Food and Agriculture Organization of the United Nations

crea
Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria

FQH
Food Quality & Health
International Research Network for Food Quality and Health

Proceedings of an International Workshop

Assessing sustainable diets within the sustainability of food systems

Mediterranean diet, organic food: new challenges

Proceedings of an International Workshop

Assessing sustainable diets within the sustainability of food systems

Mediterranean diet, organic food: new challenges

15–16 September 2014,

Research Centre for Food and Nutrition, CREA, Rome

Edited by:

Alexandre Meybeck, Suzanne Redfern, Flavio Paoletti and Carola Strassner

PREPARATION, PRODUCTION AND DISTRIBUTION OF THIS BOOK HAVE BEEN MADE POSSIBLE THANKS TO THE SUPPORT AND TECHNICAL INPUT FROM:

Food and Agriculture Organization of the United Nations

crea
Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria

FQH
Food Quality & Health
International Research Network for Food Quality and Health

Consiglio Nazionale delle Ricerche

ENEA
Agenzia nazionale per le nuove tecnologie, l'energia e lo sviluppo economico sostenibile

CIHEAM

ptbio italia

Ciiscam

Cover photo: © FAO/Ivo Balderi

ISBN 978-92-5-108825-8

Contents

Acknowledgements

The international workshop on "Assessing Sustainable Diets Within the Sustainability of Food Systems. Mediterranean Diet, Organic Food: New Challenges", held on 15–16 September 2014 at the Consiglio per la ricerca in agricoltura e l'economia agraria (CREA) - Centro di ricerca per gli alimenti e la nutrizione (Council for Agricultural Research and Economics - Research Centre for Food and Nutrition), Rome, received the patronage of the EXPO 2015 around the theme of "Feeding the Planet, Energy for Life", and a contribution from the Ministry of Agricultural, Food and Forestry Policies (MiPAAF).

Particular thanks are extended to CREA – Research Centre for Food and Nutrition and the International Research Network for Food Quality and Health (FQH) for having organized the meeting. Furthermore, we are grateful for the technical collaboration with the FAO/UNEP Sustainable Food Systems Programme, the National Research Council (CNR), the Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA), the International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM), Italian Technology Platform for Organic Farming (PTBio Italia) and the International Inter-University Center for Mediterranean Food Cultures Studies (CIISCAM).

We would like to extend our special thanks to all the participants for their contributions and papers. Our appreciation is also expressed to Nicoletta Nardo (CREA – Research Centre for Food and Nutrition) and Irene Baiamonte (CREA – Research Centre for Food and Nutrition) for their support in the preparation of the workshop.

Agenda

INTRODUCTION

The interest for sustainable diets is markedly increasing within the broader and complex context of the sustainability of the food systems. Defining a theoretical methodological framework for the assessment of the sustainability of diets presents many challenges. The definition reached in 2010 at the Conference organized by FAO and Bioversity and the related four dimensions (health and nutrition, environment, economic and socio-cultural factors) provide a starting point to initiate a multistakeholder approach involving various relevant agro-food sectors.

The International Workshop aims to address two pressing needs:

1. foster a scientific debate on how to address the question of sustainable diets within organic production/consumption concepts and achievements and what contribution the sector can provide to the ongoing discussions,
2. finalize ongoing collaborations on identification of indicators and methods for assessing sustainable diets within the improvement of the sustainability of food systems, using the Mediterranean diet and the Mediterranean area as a case study.

Monday, 15 September 2014

09.30 – 09.40 Welcome, *Elena Orban, Director in charge CREA – Research Centre for Food and Nutrition, Italy*

SESSION 1: CONTRIBUTION TO SUSTAINABLE DIETS FROM THE ORGANIC SECTOR

Chair: *Mauro Gamboni, CNR, Italy*

09.50 – 10.00 Introduction to the topic, *Flavio Paoletti, CREA –Research Centre for Food and Nutrition, Italy*

10.00 – 10.10 From vision to metrics: lessons from the organic food system, *Johannes Kahl, Chairperson FQH, The Netherlands*

10.10 – 10.25 The organic food system in Europe, *Ewa Rembiałkowska, Warsaw University of Life Sciences, Poland*

10.25 – 10.45 How the organic food system contributes to sustainability, *Christian Schader, FiBL, Switzerland*

10.45 – 11.15 Coffee break

11.15 – 11.45 How can the organic food system contribute to sustainable diets? *Sirli Pehme, Estonian University of Life Sciences, Estonia and Carola Strassner, University of Applied Sciences Münster, Germany*

11.45 – 12.10 The organic food system. The agro-ecology perspective, *Nic Lampkin, The Organic Research Centre, UK*

12.10 – 12.20 Organic durum wheat in Mediterranean diet: old varieties and traditional bread making, *Ivana Cavoski, Mediterranean Organic Agriculture Network, Italy*

12.20 – 12.30 Organic food procurement in schools – a European case study, *Anne-Kristin Løes, Bioforsk Organic Food and Farming, Norway* (via Skype)

12.30 – 12.50 Discussion

12.50 – 13.00 Wrap-up

13.00 – 14:30 Lunch

SESSION 2: NUTRITION INDICATORS TO ASSESS THE SUSTAINABILITY OF THE MEDITERRANEAN DIET AS A CASE STUDY

Chair: *Denis Lairon, INSERM/INRA/Aix-Marseille University, France*

14.30 – 15.00 Introduction, *Sandro Dernini, FAO, Rome, Italy, and Lluis Serra Majem, University of Las Palmas de Gran Canaria, Spain* (via Skype)

15.00 – 15.30 Presentation of a draft of a background document on nutrition indicators to assess the sustainability of the Mediterranean diet,
Introduction by *Denis Lairon, Aix-Marseille University, France, and Elliot Berry, Hebrew University, Jerusalem, Israel* (via Skype)

15.30 – 17.00 **WITHIN-SESSION SESSION: SELECTED NUTRITION INDICATORS TO ASSESS THE SUSTAINABILITY OF THE MEDITERRANEAN DIET**
Chair: *Giuseppe Maiani, CREA, Rome, Italy*

Diet-related morbidity mortality stats, *Lorenzo M. Donini, CIISCAM/Sapienza, Rome, Italy*
Fruit and vegetable consumption, *Aida Turrini, CREA – Research Centre for Food and Nutrition, Rome, Italy*
Vegetable and animal protein, *Barbara Burlingame, Deakin University, Melbourne, Australia*
Dietary energy supply, *Angela Polito, CREA – Research Centre for Food and Nutrition, Rome, Italy*
Dietary diversity, *Aida Turrini, CREA – Research Centre for Food and Nutrition, Rome, Italy*
Dietary energy density, *Denis Lairon, INSERM/INRA/Aix-Marseille University, France*
Nutrient density/quality, *Denis Lairon, INSERM/INRA/Aix-Marseille University, France*
Biodiversity composition and consumption, *Barbara Burlingame, Deakin University, Melbourne, Australia*
Nutritional anthropometry, *Lorenzo M. Donini, CIISCAM/Sapienza, Rome, Italy*
Physical activity, *Angela Polito, CREA – Research Centre for Food and Nutrition, Rome, Italy*

17.30 – 18.15 Discussion

18.15 – 18.30 Wrap-up

Tuesday, 16 September 2014

SESSION 3: ASSESSING SUSTAINABLE DIETS IN THE CONTEXT OF SUSTAINABLE FOOD SYSTEMS

Chair: *Alexandre Meybeck, Sustainable Food Systems Programme, FAO, Rome, Italy*

09.00 – 09.15 Sustainable diets and sustainable food systems, *Vincent Gitz, High Level Panel of Experts on Food Security and Nutrition, FAO, Rome, Italy*

09.15 – 10.30 **WITHIN-SESSION SESSION: PERSPECTIVES FROM THE MEDITERRANEAN DIET CASE STUDY**

Chair: *Roberto Capone, CIHEAM-Bari, Italy and Sandro Dernini, FAO, Rome, Italy*

A view from the Southern Mediterranean Rim, *Rekia Belahsen, Chouaib Doukkali University, Morocco*

Nutrition and health dimension, *Antonia Trichopoulou, Hellenic Health Foundation, Athens, Greece*

Socio-cultural dimension, *Xavier Medina, ICAF Europe, Universitat Oberta de Catalunya, Spain*

Economic dimension, *Felice Adinolfi, University of Bologna, Italy*

Environmental dimension, *Massimo Iannetta, ENEA, Rome, Italy*

10.30 – 11.00 Coffee break

11.00 – 11.45 **WITHIN-SESSION SESSION: PERSPECTIVES FROM THE ORGANIC SECTOR**

Profiles of organic food consumers, first lessons from the French Nutrinet cohort: a step towards diet sustainability, *Denis Lairon, INSERM/INRA/ Aix-Marseille University, France*

Putting it all together: how can organic support sustainable diet and translating it into practice? *Carola Strassner, University of Applied Sciences Münster, Germany*

11.45 – 12.45 Discussion on sustainable diets within sustainable food systems

12.45 – 13.30 Conclusion, *Alexandre Meybeck, FAO, Rome, Italy*

13.30 Lunch

Opening remarks

Stefano Bisoffi
Director, Central Administration for Scientific Activities
Council for Agricultural Research and Economics, Italy

Dear Participants,

The subject of the workshop is both relevant and timely. Sustainability, in its three aspects – environmental, social and economic – cannot be confined to production systems only, as production systems themselves are components of a broader complex network of relationships that needs to be considered in a more comprehensive way and with a really holistic approach.

Diets are a most appropriate point of view upon sustainability for a number of reasons. The world demographic growth, with population expected to reach 9 to 9.5 billion by the middle of the century, will be the major driver of global challenges in the coming years: agricultural production will have to almost double in order to keep pace with the growing demand for food and feed. Agriculture, which is already a significant contributor to greenhouse gas emission, will have to rethink itself with a view to "producing more with less". This is by no means a return to the past, to a primitive form of agriculture; on the contrary, advanced research is needed to innovate production systems, based on the most recent advancement in the fields of genetics, genomics, information technology, remote sensing, global positioning, nanotechnologies, analytical capabilities, sensoring, etc., in order to reshape production systems with sustainability as a beacon. Organic farming, being based on a reduction of external inputs, on the maximum level of recycling and on the improvement of soil functionality through an increase of organic matter content, is at the moment the best candidate as a viable example of sustainable production systems and can act as a testing ground for farming practices that are likely to become widely adopted in a hopefully near future.

Sustainable diets enter the scene in full right. What people eat has a strong impact on the environment; just think of the environmental footprint of a meat-based diet with respect to a diet where plants are the main source of protein. As nearly half of agricultural production currently goes into animal feed, the positive environmental effect of a reduction, instead of the present increase, of meat consumption is self-evident.

At the same time, a diet with less meat, possibly associated with a healthier lifestyle, including physical activity, would improve health, adding "life to years", diminishing the individual, social and economic burden of chronic, metabolic, cardiovascular diseases, thus "closing the circle" of the sustainability concept.

The CREA, as the main agricultural research institution in Italy, is deeply involved in research on the sustainability of production systems, but since the incorporation of the former Institute for Food and Nutrition Research (now Research Centre for Food and Nutrition), it is in a position to broaden its scope to nutritional and dietary aspects and to the relationships between health, diets and the environment.

The present workshop is a concrete example of this broad approach to sustainability and, as I said before, a timely one, as it precedes the Second International Conference on Nutrition (ICN2), organized by FAO and WHO, where the relationship between nutrition and sustainable development will be a central topic of discussion.

It is also my opinion that a number of international coordinated research initiatives in the field of agriculture and climate changes (such as the Joint Programming Initiative on Agriculture, Food

Security and Climate Change – JPI FACCE) and on the diet-health couple (such as the Joint Programming Initiative - A Healthy Diet for a Healthy Life – JPI HDHL) should be brought under the same broader umbrella of the "sustainable diets" concept.

Opening remarks
Assessing sustainable diets within the sustainability of food systems. Mediterranean diet, organic food: new challenges

Elena Orban
Director in Charge, Council for Agricultural Research and Economics – Research Centre for Food and Nutrition, Italy

Food production and consumption trends and patterns are among the main causes of pressure on the environment. Any step of the "life cycle" of a food product from its production (vegetable growing, fishing, animal farming, aquaculture) to its processing, storage, transport and distribution up to waste disposal, has an impact on the environment.

This impact consists of the subtraction and utilization of natural resources (i.e. water, soil), emission of greenhouse gases (GHG) in the atmosphere, pollution, incautious management of natural resources (i.e. overexploitation of seas), loss of biodiversity, energy utilization and waste production.

Consequently, sustainability together with food security, food safety, climate changes and biodiversity are the main topics in the current world food policy.

Consumers, with their lifestyle and food choices, play a leading role in orienting production, for instance when they select certain types of products, a production process or producer.

The evolution of large-scale retailers has introduced changes in consumers' behaviour and choices. New purchase models have emerged; the Mediterranean dietary model has deeply changed because of the modern lifestyle. Food products, with the introduction of new production technologies, have changed. For instance, food items once available seasonally now may be purchased all through the year.

Globalization has made food trade from all over the world easier but has dramatically increased GHG emissions into the environment and also the risk of exposure to unsafe products.

Within this context, consumers need to be helped and informed through a correct and modern health nutrition education to operate sustainable food choices.

The scientific research should provide the foundation for health nutrition education and should develop new sustainable strategies of food production, transport, storage and processing. It should also provide information on the possibility of replacing a specific food item with one more sustainable without causing a shortage of nutrients in the diet.

In recent years there has been the emanation of EC and Italian regulations to restrain unsustainable food production models. One example is the development and evolution of organic food products. Organic agriculture, organic animal husbandry and, more recently, organic aquaculture exclude the use of chemical synthesis products (fertilizers, herbicides, pesticides) and require practices respectful of the ethology and diversity of the species, also to guarantee the quality of products. Some scientific evidence has shown that the traditional Mediterranean diet is one of the most sustainable dietary models, both for human health and for the environment. CREA – Research Centre for Food and Nutrition (former INN and then INRAN) has a long and prestigious tradition of studies on the Mediterranean diet, nutrition, consumption and dietary habits of Italians. We are now assisting in the re-evaluation of the dietary model of a rural Italy, a model now modernized according to contemporary standards.

In conclusion, sustainability creates and maintains the conditions under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic and other requirements of present and future generations. All key sectors and players throughout the food system must be involved to make better use of food systems. Food is essential to life. It also forms an important part of our cultural identity, and plays an important role in the economy. People are aware that the food they eat is an important factor affecting their health, but what is less well known is the impact producing and consuming food has on the world's resources.

FIRST SESSION: CONTRIBUTION TO SUSTAINABLE DIETS FROM THE ORGANIC SECTOR

Contribution to sustainable diets from the organic sector: preliminary remarks

Mauro Gamboni
National Research Council of Italy, Department of Biology, Agriculture and Food Sciences, Rome, Italy

Can organic food and farming be considered as one of the most effective components of a sustainable food production/consumption system? Can the organic sector support the spreading of sustainable diets? The change of consumption patterns seems to be a crucial issue in the transition towards sustainable food systems and, in principle, regular organic consumption seems to be close to the sustainable diet concept. These will be the main issues dealt with in this session, where different contributions of experts from a number of research institutions in Europe will be presented. Starting from a global vision of the food and agriculture system and the related ongoing challenges, the regulatory instruments and standards on organic food and farming in Europe and worldwide will be described, as the result of the history of the organic movement. Actually, the organic approach was originally based on observation of nature and respect for natural laws, then it has been transformed into practical methods. Basically, its trend is to reconnect the food and farming system to the concept of sustainability in the broadest sense. To do that, valid instruments are needed to evaluate if and how organic food and farming are addressing sustainability. In order to explore this matter, the *Sustainability Assessment of Food and Agriculture Systems Guidelines* published by FAO and the life cycle assessment (LCA) methods will be illustrated, while the agro-ecology perspectives of organic food systems will be considered as a guiding principle, also in the light of the current EU regulation. Finally, two case studies will be presented. The first regards organic durum wheat: old varieties and traditional bread making of durum wheat. In the Mediterranean diet, durum wheat is one of the bases, in the form of bread, pasta, couscous and bulgur. Therefore, organic meals based on organic durum wheat represent a valid contribution towards sustainable diets. The second case study regards actions aimed at increasing the consumption of organic food in Europe, through implementing public procurement for organic food, especially in school meals. This allows inclusion of food knowledge as an education aspect to be explored and, in this context, organic foods are well suited to discuss and experience sustainable diets and promote healthy eating. The panorama so offered during the session can give a first representation of the main issues to be faced. The relationship between organic food consumption and its impact on human health needs further investigation, as well as its direct connection with the concept of sustainable diets. The door for in-depth study of the recognition of organic systems as a means particularly suitable for orienting consumers' dietary patterns towards sustainability is now opened.

Contribution to sustainable diets from the organic sector: an introduction

Flavio Paoletti
Council for Agricultural Research and Economics – Research Centre for Food and Nutrition, Rome, Italy

ABSTRACT

The current agricultural and food system has shown that it is able to produce enough food to meet the caloric requirements for all the world's people. Yet it is characterized by contradictions and imbalances that clearly make it unsustainable. In the near future there will be incredible challenges to face: how to feed more than 9 billion people, the expected world population in 2050, and how to achieve this goal while becoming environmentally sustainable. These challenges cannot be faced adopting only a production-, agriculture-oriented perspective. Important changes in both the agriculture system and production and consumption patterns are needed. The sustainable diets concept, as defined by FAO, highlights the role of sustainable consumption as a driver of sustainable production. Organic agriculture has been demonstrated to be a sustainable alternative to the current industrialized agriculture and food production. Moreover, the principles on which organic agriculture is based seem to be able to orient consumers' dietary patterns and lifestyle towards healthier profiles.

INTRODUCTION

In the last 50 years the human population has grown from about 3 billion in 1960 to about 7 billion today (United Nations, 2013). Even with the doubling of the human population, more than enough food has been produced to meet the caloric requirements for all of the world's people (Foley, 2011). The increase of food production (Lam, 2011) has been achieved by growing high-yielding species, strains, varieties, races and hybrids, increasing fertilizer application, water usage through irrigation and pesticide use. Yet, these intensive methods have caused significant detrimental effects on the environment and contributed to the observed climate changes. In terms of the release of greenhouse gases (Vermeulen, Campbell and Ingram, 2012):

- the full supply chain, including fertilizer manufacture, agriculture, processing, transport, retail, household food management and waste disposal contributes 19 to 29 percent of global greenhouse gas emissions per year;
- agriculture makes the greatest contribution to total food system emissions (80–86 percent of food systems emissions and 14–24 percent of global emissions).

Moreover, food production is responsible for soil erosion, surface and groundwater contamination, increased pest resistance, loss of biodiversity (the global agricultural system produces vast quantities of only a few crops: maize, rice, wheat), change in land use and deforestation.

Despite the high amount of food produced, FAO estimates that nearly 840 million people in the world were suffering from chronic undernourishment in 2010–2012 (FAO, 2014). Almost all the hungry people live in developing countries, with 16 million people undernourished in developed countries (FAO/IFAD/WFP, 2014). This means that food is not distributed equitably and, against the potentially high availability, food accessibility is not guaranteed in all the different areas of the world. At the same time, there is a worldwide increase in overweight and obesity and related chronic diseases that is ascribed mainly to global trade liberalization, economic growth and rapid urbanization. These factors continue to fuel dramatic changes in living environments, diets and lifestyles in ways that promote positive energy balance between calories consumed and calories expended (Tilman and Clark, 2014). This change is coupled with reductions in physical activity as a consequence of more mechanized and technologically driven lifestyles (Mozaffarian *et al.,* 2011). It is alarming to observe the increase of overweight and obesity among children in particular in those countries where the current rate among adults is low (OECD, 2014). It has been estimated that about one-third of food produced for human consumption is lost or wasted globally (FAO, 2011). This consequently implies that a significant amount of the resources used in food production is used in vain. Food is lost or wasted throughout the supply chain. The causes vary in low-income and medium- and high-income countries and depend on the specific conditions and local situations in each country: in medium- and high-income countries food is to a significant extent wasted at the consumption stage, meaning that it is discarded even if it is still suitable for human consumption. It results from insufficient purchase planning and the careless attitude of those consumers who can afford to waste food. In low-income countries, food is lost mostly during the early and middle stages of the food supply chain, and less at the consumer level. This is due to the awareness of food insecurity, and consumers often buy smaller amounts of food products and plan meals better.

THE SUSTAINABLE DIETS CONCEPT

The contradictions and imbalances briefly described above make clear that the world's agricultural and food system is not sustainable. However, in the near future we will have to face incredible challenges: how to feed more than 9 billion people, that is the expected world population in 2050, and how to achieve this goal while becoming environmentally sustainable. These challenges cannot be faced adopting only a production-, agriculture-oriented perspective. Enhancing the efficiency of irrigation (for example, drip irrigation), rationalizing the use of fertilizers (for example, precision agriculture), and adopting farming techniques that can help to preserve soil from erosion while improving crop yields (for example, reduced tillage, cover crops) are solutions that undoubtedly can make an important contribution to making food production more sustainable. But they would not have any effect on the current incorrect food consumption patterns and attitude of consumers towards food and food purchase which, in turn, significantly contribute to make the current agriculture and food systems unsustainable. In the future, it is expected that the increase in global population will be accompanied by an increase in the proportion of people who will have sufficiently high incomes to allow them to consume more food per person (Foley, 2011). A trend has been observed worldwide in which, as income increases, traditional diets are replaced by diets high in calories, processed foods, meat, refined sugars and fats. This diet transition is responsible in part for the global increase of overweight and obesity and incidence of related non-communicable diseases, such as type II diabetes, and of negative effects on the environment (Tilman and Clark, 2014). With regard to the increase of meat consumption, it should be emphasized that the livestock sector currently represents 14.5 percent of human-induced GHG emissions, thus playing an important role in climate change (FAO, 2013). Moreover, only 60 percent of the world's crops are meant for people, another 35 percent being used for animal feed (Foley, 2011). It is clear that human and environment health are linked and diets represent the linkage between them. In 2010, at FAO, an agreement was reached on the following definition of sustainable diets:

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

The sustainable diets concept highlights the role of sustainable consumption as a driver of sustainable production. Sustainable diets represent the link between sustainable food consumption and production that have to be dependent on food requirements and nutrient recommendations. Environment, health, economy, society and culture are the key words of the definition of sustainable diets.

HOW CAN THE ORGANIC SECTOR CONTRIBUTE TO SUSTAINABLE DIETS?

Organic agriculture is based on principles formulated by the International Federation of Organic Agriculture Movements (IFOAM): the principle of health, the principle of fairness, the principle of care, the principle of environment. These are ethical principles and the correspondence between them and the key words of the definition of sustainable diets are immediately apparent. In many countries the organic agriculture principles have been implemented through regulation by standards, including certification. In the last few decades there has been a worldwide continuous growth in organic agriculture both in terms of production and consumption (Willer and Lernoud, 2014). Also research into the different aspects related to organic farming, organic food production and consumption has increased considerably in recent years. Several studies have demonstrated the benefit for the environment resulting from the application of organic agriculture methods with respect to conventional ones, such as an increase of soil biodiversity (abundance and variety of soil micro-organisms), biological activity and fertility (Bengtsson, Ahnström and Weibull, 2005; Pimentel *et al.,* 2005; Mäder *et al.,* 2002; Scialabba and Muller-Lindenlauf, 2010), of farmland biodiversity and ecosystem services (abundance and variety of birds, insects, pollinators, butterflies, etc.) (Holzschuh *et al.,* 2007; Holzschuh, Steffan-Dewenter and Tscharntke, 2008; Rundlöf, Nilsson and Smith, 2008; Rundlöf, Bengtsson and Smith, 2008), higher amounts of carbon sequestrated by the soil (Niggli *et al.,* 2008; Pimentel *et al.,* 2005) and soil quality (Mondelaers, Aertsens and Van Huylenbroeck, 2009; Tuomisto *et al.,* 2012). Other environmental impact parameters, such as greenhouse gas emissions, and energy use resulted lower in the organic systems compared with the conventional ones when calculated per product unit. However, these differences, giving the advantage to organic agriculture, decrease, become null, or become to the advantage of conventional systems when greenhouse gas emissions are calculated per surface unit (Mondelaers, Aertsens and Van Huylenbroeck, 2009; Tuomisto *et al.*, 2012). The higher land use is a critical issue for the organic systems.

Organic agriculture has resulted in positively affecting food quality: higher content of antioxidants in organic fruit and vegetables (Baranski *et al.,* 2014; Brandt *et al.,* 2011; Smith-Spangler *et al.,* 2012), ω-3 fatty acids and conjugated linoleic acid (CLA) in organic milk (Palupi *et al.*, 2012). Moreover, the risk of contamination with agrochemicals is lower for organic than conventional vegetables (Baranski *et al.*, 2014; Smith-Spangler *et al.*, 2012; Magkos, Arvaniti and Zampelas, 2006).

At present, a relationship between organic food consumption and its impact on human health cannot be inferred from the scientific literature (Huber *et al.*, 2011). However, it has been shown that the regular consumers of organic food have dietary patterns and lifestyles that closely adhere to the recommendations for a healthy nutrition and healthy life (Kesse-Guyot *et al.*, 2013). These results seem to suggest that the adoption of the principles of organic agriculture at the consumption stage determines the adoption of a more correct and healthier behaviour by the consumers.

REFERENCES

Baranski, M., Srednicka-Tober, D., Volakakism, N., Seal, C., Sanderson, R., Stewart, G.B., Benbrook, C., Biavati, B., Markellou, E., Giotis, C., Gromadzka-Ostrowska, J., Rembiałkowska, E., Skwarło-Sonta, K., Tahvonen, R., Janovska, D., Niggli, U., Nicot, P. & Leifert, C. 2014. Higher antioxidant and lower cadmium concentrations and lower incidence of pesticide residues in organically grown crops: a systematic literature review and meta-analyses. *British Journal of Nutrition*, 112: 794–811.

Bengtsson, J., Ahnström, J. & Weibull, A.C. 2005. The effects of organic agriculture on biodiversity and abundance: a meta-analysis. *Journal of Applied Ecology*, 42: 261–269.

Brandt, K., Leifert, C., Sanderson, R. & Seal, J.C. 2011. Agroecosystem management and nutritional quality of plant foods: the case of organic fruits and vegetables. *Critical Reviews in Plant Sciences*, 30: 177–197.

FAO. 2011. *Global food losses and food waste*, by J. Gustavsson, C. Cederberg, U. Sonesson, R. van Otterdijk & A. Meybeck. Rome.

FAO. 2013. *Tackling climate change through livestock – a global assessment of emissions and mitigation opportunities*, by P.J. Gerber, H. Steinfeld, B. Henderson, A. Mottet, C. Opio, J. Dijkman, A. Falcucci & G. Tempio. Rome.

FAO. 2014. *Statistical database FAOSTAT* (available at http://faostat3.fao.org).

FAO/IFAD/WFP. 2014. *The State of Food Insecurity in the World 2014. Strengthening the enabling environment for food security and nutrition*. Rome.

Foley, J.A. 2011. Can we feed the world and sustain the planet? *Scientific American*, November: 60–65.

Holzschuh, A., Steffan-Dewenter, I. & Tscharntke, T. 2008. Agricultural landscapes with organic crops support higher pollinator diversity. *Oikos*, 117: 354–361.

Holzschuh, A., Steffan-Dewenter, I., Klejin, D. & Tscharntke, T. 2007. Diversity of flower visiting bees in cereal fields: effects of farming system, landscape composition and regional context. *Journal Applied Ecology*, 44: 41–49.

Huber, M., Rembiałkowska, E., Srednicka, D., Bügel, S. & van de Vilver, L.P.L. 2011. Organic food and impact on human health: assessing the status quo and prospects of research. NJAS – *Wageningen Journal of Life Sciences*, 58: 103–109.

Kesse-Guyot, E., Péneau, S., Méjean, C., Szabo de Edelenyi, F., Galan, P., Hercberg, S. & Lairon, D. 2013. Profiles of organic food consumers in a large sample of French adults: results from the Nutrinet-Sante´ cohort study. *PLoS ONE*, 8(10): e76998. doi:10.1371/journal.pone.0076998.

Lam, D. 2011. How the world survived the population bomb: Lessons from 50 years of demographic history. *Demography*, 48: 1231–1262.

Mäder, P., Fliessbach, A., Dubois, D., Gunst, L., Fried, P. & Niggli, U. 2002. Soil fertility and biodiversity in organic farming. *Science*, 296: 1694–1697.

Magkos, F., Arvaniti, F. & Zampelas, A. 2006. Organic food: buying more safety or just peace of mind? A critical review of the literature. *Critical Reviews in Food Science and Nutrition*, 46: 23–56.

Mondelaers, K., Aertsens, J. & Van Huylenbroeck, G. 2009. A meta-analysis of the differences in environmental impacts between organic and conventional farming. *British Food Journal*, 111: 1098–1119.

Mozaffarian, D., Hao, T., Rimm, E.B., Willett, W.C. & Hu, F.B. 2011. Changes in diet and lifestyle and long-term weight gain in women and men. *New England Journal of Medicine*, 364: 2392–2404.

Niggli, U., Fliessbach, A., Hepperly, P. & Scialabba, N. 2008. *Low greenhouse gas agriculture: mitigation and adaptation potential of sustainable farming systems*. Rome, FAO.

OECD (Organisation for Economic Co-operation and Development). 2014. *Obesity update* (available at http://www.oecd.org/els/health-systems/Obesity-Update-2014.pdf).

Palupi, E., Jayanegara, A., Ploeger, A. & Kahl, J. 2012. Comparison of nutritional quality between conventional and organic dairy products: a meta-analysis. *Journal Science Food Agriculture*, 92: 2774–2781.

Pimentel, D., Hepperly, P., Hanson, J., Douds, D. & Seidel, R. 2005. Environmental, energetic, and economic comparisons of organic and conventional farming systems. *BioScience*, 55: 573–582.

Rundlöf, M., Nilsson, H. & Smith, H.G. 2008. Interacting effects of farming practice and landscape context on bumble bees. *Biological Conservation*, 141: 417–426.

Rundlöf, M., Bengtsson, J. & Smith, H.G. 2008. Local and landscape effects of organic farming on butterfly species richness and abundance. *Journal Applied Ecology*, 45: 813–820.

Scialabba, N. & Muller-Lindenlauf, M. 2010. Organic agriculture and climate change. *Renewable Agriculture and Food Systems*, 25: 158–169.

Smith-Spangler, C., Brandeau ,M.L., Hunter, G.E., Bavinger , J.C., Pearson, M., Eschbach, P.J., Sundaram, V., Liu, H., Schirmer, P., Stave, C., Olkin, I. & Bravata, D.M. 2012. Are organic foods safer or healthier than conventional alternatives? A systematic review. *Annals of Internal Medicine*, 157: 348–366.

Tilman, D. & Clark, M. 2014. Global diets link environmental sustainability and human health. *Nature*, 515: 518–522.

Tuomisto, H.L., Hodge, I.D., Riordan, P. & Macdonald, D.W. 2012. Does organic farming reduce environmental impacts? A meta-analysis of European research. *Journal Environmental Management*, 112: 309–320.

United Nations. 2013. *World population prospects: the 2012 revision, key findings and advance tables*. Working Paper No. ESA/P/WP. 227. Department of Economic and Social Affairs, Population Division, New York, USA.

Vermeulen, S.J., Campbell, B.M. & Ingram, J.S.I. 2012. Climate change and food systems. *Review of Environment and Resources*, 37: 195–222.

Willer, H. & Lernoud, J., eds. 2014. *The world of organic agriculture. Statistics and emerging trends 2014*. FiBL-IFOAM Report. Research Institute of Organic Agriculture (FiBL), Frick, and International Federation of Organic Agriculture Movements (IFOAM), Bonn. Revised version of 24 February 2014.

From vision to metrics: lessons from the organic food system

Johannes Kahl
University of Kassel, Witzenhausen, Germany

ABSTRACT

Organic agriculture and food production represents a food system that consists of a vision as well as metrics laid down in international standards and regulations. The organic food system has been practised for over a 100 years and covers environmental aspects, animal welfare standards and food quality as well as health issues. After development in central Europe, organic agriculture was also implemented in nearly all regions throughout the world. In Europe, the organic logo is well recognized by the European consumer and associated with a sustainable and healthy food system. The organic food market has been growing fast worldwide for a decade. In Europe, mainly the Mediterranean countries represent the region with the highest shares of organic agricultural land. Several scientific studies show positive effects on environment, animal welfare, social aspects and food quality. There is a clear connection between regulation at farm and industry level and the impact on the environment and food. Compared with other food systems, organic agriculture and food production are not only described on the levels of vision, criteria and metrics but also successfully certified according to these different levels. Therefore the organic food system provides a testing model for sustainable food systems and may essentially contribute to establishing sustainable diets within sustainable food systems.

INTRODUCTION

Food consumption tends towards a westernization of diets on both a global and regional scale with the characteristic of rapid transitions in many different aspects (Kearny, 2010). This has a tremendous impact on the environment, society and individual human health (Tilman and Clark, 2014). The crucial role of the consumer in this development has been identified by Kearny (2010). This leads to integration of food consumption as well as dietary patterns as being essential parts of sustainable food systems. A sustainable food system consists of and links, as an invisible, to overall agriculture and health (Kearny, 2010). Guyomard *et al.* (2012) connected eating patterns to sustainable food systems. They suggested assessing diets from at least two different dimensions: impacts on health (nutrition) and environment. In order to develop, define and verify healthy and sustainable diets, they proposed a holistic approach. Global diets link environmental sustainability and human health, giving the diet a crucial role in solving global environmental and public health problems (Tilman and Clark, 2014). Recently, UNEP and FAO developed the Sustainable Food Systems Programme (SFSP), which "is foreseen as a significant opportunity to contribute to accelerating the shift to sustainable consumption and production" globally. The Agri-Food Task Force identified several "underlying challenges" that need further work. The programme presented here as the development of an organic diet will contribute to the SFSP in the following challenges by:

- providing a best practice example with the organic food system;
- delivering tools, information and knowledge for establishing sustainable food systems from the organic perspective;
- contributing to the understanding of what constitutes a sustainable food system based on the key issues from the organic food system example;
- supporting data, methodology and standards for developing, improving and testing sustainable food systems taking organic as a best practice example.

As the organic food system has been practised for decades on a global scale, it may contribute to these identified challenges.

THE ORGANIC FOOD SYSTEM

Organic agriculture and food production represent a food system that consists of a vision as well as metrics documented through international standards and regulations. The organic food system has been practised for over a 100 years and covers environmental aspects, animal welfare standards and food quality as well as health issues. After development in central Europe, organic agriculture was also implemented in nearly all regions throughout the world. The system is described in Codex Alimentarius (FAO/WHO, 1999), the vision is laid down in international standards (IFOAM, 2008) and it is defined on the level of metrics in regulations in Europe (EC, 2007, 2008) and also in several countries such as Canada, Japan, Switzerland and the United States of America. In addition, organic agriculture and food production are regulated through several private standards. The organic certification system is accomplished by food authentication tools (Capuano *et al.*, 2013). In Europe, organic is well recognized by the European consumer and associated with a sustainable and healthy food system (e.g. Janssen and Hamm, 2012; Torjusen *et al.,* 2004, 2012; Padel and Foster, 2005). For many years data on organic agriculture such as land use and market turnover have been available globally for many different countries (e.g. Willer and Lernoud, 2014). Several studies show the impact of the organic system on environment, society, nutrition and health. Organic farming is taken as a best practice example for sustainable agriculture (Bellon and Penvern, 2014). It has been shown that organic agriculture contributes to lowering the environmental impacts of modern agriculture (e.g. Gattinger *et al.*, 2012; Tuomisto *et al.,* 2012; Seufert, Ramankutty and Foley, 2012; Scialabba and Muller-Lindenlauf, 2010; Mondelaers, Aertsens and Van Huylenbroeck, 2009; Halberg, Alroe and Kristensen, 2006; Bengtsson, Ahnström and Weibull, 2005; Mäder *et al.*, 2002) as well as enhancing nutrition and health related food qualities (e.g. Baranski *et al*., 2014; Palupi *et al.*, 2012; Huber *et al*., 2011a; Smith-Spangler *et al.*, 2011; Brandt *et al.*, 2011). Moreover, study results indicate that organic consumption patterns seem to be connected to sustainable and healthy diets (Kesse-Guyot *et al*., 2013; Hoffman and Spiller 2010). Recently, the organic food system is described from the perspective of the food quality (Kahl *et al*., 2012, Kahl and Rembiałkowska, 2014) and also in addition organic food processing has been linked to the organic farming principles (Kahl *et al.*, 2014). As the market, especially in Europe, is growing very rapidly, actions are taken in order to sustain this development from an economic, political and scientific point of view (Padel *et al.,* 2010; Padel, Röcklinsberg and Schmid, 2009; Schmid *et al.,* 2009).

ORGANIC WITHIN SUSTAINABLE FOOD SYSTEMS AND SUSTAINABLE DIETS

Yet, the definition of what a sustainable food system as well as a sustainable diet is and how it can be verified, tested and set into practice is still not clear and first approaches are under debate. A first definition exists such as the FAO definition from 2010 (Burlingame and Dernini, 2011) as well as the documents within the FAO-UNEP Sustainable Food Systems Programme.[1] There is no doubt that those approaches have to be broken down from vision to metrics in order to support the consumer with future-oriented sustainable and healthy lifestyle pathways and in order to help social, economic and political decision processes. The crucial challenge is how to make such a definition operable (e.g. Dernini *et al.,* 2013). On the one hand, terms such as "system" are used to characterize a very complex issue; on the other hand, it seems to be a challenge to select and connect measureable parameters to the system. Examples of how this process can be managed are climate change topics as presented by Rockström *et al.* (2009) as well as dynamic health concepts (Huber *et al.*, 2011b). According to sustainable food system development challenges, organic may contribute as the process from vision to metrics has been successfully done already. Furthermore, organic connects not only a vision of alternative food production methods to metrics for testing

1 www.fao.org/ag/ags/sustainable-food-consumption-and-production/en/

and certification at local, regional and global levels but also has been and is continuously coming into practice. This is documented by the growing demand from the consumer side and the sustainable growing markets as well as the increase in total agricultural land under organic regime worldwide. In this context, organic may be used as a model system, bringing aspects such as health and sustainability together and setting up a system from vision to metrics. The requirements of the global market trade may interfere with small-scale farming and food processing as well as with a regional production and consumption of the food as is proposed for a sustainable food system (Gussow, 2006). There has to be a re-connection of organic food to these issues, which has already been taken up by, for example, the new European Action Plan for organic farming (EC, 2014). As the sustainable diet reflection has been using the Mediterranean diet as a model, as a case study, organic may contribute on the level of a best practice example as well as on the level of indicators. In Europe, mainly the Mediterranean countries represent the region with the highest shares of organic agricultural land. Several scientific studies show positive effects on the environment, animal welfare, social aspects and food quality. There is a clear connection between regulation at farm and industry level and the impact on the environment and food. In organic farming, for example, the use of mineral fertilizers, genetically modified organisms and synthetic pesticides is prohibited. The animal feeding regime and the input of nitrogen as well as processing additives are strictly regulated.

Compared with other food systems, organic agriculture and food production is not only described at the level of vision, criteria and metrics but also successfully certified according to these different levels. Therefore, the organic food system can provide the essential requirements of a sustainable diet.

CONCLUSIONS

Diets link sustainability and health at the local, regional and global levels. When the concept of a diet, such as a sustainable diet, is brought from vision to operable tools (e.g. criteria and indicators), model systems and in addition indicators connected to available and measurable parameters/data are necessary. Organic can contribute with several tools at local, regional and global scales. Here it has to be elaborated which indicators or parameters may be taken from organic agriculture and food consumption. Several study results and statistical data are available on organic food production and its (positive) impact on the environment and food quality. Moreover, results from epidemiological studies are indicating organic consumption patterns as being sustainable and healthy. Therefore, the organic food system may also be taken as a best practice example for sustainable food systems. In so doing, it has to be elaborated how far organic agriculture can be defined and tested as a global sustainable and healthy food system.

REFERENCES

Baranski, M., Srednicka-Tober, D., Volakakis, N., Seal, C., Sanderson, R., Stewart, G.B., Benbrook, C., Biavati, B., Markellou, E., Giotis, C, Gromadzka-Ostrowska, J., Rembiałkowska, E., Skwarło-Sonta, K., Tahvonen, R., Janovská, D., Niggli, U., Nicot, P. & Leifert, C. 2014. Higher antioxidant and lower cadmium concentrations and lower incidence of pesticide residues in organically grown crops: a systematic literature review and meta-analyses. *Br. J. Nutr.*, 112(5): 794–811.

Bellon, S. & Penvern, S., eds. 2014. *Organic farming, prototype for sustainable agriculture*. Dordrecht, Springer Science+Business Media.

Bengtsson, J., Ahnström, J. & Weibull, A.C. 2005. The effects of organic agriculture on biodiversity and abundance: a meta-analysis. *Journal of Applied Ecology*, 42: 261–269.

Brandt, K., Leifert, C., Sanderson, R. & Seal, J.C. 2011. Agroecosystem management and nutritional quality of plant foods: the case of organic fruits and vegetables. *Critical Reviews in Plant Sciences*, 30: 177–197.

Burlingame, B. & Dernini, S. 2011. Sustainble diets: the Mediterranean diet as an example. *Public Health Nutrition*, 12: 2285–2287.

Capuano, E., Boerrigte-Eenling, R., Veer, G. & Ruth, S.M. 2013. Analytical authentication of organic products: an overview of markers. *Journal of the Science of Food and Agriculture*, 93(1): 12–28.

Dernini, S., Meybeck, A., Burlingame, B., Gitz, V., Lacirignola, C., Debs, P., Capone, R. & El Bilali, H. 2013. Developing a methodological approach for assessing the sustainability of diets: the Mediterranean diet as a case study. *New Medit. N.*, 3: 28–36.

EC. 2007. Council Regulation (EC) No 834/2007 on organic production and labelling of organic products and repealing Regulation (EEC) No 2092/91. *Official Journal of the European Union*, L 189: 1–23.

EC. 2008. Commission Regulation (EC) No 889/2008 of 5 September 2008, laying down detailed rules for the implementation of the organic regulation on organic production and labelling of organic products with regard to organic production, labelling and control. *Official Journal of the European Union*, L 250: 1–84.

EC. 2014 Action Plan for the future of organic production in the European Union (available at http://ec.europa.eu/agriculture/organic/documents/eu-policy/european-action-plan/act_en.pdf).

FAO/WHO. 1999. *Codex Alimentarius. Guidelines for the production, processing, labelling and marketing of organically produced foods. GL 32-1999*. Adopted 1999. Revisions 2001, 2003, 2004 and 2007. Amendments 2008, 2009 and 2010 (2001, rev. 2010). Rome, FAO, and Geneva, Switzerland, WHO.

Gattinger, A., Muller, A., Haeni, M., Skinner, C., Fliessbach, A., Buchmann, N., Mäder, P., Stolze, M., Smith, P. & Scialabba, N.E.-H. 2012. Enhanced top soil carbon stocks under organic farming. *Proceedings of the National Academy of Sciences*, 109(44): 18226–18231.

Gussow, J.D. 2006. Reflections on nutritional health and the environment: The journey to sustainability. *Journal of Hunger & Environmental Nutrition*, 1: 3–25.

Guyomard, H., Darcy-Vrillon, B., Esnouf, C., Marin M., Russel, M. & Guillo, M. 2012. Eating patterns and food systems: critical knowledge requirements for policy design and implementation. *Agriculture & Food Security*, 1: 1–21.

Halberg, N., Alroe, H.F. & Kristensen, E.S. 2006. Synthesis: prospects for organic agriculture in a global context. In N. Halberg, H. Alroe, K. Fjelsted, M. Trydeman & E.S. Kristensen, eds. *Global development of organic agriculture: challenges and prospects*, pp. 343–367. Wallingford, UK, CABI Publishing.

Hoffmann, I. & Spiller, A. 2010. *Auswertung der Daten der Nationalen Verzehrsstudie II (NVS II): Eine integrierte verhaltens- und lebensstilbasierte Analyse des Bio-Konsums* (available at http://orgprints.org/18055/).

Huber, M., Rembiałkowska, E., Srednicka, D., Bügel, S. & van de Vilver, L.P.L. 2011a. Organic food and impact on human health: assessing the status quo and prospects of research. *NJAS – Wageningen Journal of Life Sciences*, 58: 103–109.

