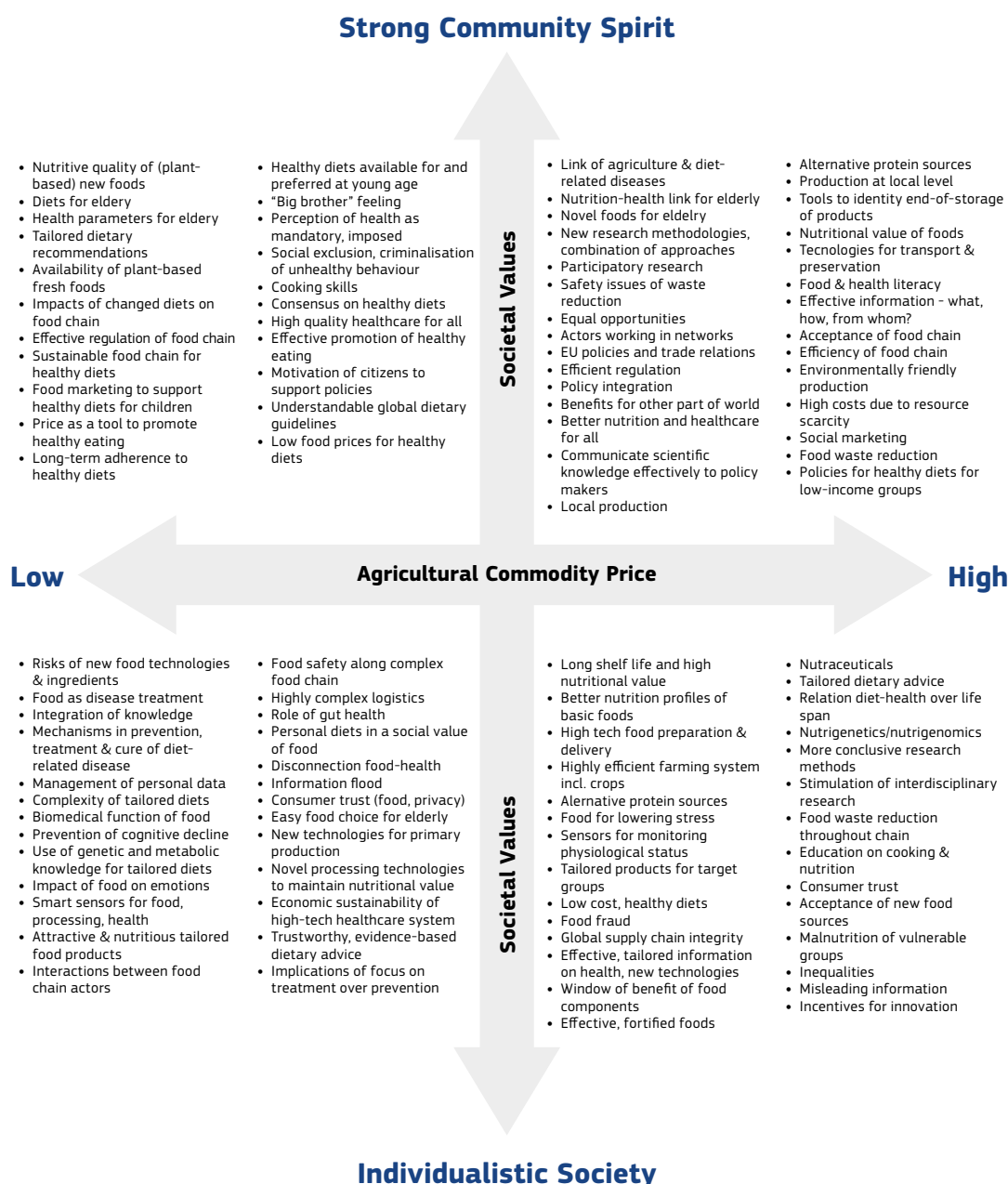


Fig. 3: Scenario-specific opportunities and challenges identified in Workshop 3

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
• 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	• Deepening the understanding of human nutrition: facing the complexities • Anticipation of emerging risks	• Data needs: creation and management of necessary data for enabling individualised diets • Analysing feasibility and impacts of individualised, healthy diets	• 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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