Huber, M., Knottnerus, J.A., Green, L., van der Horst, H., Jadad, A.R. & Kromhout, D. 2011b. How should we define health? *Brit. Med. J.*, 343. doi 10.1136/bmj.d4163.

IFOAM (International Federation of Organic Agriculture Movements). 2008. *Basic standards*. Bonn.

Janssen, M. & Hamm, U. 2012. The mandatory EU logo for organic food: consumer perceptions. *British Food Journal*, 114: 335–362.

Kahl, J. & Rembiałkowska, E. 2014. Research on organic food quality needs a system approach. *J. Sci. Food Agric.,* 94: 2577.

Kahl, J., Baars, T., Bügel, S., Busscher, N., Huber, M., Kusche, D., Rembiałkowska, E., Schmid, O., Seidel, K., Taupier-Letage, B., Velimirov, A. & Załecka, A. 2012. Organic food quality: a framework for concept, definition and evaluation from the European perspective. *J. Sci. Food Agric.*, 92: 2760–2765.

Kahl, J., Alborzi, F., Beck, A., Bügel, S., Busscher, N., Geier, U., Matt, D., Meischner, T., Paoletti, F., Pehme, S., Ploeger, A., Rembiałkowska, E., Schmid, O., Strassner, C., Taupier-Letage, B. & Załecka, A. 2014. Organic food processing: a framework for concept, starting definitions and evaluation. *J. Sci. Food Agric.*, 94: 2582–2594.

Kearny, J. 2010. Food consumption trends and drivers. *Phil. Trans. R. Soc. B.*, 365: 2793–2807.

Kesse-Guyot, E., Péneau, S., Méjean, C., Szabo de Edelenyi, F., Galan, P., Hercberg, S. & Lairon, D. 2013. Profiles of organic food consumers in a large sample of French adults: results from the Nutrinet-Santé cohort study. *PLoS ONE*, 8(10): e76998. doi:10.1371/journal.pone.0076998.

Mäder, P., Fliessbach, A., Dubois, D., Gunst, L., Fried, P. & Niggli, U. 2002. Soil fertility and biodiversity in organic farming. *Science*, 296: 1694–1697.

Mondelaers, K., Aertsens, J. & Van Huylenbroeck, G. 2009. A meta-analysis of the differences in environmental impacts between organic and conventional farming. *British Food Journal*, 111: 1098–1119.

Padel, S. & Foster, C. 2005. Exploring the gap between attitude and behaviour: understanding why consumers buy or do not buy organic food. *British Food Journal*, 107: 606–625.

Padel, S., Röcklinsberg, H. & Schmid, O. 2009. The implementation of organic principles and values in the European Regulation for organic food. *Food Policy*, 34: 245–251.

Padel, S., Niggli, U., Pearce, B., Schlüter, M., Schmid, O., Cuoco, E., Willer, E., Huber, M., Halberg, N. & Micheloni, C. 2010. *Implementation Action Plan for organic food and farming research*. TP Organics. Brussels, IFOAM- EU Group. 96 p. (available at www.tporganics.eu).

Palupi, E., Jayanegara, A., Ploeger, A. & Kahl, J. 2012. Comparison of nutritional quality between conventional and organic dairy products: a meta-analysis. *Journal Science Food Agriculture*, 92: 2774–2781.

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F.S., Lambin, E.F., Lenton, T.M., Scheffer, M., Folke, C., Schellnhuber, H.J., Nykvist, B., de Wit, C.A., Hughes, T., van der Leeuw, S., Rodhe, H., Sörlin, S., Snyder, P.K., Costanza, R., Svedin, U., Falkenmark, M., Karlberg, L., Corell, R.W., Fabry, V.J., Hansen, J., Walker, B., Liverman, D., Richardson, K., Crutzen, P. & Foley, J.A. 2009. A safe operating space for humanity. *Nature,* 461: 472–475.

Schmid, O., Padel, S., Halberg, N., Huber, M., Darnhofer, I., Micheloni, C., Koopmans C., Bügel, S., Stopes, C., Willer, H., Schlüter, M. & Cuoco, E. 2009. *Strategic Research Agenda for organic food and farming*. Technology Platform Organics. Brussels, IFOAM EU Group. 116 p. (available at www.tporganics.eu).

Scialabba, N. & Muller-Lindenlauf, M. 2010. Organic agriculture and climate change. *Renewable Agriculture and Food Systems*, 25: 158–169.

Seufert, V., Ramankutty N. & Foley, J.A. 2012. Comparing the yields of organic and conventional agriculture. *Nature*, 485: 229–232. doi:10.1038/nature11069.

Smith-Spangler, C., Brandeau, M.L., Hunter, G.E., Bavinger, J.C., Pearson, M., Eschbach, P.J., Sundaram, V., Liu, H., Schirmer, P., Stave, C., Olkin, I. & Bravata, D.M. 2012. Are organic foods safer or healthier than conventional alternatives? A systematic review. *Annals of Internal Medicine*, 157: 348–366.

Tilman, D. & Clark, M. 2014. Global diets link environmental sustainability and human health. *Nature*, 515: 518–522.

Torjusen, H., Kjaernes, U., Sangstad, U. & Doherty Jensen, K. 2004. *European consumers' conceptions or organic food: a review of available research*. Professional report. Oslo, National Institute for Consumer Research (SIFO).

Torjusen, H., Lieblein, G., Naes, T., Haugen, M., Meltzer, H.M. & Brantsaeter, A.L. 2012. Food patterns and dietary quality associated with organic food consumption during pregnancy; data from a large cohort of pregnant women in Norway. *BMC Public Health*, 12: 612–620.

Tuomisto, H.L., Hodge, I.D., Riordan, P. & Macdonald, D.W. 2012. Does organic farming reduce environmental impacts? A meta-analysis of European research. *Journal Environmental Management*, 112: 309–320.

Willer, H. & Lernoud, J., eds. 2014. *The world of organic agriculture. Statistics and emerging trends 2014*. FiBL-IFOAM Report. Frick, Research Institute of Organic Agriculture (FiBL), and Bonn, International Federation of Organic Agriculture Movements (IFOAM).

The organic food system in Europe

Ewa Rembiałkowska
Warsaw University of Life Sciences, Chair of Organic Food, Poland

ABSTRACT

The aim is to present the cultural, historic and legal aspects of organic food production, as well as certification and European Union (EU) regulation metrics. The methods of the investigation comprise analysing the older and newer literature sources and legal regulations; the own experience of the author was also taken into consideration. The results indicate that the organic food system in Europe is relatively young, about 90 years, but developing very quickly. The beginning of organic food production in Europe was based on the biodynamic concept – a spiritual and holistic approach to agriculture. Such an approach has evolved over the last decades into a much more concrete one. The legal current regulations 834/2007 and 889/2008 are quite strict and provide good conditions to produce food with higher nutritional value. The best example is a ban on the use of artificial food additives in organic food processing. However, not all production aspects are clearly indicated in the current regulations. Moreover, the final quality result depends on the knowledge and ecological awareness of the producers and traders in the organic food chain. Therefore the quality of the organic crops/products is diversified and falters between low, moderate, good and excellent, depending on the particular practices in every farm/enterprise.

The analysis of the present situation reveals several important problems in organic food production: (i) how to keep the old basic standards and ideas in the current and future development of the organic food production; (ii) how to increase the knowledge and awareness of the producers including good agricultural practices; and (iii) how to organize a not too loose and not too severe control and certification system, providing smooth functioning of the producers and simultaneously best quality of the organic products.

ORIGINS OF ORGANIC FARMING

The idea of "organic farming" as it is known today is a mix of different concepts created mainly in German-speaking and English-speaking countries. Between the two world wars technically advanced farming, using many synthetic chemical compounds, faced a crisis because of soil degradation, poor food quality and the aggravation of rural social life and traditions. Organic farming pioneers offered a new science-based concept during the 1920s and 1930s; this idea convinced many people and became a growing movement during the 1930s and 1940s. The main problems faced during this period in agriculture were inappropriate use of mineral fertilizers, acidification of soils, drought problems, and reduction in fertility and yields. As a result, the severe economic problems brought about the decay of rural tradition and rural lifestyle (Vogt, 2007).

PHILOSOPHICAL BACKGROUND OF ORGANIC FARMING

As an alternative to intensive agriculture, another system was proposed – a food system that raised incomes and increased food security and food safety at both ends. In this system, the environment should be preserved and farmers and workers should have fair access to the means of food production. The philosophy of agriculture being as much in harmony with nature as possible was in favour (Sligh and Cierpka, 2007).

HISTORY IN GERMAN-SPEAKING COUNTRIES

There were two main directions of organic farming in the German-speaking world in the early twentieth century: life reform and food reform movements and anthroposophic biodynamic agriculture. The first movement was focused on the change of eating habits; it was a contrary

Table 1: Organic and biodynamic agriculture – similarities and differences

Similarities	Differences
All basic rules are the same in organic and biodynamic agriculture!	Biodynamic farming applies some measures typical entirely for this kind of farming: • Steiner's anthropophilosophical background • biodynamic preparations (500–508) • astral calendar

trend to food production based on industrial processing, high-meat diets rich in fats and protein but poor in fibre. The medical doctors observed that such "modern" nutrition caused overweight, indigestion, circulation disorders, diabetes and caries. Food reform proposed a vegetarian or low-meat diet with little or no industrial food processing (Baumgartner, 1992).

Anthroposophic biodynamic agriculture was created by the Austrian philosopher **Rudolf Steiner (1861–1925)**, who was also a naturalist, teacher, architect, painter and researcher of the spiritual side of reality (Vogt, 2007). Steiner delivered a series of eight lectures on agriculture in 1924 at Kobierzyce near Wrocław (Silesia) that became the foundation of the worldwide movement of biodynamic agriculture. An audience of about 60 people, mainly farmers and landowners, listened to eight lectures entitled "Spiritual foundation for the renewal of agriculture" (Steiner, 1985). The listeners started to introduce anthroposophic ideas and principles in their own farms and to teach others; quite quickly biodynamic agriculture became widespread in Europe, especially in German-speaking countries.

Rudolf Steiner had several successors. One the most important was **Ehrenfried Pfeiffer (1899–1961)** who together with co-authors published several editions of *Bio-dynamic farming and gardening: soil fertility renewal and preservation* building on Steiner's concepts. In this book the soil, field and farm were viewed as living organisms. Pfeiffer stresses the importance of soil biological processes in the formation and maintenance of humus and soil functions in general, especially with respect to earthworms and soil micro-organisms (Pfeiffer, 1943; Stinner, 2007).

Organic farming practice was developed in Switzerland by naturalist **Hans Müller (1891–1988)** and his wife **Marie Müller (1899–1969)** into organic-biological agriculture. It was done not for philosophical reasons, but social ones – as a protest against poverty among farmers, dependent on industrial fertilizers. The third key person of organic-biological agriculture was the German doctor and microbiologist **Hans Peter Rusch (1906–1977)**. The main aim of this agriculture was to keep and increase soil fertility via soil organisms (Moser, 1994; Tyburski and Żakowska-Biemans, 2007).

ORGANIC FARMING IN THE ENGLISH-SPEAKING WORLD

In Great Britain the concept of organic farming was developed by Sir Albert Howard, Sir Robert McCarrison and Lady Evelyn Barbara Balfour. For these people the main issue was human health and food as the most important influencing factor. **Sir Albert Howard (1873–1947)** was an agricultural scientist, considered by many in the English-speaking world to be the father of organic farming. His main idea was that soil fertility was the precondition for healthy plants and animals (Stinner, 2007). Medical doctor **Robert McCarrison (1878–1960)** studied the health of the Hunza tribe living in India and discovered the meaning of nutrition for health (Vogt, 2007). Figure 1 presents the main idea of McCarrrison.

Lady Evelyn Barbara Balfour (1898–1990) published in 1948 one of the most important foundational books in English for the science of organic farming: *The living soil*. Inspired by the ideas of Howard and McCarrison, in the 1940s Eve Balfour founded the British organic farming organization "The Soil Association", which is still today the most important British association of organic farming stakeholders (Stinner, 2007). **Rachel Carson (1907–1964)** worked as a marine biologist with the United States Department for 17 years and wrote several best-sellers on sea life. In 1962 she published *Silent spring* – a book that sounded the alarm regarding the danger of unchecked use of chemicals (Carson, 1963). It became a cult book for all environmentalists in the United States of America and in Europe, causing a breakthrough in human mentality and increasing the understanding of interrelationships between environment, food and health (Sligh and Cierpka, 2007).

DEFINITIONS OF ORGANIC FARMING

There are many definitions of organic farming. Among them three are most popular and important. According to Council Regulation (EC) No 834/2007 of 28 June 2007 on organic production and labelling of organic products "… organic production is an overall system of farm management and food production that combines best environmental practices, a high level of biodiversity, the preservation of natural resources, the application of high animal welfare standards and a production method in line with the preference of certain consumers for products produced using natural substances and processes" (EC, 2007).

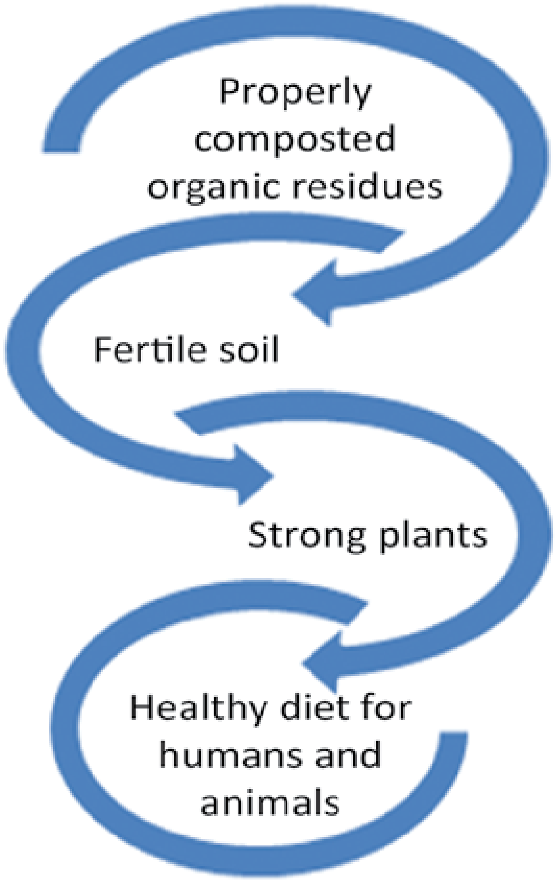


Figure 1: McCarrison's idea: "Wheel of health"
Source: Vogt (2007).

According to FAO/WHO Codex Alimentarius Commission (1999): "Organic agriculture is a holistic production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity. It emphasizes the use of management practices in preference to the use of off-farm inputs, taking into account that regional conditions require locally adapted systems. This is accomplished by using, where possible, agronomic, biological, and mechanical methods, as opposed to using synthetic materials, to fulfil any specific function within the system".[1]

Last but not least, the International Federation of Organic Agriculture Movements (IFOAM) definition is as follows: "Organic agriculture is a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved".[2]

ORGANIC MOVEMENT AND PRINCIPLES

The history of the organic movement has a clear and logical sequence. First came the philosophy and teachings, which were based on observation of nature and respect for natural laws. In turn, the organic pioneers transformed these principles into practical farming methods. Finally there emerged a worldwide organic movement (Geier, 2007).

IFOAM was founded in 1972 in Versailles. The five founding organizations were: Soil Association (United Kingdom), the Swedish Biodynamic Association (Sweden), the Soil Association of South Africa (South Africa), Rodale Press (United States of America) and Nature et Progrès (France).

[1] http://www.fao.org/organicag/oa-faq/oa-faq1/en/
[2] http://www.ifoam.org/fr/organic-landmarks/definition-organic-agriculture

In 1975 there were 50 member organizations, 100 in 1984, 500 in 1992 and close to 800 in 2014 in 118 countries.[3]

The basic principles of organic farming are holistic. Rather than looking at isolated parts, the whole farm as a living entity is the focus. It is seen as a whole, enmeshed in the intrinsic web of life and part of the interactions and relationships between all living beings.

In 2005, at the IFOAM General Assembly, the basic principles were approved:

- Principle of health (organic agriculture should sustain and enhance the health of soil, plant, animal, human and planet as one and indivisible).
- Principle of ecology (organic agriculture should be based on living ecological systems and cycles, work with them, emulate them and help sustain them).
- Principle of fairness (organic agriculture should build on relationships that ensure fairness with regard to the common environment and life opportunities).
- Principle of care (organic agriculture should be managed in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment (IFOAM principles of organic agriculture preamble).[4]

LEGAL ASPECTS

There are at present two basic legal regulations on organic farming and processing, applying in the EU: (i) Council Regulation (EC) No 834/2007 of 28 June 2007 on organic production and labelling of organic products and repealing Regulation (EEC) No. 2092/91 (EC, 2007); and (ii) Commission Regulation (EC) No 889/2008 of 5 September 2008 laying down detailed rules for the implementation of Council Regulation (EC) No 834/2007 on organic production and labelling of organic products with regard to organic production, labelling and control (EC, 2008). There are also National Acts in all EU countries, which are compatible with the mentioned EU Regulations.

These legal acts explain that organic food is produced according to certain legally regulated production standards. Production methods are environment friendly and maintain biodiversity and soil fertility. Social criteria are important (small farms, using local means of production, activation of the country areas). Organic agriculture excludes the use of synthetic fertilizers, pesticides and plant growth regulators. Only natural organic fertilizers (compost, manure), green manures and biological crop protection methods are allowed. Animal production excludes the use of antibiotics, hormones and genetically modified organisms. Food processing protects nutritional quality and excludes synthetic food additives (synthetic preservatives, synthetic colour additives, etc.).

CERTIFICATION

Control and certification in organic agriculture in the European Union can be described as three existing systems:

- System A: System of approved private inspection bodies
- System B: System of (a) designated public inspection authority(ies)
- System C: System of a designated public inspection authority and approved private inspection bodies (Jespersen, 2011)

Figures 2 and 3 illustrate the differences between the mentioned systems.

The quality and safety of organic food are affected by many factors among which are the key abiotic factors covering the quality of the environment (Figure 4, Table 2). Abiotic factors comprise the quality of air, soil, groundwater and surface waters; only if their quality is high can we expect safe and good emblements. Other biotic factors are plant cultivars and animal breeds used by farmers, moreover plant diseases and pests. Proper selection of plant cultivars and animal breeds has a huge impact on the quality of received raw materials. An effective fight against diseases and pests can also radically improve the quality of crops.

[3] http://www.ifoam.org/en/about-us-1

[4] http://www.ifoam.org/sites/default/files/ifoam_poa.pdf

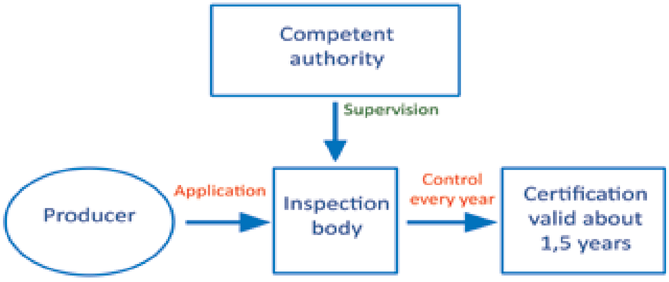


Figure 2: Control and certification (system A and C)

Figure 3: Control and certification (system B – governmental)

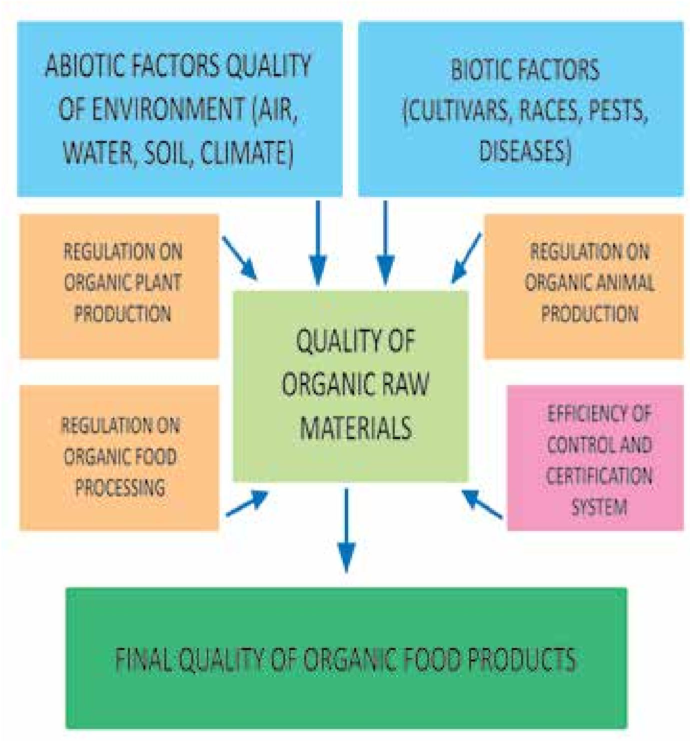


Figure 4: Factors influencing the quality of organic food products

Producers are required to use the rules of production laid down in the regulations on organic farming, mentioned above. If farmers are going to apply those principles consistently, the quality of the raw materials received will be high. This also applies to processing; in this case, the situation is completely different for the organic and conventional processors (Figure 5). Organic processing standards prohibit the use of chemicals, many synthetic preservatives, artificial colorings and sweeteners and other food additives, which are widely used in the processing of conventional foods (Beck, Kretzschmar and Schmid, 2006). Conventional food processing allows 623 different types of food additives while organic processing allows only 52 different additives and they are mostly natural substances (EC, 2008). It is important to understand that many chemicals used in food processing can be harmful to human health (Matt *et al.*, 2011).

Another important factor is the efficiency of the control and certification system, which guarantees compliance of the production process with demands determined in the relevant legal regulations. It is necessary to provide a strict, honest and leak-proof system in order to avoid fraud, which in every case is drastically diminishing the trust of the consumers and – as a result – the sale of organic products.

To summarize – if all mentioned conditions are fulfilled (proper abiotic and biotic factors, accordance of the production procedures with the legal regulations and strict, transparent control + certification system) – we can expect high-quality emblements and food products.

Table 2: Factors influencing the quality of organic food products

Factors influencing the quality of organic raw materials	Factors influencing the final quality of organic food products
Abiotic factors, quality of environment (air, water, soil, climate)	Quality of organic raw materials
Biotic factors (cultivars, races, pests, diseases)	Regulation on organic food processing
Regulation on organic plant production	Efficiency of control and certification system
Regulation on organic animal production	
Efficiency of control and certification system	

However, even of the above conditions are fulfilled, do we always have the best quality of organically produced crops? Analysing the research papers dealing with food quality we have to answer no. The nutritional and sensory properties of the organic food may not be as high as we could expect. Here we come to the organic farming methodology, farmers' skills and personalities. First of all, the legal regulations give only the main principles and directions of the farming practices, but do not give any precise recommendations on how to proceed in every type of farm and in every climate. Fertilization, crop protection, animal feeding and all other practices can be different depending on many factors and they all can be considered as organic. One of the typical examples is composting, where the individual approach and farmer's decisions strongly influence the composition and quality of compost. Figure 6 illustrates this problem – if the practices are similar in the organic and conventional system, we cannot expect any real quality differences. Another related issue is the individual ability of the farmer. Farming is a kind of art, and not everyone is capable at the same level – this issue is presented in Figure 7. If the farmers put a lot of care and good individual solutions into their work, the quality result is there. For example, if the composting process is not completely finished, the yield and quality of vegetables will not be the highest.

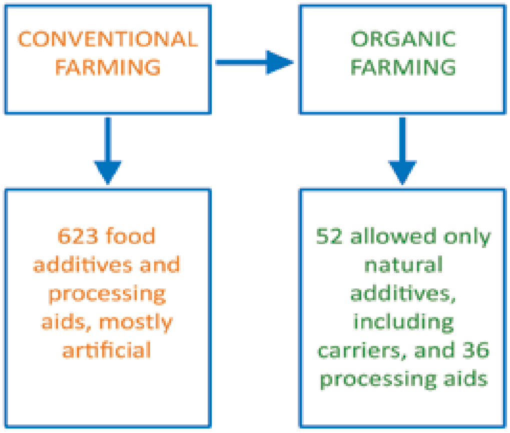


Figure 5: Food processing

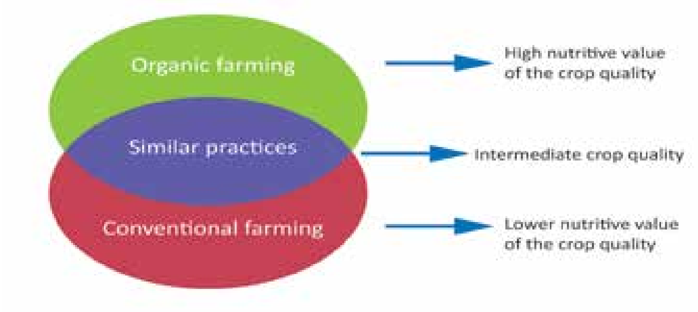


Figure 6: Type of farming

Figure 7: Art of farming

GROWING SECTOR

Organic food production is one of the fastest growing sectors with an increase of approximately 170 percent since 2002 (Willer, Lernoud and Home, 2013). The global organic food market reached a value of USD62.9 billion in 2011; 47 percent of the global market was in Europe, with increasing sales also in the United States of America and Canada. In Europe, the majority of the sales occur in the large economies

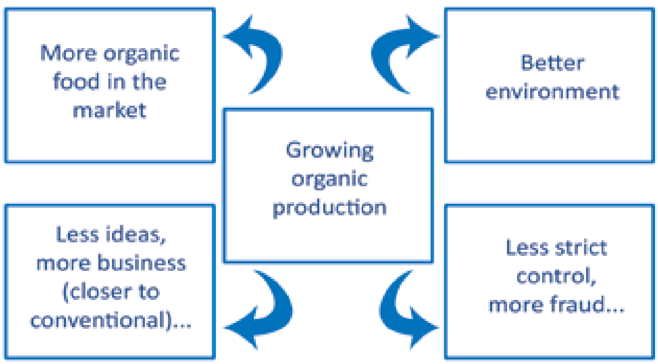


Figure 8: Growth is good, but...

(mainly Germany, France, the United Kingdom and Italy). However, there are positives and negatives of this situation (see Figure 8).

PROBLEMS TO SOLVE – SUMMARY

When trying to summarize, it should be stated that the organic sector has developed very quickly during the last ten years, and has started to lose its status of a niche market in some countries. This is generally very positive; however it has created some problems to be solved in the near future:

- how to keep the old basic standards and ideas in the current and future development of organic food production;
- how to increase the knowledge and awareness of the producers including good agricultural practices;
- how to organize the proper control and certification systems, providing smooth functioning of the producers and simultaneously best quality of the organic products.

REFERENCES

Baumgartner, J. 1992. *Ernährungsreform: Antwort auf Industrialisierung und Ernährungswandel: Ernährungsreform als Teil der Lebensreformbewegung am Beipiel der Siedlung und des Unternehmens Eden seit 1893.* Frankfurt am Main, P.Lang.

Beck, A., Kretzschmar, U. & Schmid, O. 2006. *Organic food processing – principles, concepts and recommendations for the future*. Frick, Switzerland, Research Institute of Organic Agriculture (FiBL).

Carson, R. 1963. *Silent spring*. London, Hamish Hamilton.

EC. 2007. Council Regulation (EC) No 834/2007 on organic production and labelling of organic products and repealing Regulation (EEC) No 2092/91. *Official Journal of the European Union*, L 189: 1–23.

EC. 2008. Commission Regulation (EC) No 889/2008 of 5 September 2008, laying down detailed rules for the implementation of the organic regulation on organic production and labelling of organic products with regard to organic production, labelling and control. *Official Journal of the European Union*, L 250: 1–84.

Geier, B. 2007. IFOAM and the history of the international organic movement. *In* W. Lockeretz, ed. *Organic farming: an international history*, pp. 175–186. Wallingford, UK, CABI. ISBN: 978-0-85199-833-6.

Jespersen, L.M. 2011. Organic certification in selected European countries: control fees and size of the sector (available at http://orgprints.org/18440/4/18440.pdf).

Matt, D., Rembiałkowska, E., Luik, A., Peetsmann, E. & Pehme, S. 2011. Quality of organic vs. conventional food and effects on health. Estonian University of Life Sciences, Tartu, Estonia. ISBN 978-9949-484-06-5 (available at http://orgprints.org/19504/1/Report_2011_(1).pdf).

Moser, P. 1994. *Der Stand der Bauern: Bäuerliche Politik, Wirtschaft und Kultur Gestern Und Heute*. Frauenfeld, Huber Verlag. 424 p.

Pfeiffer, E. 1943. *Bio-dynamic farming and gardening; soil fertility, renewal and preservation*, 3rd ed. Translated by F. Heckel. New York, USA, Antroposophic Press.

Sligh, M. & Cierpka, T. 2007. Organic values. *In* W. Lockeretz, ed. *Organic farming: an international history*, pp. 30–39. Wallingford, UK, CABI. ISBN: 978-0-85199-833-6.

Steiner, R. 1985. *Geisteswissenschaftliche Grundlagen zum Gedeihen der Landwirschaft*. Dornach, Switzerland, Rudolf Steiner Verlag.

Stinner, D.H. 2007. The science of organic farming. *In* W. Lockeretz, ed. *Organic farming: an international history*, pp. 40–72. Wallingford, UK, CABI. ISBN: 978-0-85199-833-6.

Tyburski, J. & Żakowska-Biemans, S. 2007. *Wprowadzenie do rolnictwa ekologicznego*. Wydawnictwo SGGW. ISBN: 978-83-7244-874-3. 275 p.

Vogt, G. 2007. The origins of organic farming. *In* W. Lockeretz, ed. *Organic farming: an international history*, pp. 9–29. Wallingford, UK, CABI. ISBN: 978-0-85199-833-6.

Willer, H., Lernoud, J. & Home, R. 2013. *The world of organic agriculture*. Frick, Switzerland, FiBL, and Bonn, Germany, IFOAM.

How the organic food system contributes to sustainability

Christian Schader, Matthias Stolze and Urs Niggli
Research Institute of Organic Agriculture, Frick, Switzerland

ABSTRACT

Despite many agricultural systems and most food companies claiming to be sustainable, recent studies show that the planetary boundaries have been exceeded mainly by food production and consumption. Against the background of a looming 9.6 billion people in 2050, many scientists argue for a further intensification of agricultural systems.

Organic food systems may offer an alternative approach towards sustainability. Many studies on organic agriculture suggest that organic practices are less harmful for the environment, may foster social well-being and may lead to economic resilience. Others argue that organic systems yield on average about 20 percent less than comparable conventional systems. On the bottom line, this may even lead to higher environmental impacts, land use and pressure on natural ecosystems and put global food availability at risk.

This paper aims at providing an overview of the contribution of organic food systems to sustainability distinguishing between different levels. Using (i) the SAFA Guidelines and (ii) the three sustainability strategies of efficiency, consistency and sufficiency as a framework, we assess how organic food systems can contribute to sustainability.

We distinguish between the operator level, the product level and the spatial/policy level. We show that the operator level (i) focuses on consistency and allows covering the widest range of sustainability themes. At the product-related level (ii), only specific environmental themes can be covered and the efficiency is the central issue addressed by the studies. The spatial/policy level (iii) addresses all three sustainability strategies, as food security and systemic changes such as dietary patterns and food waste are considered, but is often too general for looking at many social themes of sustainability.

Results show that organic food systems perform well with respect to environmental performance at the operator and spatial/policy level, while results at the product level are more heterogeneous, as yields are often lower. Differences between organic and conventional systems vary between different regions and product types. The economic performance can be judged at operators' level, which reveals context-specific differences in profitability, depending on product type and regional context. However, apart from profitability, organic food systems may provide further benefits in terms of economic resilience due to the cradle-to-cradle principle. At the spatial/policy level, food availability and food security play important roles. Global studies show how organic food systems can provide sufficient food if demand patterns change towards less resource-consuming products. The social dimension is very context-specific and cannot be judged in general.

We conclude that organic production impacts the entire food system and that organic agriculture can contribute to the efficiency, consistency and sufficiency strategies. Yet, innovation and further development of the organic system is indispensable for addressing future challenges.

INTRODUCTION

Despite agriculture's and most food companies' claim of being sustainable, recent studies show that the planetary boundaries have been exceeded mainly by food production and consumption (Rockström *et al.*, 2009). Furthermore, social well-being and the economic resilience of the farming sector are at stake in many countries. Against the background of a looming 9.6 billion people in 2050, many scientists argue for a further intensification of agricultural systems (Godfray and Garnett, 2014; Tilman *et al.*, 2011).

In order to address these challenges, efficiency, consistency and sufficiency can be distinguished as three fundamentally different strategies (Schaltegger, Burritt and Petersen, 2003). The efficiency strategy tries to optimize the relationship between the negative impacts of a system and the outputs that a system generates. The consistency strategy tries to bring production systems closer to natural systems or sustainability principles. Finally, the sufficiency strategy addresses the consumption side by reducing negative impacts on resources.

Organic food systems may offer an alternative approach towards sustainability. Many studies on organic agriculture suggest that organic practices are less harmful for the environment, may foster social well-being and may lead to economic resilience (Schader, Stolze and Gattinger, 2012). Others argue that organic systems yield on average about 20 percent less than comparable conventional systems (Seufert, Ramankutty and Foley, 2012). On the bottom line, this may even lead to higher environmental impacts, land use and pressure on natural ecosystems and put global food availability at risk (Tuomisto *et al.,* 2012).

This paper aims at providing an overview of the contribution of organic food systems to sustainability distinguishing between product, operator and spatial/policy level. Using (i) the SAFA Guidelines and (ii) the three sustainability strategies of efficiency, consistency and sufficiency (Schaltegger, Burritt and Petersen, 2003) as a framework, we assess how organic food systems can contribute to sustainability.

DIFFERENT LEVELS FOR SUSTAINABILITY ASSESSMENTS

With the increasing importance of the notion of sustainability in the discussion of future food systems, different interpretations have caused confusion among food producers, consumers and even scientists (FAO, 2013; Godfray and Garnett, 2014; McDonald and Oates, 2006). This confusion may largely be associated with differences in the scope and perspective of the assessments (Schader *et al.,* 2014a). Especially with respect to evaluating complex systems such as organic food systems, which impact both production and consumption, methodological differences in the assessment lead to different and seemingly contradicting results (Meier *et al.,* 2015; Schader, Stolze and Gattinger, 2012).

Recent efforts to generically define sustainability (FAO, 2013) and classify sustainability assessment approaches (Schader *et al.,* 2014a) aim at decreasing this confusion and clarifying the differences between the most common approaches and tools for assessing sustainability. In this paper, we distinguish between the operator, the product and the spatial/policy level.

The **operator level** looks at the sustainability performance of a company or a farm using indicator sets. The SAFA Guidelines (FAO, 2013) offer a globally applicable framework for a comprehensive view on sustainability, covering four dimensions (good governance, environmental integrity, economic resilience and social well-being) with 58 (sub)themes (Table 1). According to the SAFA Guidelines, sustainability assessments should not merely include the place where the operator is located but also consider other companies or farms that are influenced by its decisions. For instance, a dairy company can have a strong influence on its suppliers and how they produce. So, those dairy farms can be taken into account for an operator-level sustainability assessment, especially because a large fraction of the environmental and social impacts can be associated with the agricultural production processes (Bystricky *et al.,* 2014).

We show that the operator level allows covering the full range of sustainability themes. However, assessments at this level primarily look at the consistency of the companies with sustainability principles. Efficiency can only be assessed if product-related assessments are included. The sufficiency strategy is not covered within the framework of the SAFA Guidelines.

The dominant approach for conducting **product-level assessments** is life cycle assessment (LCA) (Finkbeiner *et al.,* 2010). LCAs relate environmental impacts of a production system to the so-called functional unit, which is mostly the provision of defined amount of a specific kind of food (ISO, 2006a, 2006b). There are a number of environmental impact categories such as global warming potential, eutrophication and acidification covered by the usual LCAs but impacts on

Table 1: Comparison of product, operator and spatial/policy level sustainability assessments

Level	Approaches	Tools	Coverage of topics	Efficiency	Consistency	Sufficiency
Operator level	Indicator based approaches, life cycle assessment	e.g. SMART, RISE	all dimensions	(yes)	yes	no
Product level	Attributional life cycle assessment	e.g. Sima Pro, GABI	selected environmental topics	yes	(yes)	no
Spatial / policy level	Economic modelling, consequential LCAs	e.g. SOL-m, FARMIS, CAPRI	Predominantly environmental and economic dimensions	yes	yes	yes

Source: based on Schader *et al*. (2014a).

biodiversity and soil fertility, for instance, are difficult to relate to a product-related functional unit (de Baan, Alkemade and Koellner, 2013; Jeanneret *et al.,* 2008; Milà i Canals *et al.,* 2006). However, when comparing organic and conventional food systems, these themes are important for differentiation between the systems. Furthermore, concepts for evaluating social and economic impacts within an LCA framework are still at their infancy (Finkbeiner *et al.,* 2010).

With respect to the three main sustainability strategies (efficiency, consistency and sufficiency), a product-level assessment predominantly addresses efficiency. Only selected aspects of consistency can be taken into account. The sufficiency strategy would mean dismissing the concept of a common functional unit but looking at different functional units or defining a more general functional unit.

With **spatial-/policy-level assessments**, not a single operator or product is assessed, but all operators within a geographical region or the impacts of a policy on all operators affected by it. For instance, if a conversion to organic farming is analysed at spatial/policy level, it is not sufficient to look at single products or at single farms. However, apart from the general view on a region, this level of assessment also allows looking at specific products or farm types more closely.

At a spatial/policy level all environmental and economic issues can be addressed. Social issues are often context-specific and therefore hardly generalizable, except some general considerations that result from changes in product prices and input (e.g. labour) demand. Contrary to the other two levels, the spatial/policy level allows the consideration of sufficiency aspects besides issues of consistency and efficiency, as nutrition patterns can be examined and economic considerations of changing demand and supply patterns can be integrated in the analysis.

SUSTAINABILITY PERFORMANCE OF ORGANIC FOOD SYSTEMS AT DIFFERENT LEVELS

The above description of different levels of sustainability reveals that often fundamentally different aspects are considered and different perspectives are taken in a sustainability assessment. Moreover, as differences between organic and conventional systems vary between regions and product types, general statements on the sustainability performance of organic agriculture need to be made with particular care. We therefore present an overview of studies from the different levels illustrating the sustainability performance of organic agriculture.

Operator level

From an operator level, environmental assessments reveal that organic farming performs better, i.e. has less environmental impacts, with respect to biodiversity and landscape, resource depletion, climate change, ground and surface water pollution, air quality and soil fertility. However, Table 1 shows a wide variation between the studies.

With respect to subsequent supply chain stages (transport, processing and retailing), no general statements can be made as the performance of organics is largely related to the specific operator or supply chain.

The economic performance of organic agriculture is often understood in different ways and no uniform assessment method has been established so far. For instance, the economic performance

Organic agriculture is	Much better	Better	Equal	Worse	Much worse
Biodiversity and landscape		●			
Genetic diversity			●		
Floral diversity		●			
Faunal diversity		●			
Habitat diversity		●			
Landscape			●		
Resource depletion		●			
Nutrient resources		●			
Energy resources		●			
Water resources			●		
Climate change		●			
CO_2		●			
N_2O			●		
CH_4			●		
Ground and surface water pollution		●			
Nitrate leaching		●			
Phosphorous runoff		●			
Pesticide emissions	●				
Air quality		●			
NH_3		●			
Pesticides	●				
Soil fertility		●			
Organic matter		●			
Biological activity	●				
Soil structure			●		
Soil erosion		●			

Figure 1: Relative environmental performance of organic farming at operator level
Source: based on Schader, Stolze and Gattinger (2012).

could be interpreted from an operator's goal to have a profitable and economically resilient business, but also from a societal perspective in the sense of what the operator contributes to societal goals (Schader *et al.*, 2014a). However, since the latter perspective would include the social and environmental impacts monetized, we concentrate on the first perspective here. The economic performance from an operator's perspective thus comes down to the question whether the yield gap (Seufert, Ramankutty and Foley, 2012) and the higher costs for labour compared with conventional farming can be compensated by the sum of (a) price premiums, (b) savings from purchasing less physical inputs and (c) policy payments, e.g. agri-environmental schemes in Europe (Schader, 2009). Also here, it depends very much on the farm type and regional context that one is looking at, but many cases have been reported where organic farming is competitive or even outperforming conventional counterparts (Nemes, 2009). Nevertheless, the slow uptake of organic farming practices indicates no substantial improvement of profitability in most regions of the world. However, it should be stressed that sound datasets to judge profitability are missing for many countries.

But economic resilience is not only a question of profitability. Issues such as the long-term stability of production, supply and markets are also affecting the economic resilience (FAO, 2013). Here, organic farming seems to have advantages compared with conventional farming, as it is less reliant on external inputs and has a stronger ability to conserve natural resources, e.g. soil (Gattinger *et al.*, 2012).

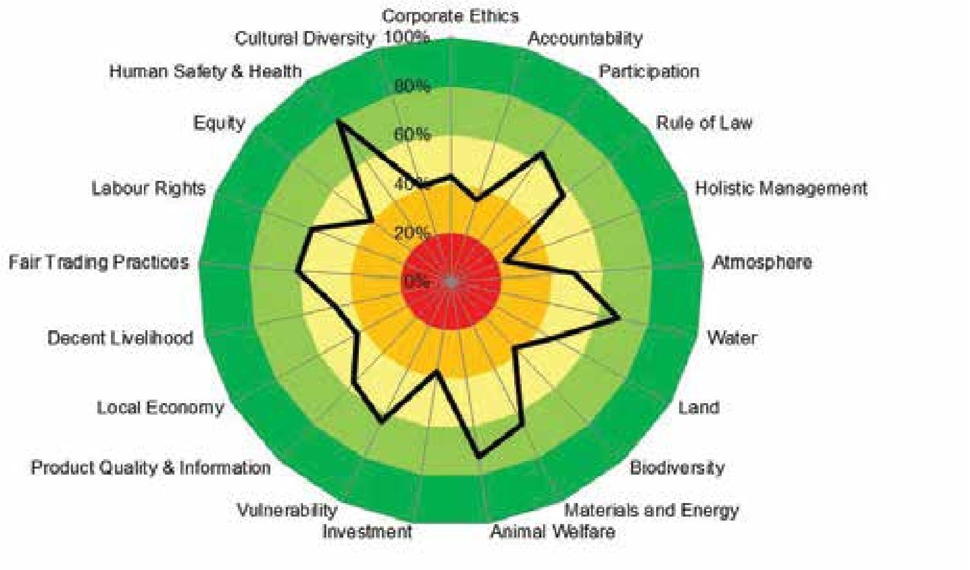


Figure 2: Exemplary summary of a full sustainability assessment of a food company with SMART
Source: FiBL and SFS (2014).

Social performance of organic farming is also influenced by local conditions. So it is very difficult to draw general conclusions. Nevertheless, if a sufficiently large number of organic and conventional operators can be assessed with an indicator set that ensures comparability, a comparison of all aspects of the sustainability could be conducted. Therefore, FiBL created the Sustainability Monitoring and Assessment Routine (SMART), which allows assessing both food companies and farms against the 58 themes specified in the SAFA Guidelines (Jawtusch *et al.*, 2013). Currently, sustainability assessments at farm and company level are conducted. This research will empirically show in which themes organic operators perform better, worse or equal to conventional operators. Figure 2 shows an example of the summary of a complete sustainability assessment of a food company with SMART. With this approach of benchmarking companies and farms against absolute sustainability objectives, even well-performing companies fail to reach maximum scores with respect to many subthemes.

Product level

The product-related environmental performance substantially differs from the operator-related one. The main reason for this difference is the relationship of the performance to a functional unit, which is usually related to the production quantity. The yield gap of 0–40 percent (on average 20–25 percent), depending on which product one is looking at (de Ponti, Rijk and van Ittersum, 2012; Ponisio *et al.,* 2015; Seufert, Ramankutty and Foley, 2012), is sometimes overcompensating the better environmental performance of organic farming (Meier *et al.,* 2015; Tuomisto *et al.,* 2012) (Table 2).

The study of LCA-based comparisons of the environmental performance by Meier *et al.* (2015) also reveals a wide variation between the studies. Table 3 shows the variability of results for dairy production. Details on beef, pig, poultry, egg and plant products can be found in Meier *et al.* (2015).

As explained above, the empirical evidence and the methodological discourse regarding the social and economic product-related sustainability assessment is currently too weak to present conclusions.

Policy level

At the policy level, more general research questions can be dealt with, as apart from production-related aspects also changes in demand patterns can be taken into account (Schader *et al.,* 2014b). This level often calculated scenarios from a resource-use perspective either globally or for specific countries or regions (Schader *et al.*, 2014a).

Table 2: Product-related environmental performance of organic agriculture compared with conventional agriculture

Livestock products[b]	Relative difference organic/integrated on per product unit[a]			
	Milk	Beef	Pork	Poultry
Energy demand	–5%	–2%	–24%	–8%
Global warming potential (GWP)	–12%	–8%	–25%	–18%
Ozone depletion	–3%	–8%	–39%	–17%
Eutrophication potential	–13%	–1%	+4%	+4%
Acidification potential	–12%	–13%	–30%	–21%
Heavy metals, water	–30%	–48%	–81%	–79%
Heavy metals, soil	–165%	–261%	+405%	–79%
Pesticide use	–100%	–99%	–100%	–100%
Water use	–69%	–76%	–73%	–73%
Land use	–1%	–23%	–32%	–32%
Fruist & vegetables[b]	**Tomatoes**	**Carrots**	**Strawberries**	**Pears**
Energy demand	–71%	+12%	+61%	+26%
Global warming potential (GWP)	–78%	–9%	+39%	+10%
Ozone depletion	–69%	–46%	+8%	–50%
Eutrophication potential	–17%	–69%	–65%	–85%
Acidification potential	–86%	+13%	+84%	+17%
Heavy metals, water	–97%	–60%	–25%	+60%
Heavy metals, soil	+306%	+2410%	+5981%	–29%
Pesticide use	–53%	–100%	–96%	–100%
Water use	–28%	+51%	+64%	+5%
Land use	+37%	–38%	–117%	–117%
Arable crops[c]	**Barley grains**	**Soybeans**	**Wheat grains**	**Potatoes**
Energy demand	–6%	–10%	–11%	–5%
Global warming potential (GWP)	+18%	–12%	–9%	+88%
Ozone depletion	–66%	–54%	–81%	–68%
Eutrophication potential	+54%	–26%	+80%	+39%
Acidification potential	–57%	–59%	–59%	–9%
Heavy metals, water	–77%	–65%	–79%	–54%
Heavy metals, soil	+333%	–105%	+665%	+1102%
Pesticide use	–100%	–100%	–100%	–100%
Water use	–65%	–54%	–68%	–12%
Land use	0%	–36%	–4%	+1%

[a] basic: conventional
[b] Inventories from LCI database of ESU-services only (Jungbluth *et al.*, 2013)
[c] Inventories from ecoinvent v2.2 (Nemecek *et al.*, 2007)
Source: Meier *et al.* (2015).

Fundamental questions that have been raised with respect to organic agriculture are: Can organic food systems feed the world? What environmental impacts would organic have? What boundary conditions would need to be met? These fundamental questions have not yet been answered in sufficient depth.

Preliminary results using the SOL-Model (Schader, Muller and Scialabba, 2014) show that organic food systems show the potential of organic farming for feeding the world sustainably under different conditions (Schader *et al.*, 2014b). Table 4 shows different scenarios for 2050 that assume a conversion to organic agriculture and/or a substitution of human-edible feedstuffs with forage not grown on arable land and food waste. These scenarios demonstrate that organic food systems could feed the world even in 2050, if the trade-off between food and feed production is resolved. One way of resolving this trade-off would be to drastically reduce the feedstuffs grown on arable land, which generates a natural boundary for the size of the livestock sector and ultimately leads to lower consumption of livestock products (Schader, Muller and Scialabba, 2014; Schader *et al.*, 2014b). Such a scenario would lead both to an improved availability of energy and protein and a wide range of environmental benefits (Table 4). Social benefits, apart from the indirect impacts from changes in food availability and resource use, are difficult to assess at global level.

Table 3: Variability of product-related environmental performance of organic dairy production

Impact category	Relative difference organic/conventional on per area unit and year[a]	Relative difference organic/ conventional on per product unit[a]	# of studies
Milk			11
Energy demand	–70 to –39%	–56 to –7%	8
Global warming potential (GWP)	–67 to –13%	–38 to +53%	10
Eutrophication potential	–76 to –2%	–66 to +63%	7
Acidification potential	–51 to –2%	–13 to +63%	7
Ecotox terrestrial	–76%	–59%	1
Pesticide use	–100 to –94%	–100 to –89%	3
Productivity	–47 to –6%		11
Land use		+6 to +90%	11

Environmental impacts on per area unit were calculated if not explicitly given in the studies.
[a] Basis: conventional
Source: Meier *et al*. (2015).

Furthermore, at policy level, economic evaluations can be conducted using economic models (Mittenzwei *et al.*, 2007; Sanders *et al.*, 2005; Zimmermann, 2008). For instance, policies that address aspects of environmental sustainability, e.g. the agri-environmental schemes in Europe, can be assessed for cost-effectiveness, the financial support for organic farming being one of these policies. Specifying economic and environmental data, a comprehensive analysis of organic farming as an agri-environmental policy and as a farming system can be done (Schader, 2009). Such an analysis for Switzerland shows that the payments for organic agriculture as an agri-environmental policy are competitive with other environmental payments from a policy-maker's perspective (Table 5). This is specifically due to the fact that policies to support organic farming address a wide range of objectives linked to environmental sustainability (Schader *et al.*, 2014c). Furthermore, there are synergies between the multitarget policy of organic agriculture support and targeted agri-environmental payments (Schader *et al.*, 2013).

CONCLUSIONS

This overview has shown that the sustainability performance of organic food systems needs to be analysed at different levels. Assessments at different levels deliver different information with partly contradicting information.

Results show that organic food systems perform well with respect to the environmental performance at the operator and spatial/policy level, while results at the product level are more heterogeneous, as yields are often lower. Differences between organic and conventional systems vary between different regions and product types. The economic performance can be judged at operator level, which reveals context-specific differences in profitability, depending on product type and regional context. However, apart from profitability, organic food systems may provide further benefits in terms of economic resilience due to the cradle-to-cradle principle. From a spatial/policy level, food availability and food security play important roles. Global studies show organic food systems can provide sufficient food if demand patterns change towards less resource-consuming products. The social dimension is very context-specific and cannot be judged in general.

This paper demonstrated that organic production impacts the entire food system and that organic agriculture can be part of efficiency, consistency and sufficiency strategies. Yet, innovation and further development of the organic system is indispensable for addressing future challenges.

Improvements in data availability and data quality as well as methodological advances at operator, product and spatial/policy level are urgently needed to get a more comprehensive picture of the sustainability performance of organic food systems. Furthermore, a stronger linkage of the different levels is needed in order to increase the consistency between results of assessments at different levels. For instance, the SOL-Model provides quantitative data for such scenarios and will be further developed to provide also country- and product-specific figures for environmental impacts. These could feed both into LCA databases and operator-level assessments such as SMART. Nevertheless, it is important to stress that all three assessment levels have their blind spots as none

Table 4: Overview of impacts of a global conversion of livestock production to organic management on food availability, the environment and human diets calculated with SOL-m

Indicator	Base year	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
	2005-2009; current situation	2050; baseline according to official FAO forecast	2050; 50% reduction of concentrate use	2050; 100% reduction of concentrate use	2050; full conversion of livestock to organic management	2050; Scenario 3 and 4 combined
Agricultural land	→ (yellow)	↗ (yellow)	↘ (yellow)	↘ (yellow)	↑ (red)	↘ (yellow)
Human population	→ (yellow)	↑ (green)	↑ (green)	↑ (green)	↑ (green)	↑ (green)
Avaliable food energy for human consumption	→ (yellow)	↑ (green)	↑ (green)	↑ (green)	↑ (green)	↑ (green)
Avaliable food protein for human consumption	→ (yellow)	↑ (green)	↑ (green)	↑ (green)	↑ (green)	↑ (green)
Share of livestock products	→ (yellow)	↑ (green)	↓ (red)	↓ (red)	↓ (red)	↓ (red)
Share of plant products	→ (yellow)	↘ (yellow)	↑ (green)	↑ (green)	↑ (green)	↑ (green)
Nitrogen surplus	→ (yellow)	↑ (red)	↗ (yellow)	↓ (green)	↓ (green)	↓ (green)
Phosphorus surplus	→ (yellow)	↓ (green)	↑ (red)	↗ (yellow)	↓ (green)	↓ (green)
Energy use	→ (yellow)	↑ (red)	↘ (yellow)	↓ (green)	↗ (yellow)	↓ (green)
Global Warming Potential (GWP)	→ (yellow)	↑ (red)	↑ (red)	↓ (green)	↓ (green)	↓ (green)
Land degradation potential	→ (yellow)	↑ (red)	↘ (yellow)	↘ (yellow)	↑ (red)	↘ (yellow)
Deforestation pressure	→ (yellow)	↑ (red)	↓ (green)	↓ (green)	↑ (red)	↓ (green)
Toxicity potential	→ (yellow)	↑ (red)	↘ (yellow)	↘ (yellow)	↓ (green)	↘ (yellow)
Grassland overexploitation	→ (yellow)	↑ (red)	↑ (red)	↗ (yellow)	↑ (red)	↗ (yellow)
Biodiversity	→ (yellow)	↑ (red)	↗ (yellow)	↑ (green)	↑ (green)	↑ (green)

The direction of the arrows specifies whether the paramer will increase in a scenario
Green arrows indicate a development that is considered beneficial from a societal perspective
Red arrows indicate a development which is considered detrimental from a societal perspective
Yellow arrow indicates constant trends or minor changes (less than 5%) according to the preliminary SOL-m calculations
Source: Schader *et al.* (2014b).

Table 5: Cost-effectiveness of organic agriculture support payments and single-target agri-environmental measures (AEM) in Switzerland for pursuing relative improvements (RI) in achieving agri-environmental policy targets

Indicator		Unit	Organic farming	Combined AEM		
				On all farms	On organic farms	On conventional farms
Cost (C)	Public expenditure	CHF/ha*year	66.58	73.17	23.11	78.62
Environmental effects (E)	Reduction of energy use	%*	5.28	1.50	3.76	1.38
	Improvement of habitat quality	%*	5.34	18.05	17.88	18.08
	Reduction of total eutrophication	%*	3.42	2.18	3.22	2.10
	Average improvement	%*	4.68	7.24	8.29	7.19
Abatement/ Provision cost (ABC)	Reduction of energy use	CHF/%RI**	12.61	48.94	6.14	56.88
	Improvement of habitat quality	CHF/%RI**	12.47	4.05	1.29	4.35
	Reduction of total eutrophication	CHF/%RI**	19.45	33.60	7.17	37.37
	Average improvement	CHF/%RI**	14.22	10.10	2.79	10.94

* relative improvement of the indicator due to the policy instrument
** CHF/year*1% improvement of the indicator
Source: own calculations based on Swiss FADN and SALCA data, Schader *et al.* (2014c).

of the approaches is able to cover all aspects of sustainability and all three sustainability strategies in sufficient depth. Therefore, when selecting tools for sustainability assessment of organic food systems, the purpose of the assessment needs to be specified exactly before selecting a level or even a specific tool for sustainability assessment.

REFERENCES

Bystricky, M., Nemecek, T., Alig, M. & Gaillard, G. 2014. *Challenges of comparing food and feed products from different countries of origin* (available at http://lcafood2014.org/papers/160.pdf).

de Baan, L., Alkemade, R. & Koellner, T. 2013. Land use impacts on biodiversity in LCA: a global approach. The *International Journal of Life Cycle Assessment*, 18(6): 1216–1230.

de Ponti, T., Rijk, B. & van Ittersum, M.K. 2012. The crop yield gap between organic and conventional agriculture. *Agricultural Systems*, 108: 1–9.

FAO. 2013. Sustainability Assessment of Food and Agriculture systems (SAFA). Rome (available at http://www.fao.org/nr/sustainability/sustainability-assessments-safa/en/).

FiBL & SFS. 2014. Sustainability Monitoring and Assessment RouTine (SMART) (available at http://www.fibl.org/en/themes/sustainability-assessment/smart-en.html).

Finkbeiner, M., Schau, E., Lehmann, A. & Traverso, M. 2010. Towards life cycle sustainability assessment. *Sustainability*, 2(10): 3309–3322.

Gattinger, A., Muller, A., Haeni, M., Skinner, C., Fliessbach, A., Buchmann, N., Mäder, P., Stolze, M., Smith, P. & Scialabba, N.E.-H. 2012. Enhanced top soil carbon stocks under organic farming. *Proceedings of the National Academy of Sciences*, 109(44): 18226–18231.

Godfray, H.C.J. & Garnett, T. 2014. Food security and sustainable intensification. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 369: 20120273.

ISO (International Organization for Standardization). 2006a. *Environmental management – life cycle assessment – principles and framework*. Geneva, Switzerland.

ISO. 2006b. *Environmental management – life cycle assessment – requirements and guidelines*. Geneva, Switzerland.

Jawtusch, J., Schader, C., Stolze, M., Baumgart, L. & Niggli, U. 2013. *Sustainability monitoring and assessment routine: results from pilot applications of the FAO SAFA Guidelines*. International Symposium on Mediterranean Organic Agriculture and Quality Signs related to the Origin, Agadir, Morocco, 2–4 December 2013.

Jeanneret, P., Baumgartner, D., Freiermuth-Knuchel, R. & Gaillard, G. 2008. A new LCIA method for assessing impacts of agricultural activities on biodiversity (SALCA-Biodiversity). *In* T. Nemecek & G. Gaillard, eds. *Proceedings of the 6th International Conference on Life Cycle Assessment in the Agri-Food Sector. Towards a sustainable management of the food-chain*, pp. 34–39. 12–14 November 2008, Zürich, Agroscope Reckenholz Tänikon (ART).

Jungbluth, N., Flury, K., Doublet, G., Leuenberger, M., Steiner, R., Büsser, S., Stucki, M., Schori, S. & Itten, R. 2013. *Life Cycle Inventory Database on Demand: EcoSpold LCI Database of ESU-services*. ESU-services Ltd., Zürich, Switzerland.

McDonald, S. & Oates, C.J. 2006. Sustainability: consumer perceptions and marketing strategies. *Business Strategy and the Environment,* 15(3): 157–170.

Meier, M.S., Stoessel, F., Jungbluth, N., Juraske, R., Schader, C. & Stolze, M. 2015. Environmental impacts of organic and conventional agricultural products – are the differences captured by life cycle assessment? *Journal of Environmental Management*, 149: 193–208.

Milà i Canals, L., Basson, L., Clift, R. Müller-Wenk, R., Bauer, C., Hansen, Y. & Brandão, M., eds. 2006. *Expert workshop on definition of best indicators for biodiversity and soil quality for life cycle assessment (LCA). Proceedings and conclusions*. Guildford, UK, Centre for Environmental Strategy, University of Surrey.

Mittenzwei, K., Fjellstad, W., Dramstad, W., Flaten, O., Gjertsen, A.K., Loureiro, M. & Prestegard, S.S. 2007. Opportunities and limitations in assessing the multifunctionality of agriculture within the CAPRI model. *Ecological Indicators*, 7(4): 827–838.

Nemecek, T., Heil, A., Huguenin, O., Meier, S., Erzinger, S., Blaser, S., Dux, D. & Zimmermann, A. 2007. *Life Cycle Inventories of Agricultural Production Systems*. Agroscope FAL Reckenholz and FAT Tänikon, Swiss Centre for Life Cycle Inventories, Dübendorf, Switzerland.

Nemes, N. 2009. *Comparative analysis of organic and non-organic farming systems: a critical assessment of farm profitability*. Rome, FAO.

Ponisio, L.C., M'Gonigle, L.K., Mace, K.C., Palomino, J., de Valpine, P. & Kremen, C. 2015. Diversification practices reduce organic to conventional yield gap. *Proceedings of the Royal Society of London B: Biological Sciences*, 282(1799): 20141396.

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F.S., Lambin, E.F., Lenton, T.M., Scheffer, M., Folke, C., Schellnhuber, H.J., Nykvist, B., de Wit, C.A., Hughes, T., van der Leeuw, S., Rodhe, H., Sörlin, S., Snyder, P.K., Costanza, R., Svedin, U., Falkenmark, M., Karlberg, L., Corell, R.W., Fabry, V.J., Hansen, J., Walker, B., Liverman, D., Richardson, K., Crutzen, P. & Foley, J.A. 2009. A safe operating space for humanity. *Nature*, 461: 472–475.

Sanders, J., Lampkin, N.H., Midmore, P. & Stolze, M. 2005. A policy impact model for organic farming in Switzerland. In U. Köpke, U. Niggli, D. Neuhoff, P. Cornish, W. Lockeretz & H. Willer, eds. *ISOFAR: Proceedings of the Conference "Researching Sustainable Systems"*, Adelaide 2005, International Society of Organic Agriculture Research (ISOFAR).

Schader, C. 2009. *Cost-effectiveness of organic farming for achieving environmental policy targets in Switzerland*. Institute of Biological, Environmental and Rural Sciences, Aberystwyth, Aberystwyth University, Wales. Research Institute of Organic Farming (FiBL), Frick, Switzerland.

Schader, C. & Scialabba, N. 2012. *Environmental and socio-economic impacts of a global conversion of livestock systems to organic management (SOL-m)*. 15th AAA Animal Science Congress. Thailand, 25–30 November 2012.

Schader, C., Muller A. & Scialabba, N. 2014. *Scenarios for organic livestock production at global level*. Global Animal Nutrition Conference (GLANCE), 20–22 April 2014, Bengaluru, India.

Schader, C., Stolze, M. & Gattinger, A. 2012. Environmental performance of organic farming. In J.I. Boye, J.I. & Y. Arcand, eds. *Green technologies in food production and processing*, pp. 183–210. New York, USA, Springer.

Schader, C., Lampkin, N., Christie, M., Nemecek, T., Gaillard, G. & Stolze, M. 2013. Evaluation of cost-effectiveness of organic farming support as an agri-environmental measure at Swiss agricultural sector level. *Land Use Policy,* 31: 196–208.

Schader, C., Grenz, J., Meier, M.S. & Stolze, M. 2014a. Scope and precision of sustainability assessment approaches to food systems. *Ecology and Society*, 19(3): 42.

Schader, C., Muller, A., El-Hage Scialabba, N., Hecht, J. & Stolze, M. 2014b. Comparing global and product-based LCA perspectives on environmental impacts of low-concentrate ruminant production. *LCAFood*, San Francisco, USA.

Schader, C., Muller, A., Lampkin, N. & Stolze, M. 2014c. The role of multi-target policy instruments in agri-environmental policy mixes. *Journal of Environmental Management*, 145: 180–190.

Schaltegger, S., Burritt R. & Petersen, H. 2003. *An introduction to corporate environmental management: striving for sustainability*. Greenleaf Publishing.

Seufert, V., Ramankutty, N. & Foley, J.A. 2012. Comparing the yields of organic and conventional agriculture. *Nature*, 485, 229–232. doi:10.1038/nature11069.

Tilman, D., Balzer, C., Hill J. & Befort, B.L. 2011. Global food demand and the sustainable intensification of agriculture. *Proceedings of the National Academy of Sciences*, 108: 20260–20264.

Tuomisto, H., Hodge, I., Riordan, P. & Macdonald, D. 2012. Does organic farming reduce environmental impacts? A meta-analysis of European research. *Journal of Environmental Management*, 112: 309–320.

Zimmermann, A. 2008. *Combination of the Swiss agrarian sector model SILAS-dyn with the life cycle assessment tool SALCA*. 107th EAAE Seminar "Modelling of Agricultural and Rural Development Policies" Seville, Spain, 29 January – 1 February 2008, European Association of Agricultural Economists.

How can the organic food system contribute to environmentally sustainable diets?

Sirli Pehme and Darja Matt
Institute of Agricultural and Environmental Sciences, Estonian University of Life Sciences, Tartu, Estonia

ABSTRACT

Organic farming aims to be an environmental friendly food production system. The aim of this paper is to discuss the organic food system's contribution to an environmentally sustainable diet from the life cycle perspective. The environmental impacts of the diet are considered as the sum of impacts of each component of the diet. As previous studies have shown, in general agriculture has the greatest contribution to environmental impacts of food products, but there is a lack of studies including the next steps after agriculture. Organic farming per output unit has clear environmental benefits in categories such as energy use, biodiversity and toxicity. Climate change, eutrophication and acidification impact results per output unit depend on yield level and practice. Lower yields in organic farming are a critical issue, but in some cases yields may even be higher in organic production. Traditional weight- or volume-based units are not suitable to compare the environmental impacts of diets that do not provide the same nutritional function.

INTRODUCTION

Societies are facing a global challenge of how to ensure food supply in adequate amount and nutrition value, and to secure good performance at economic, social and environmental scales. Dietary choices influence food supply through demand; therefore consumers are heavily involved in inducing the sustainability of food systems. To evaluate the full environmental impacts of food, the holistic life cycle perspective is needed. Life cycle assessment (LCA) is a tool to assess the potential environmental impacts and use of resources through a product's life cycle, i.e. from raw material acquisition, via production and use phases, to waste management (ISO, 2006). As many traditional environmental studies in the agri-food sector are focused only on one part of the system, LCA attempts to sum all impacts through the chain. The life cycle approach helps to avoid problem shifting from one part of the cycle to another, from one region to another, or from one environmental problem to another. Organic farming aims to be sustainable and to fit the cycles and ecological balances in nature (IFOAM, 2008). This paper discusses the potential of the organic food system's contribution to an environmentally sustainable diet from the life cycle perspective based on scientific literature.

RESULTS AND DISCUSSION

The total environmental impacts of the diet could be calculated as sum of impacts of each component of the diet. According to the holistic life cycle perspective it should include the environmental impacts and resource use of each step – farming, transport, processing, retail, consumption and waste management – for all foods in the diet. However, most LCA studies focus on farm-gate impacts; some studies consider also the processing part, but the next steps after processing are included only in a few assessments. As previous studies have shown, in general the agricultural phase has the greatest contribution to environmental impacts of food products (Roy *et al.*, 2009). Further review is based mostly on farm-gate studies of environmental impacts of organic food production.

CLIMATE CHANGE

Comparative studies show different climate change results for organic and conventional farming. As organic farming generally uses less energy-intensive inputs, the greenhouse gas (GHG) emissions are also correlatively lower per area unit, but the result per output yield can be higher due to lower yields. Based on meta-analysis by Tuomisto *et al.* (2012), GHG emissions per product unit for organic vs. conventional production vary a lot between different products. As an average for all product groups, there are no remarkable differences in GHG emissions between organic and conventional production (Tuomisto *et al.,* 2012). Meta-analysis (Mondelaers, Aertsens and van Huylenbroeck, 2009) showed GHG emissions of organic production per product unit 10 percent lower compared with conventional farming.

Organic matter can act as a sink of atmospheric CO_2, thus carbon sequestration can change the GHG balance. Organic fertilizers are more often used in organic farming compared with conventional, so there is a potential for higher carbon sequestration rate in soil. In reality it depends greatly on real farm practice and soil properties. Higher yields in conventional farms may also compensate the carbon input due to higher crop residue amount (Gosling and Shepherd, 2005), and the fertilization practices in organic farms may differ. Organic farms with the same or a higher amount of manure input as conventional systems result in significantly higher soil organic matter (SOM) content (Tuomisto *et al.,* 2012). Higher SOM content in organic farming is also confirmed by many other authors (Azeez, 2009; Knudsen *et al.*, 2011; Mondelaers, Aertsens and van Huylenbroeck, 2009). Still, soil carbon changes have mostly not been included in overall GHG calculations for agricultural systems presently (Brandão *et al.,* 2012; de Vries and de Boer, 2010). The main reason is probably the lack of methodological consensus on how to include carbon sequestration into assessments; proper tools are needed to model soil carbon changes for a longer time perspective. Inclusion of carbon sequestration to soil may change the total GHG result for organic products significantly by reducing total GHG amount (Halberg *et al.,* 2010; Petersen *et al.,* 2013). Use of organic fertilizers, lower energy and nitrogen input means good potential for organic farming to have a lower climate change impact, but still the result per output unit is dependent on yield level and practices.

EUTROPHICATION AND ACIDIFICATION

According to previous LCAs, leaching per area unit is lower in organic farming compared with conventional due to lower nutrient input, but per product unit the results vary a lot and depend on the farm practice (meta-analyses by Mondelaers, Aertsens and van Huylenbroeck, 2009; Tuomisto *et al.*, 2012). Higher eutrophication impact of organic farming in some LCA studies is caused by relatively high fertilization rate assumed for the organic scenario as explained by Schader, Stolze and Gattinger (2012). Due to lower nutrient input in organic farming, there is a great potential for lower leaching impact in organic farming, but per output unit it depends on yield and farm practices. As leaching is much more a local environmental problem compared with some other indicators, leaching per area unit may be even more relevant than per product unit in some cases.

Acidification impact has been found lower in organic farming per area unit compared with conventional, but the impact tends to be higher per product unit in organic production due to lower yields (Tuomisto *et al.,* 2012).

ENERGY USE

Energy is used directly in farms (fuel, electricity) but also indirectly (production and transport of inputs needed for farming). The production of mineral fertilizers, especially mineral nitrogen, is the main cause of high energy consumption in conventional farming. It leads to lower energy use per area unit, but also per product unit in organic farming (Gomiero, Pimentel and Paoletti, 2011; Tuomisto *et al.,* 2012). Energy consumption in organic farming is on average 21 percent lower per product unit, but a wide variation from 64 percent lower up to 40 percent higher was observed depending on crop type and practice (Tuomisto *et al.*, 2012). Due to lower use of energy-intensive inputs, organic farming has a very good potential to use less energy per output unit for most crops.

TOXICITY

Pesticide use in agriculture may also be harmful to organisms that are not actually the target; it also may result in occurrence of pesticide residues in environment, food and feed. Toxicity impacts are not usually included in LCA studies presently (De Schryver, van Zelm and Huijbregts, 2010), thus the advantage of organic food production where synthetic pesticides are forbidden is mostly not fairly covered in previous studies. The models to quantify the potential impacts of chemicals for LCA studies are based on risk assessment models; such models have been developed quite recently (Räsänen *et al.,* 2015) and are still under development. Methodological tools to include toxicity impacts into environmental assessments to fairly cover different food production systems are strongly needed.

BIODIVERSITY

Organic farms have overall higher biodiversity than conventional farms (Bengtsson, Ahnström and Weibull, 2005; Hole *et al.,* 2005; Mondelaers, Aertsens and van Huylenbroeck, 2009; Tuomisto *et al.,* 2012) due to organic farming practices such as diverse crop rotations, prohibition of synthetic pesticides and fertilizers, etc. The impact on biodiversity is mostly not included in LCAs, thus better performance of organic production from the biodiversity context is not actually reflected by those analyses.

USE OF NON-RENEWABLE RESOURCES

Significant amounts of fossil resources are used to produce energy/fuels or other inputs needed for food production. Even if to minimize the emissions from production and use of fossil materials (accounted under other impact indicators), the problem with depletion of non-renewable resources, especially mineral phosphorus, is still serious. In future, farming nutrients should be more effectively recycled; this has been one of the basic principles of organic farming already since the beginning of the movement.

WATER USE

Lower yields in organic farming may most likely result in higher water use per kg of product. Still, organic farming practices have a potential to improve water use efficiency. Organically managed soils have higher water-holding capacity and thus the potential to produce higher yields in drought conditions (Pimentel *et al.,* 2005). Water use is very much dependant on local conditions but higher water-holding capacity in organic farming offers a great potential for arid areas (see next paragraph).

LAND USE

Generally organic farming requires more land compared with conventional farming due to lower yields, lower animal density and area needed for fertility building crops (Mondelaers, Aertsens and van Huylenbroeck, 2009; Tuomisto *et al.,* 2012). The argument is that if more land would be converted to organic, more farmland would be needed to produce the same amount of outputs. If extra agricultural land is needed, it would most likely be taken by cultivating the natural land to cropland, which means high CO_2 emissions caused by land-use changes. Still, contrarily higher yields have been reported in organic farming under drought conditions (e.g. Pimentel *et al.,* 2005), caused by better water-holding capacity mainly due to the use of organic fertilizers. Badgley *et al.* (2007) reported higher organic yield ratio compared with conventional for developing countries for all crops. Their calculation showed organic farming is able to feed the world without the need for additional farmland. Still, other authors have found a lower yield level for organic production on average (Mondelaers, Aertsens and van Huylenbroeck, 2009; Tuomisto *et al.,* 2012). For all the comparisons it should also be kept in mind that today's high-yielding intensive farming is widely based on energy-intensive non-renewable resources, which may not be the case in the future, when also conventional farming will most likely be with much more recycling and, thus, facing similar challenges as organic farming today.

METHODOLOGICAL CHOICES

As mentioned above, there is a lack of LCA studies that include further steps after the farm stage such as different processing technologies, distribution and consumption of food. Environmental impact results may be strongly affected by the choice of the system boundaries; also activities at some stage of the chain may affect the environmental impacts both upstream and downstream in the product chain (Sonesson and Berlin, 2010). Although generally agriculture is considered the main contributor to the environmental impacts of food production chain, especially for animal products (Roy *et al.*, 2009; Yan, Humphreys and Holden, 2011), the next stages may also cause significant impacts or affect the impacts in other parts of the cycle. For example, LCA of milk production until the dairy gate by Hospido, Moreira and Feijoo (2003) showed the relative contribution of dairy to total environmental impacts higher than 50 percent in several impact categories. Another LCA study of milk processing suggested the possible improvement potential through fewer changes of the different products at the production line, the improvement being caused by the reduction of waste (Berlin and Sonesson, 2008). At the same time, the actual improvement takes place in another part of the chain in the farming stage. In some cases, higher energy use in the processing stage or using more packaging materials may be a good solution in a life cycle perspective if it helps to reduce food waste in later steps (Williams and Wikström, 2011). There is a strong need for more holistic food cycle studies considering all the steps from farm to consumption and waste management, different processing methods and consumption chains to evaluate the real impacts of the diet.

Different studies cover different environmental impact categories. Climate change impact is the most often calculated impact in LCAs and very often a number of other important impacts of food production are not reflected at all. Some categories such as biodiversity or toxicity are mostly not included in assessments; and, as explained above, carbon sequestration is usually not taken into account to calculate GHG balance for global warming impact.

The choice of functional unit (FU) is also important, as it may change the results significantly. As already mentioned, the results per kg of food and per ha of food production may often be totally different. If we go further to food consumption, then it raises the question about the function of food/diet, as different foods may have a different nutritional function due to their different composition. Studies concerning the environmental impacts of meals/nutrition/diets have previously mostly been based on weight or volume unit, yet nutritionally based FU would enable more fair comparison (Heller, Keoleian and Willett, 2013). Some studies have been carried out using a single nutritional aspect (caloric energy, protein content, etc.) as the FU (Heller, Keoleian and Willett, 2013); and for milk studies quite often "fat and protein corrected milk" has been used as the FU (International Dairy Federation, 2010). There are different concepts to compare the nutritional quality of different food products, for example, nutritional density (Smedman *et al.*, 2010) or nutritional profiling (Saarinen, 2012). Van Kernebeek *et al.* (2014) suggest considering nutrient quality and bioavailability to assess diets; these aspects are not presently accounted for by nutrient density concepts. Nutritional quality indices could be used either as functional unit in environmental assessments or through presenting the nutritional quality indices together with environmental impacts (Heller, Keoleian and Willett, 2013). Different nutritional quality parameters should be also addressed when comparing the environmental impacts of organic and conventional diets

CONCLUSIONS

Organic farming contributes to environmental sustainability in several environmental impact categories, but organic farming does not have a lower environmental impact in any case, especially per product unit, as it is dependent on yield level. Organic farming per output unit has clear environmental benefits in categories such as energy use, biodiversity and toxicity. Climate change, eutrophication and acidification impacts do not show clear benefits from organic farming. The higher land use is a critical issue for organic food systems. Most of the studies include only farm-gate impacts and there is a lack of studies that also include different food processing technologies, distribution and consumption patterns. Important aspects, for example carbon sequestration, are missing in previous studies. To enable a fair comparison of the environmental impacts of diets, the selection of a functional unit is essential. Traditional weight- or volume-based units are not suitable to compare diets that do not provide the same nutritional function.

REFERENCES

Azeez, G. 2009. *Soil carbon and organic farming. Soil Association* (available at http://www.soilassociation.org/LinkClick.aspx?fileticket=SSnOCMoqrXs%3D&tabid=387).

Badgley, C., Moghtader, J., Quintero, E., Zakem, E., Chappell, M.J., Avilés-Vázquez, K., Samulon, A. & Perfecto, I. 2007. Organic agriculture and the global food supply. *Renew. Agric. Food Syst.*, 22: 86. doi:10.1017/S1742170507001640.

Bengtsson, J., Ahnström, J. & Weibull, A.-C. 2005. The effects of organic agriculture on biodiversity and abundance: a meta-analysis. *J. Appl. Ecol.*, 42: 261–269. doi:10.1111/j.1365-2664.2005.01005.x.

Berlin, J. & Sonesson, U. 2008. Minimising environmental impact by sequencing cultured dairy products: two case studies. *J. Clean. Prod.*, 16: 483–498. doi:10.1016/j.jclepro.2006.10.001.

Brandão, M., Levasseur, A., Kirschbaum, M.U.F., Weidema, B.P., Cowie, A.L., Jørgensen, S.V., Hauschild, M.Z., Pennington, D.W. & Chomkhamsri, K. 2012. Key issues and options in accounting for carbon sequestration and temporary storage in life cycle assessment and carbon footprinting. *Int. J. Life Cycle Assess.,* 18: 230–240. doi:10.1007/s11367-012-0451-6.

De Schryver, A.M., van Zelm, R. & Huijbregts, M.A.J. 2010. Addressing land use and ecotoxicological impacts in life cycle assessments of food production technologies. *In* U. Sonesson, J. Berlin & F. Ziegler, eds. *Environmental assessment and management in the food industry*, pp. 177–206. Woodhead Publishing Limited.

De Vries, M. & de Boer, I.J.M. 2010. Comparing environmental impacts for livestock products: A review of life cycle assessments. *Livest. Sci.*, 128: 1–11. doi:10.1016/j.livsci.2009.11.007.

Gomiero, T., Pimentel, D. & Paoletti, M.G. 2011. Environmental impact of different agricultural management practices: conventional vs. organic agriculture. *CRC. Crit. Rev. Plant Sci.*, 30: 95–124. doi:10.1080/07352689.2011.554355.

Gosling, P. & Shepherd, M. 2005. Long-term changes in soil fertility in organic arable farming systems in England, with particular reference to phosphorus and potassium. *Agric. Ecosyst. Environ.*, 105: 425–432. doi:10.1016/j.agee.2004.03.007.

Halberg, N., Hermansen, J.E., Kristensen, I.S., Eriksen, J., Tvedegaard, N. & Petersen, B.M. 2010. Impact of organic pig production systems on CO_2 emission, C sequestration and nitrate pollution. *Agron. Sustain. Dev.,* 30: 721–731. doi:10.1051/agro/2010006.

Heller, M.C., Keoleian, G.A. & Willett, W.C. 2013. Toward a life cycle-based, diet-level framework for food environmental impact and nutritional quality assessment: a critical review. *Environ. Sci. Technol.*, 47: 12632–12647. doi:10.1021/es4025113.

Hole, D.G., Perkins, A. J., Wilson, J.D., Alexander, I.H., Grice, P.V. & Evans, A.D. 2005. Does organic farming benefit biodiversity? *Biol. Conserv.*, 122: 113–130. doi:10.1016/j.biocon.2004.07.018.

Hospido, A., Moreira, M.T. & Feijoo, G. 2003. Simplified life cycle assessment of galician milk production. I*nt. Dairy J.,* 13: 783–796. doi:10.1016/S0958-6946(03)00100-6.

IFOAM. 2008. Principles of organic agriculture. *Preamble* (available at http://www.ifoam.org/sites/default/files/ifoam_poa.pdf).

International Dairy Federation. 2010. *A common carbon footprint approach for dairy. The IDF guide to standard lifecycle assessment methodology for the dairy sector, 2010* (available at http://www.idf-lca-guide.org/Files/media/Documents/445-2010-A-common-carbon-footprint-approach-for-dairy.pdf).

ISO (International Organisation for Standardisation). 2006. ISO-14040. E*nvironmental management – life cycle assessment – principles and framework*. Geneva, Switzerland.

Knudsen, M.T., Hermansen, J., Halberg, N., Andreasen, L. & Williams, A. 2011. Life cycle assessment of organic food and farming systems: methodological challenges related to greenhouse gas emissions and carbon sequestration. *In* FAO *Organic agriculture and climate change mitigation*, pp. 32–64. Rome.

Mondelaers, K., Aertsens, J. & van Huylenbroeck, G. 2009. A meta-analysis of the differences in environmental impacts between organic and conventional farming. *Br. Food J.*, 111: 1098–1119. doi:10.1108/00070700910992925.

Petersen, B.M., Knudsen, M.T., Hermansen, J.E. & Halberg, N. 2013. An approach to include soil carbon changes in life cycle assessments. *J. Clean. Prod.*, 52: 217–224. doi:10.1016/j.jclepro.2013.03.007.

Pimentel, D., Hepperly, P., Hanson, J., Douds, D. & Seidel, R. 2005. Environmental, energetic, and economic comparisons of organic and conventional farming systems. *Bioscience*, 55: 573. doi:10.1641/0006-3568(2005)055[0573:EEAECO]2.0.CO;2.

Roy, P., Nei, D., Orikasa, T., Xu, Q., Okadome, H., Nakamura, N. & Shiina, T. 2009. A review of life cycle assessment (LCA) on some food products. *J. Food Eng.*, 90: 1–10. doi:10.1016/j.jfoodeng.2008.06.016.

Räsänen, K., Mattila, T., Porvari, P., Kurppa, S. & Tiilikkala, K. 2015. Estimating the development of ecotoxicological pressure on water systems from pesticides in Finland 2000–2011. *J. Clean. Prod.*, 89: 65–77. doi:10.1016/j.jclepro.2014.11.008.

Saarinen, M. 2012. Nutrition in LCA: are nutrition indexes worth using? In M.S. Corson & H.M.G. van der Werf, eds. *Proceedings of the 8th International Conference on Life Cycle Assessment in the Agri-Food Sector (LCA Food 2012)*, pp. 385–390. 1–4 October 2012, Saint Malo, France. Rennes, France, INRA.

Schader, C., Stolze, M. & Gattinger, A. 2012. Environmental performance of organic farming. In J.I. Boye & Y. Arcand, eds. *Green technologies in food production and processing*, pp. 183–210. Food Enginering Series, Springer Science+Business Media.

Smedman, A., Lindmark-Månsson, H., Drewnowski, A. & Edman, A.-K.M. 2010. Nutrient density of beverages in relation to climate impact. *Food Nutr. Res.*, 54: 1–8. doi:10.3402/fnr.v54i0.5170.

Sonesson, U. & Berlin, J. 2010. Towards sustainable industrial food production using life cycle assessment approaches. *In* U. Sonesson, J. Berlin & F. Ziegler, eds. *Environmental assessment and management in the food industry*, pp. 165–176.Woodhead Publishing Limited.

Tuomisto, H.L., Hodge, I.D., Riordan, P. & Macdonald, D.W. 2012. Does organic farming reduce environmental impacts? A meta-analysis of European research. *J. Environ. Management*, 112: 309–320. doi:10.1016/j.jenvman.2012.08.018.

Van Kernebeek, H.R.J., Oosting, S.J., Feskens, E.J.M., Gerber, P.J. & De Boer, I.J.M. 2014. The effect of nutritional quality on comparing environmental impacts of human diets. *J. Clean. Prod.*, 73: 88–99. doi:10.1016/j.jclepro.2013.11.028.

Williams, H. & Wikström, F. 2011. Environmental impact of packaging and food losses in a life cycle perspective: a comparative analysis of five food items. *J. Clean. Prod.,* 19: 43–48. doi:10.1016/j.jclepro.2010.08.008.

Yan, M.-J., Humphreys, J. & Holden, N.M. 2011. An evaluation of life cycle assessment of European milk production. *J. Environ. Management*, 92: 372–379. doi:10.1016/j.jenvman.2010.10.025.

How can the organic food system contribute to a sustainable diet?

Carola Strassner
Münster University of Applied Sciences (MUAS), Department of Home Economics and Nutritional Science – Facility Management, Germany

ABSTRACT

A person's diet is shaped by a myriad of individual and socio-cultural factors but also by the food system in which they live, i.e. dietary choices not only influence food supply through demand but are themselves too influenced by the nature of the food supply. This paper discusses the potential of the organic food system's contribution to a sustainable diet, addressing socio-cultural, economic and medico-nutritive aspects. Indicators being developed for assessing the sustainability of the Mediterranean diet were considered as reference properties. Regarding nutrition and health, while there is no traditional organic diet in the sense of special food-group choices such as for a vegetarian, vegan, rawfood or macrobiotic diet, there is growing evidence from profiling organic consumers, e.g. in Germany or France, of significantly different dietary choices made by such groups, specifically more healthful choices. Furthermore, such data show better nutritional anthropometry measures and physical activity prevalence for organic consumers. Regarding economy, while the robustness of a national organic food system might be measured using food self-sufficiency, analysis of organic markets shows that consumers accessing the organic food system tend to exhibit less degrees of distance to the primary producer (shorter distribution chain). All issues concerning prices are critical for the organic food system. Organic products are perceived and measured as more expensive than conventional products. Typical economic indicators lose their meaning while ecosystem services are not monetized and external costs not internalized. With regard to society and culture, though organic consumers self-report very good to good cooking skills, the involvement of consumers in the preparation of food might be a challenge for the organic food system too, because the organic product mix is growing, especially in the convenience and even ready-to-eat range. An alternative indicator, which offers potential use for policy formulation, is the degree of training in household skills in schools. Indeed, education-linked measures such as food, health or nutrition literacy, and especially ecoliteracy, might offer some use.

INTRODUCTION

The expression of food choices made over time and the pattern that results are what we call diet. A person's diet is shaped by a myriad of food choice determinants (Counihan, 2008; Hirschfelder, 2005). These include individual factors such as their knowledge, physiological, nutritional and health needs, and socio-cultural factors, such as the social and cultural meanings of foods, religious and political beliefs, family and peers (Reitmeier, 2013; von Pacensky and Dünnebier, 1999). Additionally, a person's diet is shaped by the food system in which they live, e.g. food availability through retail and food service, food deserts, regional geography, marketing. In this way dietary choices not only influence food supply through demand but are themselves too influenced by the nature of the food supply. Types of production systems such as integrated or organic agriculture and types of food quality schemes are further elements of this food system depiction.

For some time now sustainability within the food system has been a highlighted issue, largely taking a sustainable consumption and production (SCP) perspective (Reisch, Eberle and Lorek, 2013; UNEP, 2010; EC, 2008). Underlying this is a value chain approach, addressing sustainability in production and its measurement. As regards sustainability of food production, there is a growing

Table 1: Proposed indicators for assessing the sustainability of the Mediterranean food consumption patterns

A. Nutrition and health	B. Environment	C. Economy	D. Society and culture
A1. Diet-related morbidity/ mortality	B1. Water footprint	C1. Food consumer price index (FCPI): cereals, fruit, vegetables, fish and meat	D1. Proportion of meals consumed outside home
A2. Fruit and vegetable consumption/intake	B2. Carbon footprint	C2. Cost of living index (COLI) related to food expenditures: cereals, fruit, vegetables, fish and meat	D2. Proportion of already prepared meals
A3.Vegetable/animal protein consumption ratio	B3. Nitrogen footprint	C3. Distribution of household expenditure per groups: food	D3. Consumption of traditional products (e.g. proportion of product under PDO or similar recognized traditional foods)
A4. Dietary energy supply/ intakes	B4. Biodiversity	C4. Food self-sufficiency: cereals, fruit and vegetables	D4. Proportion of mass media initiatives dedicated to the knowledge of food background cultural value
A5. Dietary diversity score		C5. Intermediate consumption in the agriculture sector: nitrogen fertilizers	
A6. Dietary energy density score		C6. Food losses and waste	
A7. Nutrient density/quality score			
A8. Food biodiversity composition and consumption			
A9. Nutritional anthropometry			
A10. Physical activity prevalence			

Source: Dernini *et al.* (2013).

body on the value of organic production principles and practices. Concurrently, sustainability in consumption has focused largely on choices and behaviour of people characterized as consumers (Finney, 2014; Seyfang, 2005; Hertwich and Katzmayr, 2004). With the definition of sustainable diets (FAO/Bioversity, 2012) the scope is opened to analyse diets as regards their sustainability. In pursuit of this, the FAO/UNEP Sustainable Food Systems Programme started to identify appropriate indicators for assessing sustainability using the Mediterranean diet as a pilot case study (Burlingame and Dernini, 2011).

Having kicked off the discussion of sustainable nutrition and diets within the international research network on food quality and health in Warsaw (FQH, 2014), we decided to look at sustainable diets through the prism of the organic food system. This paper discusses the potential of the organic food system's contribution to a sustainable diet, addressing some socio-cultural, economic and medico-nutritive aspects, without intending to be an exhaustive analysis. The environmental aspects are addressed elsewhere (Pehme and Matt, this volume). Indicators being developed for assessing the sustainability of the Mediterranean diet (see Table 1) were considered as reference properties (Dernini *et al.*, 2013; FAO/CIHEAM, 2012). For the purposes of this paper the issue of the underlying non-systematic use of certain terms (sustainable diets, sustainability of food consumption patterns, sustainability of food systems) was not considered further. Also, DEFRA's (2009) Indicators for a Sustainable Food System had been developed "to measure progress" over time, while the later operationalization in comparisons and assessments of Dernini *et al.*'s (2013) proposed indicators was less explicit.

NUTRITION AND HEALTH

Dernini *et al.* (2013) propose ten indicators for assessing the sustainability of the Mediterranean food consumption patterns for the thematic area of nutrition and health (see Table 1). Further indicators were proposed (see Table 2).

Different dietary regimens can be differentiated on the basis of their different food group choices. Interestingly, there is no traditional organic diet in the sense of special food-group choices such as

Table 2: Other proposed indicators for nutrition and health

B1	Food composition
B2	Food energy density
B3	Frugality
B4	Household food security
B5	Level of food processing
B6	Local food system and seasonality
B7	Mediterranean diet adherence
B8	Nutrient profile
B9	Organic and eco-friendly consumption
B10	Global Nutritional Index

Source: Dernini *et al.* (2013).

for a vegetarian, pescetarian, vegan, rawfood or macrobiotic diet. Accordingly, studies such as long-term or intervention studies are not possible from a prescription approach. However, there are many people buying and consuming organic products regularly, as the market growth in EU and elsewhere shows. Furthermore, scientific literature comprises representative nutrition, food and lifestyle studies for specific population groups. Hence the nutrition indicators suggested (A2–A10, sometimes also A1) can be applied to data from population studies, insofar as these studies have data on the consumption of organic products. Such stratification of population studies has been carried out for example in Germany (see below) and France (see Lairon and Kesse-Guyot, this volume). There is growing evidence from profiling organic consumers of significantly different dietary choices made by such groups, specifically more healthful choices. Furthermore, such data show better nutritional anthropometry measures and physical activity prevalence for organic consumers (Eisinger-Watzl *et al.*, 2015).

In Germany, two national nutrition surveys have been carried out: Nationale Verzehrsstudie (NVS) I (1985–1988) and NVS II (2005–2006). Data from the German National Nutrition Survey II on more than 13 000 men and women between the ages of 18 and 80 years were used to investigate organic food buyers and non-buyers, considering food intake, anthropometric measurements, nutrition behaviour, health and lifestyle aspects and socio-demographic parameters (Hoffmann and Spiller, 2010). Dietary patterns were examined by means of a healthy eating index (HEI-NVS). The index was developed within the study on the basis of the recommendations of the German Nutrition Society (DGE – *Deutsche Gesellschaft für Ernährung*). Organic food buyers showed more favourable food choices than non-buyers; a higher frequency of organic food buying was positively associated with a more favourable food choice. Furthermore, the consumption of organic food was positively associated with a more detailed nutrition knowledge and better nutritional and health behaviour for both sexes (Cordts *et al.,* 2013). When compared to non-buyers, organic food buyers are more often of normal weight (less often overweight or obese), non smoker, physically active, persons with good knowledge of nutrition and they more often classify their health status as very good or good. This characterisation reveals that organic food buyers adhere to a healthier lifestyle, including a healthier nutrition. (Wittig, Eisinger-Watzl and Hoffmann, 2011; Hoffmann and Spiller, 2010).

ECONOMY

Proposed indicators for the economic sphere by Dernini *et al.* (2013) comprise:
C1. Food consumer price index: cereals, fruit, vegetables, fish and meat
C2. Cost of living index related to food expenditures: cereals, fruit, vegetables, fish and meat
C3. Distribution of household expenditure per groups: food
C4. Food self-sufficiency: cereals, fruit and vegetables
C5. Intermediate consumption in the agriculture sector: nitrogen fertilizers
C6. Food losses and waste

Considering the organic food system and the proposed indicators, food self-sufficiency (C4) may be a useful indicator to measure the robustness of a national organic food system. At the same time, some more underlying issues can also be considered: (1) What type of food distribution system will deliver a sustainable diet? In much of the diet-led debate focus lies with the distance travelled by food, such as the 100-mile diet (Kemp *et al.,* 2010; Iles, 2005). An alternative approach is to consider distribution of food within a system by the degrees of separation between the producer and the consumer, not the distance. Analysis of organic markets shows that consumers accessing the organic food system tend to exhibit less degrees of distance to the primary producer (a shorter distribution chain) (Dimitri and Greene, 2000). (2) Considering the indicators food consumer price index (C1) and cost of living index related to food expenditures (C2) show a focus on foodstuffs. All issues concerning prices of foodstuffs are critical for and within the organic food system. Organic products are perceived and measured as more expensive than conventional products (Marian *et al.,* 2014; Lim, Yong and Suryadi, 2014). If the point of interest is the sustainability of the diet then the focus should move away from the price of food and more towards the price of diet. A question might instead be posed "Is the diet economically fair and affordable?" (not: "Is the food economically fair and affordable?"). During the development of the organic market over the last decades there was a time window when the food group availability of organic products and pricing across the full organic product portfolio resulted in a self-regulating system in support of more healthy dietary choices, i.e. organic meat products were premium priced and not as widely available as today; sweets and savoury snacks were few, not always of a good, acceptable quality and expensive per weight; fresh fruit and vegetables were plentiful and relatively fairly priced. (3) Typical economic indicators lose their meaning while ecosystem services are not monetized and external costs not internalized (Teufel *et al.*, 2014). Concerning the economy indicators proposed by Dernini *et al.* (2013), we discussed as missing indicators ecosystem services or external costs. Comparing food produced by a system that externalizes certain costs or does not price and include ecosystem services with food produced by a system that does, is rather like comparing apples and oranges.

SOCIETY AND CULTURE

Proposals for the dimension of society and culture encompass four indicators (Dernini *et al.*, 2013):
D1. Proportion of meals consumed outside home
D2. Proportion of already prepared meals
D3. Consumption of traditional products (e.g. proportion of product under Protected Designation of Origin (PDO) or similar recognized traditional foods)
D4. Proportion of mass media initiatives dedicated to the knowledge of food background cultural value

Preparing and cooking food is considered an expression of the importance allocated to food by people in their daily lives and in converse can be expressed by the proportion of already prepared meals (D2). It is unclear whether the already prepared meals take varying degrees of convenience into account, and/or the degree of processing, and whether eating out of home is excluded in D2 (it is included in D1). Though organic consumers self-report "very good" to "good" cooking skills (Li, Zepeda and Gould, 2006), the involvement of consumers in the preparation of food might be a challenge for the organic food system, because the organic product mix is growing especially in the (high) convenience and even in the ready-to-eat meal range.

An alternative indicator for the involvement of the consumer in the preparation of food, which offers potential use for policy formulation, is the degree of training in household skills in schools. Data can be generated from examination of curricula covering primary and secondary education. Indeed, education-linked measures such as food, health or nutrition literacy, and especially ecoliteracy, might offer some use here. Of these, ecoliteracy describes a capacity to think in terms of whole systems, to understand the principles of organization that ecosystems have developed to sustain the web of life (Semetsky, 2010; Capra, 2007). The United Nations Decade of Education for Sustainable Development (DESD) was created as "a way of signalling that education and learning lie at the heart of approaches to sustainable development", and states that "alongside positive spiritual motivations, education is our best chance of promoting and rooting the values and behaviours which sustainable development implies" (Hayward, Pannozzo and Colman, 2010).

CONCLUSION

This paper discusses the potential contributions from the organic food system to a sustainable diet, by addressing some socio-cultural, economic and medico-nutritive aspects. Within the field of nutrition and health, studies show that organic food buyers adhere to a healthier lifestyle, including a healthier nutrition. Observations from the organic food system within the dimension of economy suggest a diet focus, rather than a food focus, while observations within the society and culture area suggest that education may offer useful indicators. In a full assessment of the sustainability of any diet we cannot ignore the system in which the diet is embedded. Food that comes from a food-producing system that is in alignment with natural lifecycles should by extension give rise to a sustainable diet. Where it does not, we should be looking at the obstacles.

REFERENCES

Burlingame, B. & Dernini, S. 2011. Sustainable diets: the Mediterranean diet as an example. *Public Health Nutrition*, 14(12A): 2285–2287.

Capra, F. 2007. Sustainable living, ecological literacy, and the breath of life. *Canadian Journal of Environmental Education*, 12(1): 9–18.

Cordts, A., Wittig, F., Schulze, B., Eisinger-Watzl, M., Heuer, T., Spiller, A. & Hoffmann, I. 2013. A typology comparing male organic purchasers and male non-organic purchasers: Nutrition, health and buying behaviours. *Ernaehrungs Umschau international*, 60(3): 36–42. DOI 10.4455/eu.2013.009.

Counihan, C., ed. 2008. *Food and culture: a reader*. 2nd ed. New York, USA, Routledge. 608 p. ISBN: 978-0-415-97777-7; 978-0-415-97776-0; 0-415-97776-2; 0-415-97777-0.

DEFRA. 2009. Indicators for a sustainable food system. Report. London (available at http://www.defra.gov.uk/statistics/files/defra-stats-foodsystemindicators.pdf).

Dernini, S., Meybeck, A., Burlinghame, B., Gitz, V., Lacirignola, C., Debs, P., Capone, R. & El Bilali, H. 2013. Developing a methodological approach for assessing the sustainability of diets: The Mediterranean diet as a case study. *New Medit.*, 12(3): 28–37.

Dimitri, C. & Greene C. 2000. Recent growth patterns in the U.S. organic foods market. *Agriculture Information Bulletin*, Economic Research Service/USDA. AIB-777, pp. 1–21.

Eisinger-Watzl, M., Wittig, F., Heuer T. & Hoffmann, I. 2015. Customers purchasing organic food - do they live healthier? Results of the German National Nutrition Survey II. EJNFS, 5(1): 59–71 Article no.EJNFS.2015.003.

EC (European Union: European Commission). 2008. Communication from the Commission to the European Parliament, the council, the European Economic and Social Committee and the Committee of the Regions on the Sustainable Consumption and Production and Sustainable Industrial Policy Action Plan, Brussels, 16 July 2008. COM(2008) 397 final.

FAO/Bioversity. 2012. Sustainable diets and biodiversity, by B. Burlingame & S. Dernini, eds. Corporate authors: FAO, Rome, Bioversity International, Rome. 309 p. ISBN-13: 978-92-5-107288-2.

FAO/CIHEAM. 2012. *Towards the development of guidelines for improving the sustainability of diets and food consumption patterns in the Mediterranean area*. Rome.

Finney, S.L. 2014. Encouraging sustainable consumption: an exploration of consumer behaviour. *Marketing Review*, 14(2): 189–203.

FQH (Food Quality and Health Association). 2014. Workshop on Sustainable Nutrition/Sustainable Diets. 4–5 November 2013, Warsaw (available at http://www.fqhresearch.org/en/fqh-network/fqh-workshops-en.html).

Hayward, K., Pannozzo, L. & Colman, R. 2007. *Developing indicators for the educated populace domain of the Canadian index of wellbeing*. Background information. Literature Review Document 2 Parts IV – VI (OF VI) & appendices.

Hertwich, E. & Katzmayr, M. 2004. Examples of sustainable consumption: review, classification and analysis. *Reports from Industrial Ecology Programme* (IndEcol). ISSN 1501-6153.

Hirschfelder, G. 2005. *Europäische Esskultur: eine Geschichte der Ernährung von der Steinzeit bis heute.* Studienausgabe – Frankfurt, Campus-Verlag. 327 p. ISBN: 3-593-37937-6.

Hoffmann, I. & Spiller, A. 2010. *Data interpretation based on the German National Nutrition Survey II (NVS II): An integrative analysis of behavioural and lifestyle-related factors for organic food consumption*. Auswertung der Daten der Nationalen Verzehrsstudie II (NVS II): eine integrierte verhaltens- und lebensstilbasierte Analyse des Bio-Konsums. Max-Rubner-Institut, Institut für Ernährungsverhalten, Karlsruhe and Georg-August-University Göttingen (available at http://orgprints.org/18055/ full study report in German with English summary).

Iles, A. 2005. Learning in sustainable agriculture: food miles and missing objects. *Environmental Values*, 14(2): 163–183.

Kemp, K., Insch, A., Holdsworth, D.K. & Knight, J.G. 2010. Food miles: Do UK consumers actually care? *Food Policy*, 35(6): 504–513.

Li, J., Zepeda, L. & Gould, B.W. 2006. The demand for organic food in the US: an empirical assessment. *Journal of Food Distribution Research*, 38(3): 54–69.

Lim, W.M., Yong, J.L.S. & Suryadi, K. 2014. Consumers' perceived value and willingness to purchase organic food. *Journal of Global Marketing*, 27(5): 298–307.

Marian, L., Chrysochou, P., Krystallis, A. & Thøgersen, J. 2014. The role of price as a product attribute in the organic food context: an exploration based on actual purchase data. *Food Quality and Preference*, 37(10): 52–60.

Reisch, L., Eberle, U. & Lorek, S. 2013. Sustainable food consumption: an overview of contemporary issues and policies. S*ustainability: Science, Practice and Policy*, 9(2): 7–25.

Reitmeier, S. 2013. *Warum wir mögen, was wir essen: eine Studie zur Sozialisation der Ernährung*. Bielefeld. Transcript. 385 p. ISBN: 978-3-8376-2335-2.

Semetsky, I. 2010. Ecoliteracy and Dewey's educational philosophy: implications for future leaders. *Foresight,* 12(1): 31–44.

Seyfang, G. 2005. Shopping for sustainability: can sustainable consumption promote ecological citizenship? *Environmental Politics* 14(2): 290-306.

Teufel, J., Baron, Y., Droste, A., Fibich, K., Gattermann, M., Grießhammer, R., Rietdorf, C., Schoßig, M. & Wackerhagen, C. 2014. *Ist gutes Essen wirklich teuer? Hintergrundbericht zum Spendenprojekt "Ist gutes Essen wirklich teuer? ‚Versteckte Kosten' unserer Ernährung in Deutschland"* Öko-Institut, Freiburg, Working Paper 2/2014 Öko-Institut e.V. / Oeko-Institut e.V. Juli 2014 (available at www.oeko.de/workingpaper/spendenprojekt2012).

UNEP (United Nations Environment Programme). 2010. ABC OF SCP. *Clarifying concepts on sustainable consumption and production. Towards a 10-Year Framework of Programmes on Sustainable Consumption and Production*. Paris.

von Paczensky, G. & Dünnebier, A. 1999. *Kulturgeschichte des Essens*. ISBN 10 3 572 10047 X.

Wittig, F., Eisinger-Watzl, M. & Hoffmann, I. 2011. *Ernährungs- und Gesundheitsverhalten von Biokäufern*. [Nutritional and health behaviour of consumer of organic food.] Paper at: 11. Wissenschaftstagung Ökologischer Landbau, Gießen, 15–18 März 2011 (available at http://orgprints.org/17626/ short German paper with English summary).

Organic food systems – an agro-ecological perspective

Nicolas Lampkin
Agricultural Research Council
Director, Organic Research Centre, Newbury, United Kingdom

ABSTRACT

Agroecology is increasingly a focus of debate in the context of sustainable intensification and food security. But like sustainability the term has different meanings to different people, ranging from a purely academic ecology focus to the social movement approach of authors like Altieri. Organic food and farming, with its focus on certified, specialist markets and restricted inputs, is seen by some to be completely different, by others a true reflection of the agro-ecological approach. This paper considers the relationship between organic and agro-ecological principles, identifying areas of common ground and of difference. The replacement of synthetic nitrogen fertilizers and pesticides by biological nitrogen fixation with legumes and beneficial insects to control pests in a passive biological control approach is consistent with an agro-ecological perspective, while seeking alternative inputs to substitute prohibited ones in a "neo-conventional" approach may be less so. The role of regulated, certified production and its positive and negative impacts on these principles is examined, recognizing that certified production for specialist markets is important for the financial viability of many farms. The question of how the agro-ecological underpinning of organic farming can be better reflected in organic regulations in future is addressed. The key issue of how productive such systems are, and the implications for food security, is also addressed, with a focus on measuring system productivity in terms of net system output representing the benefit generated per ha in terms of human needs. Depending on context, organic systems underpinned by agro-ecological principles can be as or more productive than conventional alternatives.

Organic farming and agro-ecology have long co-existed as concepts but are often seen as different in nature, sometimes fundamentally so. But the common ground between the concepts is much greater than often realized, with differences perhaps more due to perceptions and misunderstandings than reality.

Unlike agro-ecology, organic farming is often defined in terms of prohibited practices or inputs that form the basis for certification systems or legal regulations. In 1980, the USDA report on Organic Agriculture defined organic farming as:

> *"a production system which avoids or largely excludes the use of synthetically compounded fertilisers; pesticides; growth regulators and livestock feed additives"*

to which we can now add genetically modified organisms. The USDA (1980) definition continues:

> *"Organic farming is a farming system relying on the following production practices: crop rotations with legumes, green manures, crop residues, animal manures, off-farm organic wastes, mineral-bearing rocks, mechanical cultivation and biological pest control to maintain soil productivity and tilth, to supply plant nutrients and to control insects, weeds and other pests."*

This early, but at the time widely used, definition does at least not just focus on the popular conception of organic farming as not using chemical inputs, highlighting also some of the practices used to replace them, but it says nothing about livestock management and more importantly does not address the question "Why?". What are the goals of organic farming?

From the literature it is clear that organic farming reflects concerns about:

- soil fertility, health, biological activity, erosion;
- water conservation and pollution;
- biodiversity conservation and enhancement;
- climate change and greenhouse gas emissions;
- use of fossil energy and other non-renewable resources;
- animal health and welfare;
- food quality, safety, security and sovereignty;
- social and economic costs, for workers, consumers, society and public health.

In short, organic farming is concerned with issues of:

- sustainability (economic, environmental, social);
- quality (of food and environment);
- health (of soil, plant, animals and people).

Although slightly differently focused, the International Federation of Organic Agriculture Movements' (IFOAM) principles of health, ecology, fairness and care emphasize these higher goals (IFOAM, 2005). Organic agriculture should:

1. sustain and enhance the health of soil, plant, animal, human and planet as one and indivisible (health);
2. be based on living ecological systems and cycles, work with them, emulate them and help sustain them (ecology);
3. build on relationships that ensure fairness with regard to the common environment and life opportunities (fairness);
4. be managed in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment (care).

Like sustainability, agro-ecology has several definitions. As an academic discipline, agro-ecology can be defined as the study of the ecology of agricultural systems. But it is more widely used in an applied sense to refer to the application of ecological knowledge and principles to the management of agricultural systems, or agro-ecosystem management (Altieri, 1995; Gliessmann, 2006). More recently, it has, like organic farming, become identified as a social movement, encompassing the whole food system including citizens and consumers:

- The integrative study of the ecology of the entire food systems, encompassing ecological, economic and social dimensions, or more simply the ecology of food systems (Francis *et al.,* 2003).
- Encourages farmers and extensionists to participate in the design of new systems, and also contribute to social movements – a link between a political vision (the movement), a technological application (the practices) to achieve the goals, and a way to produce the knowledge (the science) (Wezel *et al.,* 2009).

WHAT DOES ALL THIS MEAN IN PRACTICE?

From a farming perspective, the challenge is communicating these principles in a way that impacts directly on farming practice.

Is farming with zero inputs "by neglect" consistent with organic or agro-ecological principles? The answer is clearly "No!" as the principles of both require active management. Therefore there is a real question whether land that has been abandoned should qualify for organic certification because it has had no inputs.

Is it sufficient to replace "unacceptable" inputs with alternative "acceptable" ones, for example using poultry manures to replace nitrogen fertilizers, steam sterilization to control soil-borne pests and diseases, liquid fertilizers in protected cropping or synthetic amino acids in poultry feeds? Although in many (but not all) cases such substitutions are permitted under organic regulations, these "neo-conventional" substitutions do not really reflect organic or agro-ecological principles either.

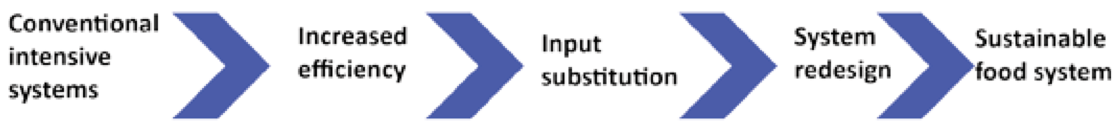
Or should we be attempting instead to solve the problem through agro-ecological redesign of systems? If we have a problem, the question is not what input can we use, but more how can we design the system to prevent the problem occurring in the first place. For example, using:

- plants such as legumes that fix nitrogen biologically, in symbiosis with bacteria, to build soil fertility;
- genetically diverse variety mixtures or composite cross-populations to promote resilience in the face of pest, disease or weather conditions (Wolfe *et al*., 2008);
- microbially rich soil amendments such as composts, or compost extracts, to modify rhizosphere or leaf surface ecology to suppress plant pathogens (e.g. Weltzien, 1991);
- non-crop plants to attract beneficial insects to assist with pest control (Wratten *et al*., 2012);
- polycultures including agroforestry systems to make better use of available resources including sunlight (Smith, Pearce and Wolfe, 2013);
- diversified rangeland to meet the nutritional requirements of poultry, in particular for key amino acids available from insects and larvae (Smith and Bauer, 2014);
- using diverse forages such as chicory and legumes to influence pasture ecology and reduce parasite pressures affecting livestock (Williams and Warren, 2004).

In short, agriculture is a biological system needing agro-ecological management solutions (eco-functional intensification) if we are really to address the environmental problems caused by overuse of non-renewable inputs. This requires diversity and complexity to deliver sustainable, stable, resilient and self-regulating systems. Multiple components (e.g. green manures, rotations) deliver multiple functions (e.g. crop nutrition, weed control) and vice versa. As Mollison (1990) puts it:

> *"The purpose of a functional and self-regulating design is to place elements or components in such a way that each serves the needs and accepts the products of other elements."*

The adoption of such organic/agro-ecological concepts can be thought of in terms of a development pathway from input-intensive industrial systems through to highly sustainable, ecological systems (Tittonell, 2014). This builds on the efficiency, substitution and redesign framework posited by Hill (1985) and MacRae e*t al*. (1989) among others.



This approach offers potential to enhance productivity, quality and sustainability. But a biological/ecological redesign focus is not enough on its own. Agriculture is a human activity system involving the complex of economic, social, cultural, ethical, legal, institutional, political and religious issues. The social context, including the relationships between producers, consumers and citizens, also matters.

Given the high degree of commonality of thought on how to achieve the best outcomes, why are there still perceptions that there are significant differences between organic and agro-ecological approaches?

It is always possible to identify differences in approach on individual farms. Agro-ecological practices are used by some organic producers, but not all organic producers use only these practices and some may not use any. There are examples of organic farms that fall well short of agro-ecological ideal, as highlighted by Guthman (2000) in California. There are also organic farms that are outstanding examples of agro-ecology in practice. Equally, not all agro-ecologists are (certifiably) organic, potentially using inputs not permitted under organic regulations.

One key contributor to this divergence between organic and agro-ecology may be the role of certification and the organic market. Organic standards help to translate principles into practice through definition of relevant practices and technologies. They enable markets to reward producers for adopting specific practices, ensuring financial viability of systems, while protecting consumers. But this can lead to a focus on inputs as easier to audit and communicate to consumers ("chemical-free") than outputs, especially societal benefits, welfare and ecosystem services. As the market grows, this requires legal underpinning leading to regulation, bureaucracy and institutionalization. This can lead to some organic producers getting caught in the "input substitution" trap (Tittonell, 2014). At worst, what should be a means to an end can become an end in itself, with the focus just on meeting standards, not delivering the broader goals identified above.

At the same time, agro-ecology also involves communication with citizens and consumers – should the process become formalized, the same challenges will be faced as in the organic. In particular, how can the complex concepts and multiple outputs of organic and agro-ecological approaches be communicated to the consumer, and also to supply chain businesses working with such products.

Organic and agro-ecology are not exclusive ideas, despite the efforts of some commentators to portray them as such. Agro-ecology should be a primary focus of best practice in organic farming and food systems. Are the perceived differences more ones of culture and the use of terms in different parts of the world? Should we be focusing more on our "common DNA" than on differences?

Certification can also have a positive role to play – agro-ecological systems need to be financially viable too. But standards and regulations need to be more focused on broader, agro-ecological goals, principles and outputs than on inputs – even if this does not coincide with consumer demands for "chemical-free" or "GMO-free" products. The emphasis on prohibiting GMOs, pesticides, etc. can detract from the main objectives and principles we are trying to deliver – particularly where a farmer who has a very well designed and managed system is affected by spray drift or adventitious GMO contamination from another farm.

Certification systems also need to be seen as a foundation to support agro-ecological innovation, not a ceiling to constrain it. Agriculture, and in particular an organic/agro-ecological approach, is knowledge, skills and information intensive. Should there be more emphasis placed on the teacher rather than the policeman role? Perhaps there are lessons to be learned from contrasting the permaculture movement's emphasis on permaculture design courses and the organic movement's focus on regulations and certification.

The agro-ecology concept has the potential to bring together many different ideas for agricultural change – the process must be an inclusive rather than an exclusive one where the shared interests of all concerned are recognized.

REFERENCES

Altieri, M.A. 1995. *Agroecology: the science of sustainable agriculture*. 2nd edition. Boulder, USA, Westview Press.

Francis, C., Lieblein, G., Gliessman, S., Breland, T.A., Creamer, N., Harwood, R., Salomonsson, L., Helenius, J., Rickerl, D., Salvador, R., Wiedenhoeft, M., Simmons, S., Allen, P., Altieri, M., Flora, C. & Poincelot, R. 2003. Agroecology: the ecology of food systems. *Journal of Sustainable Agriculture*, 22: 99–118.

Gliessmann, S.R. 2006. *Agroecology: the ecology of sustainable food systems*. 2nd edition. CRC Press.

Guthman, J. 2000. An agro-ecological assessment of grower practices in California. *Agriculture and Human Values*, 17: 257–266.

IFOAM (International Federation of Organic Agriculture Movements). 2005. *The principles of organic agriculture*. Bonn.

Hill, S.B. 1985. Redesigning the food system for sustainability. *Alternatives*, 12: 32–36.

MacRae, R.J., Hill, S.B., Henning, J. & Mehuys, G.R. 1989. Farm-scale agronomic and economic conversion from conventional to sustainable agriculture. *Advances in Agronomy*, 43: 155–198.

Mollison, W. 1990. *Permaculture: A practical guide for a sustainable future*. Island Press.

Smith, J., Pearce, B.D. & Wolfe M.S. 2013. Reconciling productivity with protection of the environment: Is temperate agroforestry the answer? *Renewable Agriculture and Food Systems*, 28(01): 80–92.

Smith, J. & Bauer, C. 2014. *Can the range contribute to the nutritional needs of organic pigs and poultry?* ICOPP Project Report. Newbury, UK, Organic Research Centre.

Tittonell, P. 2014. *Overview of the landscape of agroecology*. Paper presented at the International Symposium on Agroecology for Food Security and Nutrition, September 18–19, 2014. Rome, FAO.

USDA (United States Department of Agriculture). 1980. *Report and recommendations on organic farming.* Washington, DC.

Weltzien, H.C. 1991. Biocontrol of foliar fungal diseases with compost extracts. In *Microbial ecology of leaves.* Brock/Springer Series in Contemporary Bioscience, pp. 430–450.

Wezel, A., Bellon, S., Dor'e, T., Francis, C., Vallod, D. & David, C. 2009. Agroecology as a science, a movement and a practice. A review. *Agronomy for Sustainable Development*. doi: 10.1051/agro/2009004.

Williams, B. & Warren, J. 2004. Effects of spatial distribution on the decomposition of sheep faeces in different vegetation types. *Agriculture, Ecosystems and Environment*, 103: 237–243.

Wolfe, M.S., Baresel, J.P., Desclaux, D., Goldringer, I., Hoad, S., Kovacs, G., Löschenberger, F., Miedaner, T. & Østergård, H. 2008. Developments in breeding cereals for organic agriculture. *Euphytica*, 163(3): 323–346.

Wratten, S.D., Gillespie, M., Decourtye, A., Mader, E. & Desneux, N. 2012. Pollinator habitat enhancement: benefits to other ecosystem services. *Agriculture Ecosystems & Environment*, 159: 112–122.

Organic durum wheat in Mediterranean diet: old varieties and traditional bread making

Ivana Cavoski,[1] Jelena Turk[1] and Raffaella Di Cagno[2]
[1]CIHEAM-MAIB, Mediterranean Agronomic Institute of Bari, Valenzano, Bari, Italy
[2]Department of Soil, Plant and Food Science, University of Bari Aldo Moro, Bari, Italy

ABSTRACT

The Mediterranean diet continues to be recognized and appreciated as sustainable and culturally coherent all around the world, leading to constant increase in organic food production and consumption from this region, with consumers that are looking for food that they believe to be "natural", "healthy" and "traditional". Durum wheat is the basis of the Mediterranean diet, in the form of bread, pasta, couscous and bulgur. Bread made from durum wheat is deeply rooted into the Mediterranean diet and organic consumers tend to choose breads that are locally produced, hand-made and processed with natural ingredients. In recent years there has been a valorization of the old and local varieties of durum wheat particularly suitable for organic farming, accompanied by the application of biotechnological processes, such as traditional sourdough fermentation in bread making, being very appealing for consumers. Reasons can be found in its unique characteristics: yellowish colour, distinctive flavour and smell, uniform crumb structure and longer shelf life. Consumers expect organic food to be of high quality and produced in a sustainable context. Sourdough fermentation as a natural process may be considered as a promising bread making technology under organic food processing.

INTRODUCTION

Durum wheat (*Triticum turgidum* ssp. *durum*) is a selfing tetraploid cereal. Its history began with the domestication of wild emmer in the mountains of the Fertile Crescent around the tenth millennium BC. From this region, it spread into the Mediterranean basin, reaching the Iberian Peninsula around the seventh millennium BC (Feldman, 2001; MacKey, 2005). Nowadays, Mediterranean durum wheat landraces are expected to hold the largest genetic variability in the world for this species (Royo, Moragues and Moralejo, 2006). A landrace is '*a variety with a high capacity to tolerate biotic and abiotic stress, resulting in high yield stability under a low input agricultural system*' (Zeven, 1998). Organic agriculture requires crop varieties that can respond to the specific demands of this sector (i.e. high nitrogen use efficiency, competitiveness against weeds, resistance to biotic and abiotic stresses) as recently reviewed by Lammerts van Bueren *et al.* (2011). It is likely that the crossbreeding between old durum wheat genotypes and dwarf lines allowed some traits typical for old varieties to be maintained, such as wide adaptability and rusticity (Scarascia Mugnozza, 2005), which play a key role in the development of the cultivars suitable for organic farming.

Ancient Italian durum wheat varieties (up to year 1970) showed better technological performances than the modern ones when cultivated under organic farming (De Stefanis *et al.,* 2012). Among them, Senatore Cappelli is an ancient cultivar selected by Nazareno Strampelli from a late-maturing pure line, carefully chosen from the North African landrace Jean Retifah (Scarascia Mugnozza, 2005). It is characterized by wide adaptability to environmental conditions, good root development, dark colour of the awns, rusticity, high semolina quality (high level of protein, gluten and resistant starch) and high level of phytochemicals (dietary fibre, polyphenols, flavonoids and carotenoids) (Scarascia Mugnozza, 2005; Dinelli *et al.,* 2013).

Table 1: Beneficial effects of sourdough fermentation

Technological issues	Health properties
⇒ Improved bread texture	⇒ Antioxidant potential
⇒ A unique flavour and aroma	⇒ Antihypertensive effect
⇒ Delaying of firmness	⇒ Increasing mineral bioavability and vitamin content
⇒ Staling process of bread	⇒ Reduction of phytate content and postprandial glycemic index
⇒ Antifungal properties	⇒ Therapeutic alternatives for celiac disease
⇒ Antimicrobial properties	

The Mediterranean basin represents the most important durum wheat producing and importing region and the largest consumer of durum wheat products (Royo, Moragues and Moralejo, 2006). In the Mediterranean area organic wheat is mainly produced in Italy with a surface of 184 111 ha (Bioreport, 2012) followed by France, Spain and Turkey. Among organically produced wheat, durum wheat occupies 77 and 39 percent of the total surface in Italy and Spain, respectively. In Italy, Sicily and Apulia regions produce more than 40 percent of national production (Bioreport, 2012).

Besides products such as pasta, couscous and bulgur, durum wheat breads are very traditional for the Mediterranean region. Bread made from durum wheat, even though it produces a smaller loaf size, is very appealing for consumers because of its unique characteristics: yellowish colour, distinctive flavour and smell, uniform crumb structure and longer shelf life (Liu, Shepherd and Rathjen, 1996; Torbica, Hadnađev and Hadnađev, 2011). The oldest way of leavening bread in this region was sourdough fermentation, dated at around 1500 BC, based on mural Egyptian paintings (Goesaert *et al.*, 2005). Afterward, the sourdough bread spread to Europe, throughout ancient Greece and the Roman Empire.

Sourdough is a mixture made from water and flour that is later fermented by spontaneous lactic acid bacteria and yeasts. Sourdough is a unique food ecosystem and the distribution of the rate of microbiota is highly flexible from one sourdough ecosystem to another. In the Mediterranean area, many types of sourdough breads promote and protect names of quality agricultural products and foodstuffs (Minervini *et al.*, 2012).

Biodiversity of sourdough lactic acid bacteria differs in sourdoughs of different origins. Much research has been carried out on Greek, Italian and French sourdough. The complex sourdough microbial ecosystem is characterized by more than 50 species of lactic acid bacteria, mainly of the genus Lactobacillus and more than 20 species of yeasts, dominated by the genera *Saccharomyces* and Candida (De Vuyst and Neysens, 2005). Various factors affect sourdough microbiota and by that also the attributes of leavened baked goods: **endogenous factors**, which are type of flour (chemical, enzymatic and microbial composition of flour) and water used; **exogenous factors** representing specific process parameters (temperature, fermentation time, pH, dough yield and number of sourdough back-slopping) (Hammes and Gänzle, 1997; Minervini *et al.*, 2014); **external nutrients** (salt, milk, sugar) (De Vuyst and Neysens, 2005); **type of sourdough** and **geographical indicators** (Corsetti and Settanni, 2007). Traditional (spontaneous) sourdough fermentation is employed in small artisan bakeries and, in order to create a stable sourdough microbiota (mother dough), the continuous inoculation of dough has been sustained by bakeries for many years, of precious value due to their uniqueness (De Vuyst and Neysens, 2005). Recently, sourdough fermentation is becoming very important in the biotechnology of baking, because of many beneficial effects (Table 1).

Even though much research has focused on factors affecting sourdough and bread properties, still there is a gap in understanding their relationship to the production system, which was the main objective of our case study.

CASE STUDY

A field experiment was conducted at the Mediterranean Agronomic Institute of Bari (Apulia, South Italy), where durum wheat cultivar Senatore Cappelli was grown under different production systems. Three different organic production systems: O_{MAN} (cow manure and biopesticides), O_{LEG} (temperate intercropping with Fava bean and biopesticides) and NOinput (without inputs), were compared with a non-organic system – CON (chemical fertilizers and pesticides). The study was aimed to evaluate if different production systems leave a particular fingerprint on durum wheat along the axis *flour*, *sourdough* and *bread* (Rizzello *et al.,* 2015). Development of multidimensional evaluation tools was the main concern by application of systemic, non-targeted and holistic approaches like foodomics (Figure 1). Results are presented through the answers to several questions.

How do different production systems influence yield and flour quality?
As demonstrated in Figure 2, organic systems O_{MAN} and O_{LEG} performance in terms of yield compared with the CON was almost equal. The total amount of protein was slightly different, but the quality performance changed evidently among the systems. Results showed that the production systems had an influence on the amount and size distribution of polymeric proteins. This protein fraction is known to play the essential role for bread-making quality, which correlates with the presence or absence of specific proteins and protein subunits (Kuktaite, 2004). Organic fertility management is based on the application of inputs that contain a high range of amino acids, amino sugars and heterocyclic nitrogen compounds, the structure of which is more complex than in conventional fertilizers (Vrček *et al.*, 2014). Technologically, glutenins and gliadins are the most important wheat storage proteins. Each of them affects rheology in a unique way – dough viscosity and tensibility are affected by gliadins, whereas elasticity and dough strength by glutenins (Bushuk and Bekes, 2002). The two-dimensional electrophoresis analysis of the gliadin fractions demonstrated the large presence of these subunits in O_{MAN} and O_{LEG} and glutenins in No input organic systems. Aside from the protein quantity and structure, production systems influenced the content of phytochemicals, specifically phenolic acids. Syringic, p-coumaric, ferulic and sinapic acids in bound form were more present in organic treatments (O_{MAN} and O_{LEG}). Dinelli and coauthors (2009, 2013) underlined the unique nutraceutical value for Senatore Cappelli because of the peculiar content of bioactive phytochemicals.

Do production systems affect flour microbiota and subsequently the sourdough microbiota?
Compared with organic flours, the dough made with conventional flour showed a higher abundance of *Firmicutes*, and lower percentages of *Proteobacteria* and *Cyanobacteria*. The highest diversity among phylum *Firmicutes* was found in OLEG systems. It is stated that organic cropping systems were beneficial to bacteria from the phylum Proteobacteria in the soil (Li *et al.*, 2012; Chinnadurai, Gopalaswamy and Balachandar, 2013). Genera belonging to *Proteobacteria* (e.g. *Pantoea* and *Pseudomonas*) as well as the *Enterobacteriaceae* family and *Cyanobacteria* (e.g. *Chloroplast*) phyla were mainly identified. *Pseudomonas* and *Entobacteriaceae* family

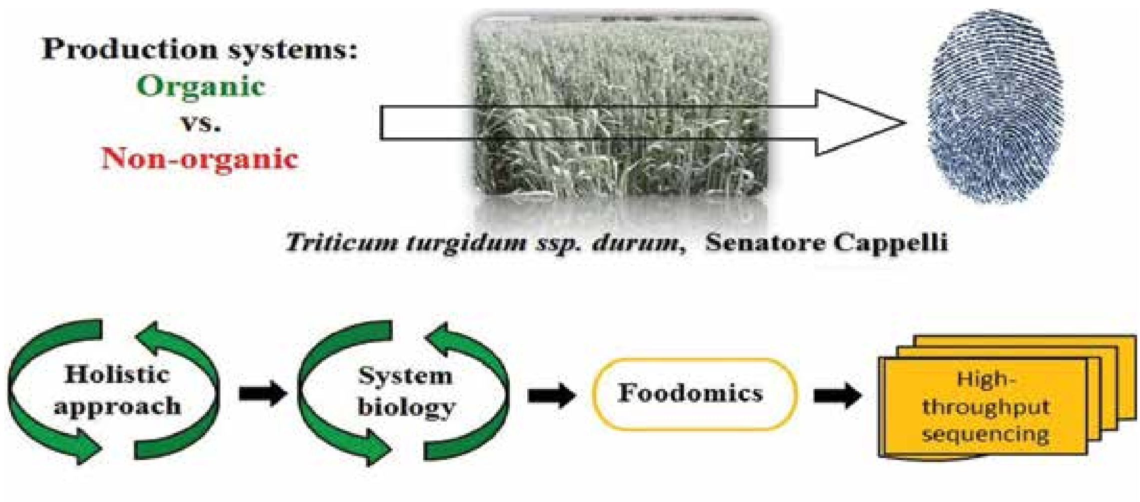


Figure 1: Study aims and new OMNIX approach

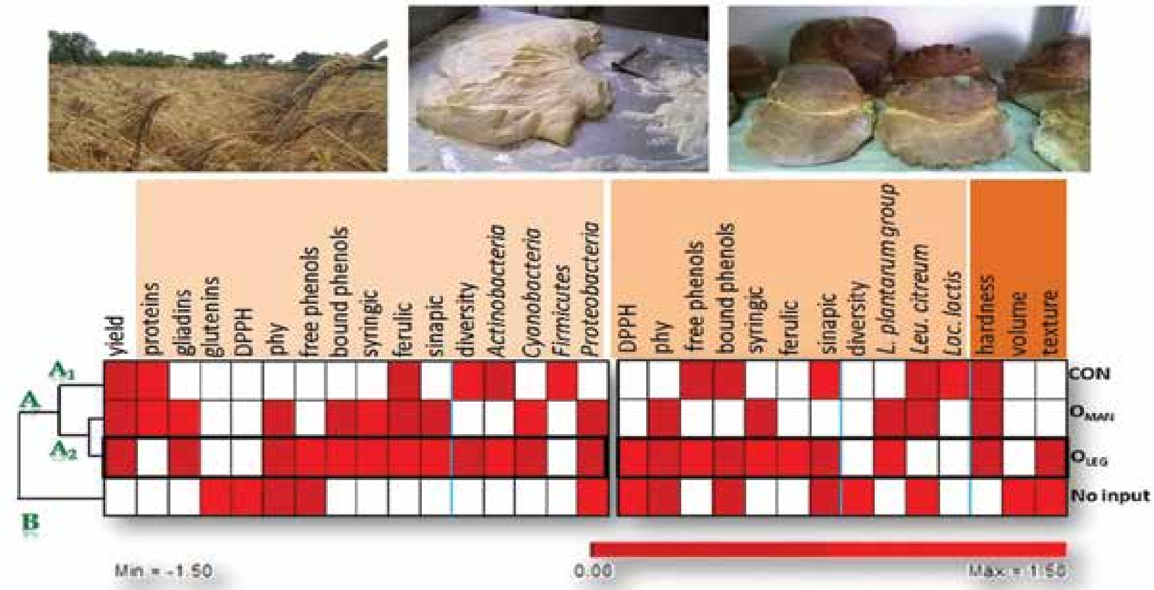


Figure 2: Heat map of differences in yield, proteins, gliadins, glutanins, antioxidant activity of flour and dough (DPPH), phytase activity of flour and doughs (Phy), free phenols and bound phenols in flour and doughs, bound phenolic acids (syringic, ferulic, sinapic) in flour and doughs, microbial diversity and hardness, volume and texture of bread

Note: The colour scale shows whether a chosen indicator is favoured or disfavoured by the system. Colours correspond to normalized mean data levels from low – white, to high – red.

were mostly represented for organic doughs. *Pseudomonas* genera are able to fix nitrogen, and consequently might help maintaining total N level in the organic farming soils (Suarez-Moreno *et al.*, 2012). In doughs, as shown by the pseudo heatmap, depicting bacterial diversity within *Firmicutes*, the highest diversity was found for all organic sourdoughs and especially for No INPUT. *Leuconostoc citreum* was the dominant species in CONV, O_{MAN} and No INPUT sourdoughs. This bacterium in the CONV sourdough was flanked by a high percentage of *Lactococcus lactis* and by a low level of *L. plantarum* group and *Lactobacillus brevis*. In fact, at species level, *Lactobacillus plantarum* group was the only one found in all doughs. Its remarkable ecological adaptability to different habitats being a highly heterogeneous and versatile species is well known (Pepe *et al.*, 2004). Sourdough fermentation increased the quantity of hydroxycinnamic acid derivatives (ferulic and sinapic acids) and reduced the quantity of hydroxybenzoic acid derivatives (vanillic and syringic). *Lactobacillus* strains are able to metabolize phenolic acids showing a strain-specific metabolism and generally corresponded to the resistance (Sanchez-Maldonado, Schieber and Ganzle, 2011). Correlation analysis between sourdough microbiota and biochemical properties underlined the importance of those strains for sourdough fermentation. The increased solubilization of phenolics might be related to the higher antioxidant activity. Reduced nitrogen availability associated with organic farming may enhance the concentration of secondary metabolites including free radical scavengers with high anti-oxidant activity (Straus *et al.*, 2012).

How do production systems and sourdough fermentation affect technological performance of bread?
Traditional sourdough fermentation was used for bread making and the visual appearance of bread in terms of texture, colour and volume was evaluated. Bread structure was influenced by the flour chemical and rheological characteristics related to the production systems. Bread made with conventional flour had a lower volume and higher hardness; oppositely a higher volume and lower hardeness was associated with the organic systems. Conventional flour produced stronger bread dough than organic flours, due to the stronger gluten in addition to extensibility/tenacity.

CONCLUSIONS

Organic food systems in the Mediterranean area are looking for a suitable wheat variety, having desirable agronomic and especially metabolic traits (e.g. nutrient-use efficiency and specific product quality). Therefore, understanding the functional links between production system variables and physiological responses is essential to improve and stabilize the productivity and quality of organic durum wheat production. Overall, in the case study presented, quality performance in the organic systems was more than outstanding. Nutritional (protein content and composition), functional (phenolic acids content) and technological features of organic flours were higher than the non-organic (conventional) one. The farming system is undoubtedly another determinant that affects the flour microbiota and, consequently, the dynamic of the sourdough microbial community and bread properties. Thus, organic cultivation of durum wheat affects flour, sourdough fermentation and bread properties, and could be considered as a suitable alternative for making sourdough breads with peculiar attributes. These findings highlight the integrated use of functional techniques (e.g. genomics and proteomics) that may allow understanding of *in situ* structure and function of wheat microbiota, which cannot be inferred by the exclusive use of genomic techniques, independently from the production system.

The organic food system may contribute to the sustainability of the Mediterranean diet and should be considered not only focusing on primary production level and environmental issues but as a food system that also integrates processing and consumption. The integrity and vital quality of the organic food should be preserved through all stages involved in the production chain. Sourdough fermentation as a natural process may be considered as a promising bread making technology under organic food processing.

REFERENCES

Bioreport. 2012. *Organic farming in Italy*. National Rural Network 2007–2013 (available at http://www.reterurale.it/flex/cm/pages/ServeBLOB.php/L/EN/IDPagina/10616).

Bushuk, W. & Bekes, F. 2002. Contribution of protein to flour quality. In A. Salgo, S. Tomoskozi R. Lasztity, eds. *Novel raw materials, technologies and products - new challenge for the quality control*, pp. 14–19. Budapest, Hungary, International Association for Cereal Science and Technology.

Chinnadurai, C., Gopalaswamy, G. & Balachandar, D. 2013. Impact of long-term organic and inorganic nutrient managements on the biological properties and eubacterial community diversity of the Indian semi-arid Alfisol. *Archives of Agronomy and Soil Science*, 60(4): 531–548.

Corsetti, A. & Settanni, L. 2007. Lactobacilli in sourdough fermentation. *Food Research International*, 40(5): 539–558.

De Stefanis, E., Sgrulletta, D., Pucciarmati, S. & Codianni, P. 2012. Effect of cultivar and nitrogen fertilizer on agronomic and quality traits of durum wheat under organic management. *Cereal Research Communications,* 40(3): 423–435.

De Vuyst, L. & Neysens, P. 2005. The sourdough microflora: biodiversity and metabolic interactions. *Trends in Food Science & Technology*, 16(1–3): 43–56.

Dinelli, G., Ilaria Marotti, I., Di Silvestro, R., Bosi, S., Bregola, V., Accorsi, M., Di Loreto, A., Benedettelli, S., Ghiselli, L. & Catizone, P. 2013. Agronomic, nutritional and nutraceutical aspects of durum wheat (Triticum durum Desf.) cultivars under low input agricultural management. *Italian Journal of Agronomy*, 8(12): 85–93.

Dinelli, G., Segura Carretero, A., Di Silvestro, R., Marotti, I., Fu, S., Benedettelli, S., Ghiselli, L. & Fernández Gutiérrez A. 2009. Determination of phenolic compounds in modern and old varieties of durum wheat using liquid chromatography coupled with time-of-flight mass spectrometry. *Journal of Chromatography A*, 1216(43): 7229–7240.

Feldman, M. 2001. Origin of cultivated wheat. In A.P. Bonjean & W.J. Angus, eds. *The world wheat book: a history of wheat breeding*, pp 3–58. Andover, England, Intercept Limited.

Goesaert, H., Brijs, K., Veraverbeke, W.S., Courtin, C.M., Gebruers, K. & Delcour J.A. 2005. Wheat flour constituents: how they impact bread quality, and how to impact their functionality. *Trends in Food Science & Technology*, 16(1–3): 12–30.

Hammes, W.P. & Gänzle, M.G. 1997. Sourdough breads and related products. In B.B. Wood, ed. *Microbiology of fermented foods*, pp. 199–216. Ames, USA, Blackwell Publishing.

Kuktaite, R. 2004. *Protein quality in wheat: changes in protein polymer composition during grain development and dough processing*. Swedish University of Agricultural Sciences, Alnarp. Doctoral thesis.

Lammerts van Bueren, E.T., Jones, S.S., Tamm, L., Murphy, K.M., Myers, J.R., Leifert, C. & Messmer M.M. 2011. The need to breed crop varieties suitable for organic farming, using wheat, tomato and broccoli as examples: A review. NJAS - *Wageningen Journal of Life Sciences*, 58(3-4): 193–205.

Li, R., Khafipour, E., Krause, D.O., Entz, M.H., De Kievit, T.R. & Fernando, W.G.D. 2012. Pyrosequencing reveals the influence of organic and conventional farming systems on bacterial communities. *PLoS One*, 7(12): e51897.

Liu, C.Y., Shepherd, K.W. & Rathjen, A.J. 1996. Improvement of durum wheat pastamaking and bread making. *Cereal Chemistry*, 73: 155–166.

MacKey, J. 2005. Wheat, its concept, evolution and taxonomy. In C. Royo, M. Nachit, N. Di Fonzo, J.L. Araus, W.H. Pfeiffer & G.A. Slafer, eds. *Durum wheat breeding: current approaches and future strategies*. Vol. I, pp. 3–62. New York, USA, Howorth Press.

Minervini, F., De Angelis, M., Di Cagno, R. & Gobbetti, M. 2014. Ecological parameters influencing microbial diversity and stability of traditional sourdough. *International Journal of Food Microbiology*, 171: 136–146.

Minervini, F., Di Cagno, R., Lattanzi, A., De Angelis, M., Antonielli, L., Cardinali, G., Cappelle, S. & Gobbetti M. 2012. Lactic acid bacterium and yeast microbiotas of 19 sourdoughs used for traditional/typical Italian breads: interactions between ingredients and microbial species diversity. *Applied and Environmental Microbiology,* 78(4): 1251–1264.

Pepe, O., Blaiotta, G., Anastasio, M., Moschetti, G., Ercolini, D. & Villani, F. 2004. Technological and molecular diversity of *Lactobacillus plantarum* strains isolated from naturally fermented sourdoughs. *Systematic and Applied Microbiology*, 27(4): 443–453.

Rizzello, C.G., Cavoski, I., Turk, J., Ercolini, D., Nionelli, L., Pontonio, E., De Angelis, M., De Filippis, F., Gobbetti, M. & Di Cagno, R. 2015. The organic cultivation of Triticum turgidum spp. durum reflects on the axis flour, sourdough fermentation and bread. *Applied and Environmental Microbiology*. doi:10.1128/AEM.04161-14.

Royo, C., Moragues, M., & Moralejo, M. 2006. Biodiversity among Mediterranean durum wheat landraces for the improvement of quality and adaptation. In J.L. Molina-Cano, P. Christou, A. Graner, K. Hammer, N. Jouve, B. Keller, J.M. Lasa, W. Powell, C. Royo, P. Shewry, & A.M. Stanca, eds. *Cereal science and technology for feeding ten billion people: genomics era and beyond*, pp. 39–42. Options Méditerranéennes: Série A. Séminaires Méditerranéens No. 81. Meeting of the Eucarpia Cereal Section, 2006/11/13-17, Lleida (Spain). Zaragoza: CIHEAM/ IRTA (available at http://om.ciheam.org/om/pdf/a81/00800799.pdf).

Sanchez-Maldonado, A. F., Schieber, A. & Gänzle, M. G. 2011. Structure-function relationships of the antibacterial activity of phenolic acids and their metabolism by lactic acid bacteria. *Journal of Applied Microbiology*, 111(5): 1176–1184.

Scarascia Mugnozza, G.T. 2005. The contribution of Italian wheat geneticists: from Nazareno Strampelli to Francesco D'Amato. *In* R. Tuberosa, R.L. Phillips, & M. Gale, eds. *In the wake of the double helix – from the green revolution to the gene revolution*. Bologna, Italy, Avenue Media.

Suarez-Moreno, Z.R., Caballero-Mellado, J., Coutinho, B.G., Mendonca-Previato, L., James, E.K. & Venturi, V. 2012. Common features of environmental and potentially beneficial plant-associated Burkholderia. *Microbial Ecology*, 63(2): 249–266.

Straus, S., Bavec, F., Turinek, M., Slatnar, A., Rozman, C. & Bavec, M. 2012. Nutritional value and economic feasibility of red beetroot (Beta vulgaris L. ssp. vulgaris Rote Kugel) from different production systems. *African Journal of Agricultural Research*, 7(42): 5653–5660.

Torbica, A., Hadnađev, M. & Hadnađev, D.T. 2011. Possibility of using durum wheat flour as an improvement agent in bread making process. *Procedia Food Science*, 1: 1628–1632.

Vrček, I.V., Čepo, D.V., Rašić, D., Peraica, M., Žuntar, I., Bojić, M., Mendaš, G. & Medić-Šarić, M. 2014. A comparison of the nutritional value and food safety of organically and conventionally produced wheat flours. *Food Chemistry*, 143: 522–529.

Zeven, A.C. 1998. Landraces: a review of definitions and classifications. *Euphytica*, 104(2): 127–139.

Organic food procurement in schools – iPOPY, a European case study

Anne-Kristin Løes
Bioforsk Norwegian Institute for Agricultural and Environmental Research, Organic Food and Farming Division, Tingvoll, Norway

ABSTRACT

iPOPY – innovative Public Organic food Procurement for Youth (2007–2010) – was a transnational market research study aimed at increasing the consumption of organic food in Europe. The project explored efficient strategies and policies for implementing organic food especially in school meals. The participating countries (Denmark, Finland, Germany, Italy and Norway) have highly variable conditions for school meals, ranging from complete, free meals to packed, private lunches. A significant proportion of organic food in school meals, up to 40 percent by weight, was found in Italy, whereas in the other countries the proportion was much lower. Strategies for increasing the share of organic food in school meals must be adapted to local conditions. Top-down measures such as public regulations and financial support are required along with bottom-up measures such as multiple embedding, e.g. by involving important stakeholders. "Captive catering" systems comprising all students, especially when serving complete meals, will maximize organic food consumption in schools provided organic food is available. Organic school food should be integrated in a broad health and environment perspective, as a "whole school approach". Linking school food consumption to food education offers a range of learning opportunities. Sustainability is on every curriculum, and organic food is well suited to discuss and experience sustainability in practice. Schools with a healthy food policy also tend to support organic food, and hence organic school policy promotes healthy eating.

BACKGROUND

The research project iPOPY (innovative Public Organic food Procurement for Youth) was funded by the CORE (Coordination of European Transnational Research in Organic Food and Farming Systems) Organic ERA net, with the aim of increasing the consumption of organic food in Europe. Five countries (Denmark, Finland, Germany, Italy and Norway) participated in the project, which lasted from 2007 to 2010. School meal systems in the participating countries, and to which extent organic food was included, were the most important study objects. Kindergartens, music festivals and the Norwegian military service were also assessed, based on former or parallel studies. Work packages were active across the study cases, and covered: policy analysis; supply chain management and certification; consumer perceptions, practices and learning; and nutrition and health. All deliverables from the project are available in the open archive Organic E-prints (www.orgprints.org), by searching for the keyword iPOPY.

In the context of how organic food production and food consumption may contribute to sustainable development and nutrition, iPOPY results and conclusions may be useful to guide future activities and supporting policies. Deliverables are available on different levels, from leaflets addressing different stakeholders, to peer-reviewed scientific journal papers. The project developed a system to compare school food systems and the extent to which these systems were supportive for consumption of organic food (Løes and Nölting, 2011). This simple system may be used also for food systems other than school meals.

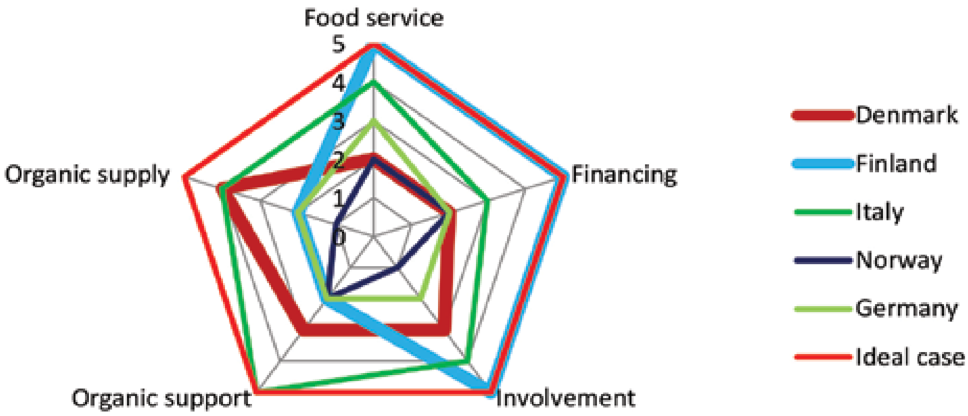


Figure 1: The potential for organic school food in Denmark, Finland, Germany, Italy and Norway, compared with an ideal case situation for a maximum consumption of organic food in schools.

WIDE VARIATION AMONG EUROPEAN SCHOOL FOOD SYSTEMS

For the assessment of school food systems and the implementation of organic food, five categories describe the main dimensions of variation (Løes and Nölting, 2011). Three categories are generally valid for any school food system: the type of school food service, if complete meals are offered or only single food items; the degree of public financing, if the public pay all costs or if the user payment is significant; and the degree of political and administrative involvement in school food procurement in general. Two additional categories are of special importance for the integration of organic food in school meals: the degree of specific support for organic school food, such as policies and regulations; and how well the supply of organic food adapted to school meals is developed. To maximize the consumption of organic food in schools, the school meals should be complete meals, served without user payment, well embedded in public regulations and nutritionally calculated, with a high share of organic ingredients, in a market with well developed supply chains for organic school catering. This ideal situation may be visualized in a radar diagram as a pentagon (Figure 1), serving as a base of comparison for the situation in each of the five countries studied in iPOPY. Finland and Italy have various patterns but, with their well-established school meals services, they are both in a leading position. Public demand for certified quality food for school meals has been a strong driver in Italy. In Finland, organic food is recognized as a means for more sustainable food consumption, and school meals are free for the users. In spite of a currently low organic share, the potential for organic school food should be significant in this country. Denmark has a well-developed organic market, and actors involved in school food service have often also combined this with a high interest in organic food. However, the traditional and well-established school meal is a packed lunch. This tradition is hard to change also in Norway, the country of origin of the sandwich lunch. The situation in Germany is rapidly changing as whole day schools become the normal practice.

MULTIPLE EMBEDDING IS REQUIRED

Policy interventions in the school food area have to tackle several issues concurrently: political support (symbolic policy), financial means, tender calls and contracts, quality standards, education, participation, etc. On the other side, such interventions have to address different actor groups very specifically. Hence, implementing organic food in existing school food aims and policies, including aims and policies for organic food purchase, is a complex task. Multiple embedding processes, on several levels and with various actors in parallel, are required. Policy measures and interventions need to be tailored for each specific school meal constellation. However, decision-makers and stakeholders should develop and establish standards and guidelines for the implementation of organic school food at national as well as at regional level. Stakeholders representing different parts of the organic school meal constellation should participate in this process.

Sufficient financial support for high-quality (organic) school meals has to be provided, such as in Italy and Finland. For a limited period, additional financial support for organic food is justified because of its positive complementary effects and because of its status as an infant industry. Initial support will foster the development of the potentially huge market of organic out-of-home catering in general, and of organic school meals specifically. School food systems vary from complete meals served by the public, such as in Finland and Italy, to sandwich-based lunches brought from home or bought nearby or in school kiosks such as in Norway and Denmark. The more formalized, politically prioritized and economically supported the school food systems are, the more embedded the systems will be in terms of pupils' participation, infrastructures such as canteen facilities, etc. On the other hand, top-down regulated systems may lose the civil embeddedness, and the pupils and parents may feel decoupled from the decisions (Kristensen, Hansen and Nielsen, 2010). However, in public catering contexts under severe cost discipline due to publicly funded free school meals, there are caterers who make initiatives to use organic and local food, to cooperate with and support food supply chains as they express professional identity for sustainability (Mikkola, 2009a). These caterers seem to exert social force for sustainability, while they need more support in terms of learning about the supply chains they attach to professionally; mediated dialog may enable such learning and systemic development (Mikkola, 2009b). Furthermore, caterers would need to understand more in-depth the role of organic agriculture in their professional work (Post and Mikkola, 2010; Risku-Norja and Mikkola, 2009).

In the less regulated systems of Norway and Denmark, there is a lack of regulatory embeddedness that gives the school food systems being tried/developed a hard time to survive because the structures are too weak. There is a lack of canteen facilities, economic support, etc. However, the involvement of the civil actors may be stronger in such cases, possibly due to this lack of regulatory embeddedness (Kristensen, Hansen and Nielsen, 2010).

ORGANIC IN ITALY DUE TO PUBLIC DEMAND

Italy has successfully improved the quality of school meals over the last decade. Actors from policy and public administration have placed emphasis especially on the quality of the products used; they should whenever possible come from controlled and certified production. Organic agriculture is the most important, but fair trade, local and special products are also prioritized. Regional laws and guidelines demand that school meals should be produced from high quality food, and this has resulted in a high consumption of organic food in Italian schools. On average, 40 percent (by weight) is organic (Spigarolo, Sarti and Giorgi, 2010). As the normal lunch during a whole-day school day in Italy is a warm meal, this constitutes a large volume of food, contributing to ranking Italy as number six on the list of top countries of organic consumption in Europe. Some 3 percent of the food and drinks consumed in Italy were certified organic by 2008; only Denmark (6.7 percent), Austria (5.3 percent), Switzerland (4.9 percent), Germany (3.4 percent) and Luxembourg (3.3 percent) had larger organic market shares (Willer and Kilcher, 2010). In spite of this remarkably high organic consumption, there is a need to develop and strengthen the organic supply chains, from the perspective of both producers and caterers. Carefully designed calls for tenders in the municipalities, being in charge of school food procurement, are a key instrument to influence the quality of school food. Best practice cases of municipal school food systems have managed to establish a good dialogue between supply chain actors and municipality stakeholders. Various stakeholders should be brought together to discuss their demands and increase the understanding between the different fields of school meal procurement, in order to serve tasty, organic meals (Kristensen *et al.*, 2009).

CATERING CERTIFICATION: CALL FOR HARMONIZATION

Certification is required to protect consumers' interest and maintain a high credibility in (premium priced) organic food. A European survey with responses from 17 countries showed that stakeholders involved in certification as well as stakeholders in close contact with catering practice were not very satisfied with the current situation that certification of mass catering is not harmonized in the European Union (EU). Hence, a harmonization would be welcomed (Lukas, Strassner and Løes, 2011). Various countries have developed highly different regulations and schemes to cope with certification of catering (Strassner, 2009; Strassner, Lukas and Løes, 2010). In countries where certification of mass catering is mandatory, such as in Norway and Germany, as well as in countries with advanced systems of labelling organic catering such as in Denmark and Finland, the certification process is found to be time consuming, but informative and useful to communicate an organic agenda (Strassner, Lukas and Løes, 2010). Italy, lacking a certification of mass catering, especially requests a harmonization of mass catering certification on the EU level. All stakeholders emphasize that harmonized relationships in this field should be flexible to adapt to the actual situation in the different countries.

ORGANIC = SUSTAINABILITY IN PRACTICE

The perceptions, preferences, practices and learning of young people related to procurement and consumption of organic food were also explored. Knowledge about the users and consumers is required for a successful implementation of organic food. In all countries, curricula were studied to reveal what the pupils learn about organic food and sustainability. Organic food is not explicitly included in the learning objectives in any national curricula, but sustainable development was included and thoroughly emphasized in all countries, commonly as a cross-cutting topic and linked with the importance of educating conscious and responsible citizens (Roos and Mikkola, 2010). Organic food is well suited as a topic in sustainability education, both due to the values these issues have in common and due to the practical, hands-on experience organic food education allows for, such as cooking, farm visits and school gardening. These activities offer involvement, authentic learning experiences and the use of different senses. Various educational materials and activities were available in the four countries in textbooks, leaflets and on the Internet, often offered by non-governmental organic associations. In Finland and Italy, where the school meals are a part of the education, one more arena is available where different issues related to food can be taught. Young people express positive perceptions of organic food in general, e.g. good for health and the environment, better taste; but ambivalence was related to increasing their consumption, e.g. high price, limited availability, questioning taste differences and evidence of organic being healthier and better for the environment (Roos and Mikkola, 2009; Roos, 2012). The more integrated organic food was in the school culture in general, the more positive the pupils' opinions were about organic food (Marley, 2008). When school food services are initiated from outside the school, the pupils may perceive that there is no link between this food and the positive impression they generally have about organic food. More should be done to embed organic food in a whole school approach (including curriculum, school policies, participatory and action-oriented educational approach and school meals). Food education for sustainable development will profit from integrating organic food, also because this implies a practice-based and experiential food education. Cultural factors need to be considered when planning education and learning processes. It is important to take into consideration that introducing organic food may cause ambivalence and resistance among consumers. Young people do not have settled perspectives on organic food, and will usually not be strong drivers for organic school food.

ORGANIC SCHOOL POLICY PROMOTES HEALTHY EATING

Unhealthy eating among children and adolescents is a growing problem causing obesity, diabetes and other nutrition-related disorders. As a result, there is a growing interest in using existing and emerging school food provision services in a more strategic manner – a development coined as a European "school food revolution" (Morgan and Sonnino, 2008). Many of these initiatives across Europe are driven by a wish to make the food more sustainable by integrating organic food supply. There is ample evidence that consumers in most cases perceive a link between organic food and individual health. Previous research from work-site eating settings has indicated that these two directions seem to go well together, and that green caterers serve healthier food than their non-green counterparts. The question is, does this hold for other settings such as schools? School food coordinators in all iPOPY countries plus Germany were asked about the "organicness" and general "healthiness" of their school food service, e.g. if the school had a food and nutrition policy, and a policy to serve organic food. In Denmark, a clear link was found between organic food supply strategies and generally healthier eating agendas in schools. Organic schools, aiming at including a certain share of organic food in the school food service, provide organizational environments that are more supportive for healthy eating than their non-organic counterparts (He and Mikkelsen, 2014). Pupils interviewed confirm that they make a close association between organic food and health (Andersen *et al*., 2010; Hansen, Laursen and Mikkelsen, 2009; Marley, 2008), but top-down initiated school food programmes struggle to become embedded in the school culture and pupils often see no link between the food offered there and what they learn about sustainable food production and consumption in their education. "Soft" interventions, such as the introduction of organic food, are too often a top-down approach. Without sufficient embedding of such initiatives among the users, the food service systems may suffer from a low degree of utilization.

This points back to the need for embedding school meals in a whole school approach where the pupils' and practitioners' everyday life-perspective is included. Then, organic school food strategies may be very supportive to promote healthy eating at school. School actors should think in terms of radical school food menu redesign when integrating organic food. Substitution of conventional products is not enough. A school food and nutrition policy should be developed, including positions on both healthy eating and organic food.

REFERENCES

Andersen, S., Burkal, A., Olsen, M.F. & Mikkelsen, B.E. 2010. Pupils' conception of organic foods and healthy eating in school. Qualitative insights from focus group interviews with 5th and 7th grade pupils in a Copenhagen elementary school. *Bioforsk Report*. Vol. 5 No. 37. 2010; iPOPY discussion paper 2/2010. Bioforsk Organic Food and Farming, Tingvoll, Norway.

Hansen, M., Laursen, R.P. & Mikkelsen, B.E. 2009. Design and pilot testing of a dietary assessment methodology for children at school. *Bioforsk Report*. Vol. 4 No. 150. iPOPY discussion paper 4/2009. Bioforsk Organic Food and Farming, Tingvoll, Norway.

He, C. & Mikkelsen, B.E. 2014. The association between organic school food policy and school food environment: results from an observational study in Danish schools. *Perspectives in Public Health*, 134: 110–116.

Kristensen, N.H., Hansen, M.W. & Nielsen, T. 2010. innovative Public Organic food Procurement for Youth (iPOPY). Lessons learned from implementing organic into European school meals – policy implications. In C. Strassner, A.-K. Løes, B. Nölting & N.H. Kristensen, eds. *Organic food for youth in public settings: potentials and challenges. Preliminary recommendations from a European study*. Proceedings of the iPOPY session held at BioFach Congress 2010. CORE Organic Project Series Report. ICROFS, CORE Organic Project Series Report, Tjele, Denmark.

Kristensen, N.H, Netterstrøm, S., He, C., Mikkelsen, B.E. & Nielsen, T. 2009. Making the organic food service chain work and survive. *Agronomy Research*, 7 (Special issue II): 618–624.

Lukas, M., Strassner, C. & Løes, A.-K. 2011. Certification of organic catering: a need for harmonization across Europe? *Ecology and Farming*, November: 30–32.

Løes, A-K. & Nölting, B. 2011. Increasing organic consumption by school meals – lessons learned in the iPOPY project. *Organic Agriculture*, 1: 91–110.

Marley, E.K. 2008 *Food for thought. Introducing organic food in Norwegian schools*. Master Thesis, Centre for Development and the Environment, University of Oslo, Norway.

Mikkola, M. 2009a. Shaping professional identity for sustainability: evidence in Finnish public catering. *Appetite*, 53(1): 56–65.

Mikkola, M. 2009b. Catering for sustainability: building a dialogue on organic milk. *Agronomy Research*, 7 (Special issue) (2): 668–676.

Morgan, K. & Sonnino, R. 2008. *The school food revolution. Public food and the challenge of sustainable development*. London, Earthscan.

Post, A. & Mikkola, M. 2012. Nordic stakeholders in catering for sustainability: chasm between ideology and practice? *British Food Journal*, 114(5): 743–761.

Risku-Norja, H. & Mikkola, M. 2009. Systemic sustainability characteristics of organic farming: a review. *Agronomy Research*, 7 (Special issue) (2): 728–736.

Roos, G. 2012. Organic food in the canteen: perceptions of organic food among cadets in Norwegian defence. In P. Lysaght, ed. *Time for food: everyday food and the changing meal habits in a global perspective*, pp. 321–329. Åbo, Finland, Åbo Akademi University Press.

Roos, G. & Mikkola, M. 2009. *The iPOPY project and how to communicate with the young generation*. 1st Nordic Organic Conference: Towards increased sustainability in the food supply chain, Gothenburg, Sweden, 18–20 May 2009, proceedings. pp. 55–57.

Roos, G. & Mikkola, M. 2010. Education about organic food and sustainability in Denmark, Finland, Italy and Norway. Findings from the iPOPY project. *Project Report*. No. 9 – 2010. Oslo, SIFO, National Institute for Consumer Research.

Spigarolo, R., Sarti, V. & Giorgi, G. 2010. Organic and conventional public food procurement for youth in Italy. *Bioforsk Report*. Vol. 5 No. 109/2010; iPOPY discussion paper 4/2010. Bioforsk Organic Food and Farming, Tingvoll, Norway.

Strassner, C. 2009. Certifying out of home operators in Europe. European Forum for Certification. Summary of a Forum held at the BioFach Congress 2009. *CORE Organic Project Series Report*. ICROFS, Tjele, Denmark.

Strassner, C., Lukas, M. & Løes, A.-K. 2010. Certification of public organic procurement in Denmark, Finland, Italy and Norway as compared to Germany. *Bioforsk Report*. Vol. 5 No. 103/ 2010; iPOPY discussion paper 5/2010. Bioforsk Organic Food and Farming, Tingvoll, Norway.

Willer, H. & Kilcher, L., eds. 2010. *The world of organic agriculture. Statistics and emerging trends 2010*. IFOAM, Bonn, and FiBL, Frick.

SECOND SESSION: NUTRITION INDICATORS TO ASSESS THE SUSTAINABILITY OF THE MEDITERRANEAN DIET AS A CASE STUDY

Introduction: a road map for the sustainability of the Mediterranean diet

Lluis Serra-Majem[1] and Sandro Dernini[2]
[1]Research Institute of Biomedical and Health Sciences (IUIBS), University of Las Palmas de Gran Canaria, Spain; International Mediterranean Diet Foundation, London, UK; Ciber Fisiopatología Obesidad y Nutrición (CIBEROBN, CB06/03), Instituto de Salud Carlos III, Madrid, Spain
[2]Department of Agriculture and Consumer Protection, FAO, Rome, Italy; International Mediterranean Diet Foundation, London, UK

ABSTRACT

Research has consistently shown that the Mediterranean diet (MD) plays a role in chronic disease prevention and in reduction of environmental dietary impacts. Unfortunately, current diets in Mediterranean countries are departing from the traditional MD, which is related to the homogenization of food behaviour in the modern era.

A road map for the Mediterranean diet from its origins and different approaches that have come to light during the last five or six decades is presented, moving from heart health as the main objective at the beginning, to its cultural approach with UNESCO recognition, and to the latest ecological concern as a sustainable diet model by looking to the future through current economic constraints.

BACKGROUND

The environmental consequences of food systems are on public health agendas. Foods are produced, processed, distributed and consumed, and these actions have consequences for both human health and the environment (Gussow and Clancy, 1986). Furthermore, food production is also inevitably a driver of environmental pressures, particularly in relation to climate change, water use and toxic emissions. Greenhouse gas (GHG) emissions, such as CO_2, CH_4 and N_2O, are responsible for global warming. Agriculture is one of the main contributors to the emissions of the last two gases mentioned while other parts of the food system contribute to CO_2 emissions due to the use of fossil fuels in processing, transportation, retailing, storage and preparation. Food items differ substantially in their environmental footprints, which can be measured, among many other descriptors, in terms of energy consumption, agriculture land use, water consumption or GHG emissions (Carlsson-Kanyama and González, 2009). Animal-based foods are by far the most land- and energy-intensive compared with foods of plant origin (Baroni *et al.*, 2007). Thus, dietary patterns can substantially vary in their resource consumption and the subsequent impact on the environment as well as on the health of a given population (Carlsson-Kanyama and González, 2009).

Research has consistently shown that certain dietary patterns, such as the Mediterranean diet (MD), play a role in chronic disease prevention (Sofi *et al.*, 2010). Moreover, the MD has been linked to higher nutrient adequacy in both observational and intervention studies (Serra-Majem *et al.*, 2009). Thus, the MD, as a plant-centred dietary pattern that does not exclude but admits moderate to low amounts of animal foods, seems to emerge as a dietary pattern that could address both health and environmental concerns (Duchin, 2005). The MD should be understood not only as a set of foods but also as a cultural model that involves the way foods are selected, produced, processed and distributed (Serra-Majem, 2010). The MD has been acknowledged by UNESCO as an Intangible Cultural Heritage of Humanity (Bach-Faig *et al.*, 2011).[1]

Unfortunately, current diets in Mediterranean countries are departing from the traditional MD insofar as the quantities and proportions of the food groups are concerned. This is due to the widespread dissemination of Western-type culture, along with the globalization of food production and consumption, which is related to the homogenization of food behaviour in the modern era (Da Silva *et al.*, 2009).

The aim of the present paper is to analyse the road map for the Mediterranean diet from its origins circa 1960, and to emphasize the different approaches that have come to light during the last five or six decades (Table 1).

THE BEGINNINGS: HEART HEALTH AS THE MAIN OBJECTIVE

Since its origins, when Ancel Keys initiated his studies on the Mediterranean diet, the principal disease outcome analysed was cardiovascular disease (CVD), and particularly coronary heart disease (Keys, 1986). Most of the research done was oriented to CVD risk factors and only at the end of the last century were large observational cohorts conducted to increase the evidence of the MD and CVD and other disease occurrence. Relevant prospective epidemiological studies and some clinical or community trials, such as the PREDIMED study (Martínez-González *et al.*, 2009), have exponentially been increasing the level and the quality of the evidence around the Mediterranean diet in the last decades. From the first systematic review of the evidence from the Mediterranean diet interventions conducted a few years ago, the Mediterranean diet showed favourable effects on lipoprotein levels, endothelium vasodilatation, insulin resistance, metabolic syndrome, antioxidant capacity, myocardial and cardiovascular mortality, and cancer incidence in obese patients and in those with previous myocardial infarction (Serra-Majem, Roman and Estruch, 2006).

From the second published systematic review, a meta-analysis by Sofi *et al.* in 2008, revisited in 2010 and 2013 (Sofi *et al.*, 2013) on the evidence of the relationship between the Mediterranean diet and health status yielded some interesting data: a two point increase in the adherence score (or 20 percent increase in MD adherence) was significantly associated with a 9 percent reduction in overall mortality; 10 percent reduction in cardiovascular disease mortality; 6 percent reduction in neoplasm incidence or mortality; and 13 percent reduction in incidence of Parkinson's disease and Alzheimer's disease in the general population.

Furthermore, the PREDIMED trial results pointed out that the Mediterranean diet, especially rich in extra-virgin olive oil, is associated with higher levels of plasma antioxidant capacity. The plasma total antioxidant capacity is related to a reduction in body weight after three years of intervention in a high cardiovascular risk population with a Mediterranean-style diet rich in extra-virgin olive oil. Moreover, further PREDIMED results suggested that there is no evidence to sustain the fear that Mediterranean food items rich in fats of vegetable origin (olive oil or tree nuts) may cause weight gain or be responsible for increased obesity risk, provided that the energy intake does not exceed energy expenditure. The Mediterranean diet has been associated in the PREDIMED study to a lower incidence of type II diabetes, both in the nut and the extra-virgin

Table 1: Steps in the pathway of addressing the Mediterranean diet

1950	Ancel and Margaret Keys. Way of living: food, health and culture.
1970	A medical diet to prevent diseases.
1990	A medical diet to treat diseases. Assessing the Mediterranean diet. Pyramids. Increasing and improving the evidence
2000–10	An anthropological view: culture. UNESCO.
2005–20	An economical view. Diet for all. Affordability.
2010–20	An environmental view: sustainability.
The road map	assessing sustainability. Malta, Bari, Barcelona, Rome, Las Palmas de Gran Canaria, Marseille, Milan (Expo 2015), etc. Worldwide coordination. New body: IFMED (International Foundation of Mediterranean Diet). Pyramid oriented to sustainability as well as to health and culture.

[1] http://www.unesco.org/culture/ich/en/RL/00394

olive oil groups (Salas-Salvadó *et al.*, 2014). And of note, its role in the primary prevention of CVD has finally been well demonstrated (Estruch *et al.*, 2013).

The Mediterranean diet, apart from its previously described traditional benefits (cardiovascular diseases, diabetes, cancer, etc), has other numerous health benefits that are currently fields of research such as immunity, allergic diseases, mental disorders such as depression or even quality of life.

THE CULTURAL APPROACH: UNESCO RECOGNITION

The Mediterranean diet is a cultural, historical, social, territorial and environmental heritage that's been transmitted from generation to generation for centuries, and is intimately linked to the lifestyles of the Mediterranean peoples throughout their history. A legacy passed on within a temporal and spatial constant flow, a living heritage encompassing unique and outstanding cultural spaces and promoting respect for cultural diversity and human creativity. It is an expression of sociability and communication between villages and individuals, a way to reinforce individuals' identities in their places of origin, an integrative element of communities with nature and history, a defence mechanism of agriculture and sustainable rural development and the landscape and environment of our territory.

Since 16 November 2010, the Mediterranean diet has been inscribed into UNESCO's Representative List of Intangible Cultural Heritage of Humanity.[2] The objective of this initiative was to safeguard the immense legacy representing the cultural value of the Mediterranean diet, as well as to share and disseminate its values and benefits internationally.

This process was conceived and had been germinating in civil society from the outset and had the privilege of counting on the involvement of national, regional and local institutions, receiving the unconditional support of the scientific community. Both aspects were fundamental and synchrony between all was decisive. It continued to enjoy the support and commitment of all the sectors that for many years had worked in favour of this Mediterranean heritage. Besides, after publicly expressing the wish to present the Mediterranean diet nomination to UNESCO, there was a genuine explosion of enthusiasm and support from institutions and all types of associations, thus consolidating the transversal nature of the project. This elation came to demonstrate that a close bond and genuine identification persisted between the Mediterranean society and its cultural and food heritage.

THE ECOLOGICAL CONCERN

As far as the environmental impact of the different food groups is concerned, in general most of the literature available, despite originating from different settings and types of analysis, converges in their global statements. Plant-based foods were the group that contributed least to the selected environmental footprint and, as expected, in the traditional MD meat and dairy presented lower figures for water consumption and to a lesser extent energy consumption compared with the current Mediterranean and Western patterns. Plant foods based on vegetables, cereals and legumes are noteworthy as the food group with the lowest GHG emissions even where processing and substantial transportation is involved (Carlsson-Kanyama and González, 2009). Legumes are clearly stated as alternatives to animal protein foods due to their low environmental impact and long durability (Carlsson-Kanyama and González, 2009).

The most relevant dietary distinctions in terms of environmental cost are those that occur between animal-based versus plant-based diets, with an important influence of the various ways foods are grown, processed and transported. The largest environmental impact of food production from the farm level to consumers is generally associated with primary production. In terms of energy consumption, differences in greenhouse production versus open-air cultivation of certain crops, and canned or frozen produce versus fresh produce are substantial (Reijnders and Soret, 2003). Besides

[2] http://www.unesco.org/culture/ich/en/RL/00394

the energy involved in agricultural production, the amount of energy used in household food storage, preparation and waste is not negligible (Carlsson-Kanyama and González, 2009).

Food policy and dietary guidelines need to develop and move on from the classical approach that only focuses on nutrients and health to one that takes into consideration environmental impact and sustainability. Consumers are becoming more and more concerned about the environment and, even more so, about their personal health and food choices, while cultural culinary traditions are not easy to modify. Some studies state that even radical changes in food consumption patterns would provoke quite small environmental benefits (Tukker, 2011; Wallén, Brandt and Wennersten, 2004). Significantly reducing environmental footprints through a shift from the current non-MD in most European Mediterranean countries towards a MD type would probably not only require substantial changes in consumers' food choices but also require significant modifications in agrofood-industry practices, public catering supply and agricultural and trade policies (Duchin, 2005; Wallén, Brandt and Wennersten, 2004). As for the major producers and exporters of typical Mediterranean products, it would make sense to maintain a MD agricultural production model in Mediterranean countries.

A shift from the current Spanish pattern towards the Mediterranean dietary pattern would be beneficial from both a health and environmental perspective. The Mediterranean dietary pattern presents lower footprints than the current Spanish pattern, and to a much larger extent than the Western dietary pattern. The Mediterranean dietary pattern results in a lower environmental impact due to the consumption of more plant-derived products and less animal products. The Mediterranean dietary pattern is presented as not only a cultural model but also as a healthy and environmentally friendly model (Burlingame and Dernini, 2011). Its adherence in Spain would make a significant contribution to greater sustainability of food production and consumption, in addition to the well-known benefits for public health (Saez-Almendros *et al.*, 2013).

A LOOK TO THE FUTURE: ECONOMIC CONSTRAINTS

Nutrition has many issues to face at a global level. The rise of obesity has been a rapidly growing problem with severe long-term consequences and in fact has dominated the nutrition scenario in higher-income countries, where lower-income populations tend to be more at risk for excess body weight. The economic constraints that these countries are facing, after decades of wealth and development, seem to have paradoxically increased these figures of overweight and obesity, which are linked with poor nutrition. This is due to the reduced access to a balanced diet, the loss of traditional diets, such as the Mediterranean diet, and/or lower access to physical activity. The erosion that can result from economic threats must be countered with actions based on nutrition education, along with the commitment that neither cost nor unfounded food choices should constitute a barrier to the availability of basic foods of the Mediterranean diet: olive oil, fruits, vegetables, grains, legumes, dairy, nuts or fish. Governments thus need to commit themselves to undertake appropriate actions that preserve our traditional and cultural knowledge, and lead to the diversity of foods and diets but not only for the health benefits that could be provided in the short and long term. The recognition by UNESCO, with the consequent increased visibility and acceptance of the Mediterranean diet around the world, along with better and more scientific evidence regarding its benefits and effectiveness on longevity, quality of life and disease prevention, make this dietary pattern experience an unprecedented historical moment. This is a favourable situation that could possibly enable the strengthening of the Mediterranean diet around the world, translating into improvements in global health indicators and in a reduction of environment impact by production and transportation of food resources. To this end, the Mediterranean diet should be seen for what it is: an extremely healthy and environmentally sustainable food model, as well as an ancient cultural heritage that confers identity and belonging.

In order to ascertain the sustainability of the Mediterranean Diet, several needs are outlined:

- Need to combine ECOLOGICAL (national/regional) and INDIVIDUAL indicators, reflecting governmental and individual concerns.

- Need to harmonize health, nutritional, environmental, economic, geographical and urban/rural indicators to assess the sustainability of the Mediterranean diet.
- Need for a global approach and a common road.

REFERENCES

Bach-Faig, A., Berry, E.M., Lairon, D., Reguant, J., Trichopoulou, A., Dernini, S., Medina, F.X., Battino, M., Belahsen, R., Miranda, G. & Serra-Majem, L. 2011. Mediterranean Diet Foundation Expert Group. Mediterranean diet pyramid today. Science and cultural updates. *Public Health Nutr*., 14(12A): 2274–2284.

Baroni, L., Cenci, L., Tettamanti, M. & Berati, M. 2007. Evaluating the environmental impact of various dietary patterns combined with different food production systems. *Eur. J. Clin. Nutr.*, 61: 279–286.

Burlingame, B. & Dernini, S. 2011. Sustainable diets: the Mediterranean diet as an example. *Public Health Nutr.,* 14(12A): 2285–2287.

Carlsson-Kanyama, A. & González, A.D. 2009. Potential contributions of food consumption patterns to climate change. *Am. J. Clin. Nutr.,* 89 (Suppl): 1704S–1709S.

Da Silva, R., Bach-Faig, A., Raidó Quintana, B., Buckland, G., Vaz de Almeida, M.D. & Serra-Majem, L. 2009. Worldwide variation of adherence to the Mediterranean diet, in 1961-1965 and 2000-2003. *Public Health Nutr.,* 12: 1676–1684.

Duchin, F. 2005. Sustainable consumption of food: a framework for analyzing scenarios about changes in diets. *Journal of Industrial Ecology*, 9: 99–114.

Estruch, R., Ros, E., Salas-Salvadó, J., Covas, M.I., Corella, D., Arós, F., Gómez-Gracia, E., Ruiz-Gutiérrez, V., Fiol, M., Lapetra, J., Lamuela-Raventos, R.M., Serra-Majem, L., Pintó, X., Basora, J., Muñoz, M.A., Sorlí, J.V., Martínez, J.A. & Martínez-González, M.A.; the PREDIMED Study Investigators. 2013. Primary prevention of cardiovascular disease with a Mediterranean diet. *N. Engl. J. Med*, 368(14): 1279-1290.

Gussow, J.D. & Clancy, K.L. 1986. Dietary guidelines for sustainability. *J. Nutr. Educ.,* 18: 1–5.

Keys, A., Menotti, A. & Karoven, M.I. 1986. The diet and the 15-year death rate in the Seven Countries Study. *Am. J. Epidemiol,* 124: 903–915.

Martínez-González, M.A., Bes-Rastrollo, M., Serra-Majem, L., Lairon, D., Estruch, R. & Trichopoulou, A. 2009. Mediterranean food pattern and the primary prevention of chronic disease: recent developments. *Nutr. Rev*, 67: S111–S116.

Reijnders, L. & Soret, S. 2003. Quantification of the environmental impact of different dietary protein choices. Am. *J. Clin. Nutr.*, 78(Suppl 3): 664S–668S.

Sáez-Almendros, S., Obrador, B., Bach-Faig, A. & Serra-Majem, L. 2013. Environmental footprints of Mediterranean versus Western dietary patterns: beyond the health benefits of the Mediterranean diet. *Environ. Health*, 12:118. doi: 10.1186/1476-069X-12-118.

Salas-Salvadó, J., Bulló, M., Estruch, R., Ros, E., Covas, M.I., Ibarrola-Jurado, N., Corella, D., Arós, F., Gómez-Gracia, E., Ruiz-Gutiérrez, V., Romaguera, D., Lapetra, J., Lamuela-Raventós, R.M., Serra-Majem, L., Pintó, X., Basora, J., Muñoz, M.A., Sorlí, J.V., Martínez-González, M.A. 2014. Prevention of diabetes with Mediterranean diets: a subgroup analysis of a randomized trial. *Ann. Intern Med*., 160(1): 1–10.

Serra-Majem, L. 2010. Nutrición comunitaria y sostenibilidad: concepto y evidencias. *Rev. Esp. Nutr. Comunitaria,* 16: 35–40.

Serra-Majem, L., Bes-Rastrollo, M., Román, B., Pfrimer, K., Sánchez-Villegas, A. & Martínez-González, M.A. 2009. Dietary patterns and nutritional adequacy in a Mediterranean country. *Br. J. Nutr.*, 101 (Suppl 2): S21–S28.

Serra-Majem, L., Roman, B. & Estruch, R. 2006. Scientific evidence of interventions using the Mediterranean diet: a systematic review. *Nutr Rev*, 64(2 Pt 2): S27–47.

Sofi, F., Abbate, R., Gensini, G.F. & Casini, A. 2010. Accruing evidence on benefits of adherence to the Mediterranean diet on health: an updated systematic review and meta-analysis. *Am. J. Clin. Nutr*., 92: 1189–1196.

Sofi, F., Macchi, C., Abbate, R., Gensini, G.F. & Casini, A. 2014. Mediterranean diet and health status: an updated meta-analysis and a proposal for a literature-based adherence score. *Public Health Nutr*., 17 (12): 2769–2782. Epub 29 November 2013.

Tukker, A., Goldbohm, R.A., De Koning, A., Verheijden, M., Kleijn, R., Wolf, O., Pérez-Domínguez, I. & Rueda-Cantuche, J.M. 2011. Environmental impacts of changes to healthier diets in Europe. *Ecological Economics*, 70: 1776–1788.

Wallén, A., Brandt, N. & Wennersten, R. 2004. Does the Swedish consumer's choice of food influence greenhouse gas emissions? *Environ. Sci. Policy*, 7: 525–535.

Presentation of a draft of a background document on nutrition indicators to assess the sustainability of the Mediterranean diet, and building a composite index for sustainability

Denis Lairon[1] *and Elliot M. Berry*[2]
[1]*Emeritus Research Director at INSERM, Aix-Marseille Université, Joint Research Unit NORT, Human Nutrition; Inserm, UMR-1062; Inra, UMR-1260, Marseille, France*
[2]*Department of Human Nutrition and Metabolism, Braun School of Public Health, Hebrew University-Hadassah Medical School, Jerusalem, Israel*

ABSTRACT

This session dealt with the methodology involved in choosing indicators for each of the four dimensions of sustainable diets – nutrition, environment (agro-ecology), economy and socio-cultural. The process was outlined whereby a composite index could be built to enable policy-makers to determine the challenges associated with sustainable diets in their country/region. Emphasis was given to the Mediterranean diet as a case study for such a process.

INTRODUCTION

A global definition of sustainable diets was proposed during an FAO international symposium on biodiversity and sustainable diets united against hunger held in 2010 in Rome (FAO, 2012). This definition states: "Sustainable diets are those diets with low environmental impact which contribute to food and nutrition security and to a healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable, nutritionally adequate, safe and healthy, while optimizing natural and human resources." This suggests that any change to improve the sustainability of food systems should involve steps based on key words present in the above definition.

On the other hand, the traditional Mediterranean diet pattern deserves important cultural and scientific attention. This has resulted in registration in the intangible human heritage by UNESCO in 2010 of the traditional Mediterranean diet.

During the last decade, new and impressive scientific studies have been performed in numerous countries and published, establishing the protective effect of an important adherence to a traditional Mediterranean diet pattern against obesity and most non-communicable diseases. In that line, an international expert consultation elaborated the proposal of an updated Mediterranean diet pyramid for today (Baich-Faig *et al.*, 2011) to counteract the progressive erosion of adherence to the Mediterranean diet. This was based on the traditional Mediterranean diet pattern and recent scientific literature, together with new aspects such as biodiversity, seasonality of foods, traditional and local foods and eco-friendly products as well as culinary activities.

Considering the important and evident connections between these two developments, discussions have been specifically conducted by international experts on the sustainability of the

Mediterranean diet. These were initiated in 2010 and continued in 2011 and 2012 during meetings, with collaboration between FAO and CIHEAM-MAI Bari (Burlingame and Dernini, 2011).

Indeed, while the traditional Mediterranean agro-diet system was in the past a fully environment-integrated system, the modern developments in the Mediterranean area have led to rather unsustainable food systems based on high energy, water, chemical fertilizer and pesticide use, associated with soil erosion, biodiversity loss, pollution, increased greenhouse gas emissions and social problems.

To achieve such an evaluation of the sustainability of the Mediterranean agro-diet system, a strategy has been developed to elaborate a list of indicators. To that aim, a methodological framework has been elaborated (Dernini *et al.*, 2013) and we first identified four priority areas for assessing sustainability of diets, in line with the sustainability concept:

a) nutrition and health;
b) environment;
c) economy;
d) socio-cultural factors.

For these four key areas, it was then necessary to identify and define specific indicators. It should be remembered that according to FAO (2005), an indicator generally comprises elements (a cut-off value, a frame of reference, a mode of expression, etc.) that allow a relatively universal appreciation of the information it supplies and also facilitate comparison in time and space.

- In 2011, a first list of 74 potential sustainability indicators in the four areas was compiled (Draft document, Annex 1).
- In 2012, by further considering limitations (including limited available data resources, manageability, workload), a reduced list of 24 key indicators in the four areas was raised (Draft document, Table 1). This list is reproduced below:

A. Nutrition and health
A1. Diet-related morbidity/mortality
A2. Fruit and vegetable consumption/intake
A3. Vegetable/animal protein consumption ratio
A4. Dietary energy supply/intakes
A5. Dietary diversity score
A6. Dietary energy density score
A7. Nutrient density/quality score
A8. Food biodiversity composition and consumption
A9. Nutritional anthropometry
A10. Physical activity prevalence

B. Environment
B1. Water footprint
B2. Carbon footprint
B3. Nitrogen footprint
B4. Biodiversity

C. Economy
C1. Food consumer price index (FCPI): cereals, fruit, vegetables, fish and meat
C2. Cost of living index (COLI) related to food expenditures: cereals, fruit, vegetables, fish and meat
C3. Distribution of household expenditure per groups: food
C4. Food self-sufficiency: cereals, fruit and vegetables
C5. Intermediate consumption in the agricultural sector: nitrogen fertilizers
C6. Food losses and waste

D. Society and culture

D1. Proportion of meals consumed outside home

D2. Proportion of already prepared meals

D3. Consumption of traditional products (e.g. proportion of product under PDO or similar recognized traditional foods)

D4. Proportion of mass media initiatives dedicated to the knowledge of food background cultural value.

- To optimally cover the nutrition area, in addition to the nutrition and health indicators list, a second list of indicators for nutrition was extracted from the initial large list and was more recently brought into discussion (Draft document, Table 2) as reproduced below, with the additional purpose of expecting to integrate some of them (italicized) considered of great importance:
  – B1 Food composition
  – B2 Food energy density
  – B3 Frugality
  – B4 *Household food security*
  – B5 Level of food processing
  – B6 *Local food system and seasonality*
  – B7 Mediterranean diet adherence
  – B8 Nutrient profile
  – B9 *Organic and eco-friendly consumption*
  – B10 Global nutritional index

The next part of this session of the seminar is thus dedicated to discuss again on the definition draft elaborated for each indicator of the nutrition and health area.

While it is necessary to individually define each indicator to be able to further use it during studies, one should keep in mind that most of them are in interaction with each other. For example, it has recently been shown that the nutrient adequacy or the cost of a daily diet is negatively associated with its energy density, and that the daily food selection is associated with variable impacts on food weight, energy density intake, cost and greenhouse gas emissions.

This clearly illustrates the need to elaborate a final global frame including all these indicators of the four areas and their combinations.

Indeed, the methodological framework (Dernini *et al*., 2013) identified as further steps, after identification of appropriate indicators for the four priority areas, the following:

- select one or more Mediterranean countries where to test and further refine this methodological approach;
- identify food groups and serving sizes in the selected countries;
- assess current food consumption patterns in selected Mediterranean countries;
- assess their adherence to the revised Mediterranean diet pyramid (Baich-Faig *et al*., 2011);
- calculate a value/score using the data gathered for each indicator;
- combine all scores into a scale and analyse trends over relevant time series;
- assess from this set of indicators/scores the relationship between current dietary patterns, adherence to the Mediterranean diet pattern and the sustainability of food consumption at country level.

BUILDING A COMPOSITE INDEX FOR SUSTAINABILITY

The following section deals with the practical aspects involved in building a composite index. As discussed above, four dimensions have been identified for sustainability – nutrition and health, environment including agro-ecology, economy and society-culture. It is suggested that the next step in the process of dealing with the sustainability of the Mediterranean diet is to organize them into a composite index to enable quantifying sustainability and to use it to follow progress over time. The methodology has been established as a two stage approach to determine first *within* each

Table 1: Examples of physical activities, physiologic pathways and health outcomes[a]

1.	Relevant: to the needs of potential users
2.	Valid: is the best scientific indicator currently available to answer the question
3.	Data that are accurate, accessible, available over time and responsive to change
4.	Understandable and easy to interpret
5.	Comparable: with indicators developed in other countries and visually graphic
6.	Cost-effective: for repeated measures and time trends

Source: after Watson *et al.*, (2010).

dimension the relative weightings of the indicators selected and then the weightings *between* each dimension to enable building a composite index which can be easily disaggregated (OECD, 2008).

The choice of the indicators is indeed a compromise between what is desirable and what is practical and available in which countries. Table 1 summarizes some of the principal considerations governing the suitability of the indicators to be used in an index.

The within dimension analysis may be performed by principal component analysis while the between dimension weightings will depend on circumstances and the priorities for which the index is constructed. This does not mean that each of the four dimensions will automatically have a weighting of 25 percent. Figures 1 and 2 describe this process.

It should be emphasized that the methodology allows for a certain degree of flexibility in that indicators may be added as they become available and incorporated in the index. Thus, for the sustainability of diets in general the four dimensions are sufficient. If the Mediterranean diet is being considered specifically, then extra indicators will have to be added that take into account specifically its adherence. These and other points have been discussed recently concerning the connection between food security and sustainability (Berry *et al.*, 2015) and the Mediterranean diet (Dernini and Berry, 2015).

FUTURE WORK

The hope is that we now will be able to progress from our detailed discussions, which have been on-going for many years, to a practical demonstration of their usefulness. This will require building a country-based databank of the indicators we have identified, preferably with a time series. These may be collected from existing large organizations such as FAO, WHO and the OECD that have

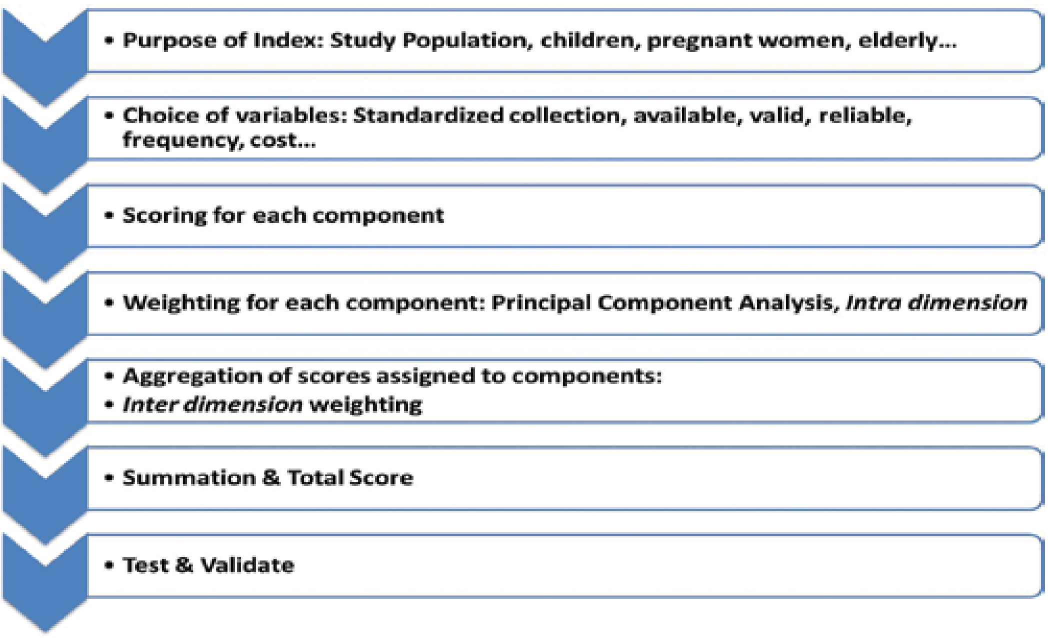


Figure 1: Methodology for the development of a composite index
Source: after Kourlaba and Panagiotakos (2009).

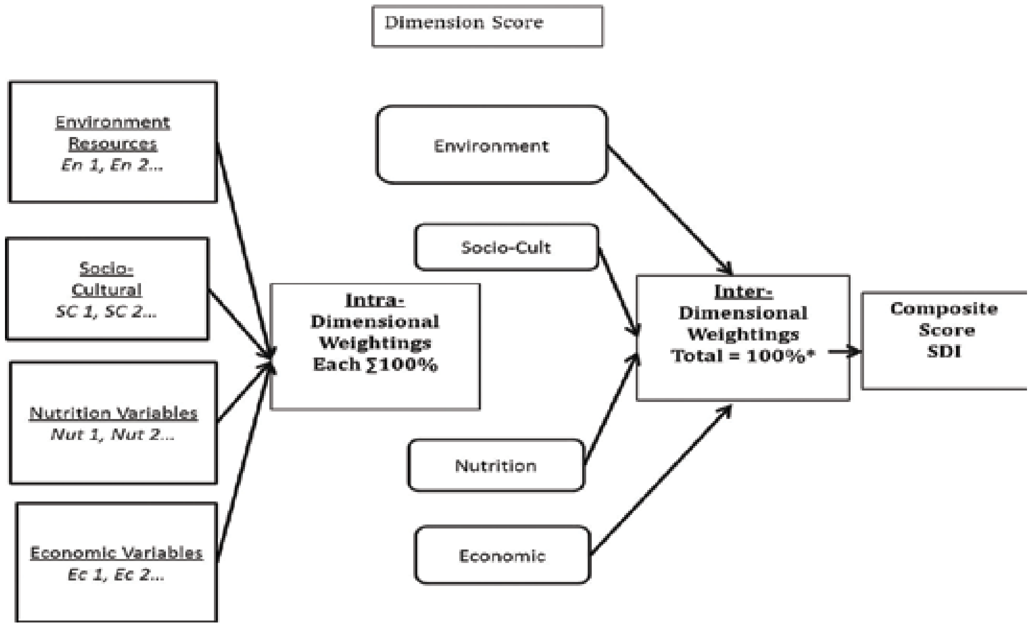


Figure 2: Building a composite sustainability diet index (SDI)

wide country coverage. Then we shall have to apply the appropriate statistical methodology to develop a composite index. This road is a long one but we have started the journey and we must keep up the momentum.

REFERENCES

Bach-Faig, A., Berry, E.M., Lairon, D., Reguant, J., Trichopoulou, A., Dernini, S., Burlingame, B., Medina, F.X., Battino, M., Miranda, G. & Serra-Majem, L. 2011. Mediterranean diet pyramid today. Science and cultural updates. *Public Health Nutr.*, 14(12A): 2274–2284. doi:10.1017/S1368980011002515.

Berry, E.M., Dernini, S., Burlingame, B., Meybeck, A. & Conforti, P. 2015. Food security and sustainability: can one exist without the other? *Public Health Nutrition*, 16: 1–10.

Burlingame, B. & Dernini, S. 2011. Sustainable diets: the Mediterranean diet as an example. *Public Health Nutr.,* 14(12A): 2285–2287. doi:10.1017/S1368980011002527.

Dernini, S., Meybeck, A., Burlingame, B., Gitz, G., Lacirignola, C., Debs, P., Capone, C. & El Bilali, H. 2013. Developing a methodological approach for assessing the sustainability of diets: the Mediterranean diet as a case study. *New Medit.*, 12(3): 28–36.

Dernini, S. & Berry, E.M. 2015. The evolution of the Mediterranean diet towards a sustainable dietary pattern. *Front. Nutr.* 2: 15. doi:10.3389/fnut.2015.00015.

FAO. 2005. *Nutrition indicators for development*. Rome.

FAO. 2012. Sustainable diets and biodiversity, directions and solutions for policy, research and action. *In* B. Burlingame & S. Dernini, eds. *Proceedings of FAO International Scientific Symposium Sustainable Diets and Biodiversity United Against Hunger*, 3–5 November 2010. Rome.

Kourlaba, G. & Panagiotakos, D.B. 2009. Dietary quality indices and human health: a review. *Maturitas*, 62: 1–8.

OECD. 2008. *Handbook on constructing composite indicators: methodology and user guide*. Paris.

Watson, D., Lorenz, U., Stenbæk Hansen, M., Szlezak, J., Zoboli, R., Kuhndt, M., Wilson, C., Mont, O., Wittmer, D. and external SCP experts. 2010. *Towards a set of indicators on sustainable consumption and production (SCP) for EEA reporting*. Copenhagen, European Topic Centre on Sustainable Consumption and Production (ETC/SCP).

WITHIN-SESSION SESSION: SELECTED NUTRITION INDICATORS TO ASSESS THE SUSTAINABILITY OF THE MEDITERRANEAN DIET

Selected nutrition indicators to assess the sustainability of the Mediterranean diet

Giuseppe Maiani and Federica Intorre
Council for Agricultural Research and Economics – Research Centre for Food and Nutrition, Rome, Italy

As the interest in sustainable diets is markedly increasing within the broader and complex context of the sustainability of food systems, the international workshop "Assessing Sustainable Diets within the Sustainability of Food Systems. Mediterranean Diet, Organic Food: New Challenges", aimed at addressing two issues: the question of sustainable diets within organic production/ consumption concepts and achievements and the identification of indicators and methods for assessing sustainable diets within the improvement of the sustainability of food systems. The main topics covered in the workshop were distributed over three sessions. In particular, during the second session "Selected nutrition indicators to assess the sustainability of the Mediterranean diet", special emphasis was given to an ensemble of appropriate nutrition and health indicators, which have been selected in order to assess the sustainability of the diets in the Mediterranean area and their adherence to the Mediterranean diet (MD) model.

THE MEDITERRANEAN DIET AS A CASE STUDY FOR SUSTAINABLE DIETS

According to FAO (2012): "...Sustainable diets are those diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources." The term "Mediterranean diet" implies the existence of some common dietary characteristics in Mediterranean countries such as high amounts of olive oil and olives, fruits, vegetables, cereals (mostly unrefined), legumes, nuts and fish, moderate amounts of dairy products (preferably cheese and yoghurt), low quantities of meat and meat products and moderate intake of alcohol (mainly wine during meals) (Bach-Faig *et al*., 2011). The pioneer Seven Countries Study (Keys, 1970) and numerous and increasing recent epidemiological studies have established the health benefits associated with the adherence to the MD pattern, mainly in relation to reducing the risk of developing the metabolic syndrome, type 2 diabetes, cardio-vascular disease and some neurodegenerative diseases and cancers (Sofi *et al.*, 2010). Moreover, the MD does not only offer considerable health benefits but also respects the environment: not only do people live better, but there is decidedly less impact – or better, footprint – on the environment. The MD is adapted to the different nutritional and socio-economic contexts of the Mediterranean region and takes into consideration updated recommendations considering the lifestyle, dietary, socio-cultural, environmental and health challenges that the current Mediterranean populations are facing (Capone *et al.*, 2013).

This definition of a sustainable diet and the associated four dimensions (health and nutrition, environment, economic, socio-cultural) provide a starting point for developing a theoretical methodological framework to assess the sustainability of diet models; indeed, considering that a sustainable diet should not generate long-term deleterious effects on health, environment (e.g. biodiversity, soil, water, climate, etc.), society and economy and meanwhile improve the human nutrition, well-being, lifestyle and quality of life, the MD can be selected as a case study.

METHODOLOGICAL APPROACH FOR THE ASSESSMENT OF SUSTAINABLE DIETS

The first methodological approach was started in 2010 by FAO, and was further developed in 2011 and 2012 with collaboration between FAO and CIHEAM-Bari and through expert meetings. The methodological approach allowed the identification of four priority areas for assessing sustainability of diets (health and nutrition, environment, economic, socio-cultural) and, for each area, appropriate indicators to be applied at individual, household and country level. Taking into account the availability of data sources and data manageability, from an initial list of more than 70 potential sustainability indicators in four areas compiled in 2011, a reduced list was presented in 2012. The following steps to take are to select one or more Mediterranean countries in which to test and further refine the indicators, to calculate a score using the data gathered for each indicator, and to combine all data.

Regarding the health and nutrition dimension, the selected indicators have been presented following a logical path, starting from diet-related morbidity and mortality statistics, passing through indicators of diet (fruit and vegetable consumption, vegetable and animal protein, dietary energy supply, dietary diversity, dietary energy density, nutrient density and quality, biodiversity composition and consumption) up to indicators of nutritional status (nutritional anthropometry, physical activity). Each health and nutrition indicator will be described below by specialists in their respective fields.

DISCUSSION

At the end of the session, each indicator has been discussed extensively; the following points have been raised:

- *A1) Diet-related morbidity mortality stats*: No points raised.
- *A2) Fruit and vegetable consumption*: This indicator needs further discussion. It is necessary to add in the text, in the methodological section, the following sentence: Methodological aspects must be well defined to ensure comparability and compatibility. Moreover, it is essential to distinguish fruit from vegetables and to discuss again if legumes are to be considered separately.
- *A3) Vegetable and animal protein*: It is necessary to decide which is the right indicator: plant:animal protein ratio or plant:animal dietary energy ratio or plant:animal ratio in grams per person per day.
- *A4) Dietary energy supply/intake*: Some points of discussion concerning this indicator are in common with other indicators, in particular concerning the data sources (food balance sheets, household budget survey, and individual dietary data). Considering the pros and cons of data sources, it is necessary to define which could be the right indicator, dietary energy intake or dietary energy supply. Moreover, the limitation of using dietary energy intake should be added in the document.
- *A5) Dietary diversity*: This aspect is related to nutritional profiles (diet side) and is in some way related to biodiversity (production side), but up to now a specific measure for dietary diversity alone is not available using current statistics. There is a score proposed by FAO for diversity based on a specific questionnaire but the methods can be "exported" to other contexts so an adaptation can be made, on the basis of the methodological guidelines 2009–2013.
- *A6) Dietary energy density and A7) Nutrient density/quality*: Is it necessary to have these indicators?
- *A8) Biodiversity composition and consumption*: There is a methodological problem. In the individual dietary survey, dieticians are not interested in this matter and people do not know which variety of food they eat. There are two booklets, edited by FAO, in which there is information on food consumption and food composition. It could be interesting to combine data from individual dietary surveys with data from commercial statistics.

A9) *Nutritional anthropometry*: There is a problem in self-reporting weight and height, because individuals tend to overestimate their height and underestimate their weight. Anthropometric measurements have to be performed by skilled personnel according to a standardized procedure. If it is not possible to take measurements, self-reported data could be used. All the anthropometric measurements have to be considered together. Waist circumference is a measure of visceral adiposity and consequently of cardiovascular risk.

A10) *Physical activity level and physical inactivity prevalence*: As physical activity is a key determinant of energy expenditure, it is fundamental to energy balance and weight control. Is physical activity a nutritional indicator? Or is this a cofactor? How we can include this indicator? Nevertheless, it is important to underline that MD is a lifestyle and the regular practice of physical activity is a component of the MD pyramid.

Moreover, an additional list of B indicators was presented and preliminarily discussed.

CONCLUSIONS AND NEXT STEPS

In conclusion, once the indicators are defined, the next step will be to evaluate any possible relationship among them and to agree on the methodology on how to calculate a score using the data gathered for each indicator in order to make up a composite index, considering the interactions between nutrition and health indicators and the other dimensions of sustainability (i.e. environment, economic and socio-cultural factors).

REFERENCES

Bach-Faig, A., Berry, E.M., Lairon, D., Reguant, J., Trichopoulou, A., Dernini, S., Medina, F.X., Battino, M., Miranda, G. & Serra-Majem, L. 2011. Mediterranean diet pyramid today. Science and cultural updates. *Public Health Nutrition*, 14(12A): 2274–2284.

Capone, R., Iannetta, M., El Bilali, H., Colonna, N., Debs, P., Dernini, S., Maiani, G., Intorre, F., Polito, A., Turrini, A., Cardone, G., Lorusso, F. & Belsanti, V. 2013. A preliminary assessment of the environmental sustainability of the current Italian dietary pattern: water footprint related to food consumption. *Journal of Food and Nutrition Research*, 1(4): 59–67.

FAO. 2012. *Sustainable diets and biodiversity - directions and solutions for policy, research and action*. Rome.

Keys, A (ed). 1970. Coronary heart disease in seven countries. *Circulation*, 41(4):I 1–200.

Sofi, F., Abbate, R., Gensini, G,F, & Casini, A. 2010. Accruing evidence on benefits of adherence to the Mediterranean diet on health: an updated systematic review and meta-analysis. *Am. J. Clin. Nutr*., 92: 1189–1196.

Diet-related morbidity/mortality statistics

Lorenzo M. Donini
Centro Interuniversitario Internazionale di Studi sulle Culture Alimentari Mediterranee (CIISCAM), Sapienza University of Rome

ABSTRACT

The prevalence of obesity has increased worldwide and is a source of concern since the negative consequences of obesity start from childhood. Nutrition-related chronic diseases are increasing leading to disabilities and deaths globally and in developing countries, including Mediterranean countries. This indicator monitors the occurrence of cardiovascular diseases, type II diabetes, hypertension, osteoporosis, neurodegenerative diseases, and some types of cancer as a proxy for the consumption of healthy diets. The parameters considered are the prevalence of individuals having physician-diagnosed obesity (and related comorbidities) and disability-adjusted life year (DALY) as a measure of overall disease burden.

This indicator monitors the occurrence of cardiovascular diseases, type II diabetes, hypertension, osteoporosis, neurodegenerative diseases and some types of cancer as a proxy for the consumption of healthy diets.

The parameters considered are:

- prevalence of individuals having physician-diagnosed obesity, cardiovascular diseases (hypertension, CHD), type II diabetes, osteoporosis, cancers possibly linked to obesity (oesophagus, pancreas, colon and rectum, breast, endometrium, prostate, kidney, thyroid, gallbladder);
- disability-adjusted life year (DALY) as a measure of overall disease burden expressed as the number of years lost due to ill-health, disability or early death associated with nutrition-related factors: high blood pressure, high cholesterol (total and LDL), high blood sugar (insulin resistance and/or diabetes).

The prevalence of obesity has increased worldwide and is a source of concern since the negative consequences of obesity start from childhood. Nutrition-related chronic diseases are increasing leading to disabilities and deaths globally and in developing countries, including Mediterranean countries (WHO, 2003; WCRF/AICR, 2007). The epidemiology of non-communicable diseases, such as cardiovascular diseases (hypertension, CHD and stroke), diabetes and cancer, gastrointestinal diseases (in particular non-alcoholic fatty liver disease [NAFLD] and non-alcoholic steato-hepatitis [NASH]), respiratory diseases (obstructive sleep apnea syndrome [OSAS] and restrictive lung ventilatory dysfunction), mental illness and immune impairment, functional impairment (with increased disability), and the risk factors for these diseases (mainly obesity) are closely related to food consumption, dietary patterns, nutrition and lifestyles (Bastien *et al.*, 2014; Corrado, Torres and Harrison, 2014; Diaz-Melean *et al.*, 2013; Barone and Krieger, 2013; Klop, Elte and Cabezas, 2013).

The excess of body fat (particularly visceral obesity) is associated with metabolic abnormalities and inflammatory status. In fact, adipose tissue can now be considered as an endocrine organ, orchestrating crucial interactions with vital organs and tissues such as the brain, the liver, the skeletal muscle, the heart and blood vessels themselves. Inflammation is also associated with obesity and central adiposity and anaemia or iron deficiency coexisting in countries in nutrition transition. Moreover, obesity related comorbidity and disability, together with psychological issues, impact on all aspects of an individual's quality of life (Taylor *et al.*, 2013). Reports present alarming figures for the prevalence of this phenomenon, accounting for 63 percent of the 57 million total deaths in 2008 (WHO, 2011).

Finally, there is to be noted that over- and undernutrition frequently coexist. In developing countries the transition phase is characterized by a high prevalence of both malnutrition (still not eradicated) and obesity (depending on the shift in dietary consumption and energy expenditure that coincides with economic, demographic and epidemiological changes leading to a transition from traditional diets high in cereal and fibre to more Western pattern diets high in sugars, fat and animal-source food) (Gartner *et al.*, 2014; Popkin, 1993; Hawkes, 2006). Moreover, even in "developed" countries and also in obese subjects, signs and symptoms can be found due to malnutrition (sarcopenic obesity; mineral-vitamin deficits in obese subjects and in immigrants; calorie-protein malnutrition in elderly subjects) (Correja Horvath *et al.*, 2014).

Data can be obtained from national surveys and WHO World Health Statistics.[1]

However, these data sources do not always allow a reliable evaluation of the prevalence of the diet-related morbidity and mortality. Some pathologies can be undiagnosed or underreported in some countries and data may not be available for the same age groups. If data are not available, mortality prevalence will be used.

REFERENCES

Barone, D.A. & Krieger, A.C. 2013. Stroke and obstructive sleep apnea: a review. *Curr. Atheroscler. Rep.*, 15(7): 3–34. doi: 10.1007/s11883-013-0334-8.

Bastien, M., Poirier, P., Lemieux, I. & Després, J.P. 2014. Overview of epidemiology and contribution of obesity to cardiovascular disease. *Prog. Cardiovasc. Dis.,* 56(4): 369–381. doi: 10.1016/j.pcad.2013.10.016.

Corrado, R.L., Torres, D.M. & Harrison, S.A. 2014. Review of treatment options for nonalcoholic fatty liver disease. *Med. Clin. North Am.*, 98(1): 55–72. doi: 10.1016/j.mcna.2013.09.001.

Correja Horvath, J.D., Dias de Castro, M.L., Kops, N., Kruger Malinoski, N. & Friedman R. 2014. Obesity coexists with malnutrition? Adequacy of food consumption by severely obese patients to dietary reference intake recommendations. *Nutr. Hosp.,* 29(2): 292–299.

Diaz-Melean, C.M., Somers, V.K., Rodriguez-Escudero, J.P., Singh, P., Sochor, O., Llano, E.M. & Lopez-Jimenez, F. 2013. Mechanisms of adverse cardiometabolic consequences of obesity. *Curr. Atheroscler. Rep.,* 15(11): 364. doi: 10.1007/s11883-013-0364-2.

Gartner, A., El Ati, J., Traissac, P., Bour, A., Berger, J., Landais, E., El Hsaini, H., Ben Rayana, C. & Delpeuch, F. 2014. A double burden of overall or central adiposity and anemia or iron deficiency is prevalent but with little socioeconomic patterning among Moroccan and Tunisian urban women. *The Journal of Nutrition*, 144(1): 87–97.

Hawkes, C. 2006. Uneven dietary development: linking the policies and processes of globalization with the nutrition transition, obesity, and diet-related chronic diseases. *Global Health*, 2(4): 1–18.

Klop, B., Elte, J.W. & Cabezas, M.C. 2013. Dyslipidemia in obesity: mechanisms and potential targets. *Nutrients,* 5(4): 1218–1240. doi: 10.3390/nu5041218.

Popkin, B.M. 1993. Nutritional patterns and transitions. *Population and Development Review*, 19(1): 138–157.

Taylor, V.H., Forhan, M., Vigod, S.N., McIntyre, R.S. & Morrison, K.M. 2013. The impact of obesity on quality of life. *Best Pract. Res. Clin. Endocrinol. Metab*., 27(2): 139–146. doi: 10.1016/j.beem.2013.04.004.

WCRF/AICR (World Cancer Research Fund/American Institute for Cancer Research). 2007. *Food, nutrition, physical activity, and the prevention of cancer: a global perspective*. Washington, DC, AICR.

WHO. 2003. *Diet, nutrition and the prevention of chronic diseases*. Report of the Joint WHO/FAO Expert Consultation, Geneva, Switzerland.

WHO. 2011. *The global burden of non-communicable diseases*. Geneva, Switzerland.

[1] http://www.who.int/mediacentre/factsheets/fs311/en/
http://www.who.int/mediacentre/factsheets/fs311/en/
http://www.who.int/healthinfo/global_burden_disease/GlobalHealthRisks_report_full.pdf

Fruit and vegetable consumption

Aida Turrini
Council for Agricultural Research and Economics – Research Centre for Food and Nutrition, Rome, Italy

ABSTRACT

Nutrition policies have strongly promoted the consumption of a diet containing 400 g/day of fresh fruit and vegetables (excluding potatoes and other starchy tubers) as a nutritional goal for health promotion. Methodological issues are also discussed in order to correctly build an indicator. The research question in the present paper is aimed at addressing whether current surveys provide statistics usable as "fruit and vegetables consumption" indicator, i.e. a user-friendly figure helpful for policy purposes. The identified indicator could be used as a variable in the system to evaluate dietary sustainability where nutrition (dietary adequacy, dietary safety) is one of the pillars together with the economic, social and environmental dimensions.

BACKGROUND

A wide consensus exists on the health-protective role of fruits and vegetables (EURODIET, 2001) in preventing degenerative diseases (Agudo, 2005), as well as in alleviating several micronutrient deficiencies especially in less developed countries (Thomson and Amoroso, 2011), which is consistent and trustworthy. Nutrition policies have strongly promoted the consumption of a diet containing 400 g/day of fresh fruit and vegetables (excluding potatoes and other starchy tubers) as a nutritional goal for health promotion (WHO, 2003).

The results are confirmed in one of the most recent publication written by Oyebode *et al.* in 2014 entitled "Fruit and vegetable consumption and all-cause, cancer and CVD mortality: analysis of Health Survey for England data" that follows "Fruit and Vegetable Consumption and Mortality; European Prospective Investigation Into Cancer and Nutrition", by Leenders *et al.* in 2013. These complete preceding literature (AbdullRazis and Noor, 2013; Bouchenak and Lamri-Senhadji, 2013; Hartley *et al.*, 2013; Liu , 2013; Martin *et al.*, 2013; Nicklett and Kadell, 2013; Rees *et al.*, 2013; Ros and Hu, 2013; Woodside, Young and McKinley, 2013).

Consumers can obtain their nutrients, antioxidants, bioactive compounds and phytochemicals from a balanced diet with a wide variety of fruits, vegetables, whole grains and other plant foods for optimal nutrition, health and well-being, rather than from dietary supplements. Five portions of fruit and vegetables a day represent a public health version to promote eating fruit and vegetables (NOO, 2010). Pulses (i.e. dry beans), nuts and seeds are separately indicated by the FAO/WHO Committee (Nishida *et al.*, 2004).

METHODOLOGICAL FRAMEWORK

Dietary quality is a function of several variables. Defining objectives in evaluating nutritional intake profiles is crucial to identify the relationship between the dietary component (either food or nutrient) and the level at which the component is included.

Overall the daily energy requirement (DER) per person (kcal/day/per capita) is a function of body and activity requirements such as the following:

$$\textbf{(1) DER [Energy}^{(kcal)}\textbf{]} = f(\textbf{body}_{gender/age}\ \textbf{weight \& height; physical activity level}_{gender/age/occupation/lifestyle})$$

Daily energy intake (DEI) per person is defined by an equation concerning nutrients, e.g.

$$\textbf{(2) DEI [Energy}^{(kcal)}\textbf{] =}$$
$$\textbf{(9 x lipids}^{(g)}\textbf{) + (4 x proteins}^{(g)}\textbf{) + (3.75 x carbohydrates}^{(g\ monosaccharides)}\textbf{)+ (7 x alcohol}^{(g)}\textbf{)}$$

The balance requires DEI = DER. When this does not happen overweight is likely to occur.

On the other hand, DEI is a function of food dietary profiles, i.e. the sum of energy assumed daily on average from each food k:

$$\textbf{(3) DEI = Sum of energy}^{(kcal)}\textbf{ from food k; k = 1, …, m}$$

These objectives are subject to a number of constraints, such as:

- Energy % from lipids ≤ 30%
- Energy % from saturated fatty acids ≤ 10%
- Energy % from soluble carbohydrates fatty acids ≤ 10%
- etc.

and the source of nutrients, formulated as follows:

- Lipids = Lipids $Food_1$ + Lipids $Food_2$ + … + Lipids Food k_{lipids} (k_{lipids} = number of foods containing lipids)
- Carbohydrates (CHO) (monosaccharides) = CHO Food 1 + CHO Food 2 + … + CHO Food kCHO (kCHO = number of foods containing carbohydrates)
- etc.

MEANING OF THE INDICATOR

Increasing fruit and vegetable consumption has beneficial effects because of the micronutrients and bioactive substances intake, but also by providing less calories. The most recent Italian dietary survey data are taken as example for this (Table 1). Vegetables provide the highest contribution in grams (9.3 percent) of the plant foods and the second to last in energy percent (2.2 percent).

In the same study, the contribution for a number of vitamins and minerals was estimated. The same food groups, as those in the table, resulted as providing 35.2 percent of potassium intake, 30.3 percent of magnesium intake, 27.0 of iron intake, 16.7 percent of phosphorus intake, and 14.4 percent of phosphorus. The percentage of vitamin intake provided was 90.6 percent for β-carotene, 56.9 percent for vitamin A (retinol equivalent), 56.1 percent for vitamin C, 26.1 percent for vitamin B6, 25.8 percent for thiamine (B1), 23.3 percent for vitamin E and 20.8 percent for riboflavin (B2) (Sette *et al.*, 2013).

Thus, fruit and vegetable intakes are taken as an indicator of dietary quality at public health level. Amounts have been defined by the FAO/WHO Committee summarized in the EURODIET report (2001); a recommended value is over 400 g/day/per capita (achievable by eating five portions/day/person as proxy although some claim at least ten). Fruit and vegetable consumption is quite easy to monitor so it has been adopted as a public health indicator (ECHIM, 2008–2013[1]). National food balance sheets (FBS), sometimes household budget surveys (HBS) and individual dietary surveys (IDS) estimate consumed amounts at different levels of detail. Current national health/lifestyle surveys such as the Italian "daily life aspects" survey (ISTAT, 2013) and surveillance programmes (see WHO Web site[2]); the Italian PASSI[3] also allows for recording the number of fruit and vegetable portions per day. FAO FBS are available for several countries all over the world and provide comparable figures. WHO/FOS has published 17 cluster diets.

[1] European Community Health Indicators Monitoring (available at www.echim.org, accessed 14/08/2014).

[2] WHO nutrition monitoring and surveillance (http://www.emro.who.int/nutrition/growth-monitoring-and-surveillance/).

[3] ISS – Italian National Health Institute (available at http://www.iss.it/statistica/index.php?lang=1&id=159&tipo=15).

Table 1: Percentage contribution of vegetable foods to the Italian diet – INRAN-SCAI 2005-06 study

Food group	Percentage contribution to average daily dietary intake in Italy	
	Weight (g)*	**Energy (kcal)§**
Vegetables, fresh and processed	9.3%	2.2%
Fruit, fresh and processed	4.8%	4.9%
Pulses, fresh and processed	0.9%	0.7%
Potatoes, tubers and their products	1.4%	2.3%

Source: *Leclercq *et al.* (2009); Sette *et al.* (2013).

Table 2: Estimated cluster diets 2012 – countries showing the highest fruit and vegetable consumption

Cluster	Countries	Fruit	Vegetables	Fruit and vegetables
Maximum food supply (g/day/per-capita)				
G06	**Armenia, Cuba, Egypt, Greece, Iran (Islamic Republic of), Lebanon**	**420**	**441**	**861**
Intermediate food supply (g/day/per-capita)				
G12		652	125	**777**
G09		226	427	**653**
G04		320	267	**587**
G17		460	71	**531**
G16		464	56	**520**
G15		226	287	**513**
G10		201	303	**504**
G08		227	272	**499**
G02		128	315	**443**
G07		175	217	**392**
G11		182	204	**386**
G14		224	116	**340**
G05		160	150	**310**
G01		151	155	**306**
G03		150	66	**216**
Minimum food supply (g/day/per-capita)				
G13	Botswana, Burkina Faso, Central African Republic (The), Gambia, Haiti, Malawi, Mali, Namibia, Nigeria, Senegal, Somalia, Swaziland, United Republic of Tanzania	116	98	**213**

Source: Elaboration performed using the applicative software available at https://extranet.who.int/sree/Reports?op=vs&path=/WHO_HQ_Reports/G7/PROD/EXT/GEMS_cluster_diets_2012 (no longer available).

FRUIT AND VEGETABLE INDICATORS WORLDWIDE

The weight of fruit and vegetables – raw, free from inedible parts – was estimated for the cluster diets by the Global Environmental Monitoring System within WHO. The following map was obtained with the application available online as at August 2014. This Web site is no longer available. Using the applicative working at time the data reported in Table 2 were elaborated.

The set of countries with the highest consumption of fruit and vegetables belongs to cluster G06 in the Middle East. Different countries are included in the clusters showing the lowest consumption of fruit and vegetables likely corresponding to areas with non-favourable climate conditions.

The table shows different proportion between fruit and vegetables in some of the clusters, suggesting consideration of the two categories separately. The higher the consumption of "fruit and vegetable", the higher the proportion of vegetables, and the lower the proportion of fruit.

Moreover, we can hypothesize that the different proportions of fruit vs. vegetable consumption likely reflect differences in the food market structure and the food environment in general.

DISCUSSION

Comparability and compatibility of food supply/availability/consumption/intake are crucial points to tackle when working in an international context. The quality of data must be the first factor to deal with (Turrini, 2000).

Data obtained from food balance sheets do not reflect the effective food intake, because they relate to the food quantities reaching the consumer; the amounts of food consumed are usually lower than those reported in food balance sheets (Cialfa, Turrini and Lintas 1991), due to the degree of losses of edible food and nutrients in the household/catering, e.g. during storage, in preparation and cooking, as plate waste or quantities fed to domestic animals and pets, or thrown away. However, when national individual dietary surveys are not available the HBS and/or FBS provide a good variable to compare several countries and different time periods.

Overall we have the following relationship for one food k

$$(4)\ \text{FBS k} > \text{HBS k} > \text{IDS k}$$

As

FBS = include eating out and food chain losses (national data are adjusted by reuse of crops for production and stock variations)

HBS = do not include eating out, include kitchen losses and left-overs

IDS = include eating at home and outside of home consumption; foods are reported after removal of inedible parts.

Each kind of data (FBS, HBS, IDS and others) can be used taking into account its nature in countries where food supply (food balance sheets), household food availability (household budget surveys), and individual dietary surveys (IDS) are available.

The comparability of food data is strongly related to the alignment of definitions. Therefore, two pending issues must still be addressed.

- Food classification is not still completely formalized (fuzzy nature of subsets due to the number of different characteristics usually). This affects the comparability via the products included in each food group (possible lack of alignment).
- It is not always possible to have data at the maximum precision level:
  - Detailed food product
  - Comparable expression (raw, cooked, edible part/whole food)
  - Weight/frequency/number of portions (full/fraction)
  - whatever choice is made it is desirable.

CONCLUSIONS

Fruit and vegetable consumption separately and together can be used as an indicator for a healthy diet at public health level, as current statistics and individual dietary surveys can be used as a data source.

The same indicators are suitable as indicators for nutrition in the context of evaluating dietary sustainability. In fact, this represents a link between environment and economics and is related to the cultural and social aspects related to eating habits.

Technical aspects in the formation of the data such as survey methods, food description and food classification must be taken into account when comparing results from different surveys.

REFERENCES

AbdullRazis, A.F. & Noor, N.M. 2013. Cruciferous vegetables: dietary phytochemicals for cancer prevention. *Asian Pac. J. Cancer Prev*., 14(3): 1565–1570.

Agudo, A. 2005. *Measuring intake of fruit and vegetables.* Background paper. Geneva, Switzerland, WHO (available at http://www.who.int/dietphysicalactivity/publications/f&v_intake_measurement.pdf).

Bouchenak, M. & Lamri-Senhadji, M. 2013. Nutritional quality of legumes, and their role in cardiometabolic risk prevention: a review. *J. Med. Food*, 16(3): 185–198. doi: 10.1089/jmf.2011.0238.

Cialfa, E., Turrini, A. & Lintas, C. 1991. A national food survey. Food balance sheets and other methodologies: a critical overview. *In* I. Macdonald, ed. I*LSI monographs – Monitoring dietary intakes*, pp. 24–44. Chapter. 4.

EURODIET. 2001. *Nutrition and diet for healthy lifestyles in Europe*. A.G. Kafatos, coordinator (available at http://ec.europa.eu/health/archive/ph_determinants/life_style/nutrition/report01_en.pdf).

Hartley, L., Igbinedion, E., Holmes, J., Flowers, N., Thorogood, M., Clarke, A., Stranges, S., Hooper, L. & Rees, K. 2013. Increased consumption of fruit and vegetables for the primary prevention of cardiovascular diseases. *Cochrane Database Syst*. Rev., 6: CD009874. doi: 10.1002/14651858.CD009874.pub2.

ISTAT (Italian National Statistics Bureau). 2013. *Aspetti della vita quotidiana [Daily life aspects]* (available at http://www.istat.it/it/archivio/96427).

Leclercq, C., Arcella, D., Piccinelli, R., Sette, S., Le Donne, C. & Turrini, A. 2009. The Italian National Food Consumption Survey INRAN-SCAI 2005-06. Main results in terms of food consumption. *Public Health Nutrition*, 12(12): 2504–2532 doi:10.1017/S1368980009005035.

Leenders, M., Sluijs, I., Ros, M.M., Boshuizen, H.C., Siersema, P.D., Ferrari, P., Weikert, C., Tjønneland, A., Olsen, A., Boutron-Ruault, M.C., Clavel-Chapelon, F., Nailler, L., Teucher, B., Li, K., Boeing, H., Bergmann, M.M., Trichopoulou, A., Lagiou, P., Trichopoulos, D., Palli, D., Pala, V., Panico, S., Tumino, R., Sacerdote, C., Peeters, P.H., van Gils, C.H., Lund, E., Engeset, D., Redondo, M.L., Agudo, A., Sánchez, M.J., Navarro, C., Ardanaz, E., Sonestedt, E., Ericson, U., Nilsson, L.M., Khaw, K.T., Wareham, N.J., Key, T.J., Crowe, F.L., Romieu, I., Gunter, M.J., Gallo, V., Overvad, K., Riboli, E. & Bueno-de-Mesquita, H.B. 2013. Fruit and vegetable consumption and mortality; European prospective investigation into cancer and nutrition. American *Journal of Epidemiology* (available at http://aje.oxfordjournals.org/content/early/2013/04/17/aje.kwt006.full).

Liu, R.H. 2013. Health-promoting components of fruits and vegetables in the diet. *Adv. Nutr.*, 4(3): 384S–392S. doi: 10.3945/an.112.003517.

Martin, C., Zhang, Y., Tonelli, C. & Petroni, K. 2013. Plants, diet, and health. *Annu. Rev. Plant Biol.*, 64: 19–46. doi: 10.1146/annurev-arplant-050312-120142.

Nicklett, E.J. & Kadell, A.R. 2013. Fruit and vegetable intake among older adults: a scoping review. *Maturitas,* 75(4): 305–312. doi: 10.1016/j.maturitas.2013.05.005.

Nishida, C., Uauy, R., Kumanyika, S. & Shetty, P. 2004. Joint WHO/FAO Expert Consultation on diet, nutrition and the prevention of chronic diseases: process, product and policy implications. *Public Health Nutrition*, 7(1A): 245–250.

NOO (National Obesity Observatory). 2010 *Review of dietary assessment methods in public health* (available at http://www.noo.org.uk/uploads/doc/vid_7237_Review_new.pdf accessed 14/08/2014).

Oyebode, O., Gordon-Dseagu, V., Walker, A. & Mindell, J.S. 2014. Fruit and vegetable consumption and all-cause, cancer and CVD mortality: analysis of Health Survey for England data. *JECH Online First*, published 31 March 2014 as 10.1136/jech-2013-203500 (available at http://jech.bmj.com/content/early/2014/03/03/jech-2013-203500.full.pdf+html).

Rees, K., Hartley, L., Flowers, N., Clarke, A., Hooper, L., Thorogood, M. & Stranges, S. 2013. 'Mediterranean' dietary pattern for the primary prevention of cardiovascular disease. *Cochrane Database Syst. Rev.*, 8: CD009825. doi: 10.1002/14651858.CD009825.pub2.

Ros, E. & Hu, F.B. 2013. Consumption of plant seeds and cardiovascular health: epidemiological and clinical trial evidence. *Circulation*, 128(5): 553–565. doi: 10.1161/CIRCULATIONAHA.112.001119.

Sette, S., Le Donne, C., Piccinelli, R., Mistura, L., Ferrari, M. & Leclercq, C. 2013. The third National Food Consumption Survey, INRAN-SCAI 2005–06: major dietary sources of nutrients in Italy. *Int. J. Food Sci. Nutr.,* Early Online: 1–8 DOI: 10.3109/09637486.2013.816937.

Thomson, B. & Amoroso, L., eds. 2011. *Combating micronutrient deficiencies: food-based approaches*. Rome, FAO (available at www.cabi.org).

Turrini, A. 2000. Food data quality in nutritional surveys: which issues are to be tackled? *Journal of Food Composition and Analysis*, 13(4): 597–609.

WHO (World Health Organization). 2003. *Diet, nutrition and the prevention of chronic diseases*. Report of the Joint WHO/FAO Expert Consultation, Geneva, Switzerland (available at http://www.who.int/dietphysicalactivity/publications/trs916/download/en/).

Woodside, J.V., Young, I.S. & McKinley, M.C. 2013. Fruit and vegetable intake and risk of cardiovascular disease. *Proc. Nutr. Soc.*, 72(4): 399–406. doi:10.1017/S0029665113003029.

Plant/animal protein ratio

Barbara Burlingame
Adjunct Professor, Deakin University, Melbourne, Australia
Ex-Deputy Director, FAO, Nutrition Division

ABSTRACT

Dietary protein sources play a direct role in human health and disease and environmental impacts. In developed countries, diets high in plant-source proteins are associated with lower risk for chronic diseases, while diets high in animal-source proteins are associated with increased risk for cardiovascular disease, certain cancers, inflammation, and more. In developing countries, intake of animal proteins is associated with lower prevalences of malnutrition, including stunting. Environmental impacts and pressures on natural resources are generally considered greater for the production of animal source proteins, whether they be from intensive or extensive systems. Useful protein data are available through FAOSTAT, allowing comparisons among and between different geographical areas, and in single countries over an extended time series. Combining these data with statistics on diet-related morbidity and mortality, as well as GHG emissions and other markers of environmental impacts, will provide useful metrics for sustainable diets.

INTRODUCTION

Plant-based diets have long been associated with lower risk of cardiovascular diseases (Kritchevsky, 1979), certain cancers, hypertension (Alonso *et al.,* 2006), obesity, inflammation and metabolic stresses. In many cases, it is thought that the non-haem proteins of plant origin are responsible, at least in part, for the benefits. Metabolic studies have shown that intake of haem protein is associated with higher inflammation markers due to the fact that it contains more iron than non-haem protein (Vallianou *et al.,* 2013), and a number of clinical studies demonstrate that animal protein is more cholesterolemic and atherogenic than vegetable protein. Moreover, diets that are rich in animal foods and lower in plant foods, typical of industrialized countries, lead to a higher net acid load that has a negative effect on calcium balance (Sellmeyer *et al.,* 2001). In metabolically stressed patients, both inadequate and excessive protein can cause problems.

In many developing countries with high prevalences of malnutrition and food insecurity, animal source proteins are relied upon as a dependable and sustainable solution for improving diet quality. Introducing animal-source foods to largely plant-based diets has been shown to reduce the prevalence of stunting in children and other manifestations of malnutrition (WHO, 2003).

As a crude generalization, production systems for animals require much more land area, water and energy inputs, and produce more greenhouse gas (GHG) emissions than production systems for most food plants (Macdiarmid *et al.,* 2012). Thus, animal-source proteins have a higher environmental impact than plant-based proteins (Carlsson-Kanyama and Gonzales, 2009).

Therefore developing countries will strive to decrease the plant:animal protein ratio, while developed countries with high prevalences of non-communicable disease and overweight/obesity will strive to increase the ratio. Regardless, the epidemiology of protein intake forms a bell-shaped curve, with the lowest and the highest levels contributing to the greatest risk for human health. For environmental sustainability, the plot is a straight line, i.e. the higher the intake the greater the threat to environmental sustainability.

The optimal dietary protein ratio needs to be agreed as a basic assumption for this indicator, ideally with the traditional Mediterranean diet (MD) as the standard. The ratio is likely to be at least 4:1, plant to animal. From this, dietary patterns can be assessed for sustainable diets, with the understanding that protein-related sustainability and nutrition-related goals, both for populations and individuals, will be different across the spectrum of countries and regions (Masset *et al.,* 2014).

DEFINITION

This indicator is a ratio of the relative intakes of protein from plant and animal sources, assessing adherence to an optimal dietary pattern, and a proxy for environmental impact of diets.

METHODOLOGY

The methodology is a straightforward calculation of the ratio of plant (cereals, vegetables, pulses, fruit) and animal (meat, fish, eggs, dairy products) proteins in the diet using existing data. Adherence to an optimal ratio, including the MD, can be judged by simple comparison, and the trend can be monitored over the time series of available data, regardless of the data source.

BACKGROUND

Dietary protein can be expressed in different ways, with four major dimensions for consideration: source, quality, quantity and impact. Source can be presented at several levels of aggregation, from the crude classification of kingdoms (plant, animal), to finer divisions, e.g. terrestrial and aquatic, through to the most disaggregated taxonomic levels of subspecies, variety, cultivar and breed, reflecting biodiversity.

The most basic classification for dietary protein, with the most available data, is a simple division into plant- and animal-source. This classification is a useful proxy for nutritional quality, as the amino acid patterns of animal-source foods are better suited to human requirements, and a somewhat useful proxy for environmental sustainability, at least in terms of GHG emission and land/water use, with plant source performing better than animal source, acknowledging differences in production systems, geographical considerations and dietary traditions.

DATA SOURCES

FAOSTAT Food Balance Sheets and Commodity Balances provide data for domestic availability of a food, and food component in the case of protein (FAO, 2015). The contributing data include the sum of production and imports, with exports and non-food use subtracted. New modules to the FAOSTAT family of databases, including land use, emission, pesticide, fertilizer and irrigation, will provide more data on environmental sustainability when analysed with protein ratio data. Food consumption studies, national nutrition surveys, Household Budget Surveys, etc. will be available in some countries to augment or replace FAOSTAT data.

LIMITATIONS OF THE INDICATORS

FAOSTAT data from Food Balance Sheets and Commodity Balances reflect domestic availability of foods, not consumption or production per se. While these data have proven useful for assessing nutritional adequacy of diets, with a long history of use, they may significantly misrepresent sustainability issues. For example, livestock production has a greater role in GHG emission than livestock consumption. If meat is imported rather than domestically produced, the calculation of environmental impact may be skewed if using Food Balance or Commodity Balance datasets. Similarly, national nutrition surveys do not address the issue of production. Food losses and waste not accounted for in the datasets will affect the calculations and interpretation. Additionally, the advantages of using plant:animal protein ratio, as opposed to plant:animal dietary energy ratio or plant:animal ratio in grams per person per day, need to be elaborated.

BIBLIOGRAPHY

Alonso, A., Beunza, J.J., Bes-Rastrollo, M., Pajares, R.M.& Martínez-González, M.A. 2006. Vegetable protein and fiber from cereal are inversely associated with the risk of hypertension in a Spanish cohort. *Arch. Med. Res.*, 37(6): 778–786.

Carlsson-Kanyama, A. & Gonzalez, A.D. 2009. Potential contributions of food consumption patterns to climate change. *Am. J. Clin. Nutr.*, 89: 1704S–1709S.

FAO. 2015. FAOSTAT (avaliable at http://faostat3.fao.org/browse/FB/*/E).

Kritchevsky, D. 1979. Vegetable proteins and atherosclerosis. *Journal of the American Oil Chemists' Society*, 3: 135–140.

Macdiarmid, J.I., Kyle, J., Horgan, G.W., Loe, J., Fyfe, C., Johnstone, A. & McNeill, G. 2012. Sustainable diets for the future: can we contribute to reducing greenhouse gas emissions by eating a healthy diet? *Am. J. Clin. Nutr.*, 96: 632–639.

Masset, G., Soler, L.G., Vieux, F. & Darmon, N. 2014. Identifying sustainable foods: the relationship between environmental impact, nutritional quality and prices of foods representative of the French diet. *J. Acad. Nutr. Diet*, 114: 862–869.

Sellmeyer, D.E., Stone K.L., Sebastian, A., Cummings. S.R. for the Study of Osteoporotic Fractures Research Group. 2001. A high ratio of dietary animal to vegetable protein increases the rate of bone loss and the risk of fracture in postmenopausal women. *Am. J. Clin. Nutr*., 73: 118–122.

Vallianou, N.G., Bountziouka, V.P., Georgousopoulou, E., Evangelopoulos, A.A., Bonou, M.S., Vogiatzakis, E.D., Barbetseas, J.D., Avgerinos, P.C., Panagiotakos, D.B. 2013. Influence of protein intake from haem and non-haem animals and plant origin on inflammatory biomarkers among apparently-healthy adults in Greece. *J. Health Popul. Nutr.*, 31(4): 446–454.

WHO. 2003. Diet, nutrition and the prevention of chronic diseases: report of a joint WHO/FAO expert consultation, Geneva.

World Bank. 2015. Global Consumption Database (avaliable at http://datatopics.worldbank.org/consumption/).

Yoon, G.A. & Hwang, H.J. 2006. Effect of soy protein/animal protein ratio on calcium metabolism of the rat. *Nutrition*, 22(4): 414–418.

Dietary energy intake and dietary energy supply

Angela Polito, Federica Intorre, Donatella Ciarapica and Lorenzo Barnaba
Council for Agricultural Research and Economics – Research Centre for Food and Nutrition, Rome, Italy

ABSTRACT

The dietary energy intake together with the total energy expenditure defines the energy balance that has to be maintained in order to avoid under- or overnutrition conditions.

Individual dietary surveys provide the best evidence on food consumption and constitute the optimal method for assessing energy intake and more generally dietary patterns and evaluating diet–disease associations. Being expensive and labour-intensive, these surveys are undertaken only in a limited number of countries, often at regional or local level or in specific population groups; furthermore, it is difficult to accomplish comparability at the international level because the assessment methods are variable, self-reported and consequently subject to considerable measurement errors.

In order to overcome these problems, the per capita dietary energy supply (DES) can be used as a nutritional indicator, instead of the dietary energy intake. DES is an estimate of the per capita amount of energy (kcal or kJ) in food available for human consumption during a reference period (three-year average period). It represents only the average supply available for each individual in the population as a whole and does not indicate what is actually consumed. Data on DES can be gathered from food balance sheets (FBS) and household budget surveys (HBS).

Even if both FBS and HBS overestimate food consumption with respect to individual dietary surveys, they represent valid tools providing continuous and comparable information for large-scale population studies. For future research, it would be important to develop dietary assessment methods and statistical techniques that minimize the errors inherent in self-reported dietary intakes in order to harmonize data into a comparable form. Moreover, it is important to link energy intake to energy expenditure and therefore include physical activity levels.

INTRODUCTION

The dietary energy intake represents the metabolizable energy content of food (expressed as kcal or kJ) provided by the four macronutrient categories (i.e. carbohydrate, protein, fat and alcohol) and together with the total energy expenditure defines the energy balance. Several epidemiological studies have demonstrated that an imbalanced intake of energy and nutrients is associated with increased morbidity and mortality from chronic degenerative diseases, including cardiovascular diseases, cancer, diabetes and osteoporosis (WHO, 2007).

Over- and undernutrition have been described as heterogeneous disorders with multiple aetiologies, related in particular to genetic, psychological and environmental factors and above all to diet (Serra-Majem and Bautista-Castaño, 2013). It is important to underline that these two conditions frequently coexist in a population. Evidence suggests that a large percentage of obesity cases involve a clear environmental component linked to sedentary lifestyles and dietary habits that lead to positive energy balance and, as a result, the gradual, relentless accumulation of fatty tissue. Diverse epidemiological studies describe a direct relationship between an increased body mass index, when correlated with an increase in fat mass, and mortality (Gupta, Krueger and Lastra, 2012). The epidemic of obesity with its attendant comorbidities is not a problem limited

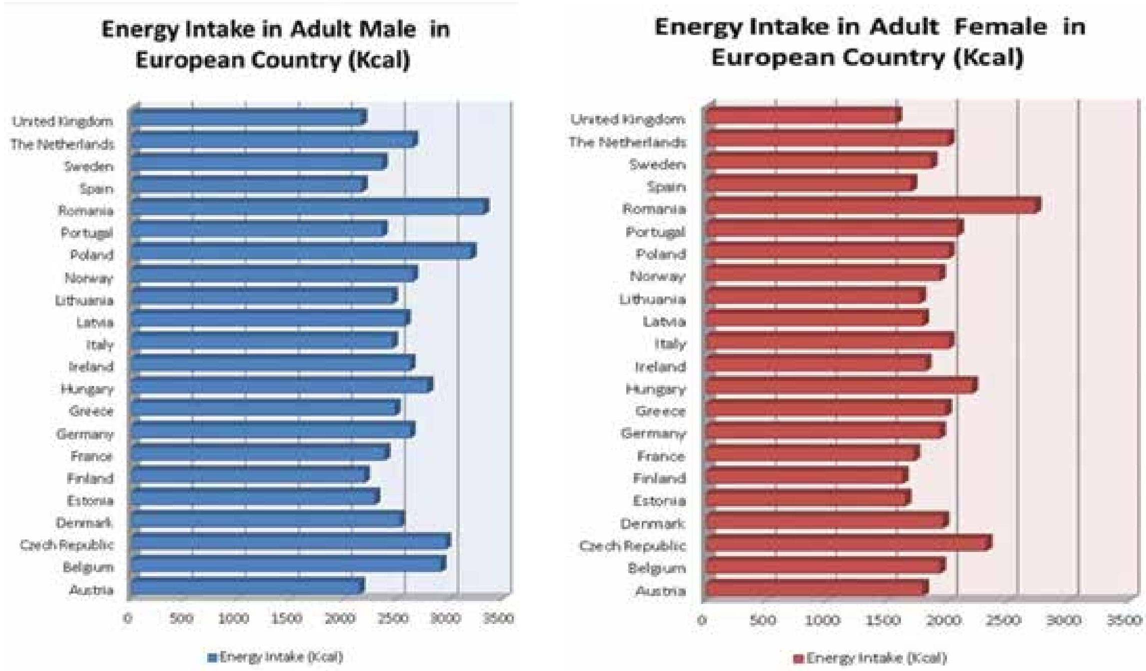


Figure 1: Daily energy intake in different European countries
Source: modified from Elmadfa (2009).

to industrialized countries but is present, together with malnutrition, also in developing countries affected by rapid globalization, industrialization and urbanization (Caballero, 2005). However, the nutrition transition occurring in such countries, while associated with diets higher in energy, is also marked by poor diet quality (Eckhardt, 2006). Even in developed countries and also in obese subjects, there are signs and symptoms due to malnutrition, such as micronutrient deficiency and protein-energy malnutrition (Müller and Krawinkel, 2005).

MEASUREMENT OF DIETARY ENERGY INTAKE

Many different methods have been developed for the purpose of assessing dietary intake. Individual dietary surveys (IDS), using dietary records, 24-hour dietary recalls or food frequency questionnaires are based on nationally representative population samples, provide food and related energy and nutrient intakes and constitute the optimal method for assessing energy intake and more generally dietary patterns and evaluating diet–disease associations. The variety and complexity of data sampling and collection, documentation and interpretation in the field of diet, health promotion and the prevention of nutrition-related diseases require regular survey and analysis of relevant and available information.

Up to now, there is no fully harmonized European database on individual food consumption. The European Nutrition and Health Report (Elmadfa, 2009), with the aim to provide a comprehensive view of the health and nutrition status in the European Union, reports information on individual food consumption of adults in European countries coming from national and regional dietary surveys.

Figure 1 presents the daily intake of energy in different European countries. The daily energy intake was between about 2 000 and 3 300 kcal in males and between 1 500 and 2 700 kcal in females; these intakes are below the reference values ranging respectively from 2 500 to 3 000 kcal/day for males and from 2 000 to 2 400 kcal/day for females, partially due to underreporting of food intake (Elmadfa, 2009).

Although the comparability of data is limited because of the use of different methods such as 24-hour recalls or food frequency questionnaires, different years and periods of data collection and different age classifications, it can give an overview on the nutritional situation in the European

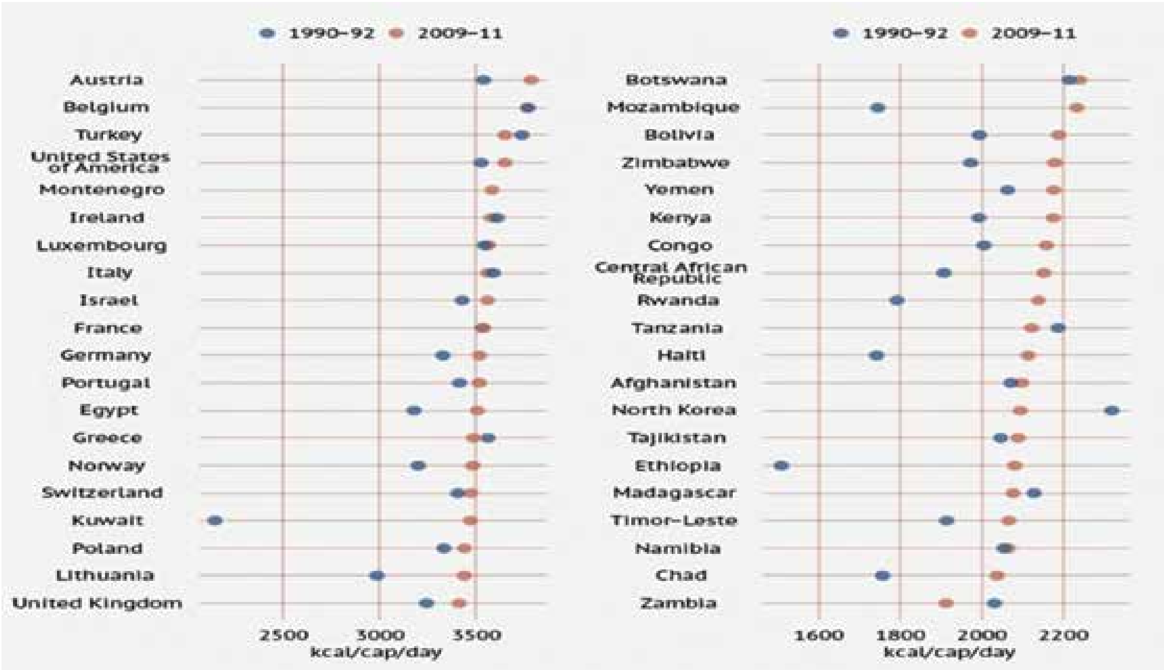


Figure 2: Changes over time of dietary energy supply in 40 countries (1990–92 and 2009–11)
Source: modified from FAO (2014).

countries. Essentially, the individual dietary surveys (IDS), being expensive and labour-intensive, are undertaken only in a limited number of countries, often at regional or local level or in specific population groups. For instance, in Italy, the three national food consumption surveys (Saba *et al.*, 1988; Turrini *et al.*, 2001; Leclercq *et al.*, 2009), have been conducted using different methodologies in different ages groups. In order to overcome these problems, it would be important to develop dietary assessment methods and statistical techniques that minimize the errors as much as possible with the purpose of harmonizing data into a comparable form.

MEASUREMENT OF DIETARY ENERGY SUPPLY

Dietary energy supply (DES) is an estimate of the per capita amount of energy (kcal or kJ) in food available for human consumption during a reference period (three-year average period).

Data on DES can be gathered from food balance sheets (FBS)[1] and household budget surveys (HBS).[2]

The FBS of FAO are agricultural statistics that have so far been published yearly since 1961 for almost all commodities and for nearly all countries. To estimate food supply, they take into account data on total production, imports, stock changes and exports of food as well as its utilization for non-food purposes in a given country in both the household and non-household sectors. The consistency of methods and the coverage of a large number of countries worldwide make FBS a valuable source of information about the pattern of a country's food supply during a specified reference period. Especially, they allow international comparisons and the detection of international and national trends. In turn, regional differences within one country or between groups of its population cannot be discerned; indeed, data are obtained on a per capita basis without any differentiation between genders and age groups. Additionally, losses due to waste and spoilage can only roughly be accounted for so that supply data are higher than the actual intake. Nevertheless, FBS are a unique source for showing international trends in food supply (Elmadfa,

[1] http://faostat3.fao.org/faostat-gateway/go/to/home/E
[2] http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/

2009), representing an important knowledge base that permits comparative analysis over time. Figure 2 reports the changes over time of DES in 40 countries.

The HBS are national surveys mainly focusing on consumption expenditure, referring to the quantities of food available to or acquired by the household, and are confined only to the part flowing to the household sector. Like other self-reporting methods, HBS are challenged by various uncertainties, such as recall and reporting errors. To study food consumption using HBS, data should ideally be collected both on food consumed in the household and away from home. If household expenditure is used to estimate food intake, there is a risk that food eaten outside the home will be excluded. Other reliability issues arising from the use of these surveys include the difficulty of accounting for food consumed by guests in the household and of adjusting for food that is purchased and stored without being consumed during a recall period (as well as the reverse, if food is consumed that was purchased prior to the recall period).

The HBS occupy a position between the FBS and the individual dietary survey. Like FBS, the HBS allow between-country comparisons on a regular basis but, in moving from total population to household level, the HBS can provide a more detailed description of the dietary choices of the population, as well as of population subgroups (Trichopoulou, 1992).

The use of the national HBS for nutrition monitoring purposes has been evaluated through the EU-supported Data Food Networking (DAFNE) initiative, which, interrelating 26 European countries, built up a regularly updated food-based databank. It allows the identification of dietary patterns prevailing in Europe and of their socio-demographic determinants, the follow-up of time trends in food habits, and the evaluation of nutrition action plans and strategies implemented at national or international level (Trichopoulou and Naska, 2003; Elmadfa, 2009). The DAFNE data, showing a comparison between countries, document disparities in food habits in Europe.

DISCUSSION AND CONCLUSION

A regular supply of dietary energy is essential for life and is required to fuel many different body processes, therefore representing an important indicator of nutritional status both for individuals and population groups.

The IDS, when undertaken as adequately as possible, represent the most accurate assessment method of the eating habits of a population. It is well known that methods used to assess dietary intake on an individual level are hampered by various limitations and inherent errors that affect reliability. For this reason, data gathered from IDS are replaced with those from FBS and HBS, that available for all countries, but provide data on food availability instead of food consumption, overestimating both nutrient and energy intake compared with IDS. Serra-Majem *et al.* (2003) showed a comparative analysis of nutrition data from national, household and individual levels, using FBS, HBS and individual dietary data; differences in study design and methodological approaches were taken into consideration. There is a huge overestimation in energy intake; on average, FBS overestimate energy intake by 55 percent and HBS by 16 percent compared with individual dietary surveys, with variations from one country to another. However, the three levels of dietary data provide unique information about the availability and reported intake of food in populations and their comparisons are difficult to interpret because each represents different steps of the food chain (Serra-Majem *et al.*, 2003).

In the framework of the construction of a composite index including all the health and nutrition indicators, similarly to the dietary energy intake, there could be a limitation in the use of DES because the overestimation of energy intake from FBS can influence the assessment of the diet sustainability. This overestimation could be reduced, for example, considering losses and waste in the food chain. Moreover, it is necessary to consider that both dietary energy intake and DES have to be considered in a broader context, i.e. energy balance, related to energy expenditure; nowadays, in selecting nutritional indicators related to diet-related-disease, it is considered essential to add an indicator of energy balance (van Dooren *et al.,* 2013). Supplying enough food to the population is a necessary, but insufficient, condition for ensuring adequate access for individuals: for example, it has been demonstrated that in most countries and regions, despite abundant food supplies, there

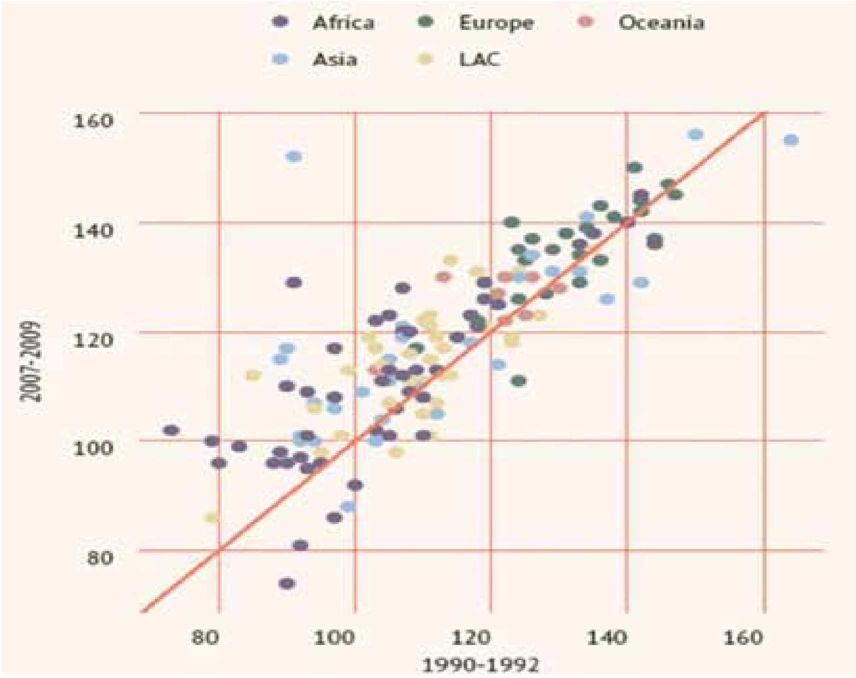


Figure 3: Average dietary supply adequacy (1990–1992 and 2007–2009)
Source: modified from FAO (2013).

is a prevalence of undernourishment. For this reason, FAO (2013), considering new approaches for the measurement of food security, suggested as an indicator of food availability the average dietary supply adequacy, which expresses the DES as a percentage of the average dietary energy requirement (ADER). Each country's or region's average supply of calories for food consumption is normalized by the ADER estimated for its population, to provide an index of adequacy of the food supply in terms of calories. As reported in Figure 3, this value has increased globally from 114 percent to 120 percent in the last 20 years (FAO, 2013).

In conclusion, data on food consumption can be derived from IDS, FBS or HBS, each method having well-documented weaknesses. Notwithstanding, IDS are one of the most accurate (and costly) methods for obtaining data on food consumption, the per capita DES, providing continuous and comparable information for large-scale population studies, and can, however, be considered as a population-based proxy for consumption. However, as a nutritional and health indicator of a sustainable diet, it could be better to use the **average dietary supply adequacy**, recently proposed by FAO. This indicator embraces requirements, i.e. also energy expenditure, and consequently considers the energy balance that has to be maintained in order to avoid under- or overnutrition conditions, measures the adequacy of the national food supply in terms of calories and helps understanding whether undernourishment is mainly due to insufficient food supply or to bad distribution.

REFERENCES

Caballero, B. 2005. A nutrition paradox - underweight and obesity in developing countries. *N. Engl. J. Med.,* 352(15): 1514–1515.

Eckhardt, C.L. 2006. *Micronutrient malnutrition, obesity, and chronic disease in countries undergoing the nutrition transition: potential links and program/policy implications*. FCND Discussion Paper 213.

Elmadfa, I. 2009. *European Nutrition and Health Report 2009*. Forum of Nutrition Series Vol. 62. Vienna, 412 p.

FAO. 2013. *Statistical Yearbook 2013*. Rome.

FAO. 2014. *Food and nutrition in numbers*. Rome.

Gupta, D., Krueger, C.B. & Lastra, G. 2012. Over-nutrition, obesity and insulin resistance in the development of B-cell dysfunction. *Curr. Diabetes Rev.,* 8(2): 76–83.

Leclercq, C., Arcella, D., Piccinelli, R., Sette, S., Le Donne, C. & Turrini A, on behalf of the INRAN-SCAI 2005–06 Study Group. 2009. The Italian National Food Consumption Survey INRAN-SCAI 2005–06: main results in terms of food consumption. *Public Health Nutrition,* 12: 2504–2532.

Müller, O. & Krawinkel, M. 2005. Malnutrition and health in developing countries. CMAJ., 173(3): 279–286.

Saba, A., Turrini, A., Mistura, G. & Cialfa, E. 1988. Indagine nazionale sui consumi alimentari delle famiglie 1980–1984 alcuni principali risultati. *Riv. Soc. It. Sc. Alim.,* 19: 53–65.

Serra-Majem, L., MacLean, D., Ribas, L., Brulé, D., Sekula, W., Prattala, R., Garcia-Closas, R., Yngve, A., Lalonde, M. & Petrasovits, A. 2003. Comparative analysis of nutrition data from national, household, and individual levels: results from a WHO-CINDI collaborative project in Canada, Finland, Poland, and Spain. *J. Epidemiol. Community Health*, 57: 74–80.

Serra-Majem, L. & Bautista-Castaño, I. 2013. Etiology of obesity: two "key issues" and other emerging factors. *Nutr. Hosp., Suppl* 5: 32–43.

Trichopoulou, A. 1992. Monitoring food intake in Europe: a food data bank based on household budget surveys. *Eur. J. Clin. Nutr.*, 46 (Suppl. 5): S3–8.

Trichopoulou, A, Naska, A. and the DAFNE III Group. 2003. European food availability databank based on household budget surveys – the Data Food Networking initiative. *Eur. J. Public Health 13* (Suppl): 24–28.

Turrini, A., Saba A., Perrone, D., Cialfa, E. & D'Amicis, A. 2001. Food consumption patterns in Italy: the INN-CA Study 1994-96. *Eur. J. Clin. Nutr.*, 55: 571–588.

van Dooren, C., Marinussen, M., Blonk, H., Aiking, H.& Vellinga, P. 2014. Exploring dietary guidelines based on ecological and nutritional values: A comparison of six dietary patterns. *Food Policy* 44: 36–46.

WHO (World Health Organization). 2007. T*he challenge of obesity in the WHO European region and strategies for response*, by F. Branca, H. Nikogosian & T. Lobstein, eds. Copenhagen, WHO Regional Office for Europe (available at http://www.euro.who.int/document/E90711.pdf).

Dietary diversity

Aida Turrini
Council for Agricultural Research and Economics – Research Centre for Food and Nutrition, Rome, Italy

ABSTRACT

Dietary diversity is a concept related to nutritional profiles (diet side) and is in some way related to biodiversity (production side). A monotonous diet is considered to be unhealthy. An indicator was defined in order to assess a qualitative measure of food consumption that reflects household access to a variety of foods, and is also a proxy for nutrient adequacy of the diet of individuals. Issues related to the formula for calculation and the data sources to use for obtaining the most suitable food consumption data from current statistics are discussed. Further analyses seem to be necessary to complete the methodological path for defining an indicator, i.e. a user-friendly statistical figure representing an aspect of interest.

BACKGROUND

Dietary profiles are described by foods, energy, nutrient and all food compound intakes. *The measurement of dietary intake is complex and presents significant challenges, particularly at a group and population level* (NOO, 2010). Dietary balance is obtained following recommendations based on reference values elaborated by highly expert committees (Nishida *et al.,* 2004) at national level and gathered and coordinated at international level by bodies such as the World Health Organization (WHO),[1] and the European Food Safety Authority (EFSA).[2] Many relationships, determinants and outcomes must be considered in dietary quality evaluation (adequacy, compliance, security, safety).

Energy requirements drive global dietary amounts (e.g. see Elmadfa, 2009, pp. 323–324) also via the balancing of macronutrients providing calories, but the inner composition is extremely variable and a set of constraints must be taken into account (proteins, maximum lipids, minimum carbohydrates, minimum of fruit and vegetable intake, vegetable > fruit, etc.) (WHO, 2003).

Several indices were developed (Fransen and Ocké, 2008; Hashemi *et al.,* 2013; Kourlarba and Panagiotakos, 2009) such as the healthy eating index (HEI) (Kennedy *et al.,* 1995), and the adherence to internationally recognized healthy food consumption models such as the Mediterranean diet (Bach *et al.,* 2006). Validation of indicators has also been performed for different age population groups, like children (Falciglia *et al.*, 2009) and adolescents (Vincke *et al.,* 2013)

An environment facilitating access to healthy food is one of the conditions to monitor – because if favourable conditions for variety, quality and price do not occur (i.e. a "food desert" condition occurs), it is difficult to promote healthy food choices (Food and Nutrition Board/Board on Agriculture and Natural Resources/Board on Population Health and Public Health Practice/ Institute of Medicine/National Research Council, 2009). The healthy eating indicator shopping basket (HEISB) tool was developed in this research context to reflect dietary recommendations, actual consumption patterns, food composition data and food prices (Anderson *et al.,* 2007). In practice, the HEISB is a tool to estimate whether it is likely for the household to buy basic healthy foods in a fixed environment.

Dietary diversity deals also with tackling micronutrient deficiencies (Acham, Oldewage-Theron and Egal, 2012; Steyn *et al.*, 2014). Therefore, a synergy between variables related to production and variables related to consumption (from farm to fork) exists. Measuring dietary diversity can

[1] www.who.it
[2] www.efsa.europa.eu

be used as a proxy for dietary balance, considering that monotonous diets are generally not healthy (Kennedy *et al.*, 2010, 2011). Dietary diversity is inevitably related to the availability of a range of different foods related in its turn to biodiversity. *Food biodiversity is defined as the diversity of plants, animals and other organisms used as food, covering the genetic resources within species, between species and provided by ecosystems. Information on food biodiversity can be collected by expanding one or more of the dietary diversity food groups of the questionnaire* (FAO, 2010).

However, the public health context requires the availability of, as much as possible, simple indicators (for a definition of indicator, see EQAVET, 2013–2015) to use for policy decisions (NOO, 2010).

METHODOLOGICAL FRAMEWORK

The rationale behind the consideration of the dietary diversity indicator is related to the aims of

(a) optimizing nutrients intake to achieve nutrients goals[3] (WHO, 2003);

(b) increasing the beneficial/harmful substances ratio.

Food-based dietary guidelines (FBDG) aim to address the nutritional requirements at the population level in order to prevent diseases and promote a healthy lifestyle. Overall diet quality measurements have been suggested as useful tools to assess diet–disease relationships. Diet quality indices can be used to assess the compliance with these FBDG (EURODIET, 2001).

A comparative study highlights the similarities and differences between the different tools aimed at analysing food consumption through dietary diversity scores (Kennedy *et al.,* 2010). The choice of indicator for food diversity or quality assessment and surveillance will vary depending on user needs.

The Mediterranean model is correlated with a lower prevalence of degenerative chronic diseases. These health effects are related to the biochemical and nutritional characteristics of the plant-based eating pattern (e.g. antioxidant capacity, low inflammation status) that are considered protective against cell damage and related metabolic complications. An ample source of molecules with antioxidant and anti-inflammatory actions, among which are omega-3 fatty acids, oleic acid and phenolic compounds, characterize the Mediterranean model (Trichopoulou *et al.,* 2014).

The variety of the diet is the prerequisite to obtaining the benefits in terms of health attributed to the Mediterranean model. This aspect is related to nutritional profiles (diet side) and is in some way related to biodiversity (production side). A monotonous diet is considered to be unhealthy (Kennedy *et al.*, 2011).

MEANING OF THE INDICATOR

The dietary diversity score is related to the administration of a questionnaire based on food groupings as reported in Table 1 that are combined differently in two versions for household (Household Dietary Diversity Score HDDS, 12 food groups) and for women (Women Dietary Diversity Score – WDDS, 9 food groups) (FAO, 2010). It is intended to provide a qualitative indication about household (HDDS) or individual (WDDS) food security.

DISCUSSION

The dietary diversity score in its two versions (HDDS and WDDS) was developed as a qualitative measure of food security – a condition not always representing a problem. In developed countries, the consumption of all food groups is usually achieved (see as an example, Elmadfa, 2009). Nevertheless, dietary diversity is a crucial aspect of dietary quality and is stressed in national dietary guidelines.

Moreover, *there is no international consensus on which food groups to include in the scores and the results of new research could justify changing the groups proposed in these guidelines* (FAO, 2010). Moreover, cut-offs to identify security have not been estimated, only ranges are defined HDDS 0-12, WDDS 0-9 (FAO, 2010).

[3] http://www.fao.org/docrep/005/AC911E/ac911e07.htm#TopOfPage

Table 1: Food groups included in the developed questionnaire for evaluating dietary diversity

Food group	Food items
1 Cereals	corn/maize, rice, wheat, sorghum, millet or any other grains or foods made from these (e.g. bread, noodles, porridge or other grain products) + insert local foods e.g. *ugali*, *nshima*, porridge or paste
2 White roots and tubers	white potatoes, white yam, white cassava, or other foods made from roots
3 Vitamin A rich vegetables and tubers	pumpkin, carrot, squash, or sweet potato that are orange inside + other locally available vitamin A rich vegetables (e.g. red sweet pepper)
4 Dark green leafy vegetables	dark green leafy vegetables, including wild forms + locally available vitamin A rich leaves such as amaranth, cassava leaves, kale, spinach
5 Other vegetables	other vegetables (e.g. tomato, onion, eggplant) + other locally available vegetables
6 Vitamin A rich fruits	ripe mango, cantaloupe, apricot (fresh or dried), ripe papaya, dried peach, and 100% fruit juice made from these + other locally available vitamin A rich fruits
7 Other fruits	other fruits, including wild fruits and 100% fruit juice made from these
8 Organ meat	liver, kidney, heart or other organ meats or blood-based foods
9 Flesh meats	beef, pork, lamb, goat, rabbit, game, chicken, duck, other birds, insects
10 Eggs	eggs from chicken, duck, guinea fowl or any other egg
12 Legumes, nuts and seeds	dried beans, dried peas, lentils, nuts, seeds or foods made from these (e.g. hummus, peanut butter)
13 Milk and milk products	milk, cheese, yoghurt or other milk products
14 Oils and fats	oil, fats or butter added to food or used for cooking
15 Sweets	sugar, honey, sweetened soda or sweetened juice drinks, sugary foods such as chocolates, candies, cookies and cakes
16 Spices, condiments, beverages	spices (black pepper, salt), condiments (soy sauce, hot sauce), coffee, tea, alcoholic

Therefore, development of an internationally shared approach is necessary in order to build a comparable indicator, calculable using current statistics validation is needed.

Up to now a specific measure for dietary diversity alone is not available using current statistics. Indicators are to be tested on national individual dietary surveys (IDS), household budget surveys (HBS) or food balance sheets (FBS). This aspect is crucial for a user-friendly variable to build on.

One question we wish to pose in the present work is: can simpler indexes be developed such as adapting the Shannon formula (1) for diversity index for population with an infinite number of elements?

$$(1)\ H = -\Sigma_n\ pi \log_2 p_i \text{ where } n = 1, \dots, s$$

In the original formula, pi is the proportion of the i-th species (Σ_i pi = 1, *i* =1,…, s) and s is the number of species.

In our case, the number of species could be the number of food groups and pi the proportion of food products included into the i-th group.

Similarly, other diversity scores have been developed, including an index of equitability/evenness calculated using H and the maximum value the indicator can reach ($E_H = H / H_{max} = H \ln s$).[4]

At this stage of knowledge, developing a simple indicator other than fruit and vegetable consumption does not seem easy. The National Obesity Observatory (UK) tries to answer the research question about the possibility to have simple estimates using an ad hoc *short form food frequency questionnaire* (NOO, 2010).

Alternatively, developing a specific food frequency questionnaire (short for food frequency questionnaire SFFQ) can be used to evaluate this aspect at public health level (NOO, 2010).

Dietary diversity deals with the food environment. The score developed by FAO (2010) considers the access to food by the household a condition to eat enough and well.

[4] http://www.tiem.utk.edu/~gross/bioed/bealsmodules/shannonDI.html

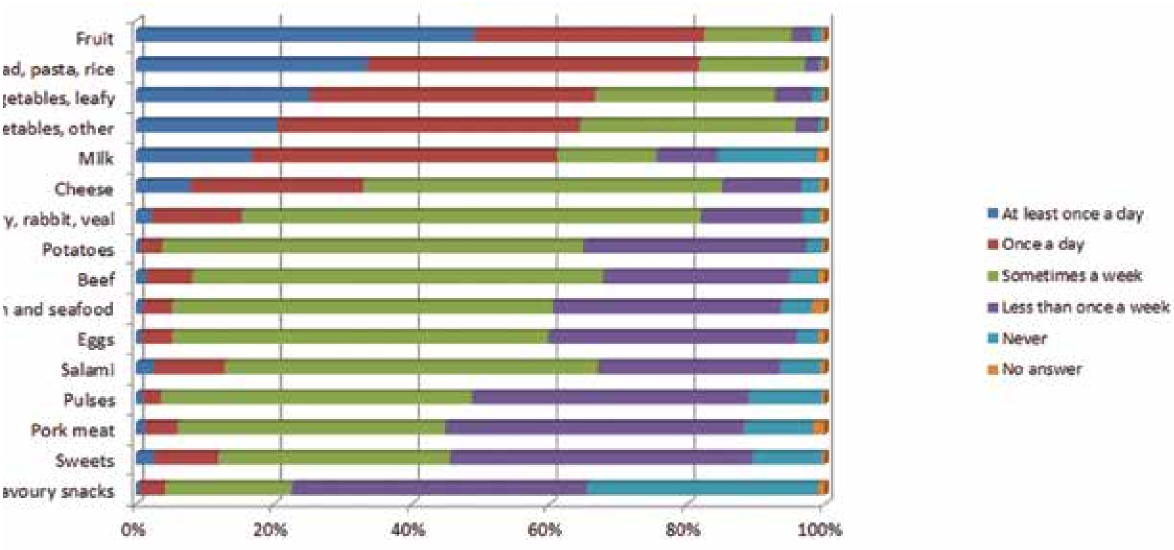


Figure 1: Frequency of consumption of main food groups, Italy, 2011 (adults 18+ years old)
Source: REGALIM study 2011 – CREA, supported by the Italian Ministry of Agriculture, Food, and Forestry Policy (MiPAAF).

In western countries, the theme of access to healthy food is analysed to understand how to facilitate following a healthy diet. Statistical analyses are used to select popular foods combining the compliancewith dietary recommendations, actual consumption patterns, food composition data and food prices. In this view, a healthy eating indicator shopping basket (HEISB) tool is a practical tool to estimate whether it is likely for the household to buy basic healthy foods in a fixed environment. Were favourable conditions for variety, quality and price are not present it is difficult to promote healthy food choices (Anderson *et al.*, 2007).

A solution can be tried considering the average profile for food frequency ranking foods as daily consumption and more, weekly, less than weekly, and so on, using current statistics compared with recommendations. Too little and too much for a selected food group should indicate a potential unbalance.

An example of understanding whether food groups are properly distributed is reported in Figure 1 concerning Italian data collecting the frequency of consumption for all food categories and the number of portions for fruit and vegetables.

CONCLUSIONS

Dietary diversity is an essential aspect of dietary intakes linked to food security, food safety and environmental sustainability, via its analogy with biodiversity, but up to now a specific measure for dietary diversity alone is not yet available using current statistics.

Therefore, further data analyses are necessary to define an indicator drawn from current statistics, maybe arranging specific workshops with experts and policy-makers in different sectors, mainly agriculture, environment and health, to try to combine information and to integrate with each other.

REFERENCES

Acham, H., Oldewage-Theron, W.H. & Egal, A. 2012. Dietary diversity, micronutrient intake and their variation among black women in informal settlements in South Africa: a cross-sectional study. *International Journal of Nutrition and Metabolism*, 4(2): 24–39 (available at http://www.academicjournals.org/IJNAM). DOI: 10.5897/IJNAM11.059.

Anderson, A.S., Dewar, J., Marshall, D., Cummins, S., Taylor, M., Dawson, J. & Sparks, L. 2007. The development of a healthy eating indicator shopping basket tool (HEISB) for use in food access studies – identification of key food items, *Public Health Nutrition*, 10(12): 1440–1447.

Bach, A., Serra-Majem, L., Carrasco, J.L., Roman, B., Ngo, J., Bertomeu, I. & Obrador, B. 2006. The use of indexes evaluating the adherence to the Mediterranean diet in epidemiological studies: a review. *Public Health Nutr.*, 9(1A): 132–146.

Elmadfa, I., ed. 2009. European Nutrition and Health Report 2009. *Annals of Nutrition and Metabolism*, 55(S2). Karger, Basel, Freiburg, Paris, London, New York, Bangalore,Bangkok, Shanghai, Singapore, Tokyo, Sydney (available at http://www.univie.ac.at/enhr/downloads/enhrii_book.pdf).

EQAVET. 2013–2015. Implementing quality assurance in member states in vocational education and training (available at http://www.eqavet.eu/gns/home.aspx); Glossary (available at http://www.eqavet.eu/qa/gns/glossary/s/statistical-indicator.aspx). See the Work Programme (available at http://www.eqavet.eu/Libraries/Miscellaneous/EQAVET_Work_Programme_2013-2015.sflb.ashx).

EURODIET. 2001. *Nutrition and diet for healthy lifestyles in Europe*. A.G. Kafatos, coordinator (available at http://ec.europa.eu/health/archive/ph_determinants/life_style/nutrition/report01_en.pdf).

Falciglia, G.A., Horner, S.L., Liang, J., Couch, S.C. & Levin, L.S. 2009. Assessing dietary variety in children: development and validation of a predictive equation. *J. Am. Diet Assoc.*, 109(4): 641–647. doi: 10.1016/j.jada.2008.12.012.

FAO. 2010. *Guidelines for measuring household and individual dietary diversity* (available at http://www.foodsec.org/web/tools/nutrition/dietary-diversity/en/; reprinted in 2013. http://www.fao.org/docrep/014/i1983e/i1983e00.pdf).

Food and Nutrition Board/Board on Agriculture and Natural Resources/Board on Population Health and Public Health Practice/Institute of Medicine/National Research Council. 2009. The public health effects of food deserts. *National Academies Press*.

Fransen, H.P. & Ocké, M.C, 2008. Indices of diet quality. *Curr. Opin. Clin. Nutr. Metab. Care*, 11(5): 559–565. doi: 10.1097/MCO.0b013e32830a49db.

Hashemi Kani, A., Alavian, S.M., Esmaillzadeh, A., Adibi, P. & Azadbakht, L. 2013. Dietary quality indices and biochemical parameters among patients with non-alcoholic fatty liver disease (NAFLD). *Hepat. Mon.*, 13(7): e10943. doi: 10.5812/hepatmon.10943. eCollection 2013.

Kennedy, E.T., Ohls, J., Carlson, S. & Fleming, K. 1995. The healthy eating index: design and applications. *Journal of the American Dietetic Association*, 95(10): 1103–1108.

Kennedy, G., Berardo, A., Papavero, C., Horjus, P., Ballard, T., Dop, M., Delbaere, J. & Brouwer, I.D. 2010. Proxy measures of household food consumption for food security assessment and surveillance: comparison of the household dietary diversity and food consumption scores. *Public Health Nutr.*, 13(12): 2010–2018. doi: 10.1017/S136898001000145X.

Kennedy, G., Razes, M., Ballard, T. & Dop, M.C. 2011. *Measurement of dietary diversity for monitoring the impact of food based approaches* (available at http://www.foodsec.org/web/pubshome/pubsdetail/ar/c/80795/).

Kourlarba, G. & Panagiotakos, D.B. 2009. Dietary quality indices and human health: a review. *Maturitas*, 62: 1–8.

Nishida, C., Uauy, R., Kumanyika, S. & Shetty, P. 2004. Joint WHO/FAO Expert Consultation on diet, nutrition and the prevention of chronic diseases: process, product and policy implications. *Public Health Nutrition*, 7(1A): 245–250.

NOO (National Obesity Observatory). 2010. *Review of dietary assessment methods in public health* (available at http://www.noo.org.uk/uploads/doc/vid_7237_Review_new.pdf).

Steyn, N.P., Nel, J., Labadarios, D., Maunder, E.M. & Kruger, H.S. 2014. Which dietary diversity indicator is best to assess micronutrient adequacy in children 1 to 9 y? *Nutrition*, 30(1): 55–60. doi: 10.1016/j.nut.2013.06.002.

Trichopoulou, A., Martínez-González, M.A., Tong, T.N.Y., Forouhi, N.G., Khandelwal, S., Prabhakaran, D., Mozaffarian, D., & de Lorgeril, M. 2014. Definition and potential health benefits of the Mediterranean diet: views from experts around the world. *BMC Medicine*, 12: 112.

Vyncke, K., Cruz Fernandez, E., Fajó-Pascual, M., Cuenca-García, M., De Keyzer, W., Gonzalez- Gross, M., Moreno, L.A., Beghin, L., Breidenassel, C., Kersting, M., Albers, U., Diethelm, K., Mouratidou, T., Grammatikaki, E., De Vriendt, T., Marcos, A., Bammann, K., Börnhorst, C., Leclercq, C., Manios, Y., Dallongeville, J., Vereecken, C., Maes, L., Gwozdz, W., Van Winckel, M., Gottrand, F., Sjöström, M., Díaz, L.E., Geelen, A., Hallström, L., Widhalm, K., Kafatos, A., Molnar, D., De Henauw, S. & Huybrechts, I. 2013. Validation of the Diet Quality Index for Adolescents by comparison with biomarkers, nutrient and food intakes: the HELENA study. *Br. J. Nutr.*, 109(11): 2067–2078. doi: 10.1017/S000711451200414X.

WHO (World Health Organization). 2003. *Diet, nutrition and the prevention of chronic diseases*. Report of the Joint WHO/FAO Expert Consultation, Geneva, Switzerland (available at http://www.who.int/dietphysicalactivity/publications/trs916/download/en/).

Selected nutrition indicators to assess the sustainability of the Mediterranean diet: dietary energy density and nutrient density/quality

Denis Lairon
NORT (Unité mixte de recherche Nutrition, obésité et risque thrombotique), Inserm (U 1062); Inra (U 1260), Aix-Marseille Université, Faculté de médecine, Marseille, France

ABSTRACT

Dietary energy density (DES or EDi) reflects the amount of energy present in the amount of foods ingested per capita daily.

The quality of given foods and of a whole diet can be defined by a high content in necessary nutrients, fibre and protective compounds, along with a low content in items to reduce or avoid such as salt, sugar and saturated fat. The MAR (mean adequacy ratio) has been used to estimate the nutrient adequacy of the total diet, on a per capita and daily basis. The last adaptation of MAR was based on the mean percentage of adequacy of intakes vs recommended intakes for 23 key nutrients (proteins, fibres, 3 fatty acids , 10 vitamins, 8 minerals).

INTRODUCTION

The traditional Mediterranean diet is characterized by a certain frugality and a high nutrient supply, while the modern/western present dietary pattern is more characterized by energy-dense foods, especially due to high sugar/carbohydrate and fat, and low fibre content. The present dietary pattern, along with reduced physical activity, is strongly associated with obesity worldwide. Indeed, a growing body of laboratory-based, clinical and epidemiological data suggests that low-energy-dense and nutrient-rich diets are associated with better diet quality, lower energy intakes and body weight in adults as well as children and teenagers. It should be remembered that WHO (2003) recommended reducing the energy density of the diet as a viable strategy to stem the global obesity epidemic. One limitation is that diets with a lower energy density tend to be associated with higher food costs.

DIETARY ENERGY INTAKE AND DENSITY

This indicator is a quantitative or semi-quantitative measure of the amount of energy in the diet. Using dietary intake survey data (e.g. food diaries, dietary recalls), actual food consumption can be estimated.

Dietary energy intake is generally calculated per capita on a daily basis (kcal or kJ/day).

An estimate of the per capita amount of energy (kcal or kJ) in food available for human consumption is obtained from food composition databases. Dietary energy intake is an indicator reflecting energy input, associated with physical energy expenditure and, as a result, with body mass index. Dietary energy supply (DES) is expressed in kcal per capita a day.

Dietary energy density (DES or EDi) reflects the amount of energy present in the amount of foods ingested per capita daily. It is calculated by the ratio of daily energy intake/daily weights of foods; in MJ/kg or /100 g. This is computed from the energy density of the various foods consumed daily.

The data sources are: national surveys, cohort follow-ups, (food balance sheets if no other data are available and with correction for overestimation of actual consumption).

The limitations are: various options for calculations with share of energy supply provided by food groups (not always defined with the same foods), with or without other food groups than cereals and starchy roots, and with or without liquid foods and alcohol.

NUTRIENT DENSITY/QUALITY SCORE

The quality of given foods and of a whole diet can be defined by a high content in necessary nutrients, fibre and protective compounds, along with a low content in items to reduce or avoid such as salt, sugar and saturated fat. This is based on the recommended daily intakes for all these compounds. The nutrient profile is a concept implying that it is possible to discriminate between foods according to their contribution to a healthy diet. Scores have been raised to evaluate the nutrient density of foods aiming at food profiling. Nutrient density scores have been proposed: they could refer either to 100 g, 100 kcal or cost of a given food. Also, various scores have been proposed to evaluate the nutrient quality or adequacy of global diets. The MAR (mean adequacy ratio) has been used to estimate the nutrient adequacy of the total diet, on a per capita and daily basis. The last adaptation of MAR was based on the mean percentage of adequacy of intakes vs recommended intakes for 23 key nutrients (proteins, fibres, fatty acids (3), vitamins (10), minerals (8)). These nutrients and fibre contents are available in a food-composition database and the per capita daily intakes are calculated from the daily amount of each food or food group consumed. The MAR has been repeatedly shown to be positively associated with other indexes of diet quality, notably those estimating dietary diversity or variety, but is negatively associated with dietary energy density. Positive relations with health indicators have been also reported.

The mean excess ratio (MER) is the mean percent of maximal recommended values for three nutrients to be limited (Na, SFA, free sugar), on a per capita and daily basis. Its calculation is as for MAR.

A combination of the MAR and the MER could be an optimal option. A simplified option is to use the SAIN (proteins, fibre, ascorbic acid, calcium, iron) and LIM (sodium, added sugars and saturated fat acids) system as developed and used in France (Darmon *et al.*, 2009).

The data sources are: national surveys, cohort follow-ups (food balance sheets if no other data are available and with correction for overestimation of actual consumption).

The limitations are: (i) the need for accurate and quantitative dietary intake data and food composition databases; (ii) between countries comparisons are limited by possibly different daily recommended intakes (energy, nutrients and fibre); and (iii) between studies comparisons need to use the same nutrients and total number of nutrients.

REFERENCES

Darmon, N., Vieux, F., Maillot, M., Volatier, J.L. & Martin, A. 2009.Nutrient profiles discriminate between foods according to their contribution to nutritionally adequate diets: a validation study using linear programming and the SAIN,LIM system. *Am. J. Clin. Nutr.*, 89: 1227–1236.

Kant, A.K. 1996. Indexes of overall diet quality: a review. *J. Am. Diet Assoc.*, 96(785–791.

Maillot, M., Darmon, N., Vieux, F. & Drewnowski, A. 2007. Low energy density and high nutritional quality are each associated with higher diet costs in French adults. *Am. J. Clin. Nutr.*, 86: 690–896.

Pérez-Escamilla, R., Obbagy, J.E., Altman, J.M., Essery, E.V., McGrane, M.M., Wong, Y.P., Spahn, J.M. & Williams, C.L. 2012. Dietary energy density and body weight in adults and children: a systematic review. *J. Acad. Nutr. Diet*, 112(5): 671–684. doi: 10.1016/j.jand.2012.01.020.

Rolls, B.J., Drewnowski, A. & Ledikwe, J.H. 2005. Changing the energy density of the diet as a strategy for weight management. *Journal of the American Dietetic Association*, 105(5): 98–103.

WHO. 2003. Diet, nutrition and the prevention of chronic diseases. *Report of the Joint WHO/FAO Expert Consultation*. Geneva, Switzerland.

Food biodiversity composition and consumption

Barbara Burlingame
Adjunct Professor, Deakin University, Melbourne, Australia
Ex-Deputy Director, FAO, Nutrition Division

ABSTRACT

Food biodiversity – that is local food resources identified at the taxonomic level of variety/cultivar, and/or by local food name; and wild, neglected or underutilized species – is an important consideration for sustainable diets. These food resources are respected and well represented in the traditions of the Mediterranean diet, contributing to nutritional adequacy as well as ecosystem health. Indicators have been developed, with periodic monitoring and reporting, to assess biodiversity use in the context of sustainable diets. Indicator 1 addresses the nutrient content of food biodiversity (i.e. food composition) and Indicator 2 addresses the use of food biodiversity (i.e. food consumption). A time-series is now available for both indicators, with results suggesting that food biodiversity awareness and acknowledgement of its importance in achieving sustainable diets is increasing.

INTRODUCTION

"Eat a variety of foods" has long been the first rule in national and international food-based dietary guidelines. The nutrition community, however, is only recently appreciative of the relevance of "biodiversity" to this message. Until recently it was considered acceptable to judge dietary diversity as food-group diversity (e.g. dietary diversity score) and generic food diversity. However, it is known that the nutrient content differences within species can be significant, varying by factors of 1 000 or more in some cases (Huang, Tanudjaja and Lum, 1999; Englberger *et al.,* 2003, 2006). These facts, coupled with the dramatic loss in food biodiversity in recent decades, provided a strong case for examining biodiversity in the context of human nutrition and sustainable diets (Toledo and Burlingame, 2006).

Through a series of international conferences and consultations, two nutrition indicators for biodiversity were developed and are now being monitored: Indicator 1 on food composition (FAO/INFOODS, 2008; Burlingame, Charrondiere and Mouille, 2009) and Indicator 2 on food consumption (FAO/INFOODS, 2010). These indicators are used to assess the extent to which food biodiversity is being documented for purposes of human nutrition. In 2008, the baseline report counted 5 519 foods for Indicator 1. In the following years, between 835 and 5 186 foods were added annually (FAO/INFOODS, 2013a). Researchers throughout the world are submitting their data to the FAO/INFOODS Food Composition Database for Biodiversity (2013b), which serves as an international repository. These data are freely available, widely disseminated and frequently cited.

Indicator 2 is a count of the number of biodiverse foods reported in food consumption or similar surveys (FAO/INFOODS, 2010). In 2009, the baseline report counted 3 119 foods. In the subsequent two reporting periods, 1 827 and 1 375 foods were added. A secondary survey indicator was developed as a count of the number of food consumption and similar surveys taking biodiversity into consideration in their design and/or reporting, with at least one reported food meeting the criteria for Indicator 2 (FAO/INFOODS, 2013a).

The indicators have proved useful in stimulating the production, collection and dissemination of biodiversity data for food composition and consumption. They are also advocacy tools for effectively raising awareness of the importance of biodiversity for nutrition and providing documentation of the ever-increasing knowledge of biodiversity and human nutrition. They are also thought to be useful as a proxy for environmental sustainability of diets and resilience of local food systems (FAO, 2013; AFROFOODS, 2009).

DEFINITION

Biodiversity covers diversity within species, between species and of ecosystems; synonyms are: biological diversity, ecological diversity. For the purposes of human nutrition, biodiversity refers to foods identified at the taxonomic level below species (e.g. cultivar, breed) or by local varietal name, and wild, neglected and/or underutilized species. Biodiversity is distinctly different from "dietary diversity", which reflects intake at the level of aggregate food groups.

METHODOLOGY

Indicator 1, Food Composition: A count of the number of foods

- at variety/cultivar/breed level for common foods
- species level for wild/indigenous/underutilized foods

with at least one value for component found in published and unpublished sources.

Indicator 2, Food Consumption:

- the taxonomic diversity of foods, as for food composition. Additional information will be reported on:
    - study (scope, date, number and description of subjects, geographical/ethnic coverage, instrument used; reference, total number of studies examined);
    - food (number of foods reported, food list);
- number of surveys with at least one reported food counting for biodiversity.

BACKGROUND

The biodiversity indicators were deemed necessary in order to understand, quantify and monitor the role of biodiversity in human nutrition, and the impact of biodiversity-related nutrition interventions and initiatives. They were developed as one of the important activities under the Cross-cutting Initiative on Biodiversity for Food and Nutrition (CBD, 2004, 2006ab), and within the framework of the Biodiversity Indicator Partnership (BIP, 2013), and they are monitored by FAO with a regular reporting schedule (FAO/INFOODS, 2013a).

DATA SOURCES

FAO/INFOODS compile data and report periodically (FAO/INFOODS, 2013b).

For Indicator 1, composition, data are obtained by searching peer-reviewed journals using the search engines Scopus and Science Direct, and through a call for data conducted via INFOODS (International Network of Food Data Systems). These data are then compiled in a Biodiversity Food Composition Database (Charrondiere *et al.*, 2012; FAO/INFOODS, 2013b).

Food consumption data from all surveys contribute to Indicator 2, including national nutrition surveys, market surveys, ethno-biological investigations and inventory studies. All published and unpublished available resources are searched including peer-reviewed journals, official international/regional/national/subnational survey reports, conference presentations and published matter, including posters), abstracts published from meetings and theses.

LIMITATIONS OF THE INDICATORS

The development and reporting activity on the indicators is recent, and only two to three time points are available. The usefulness of the indicators should be assessed in the future, and judged against market survey data as well as nutritional outcomes. For the moment, the results represent a reflection of the attention being paid to biodiversity by researchers designing food composition studies and dietary surveys. The monitoring and reporting activity on the biodiversity indicators is the responsibility of FAO/INFOODS. It is a time-consuming activity and, for the 2014–2015 biennium, FAO has put few or no resources into the continuation of this effort.

REFERENCES

AFROFOODS. 2009. *Call for action from the door of return for food renaissance in Africa* (available at http://www.fao.org/fileadmin/templates/food_composition/documents/pdf/AFROFOOD_CALL_and_APPEL.pdf).

BIP (Biodiversity Indicators Partnership). 2013. Homepage (available at http://www.bipindicators.net/).

Burlingame, B., Charrondiere, U.R. & Mouille, B. 2009. Food composition is fundamental to the cross-cutting initiative on biodiversity for food and nutrition. *Journal of Food Composition and Analysis*, 22(5): 361–365.

CBD (Convention on Biological Diversity). 2004. *COP 7 Decision VII/32*. Seventh Meeting of the Conference of the Parties to the Convention on Biological Diversity, Kuala Lumpur, Malaysia, 9–20 February 2004 (available at http://www.cbd.int/decision/cop/default.shtml?id=7769).

CBD. 2006a. *COP 8 Decision VIII/23*. Eighth Meeting of the Conference of the Parties to the Convention on Biological Diversity, Curitiba, Brazil, 20–31 March 2006 (available at http://www.cbd.int/agro/food-nutrition/default.shtml).

CBD. 2006b. *Agricultural biodiversity: a cross-cutting initiative on biodiversity for food and nutrition* (available at https://www.cbd.int/decision/cop/default.shtml?id=11037).

Charrondiere, U.R., Stadlmayr, B., Rittenschober, D., Mouille, B., Nilsson, E., Medhammar, E., Olango, T., Eisenwagen, S., Persijn, D., Ebanks, K., Nowak, V., Du, J. & Burlingame, B. 2012. FAO/INFOODS Food Composition Database for Biodiversity. *Food Chemistry*, 140: 408–412.

Englberger, L., Aalbersberg, W., Fitzgerald, M., Marks, G. & Chand, K. 2003. Provitamin A carotenoid content of different cultivars of edible pandanus fruit. *Journal of Food Composition and Analysis*, 16: 237–247.

Englberger, L., Aalbersberg, W., Schierle, J., Marks, G.C., Fitzgerald, M.H., Muller, Fred, Jekkein, A., Alfred, J. & Vander Velde, N. 2006. Carotenoid content of different edible pandanus fruit cultivars of the Republic of the Marshall Islands. *Journal of Food Composition and Analysis*, 19: 484–494.

FAO/INFOODS. 2008. *Expert Consultation on Nutrition Indicators for Biodiversity - 1. Food Composition*. Rome (available at ftp://ftp.fao.org/docrep/fao/010/a1582e/a1582e00.pdf).

FAO/INFOODS. 2011. *Expert Consultation on Nutrition Indicators for Biodiversity – 2. Food consumption*. Rome (available at: http://www.fao.org/docrep/014/i1951e/i1951e00.htm).

FAO/INFOODS. 2013a. FAO/INFOODS *Report on the Nutrition Indicators for Biodiversity – Global Progress Report*. Rome, FAO (available at http://www.fao.org/docrep/019/i3559e/i3559e.pdf).

FAO/INFOODS. 2013b. FAO/INFOODS *Food composition database for biodiversity version 2.1 - BioFoodComp2.1*. Rome, FAO (available at http://www.fao.org/infoods/infoods/food-biodiversity/en/).

FAO. 2013. *Review of key issues on biodiversity and nutrition. Commission on Genetic Resources for Food and Agriculture*, CGRFA-14/13/8. Rome.

Huang, A.S., Tanudjaja, L. & Lum, D. 1999. Content of alpha-, betacarotene and dietary fiber in 18 sweetpotato varieties grown in Hawaii. *Journal of Food Composition and Analysis,* 12: 147–151.

Toledo, A. & Burlingame, B. 2006. Biodiversity and nutrition: a common path toward global food security and sustainable development. *Journal of Food Composition and Analysis*, 19(6–7): 477–483.

Nutritional anthropometry

Lorenzo M. Donini
Centro Interuniversitario Internazionale di Studi sulle Culture Alimentari Mediterranee (CIISCAM), Sapienza University of Rome

ABSTRACT

Overweight and obesity are increasing worldwide and in developing countries, including Mediterranean countries. Moreover, many low- and middle-income countries are now facing a “double burden” of disease.. This indicator is based on the Body Mass Index (BMI) and the waist circumference (WC), which are used in a wide variety of contexts as simple methods to assess how much an individual’s body weight departs from what is normal or desirable for a person of his or her height.

This indicator is based on the body mass index (BMI) and the waist circumference (WC) that are used in a wide variety of contexts as simple methods to assess how much an individual’s body weight departs from what is normal or desirable for a person of his or her height (WHO, 2005).

BMI in both men and women represents a measure of underweight (<18.5 kg/m^2) or different levels of overweight (25–29.9, 30–34.9, 35–39.9, ≥40 kg/m^2).

WC in both men and women represents a measure of visceral adiposity (>88 cm in women and 102 cm in men). Increased waist circumference can be a marker for increased risk, even in people of normal weight associated with insulin resistance.

Over- and undernutrition frequently coexist in a population. Weight loss, real to ideal weight ratio, and specific nutritional assessment tools (mini nutritional assessment [MNA]; just a nutritional score [JANUS]) (Guigoz, Vellas and Garry, 1996; Donini *et al.,* 2014) may be useful to detect the presence of malnutrition.

The parameters considered are:

- for undernutrition: the prevalence of individuals having a BMI <18.5 kg/m^2 calculated from self-reported weight and height;
- for overweight or obesity: prevalence of individuals having a BMI ≥25.0 kg/m^2 calculated from self-reported weight and height and/or WC >88 cm in women and 102 cm in men

Overweight and obesity are increasing worldwide and in developing countries, including Mediterranean countries. Overweight and obesity are defined as abnormal or excessive fat accumulation that may impair health. Obesity is strongly associated with a number of chronic diseases, including diabetes mellitus, cancers, hypertension and cardiovascular diseases and increases the risk of mortality from these conditions. The fundamental cause of obesity and overweight is an energy imbalance between calories consumed and calories expended. Globally, there has been an increased intake of energy-dense foods that are high in fat, salt and sugars but low in vitamins, minerals and other micronutrients and a decrease in physical activity due to the increasingly sedentary nature of many forms of work, changing modes of transportation and increasing urbanization. In some countries recently it is possible to observe a decrease of underweight and an increase of overweight. Large disparities exist among different socio-economic classes and between urban and rural areas. It is important for policy-makers to have accurate information not only about obesity at national level, but also about how obesity varies across different populations and by socio-economic and demographic factors (Yusuf *et al.*, 2004; Haslam and James, 2005; Kushner, 2007).

Many low- and middle-income countries are now facing a “double burden” of disease. While they continue to deal with the problems of infectious disease and undernutrition, they are experiencing a rapid upsurge in non-communicable disease risk factors such as obesity and

Table 1: Classification of overweight and obesity by BMI, WC and associated disease risks. Disease risk* relative to normal weight and waist circumference

	BMI (kg/m^2)	Obesity class	Men 102 cm or less Women 88 cm or less	Men >102 cm Women > 88 cm
Underweight	<18.5		-	-
Normal	18.5–24.9		-	-
Overweight	25.0–29.9		Increased	High
Obesity	30.0–34.9 35.0–39.9	I II	High Very high	Very high Very high
Extreme obesity	40.0 +	III	Extremely high	Extremely high

Source: http://www.nhlbi.nih.gov/health/public/heart/obesity/lose_wt/bmi_dis.htm
*Note: * Disease risk for type 2 diabetes, hypertension and CVD.*

overweight, particularly in urban settings. It is not uncommon to find undernutrition and obesity existing side-by-side within the same country, the same community and the same household (Jaacks, Slining and Popkin, 2015; Wojcicki, 2014).

The term "body mass index" (previously called the Quetelet index from the nineteenth century) was first proposed in the July edition of 1972 in the Journal of Chronic Diseases by A. Keys, which found the BMI to be the best proxy for body fat percentage among ratios of weight and height. It provides a simple numeric measure of a person's thickness or thinness (Keys *et al.*, 1972). In different epidemiological studies, BMI was correlated with increased morbidity and mortality in all age classes, both in males and females, in different settings (free-living, hospitalized or institutionalized subjects) and in different populations all over the world. Despite its limits in defining body composition, in particular in over- and undernutrition, it is still considered to be the screening tool with the best value for cost (National Heart, Lung, and Blood Institute, 1998; Douglas *et al.*, 2014 ; Flegal *et al.*, 2013).

Together with an increased BMI, excess abdominal fat is considered a risk factor for developing heart and vascular diseases, as well as other obesity-related diseases (metabolic syndrome) or Alzheimer's disease. A study published in the European Heart Journal April 2007 showed that waist circumference and waist:hip ratio were predictors of cardiovascular events (de Koning *et al.*, 2007; Carey, 1998; Razay, 2006).

Data for these parameters will be obtained from WHO Global Database and from locally available national surveys.[1] However, some limitations can be considered for the selected parameters. Individuals tend to overestimate their height and underestimate their weight, leading to underestimation of BMI and of the prevalence of overweight and obesity. Moreover, anthropometric measurements have to be performed by skilled personnel according to a standardized procedure.

Self-reported national surveys might be subject to systematic error (lower reported weight and higher reported height) resulting from non-coverage (e.g. lower telephone coverage among populations of low socio-economic status), non-response (e.g. refusal to participate in the survey or to answer specific questions) or measurement (e.g. social desirability or recall bias). Finally, data were not available for some countries.

REFERENCES

Carey, D.G.P. 1998. Abdominal obesity. *Current opinion in lipidology*, 9(1): 35–40.

de Koning, L., Merchant, A.T., Pogue, J. & Anand, S.S. 2007. Waist circumference and waist-to-hip ratio as predictors of cardiovascular events: meta-regression analysis of prospective studies. *European Heart Journal,* 28(7): 850–856.

Donini, L.M., Ricciardi, L.M., Neri, B., Lenzi, A. & Marchesini, G. 2014. Risk of malnutrition (over and under-nutrition): validation of the JaNuS screening tool. *Clin. Nutr.*, 33: 1087–1094.

[1] http://www.cdc.gov/nchs/data/nhanes/nhanes3/cdrom/nchs/manuals/anthro.pdf
http://www.fao.org/fileadmin/templates/food_composition/documents/Nutrition_assessment/c2.pdf
http://www.measuredhs.com; http://www.childinfo.org/mics.html; http://www.who.int/bmi/index.jsp

Douglas, B.K.I., dos-Santos-Silva, F.H., Leon, D.A. & Smeeth, L. 2014. Body-mass index and risk of 22 specific cancers: a population-based cohort study of 5.24 million UK adults. *Lancet*, 384(9945): 755–765.

Flegal, K.M., Kit, B.K., Orpana, H. & Graubard, B.I. 2013. Association of all-cause mortality with overweight and obesity using standard body mass index categories a systematic review and meta-analysis. *The Journal of the American Medical Association (The American Medical Association)*, 309(1): 71–78.

Gibson, R.S. 1990. P*rinciples of nutritional assessment*. Oxford, UK, Oxford University Press.

Guigoz, Y., Vellas, B. & Garry, P.J. 1996. Assessing the nutritional status of the elderly: the mini nutritional assessment as part of the geriatric evaluation. *Nutr. Rev.*, 54: S59–S65.

Haslam, D.W. & James, W,P. 2005. Obesity. *Lancet*, 366(9492): 1197–1209.

Jaacks, L,M., Slining, M.M. & Popkin, B.M. 2015. Recent underweight and overweight trends by rural-urban residence among women in low- and middle-income countries. *J. Nutr.*, 145(2): 352–357.

Jelliffe, D.B. 1966. The assessment of the nutritional status of the community. *WHO Monograph No. 53.* Geneva, Switzerland.

Keys, A., Fidanza, F., Karvonen, M.J., Kimura, N., Taylor, H.L. 1972. Indices of relative weight and obesity. *J. Chronic Dis.,* 25(6): 329–343.

Kushner, R. 2007. *Treatment of the obese patient (contemporary endocrinology).* Totowa, USA, Humana Press. 158 p.

National Heart, Lung, and Blood Institute. 1998. Executive Summary. *Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults: the evidence report.* September. pp. xi–xxx.

Razay, G. 2006. Obesity, abdominal obesity and Alzheimer's disease, Dementia & Genetic Cognitive Disorders, July.

Shetty, P. 2002. Keynote paper: measures of nutritional status from anthropometric survey data. In *Measurement and assessment of food deprivation and undernutrition*. International Scientific Symposium, 26–28 June 2002. Rome, FAO (available at http://www.fao.org/docrep/005/Y4249E/y4249e0b.htm).

WHO. 1983. *Measuring change in nutritional status. Guidelines for assessing the nutritional impact of supplementary feeding programmes for vulnerable groups*. Geneva, Switzerland.

WHO. 2005. *Physical status: the use and interpretation of anthropometry*. Geneva, Switzerland.

Wojcicki, J.M. 2014. The double burden household in sub-Saharan Africa: maternal overweight and obesity and childhood undernutrition from the year 2000: results from World Health Organization Data (WHO) and Demographic Health Surveys (DHS). *BMC Public Health*, 14: 112.

Yusuf, S., Hawken, S., Ounpuu, S., Dans, T., Avezum, A., Lanas, F., McQueen, M., Budaj, A., Pais, P., Varigos, J., Lisheng, L. & INTERHEART Study Investigators. 2004. Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study. *Lancet,* 364(9438): 937–952.

Physical activity level and physical inactivity prevalence

Angela Polito, Federica Intorre, Donatella Ciarapica and Lorenzo Barnaba
Council for Agricultural Research and Economics – Research Centre for Food and Nutrition, Rome, Italy

ABSTRACT

Physical activity is a complex behavior and is defined as any bodily movement produced by skeletal muscles increasing energy expenditure above the resting level. Subcomponents of physical activity include the type, frequency, duration, intensity and the context where physical activity takes place (i.e. domains of physical activity). It is closely related to but different from physical exercise, which is planned, structured and repetitive bodily movement done to improve or maintain fitness. The amount and character of all activities have physiological and medical consequences. Physical inactivity is the fourth leading risk factor for global mortality and causes 6 percent of all deaths. The levels of physical inactivity increased across the world. Globally, around 31 percent of adults aged 15 and over were not active enough in 2008 (men 28 percent and women 34 percent). In high-income countries, 41 percent of men and 48 percent of women were insufficiently physically active, as compared with 18 percent of men and 21 percent of women in low-income countries. Surveillance of physical activity can be done either through objective measurements (pedometer, accelerometer) or through subjective assessments by means of questionnaires administered by skilled personnel or telephone interview or self-administered questionnaires. The two most widely used standardized questionnaire instruments are the International Physical Activity Questionnaire (IPAQ) developed in 1997 as a result of various research projects and the Global Physical Activity Questionnaire (GPAQ) developed in 2001 as part of the STEPwise approach to surveillance (STEPS programme). However, in many of the national surveys, non-standardized questionnaires and different concepts and indicators of physical activity and/or inactivity have been used, leading to results that are not comparable across countries. There is a requirement for improved harmonization of methodologies in surveillance and intervention research, including analysis of existing datasets, field-testing of selected indicators to promote interinstitutional dialogue and to reach consensus on best indicators.

INTRODUCTION

Physical activity is a complex behaviour and is defined as any bodily movement produced by skeletal muscles increasing energy expenditure above the resting level. Physical activity-related energy expenditure (PAEE) is quantitatively the most variable component of total energy expenditure, usually accounting for 25–50 percent of energy expenditure, up to a maximum of 75 percent in some unusual circumstances (SACN, 2011). Subcomponents of physical activity include the type, frequency, duration, intensity and the context where physical activity takes place (i.e. domains of physical activity). The term "physical activity" should not be mistaken with "exercise". Exercise is a subset of physical activity that is planned, structured and repetitive, characterized by the choice of predetermined finalizing specific movements and has, as a final or an intermediate objective, the improvement or maintenance of physical fitness and/or health to produce positive effects on physical, psychological and/or social well-being (SACN, 2011). Physical activity includes exercise as well as other activities that involve bodily movement and are done as part of playing, working, active transportation, house chores and recreational activities. These activities are indicated as spontaneous physical activity (SPA), a term used to describe all body movements associated with activities of daily living, change of posture, "fidgeting" and involuntary choices between low and high expenditure (e.g. standing or walking up escalators). SPA accounts for a between-individual variation in energy expenditure of 15 percent. The potential for variable SPA throughout the range of defined activities adds to the uncertainty that their energy costs can be predicted (SACN, 2011). SPA displays an inverse relationship with future weight gain (Zurlo *et al.,* 1992) and it has therefore been described as a putative obesity subphenotype (SACN, 2011).

HEALTH BENEFITS OF PHYSICAL ACTIVITY

As reported by the WHO Global InfoBase,[1] insufficient physical activity has been identified as the fourth leading risk factor for mortality, as well as the main cause for approximately 21–25 percent of breast and colon cancers, 27 percent of diabetes and approximately 30 percent of ischaemic heart disease burden. It is only outstripped by high blood pressure (13 percent) and tobacco use (9 percent) and carries the same level of risk as high blood glucose (6 percent). Approximately 3.2 million people die each year because they are not active enough. Physical inactivity has been identified as one of the biggest public health problems of the twenty-first century (Blair, 2009). Regular and adequate levels of physical activity improve muscular and cardiorespiratory fitness, improve bone and functional health, reduce the risk of non-communicable diseases (cardiovascular diseases, cancers, chronic respiratory diseases and diabetes), of depression and risk of falls as well as hip or vertebral fractures, are a key determinant of energy expenditure, and are thus fundamental to energy balance and weight control. People who are insufficiently physically active have a 20–30 percent increased risk of all-cause mortality compared with those who engage in at least 30 minutes of moderate intensity physical activity most days of the week. Physically active people exhibited a 30–40 percent reduction in the relative risk of colon cancer, and physically active women a 20–30 percent reduction in the relative risk of breast cancer compared with their inactive counterparts (Warburton, Nicol and Bredin, 2006). One prospective cohort study showed walking at least two hours per week was associated with a reduction in the incidence of premature death of 39–54 percent from any cause and of 34–53 percent from cardiovascular disease among patients with diabetes (Gregg *et al.*, 2003). Moderate physical activity for at least 150 minutes per week was found to be more effective than metformin alone in reducing the incidence of diabetes (Warburton, Nicol and Bredin, 2006). Regular physical activity was associated with an average increase in life expectancy of one to two years by the age of 80 and the benefits were linear even at lower levels of energy expenditure (Warburton, Nicol and Bredin, 2006).

The mechanisms by which regular physical activity induces these benefits lie in the acute and chronic physiologic changes it causes. The physiologic changes caused by various physical activities overlap considerably. However, some activities are more closely associated than others with some physiologic changes. For example, aerobic activities cause many changes to the cardiovascular system that improve the capacity and efficiency of the delivery of oxygen and glucose to tissues that need them. Ambulatory activities improve muscle and bone strength along the axial skeleton and lower extremities. Swimming, another aerobic activity, has greater impact on upper body musculature and less impact on the skeletal system. Therefore, different types of physical activity acting through multiple physiologic pathways influence a broad array of health outcomes (Table 1) (Powell, Paluch and Blair, 2011).

The levels of physical inactivity increase across the world. Globally (Figure 1), around 31 percent of adults aged 15 and over were not active enough in 2008 (men 28 percent and women 34 percent). In high-income countries, 41 percent of men and 48 percent of women were insufficiently physically active, as compared with 18 percent of men and 21 percent of women in low-income countries (WHO, 2014).

[1] https://apps.who.int/infobase/

In 2010 WHO developed the Global recommendations on physical activity for health (WHO, 2010) with the overall aim of providing national and regional level policy-makers with guidance on the dose-response relationship between the frequency, duration, intensity, type and total amount of physical activity needed for the prevention of non-communicable diseases (NCDs). International recommendations provide guidance for three age groups (5–17 years old, 18–64 years old and 65 years old and above), selected taking into consideration the nature and availability of the scientific evidence relevant to the selected outcomes (Table 2).

Table 1: Examples of physical activities, physiologic pathways and health outcomes[a]

Examples of physical activities	Examples of physiologic changes	Examples of health outcomes
Gardening	↑ Autonomic balance	
Home repair	↑ Bone density	↓ Breast cancer
Painting	↑ Capillary density	↓ Colon cancer
Raking	↑ Coronary artery size	↓ Coronary heart disease
Shovelling	↑ Endothelial function	↓ Depression
Sweeping	↑ High density lipoprotein	↓ Excess weight gain
Vacuuming	↑ Immune function	↓ Fractures
Basketball	↑ Insulin sensitivity	↓ Injurious falls
Cycling	↑ Lean body mass	↓ Osteoporosis
Dancing	↑ Mitochondrial volume	↓ Risk of death
Running	↑ Motor unit recruitment	↓ Stroke
Skiing	↑ Muscle fibre size	↓ Type 2 diabetes
Soccer	↑ Neuromuscular coordination	↑ Cognitive function
Swimming	↑ Stroke volume	↑ Physical function
Tennis	↓ Blood coagulation	↑ Weight management
Walking	↓ Inflammation	

[a] Arrows indicate direction of physiologic change or health outcome associated with increased physical activity. The table is designed to be read only by column. Different physical activities act through a variety of physiologic pathways to influence different health outcomes.
Source: modified from Powell, Paluch and Blair (2011).

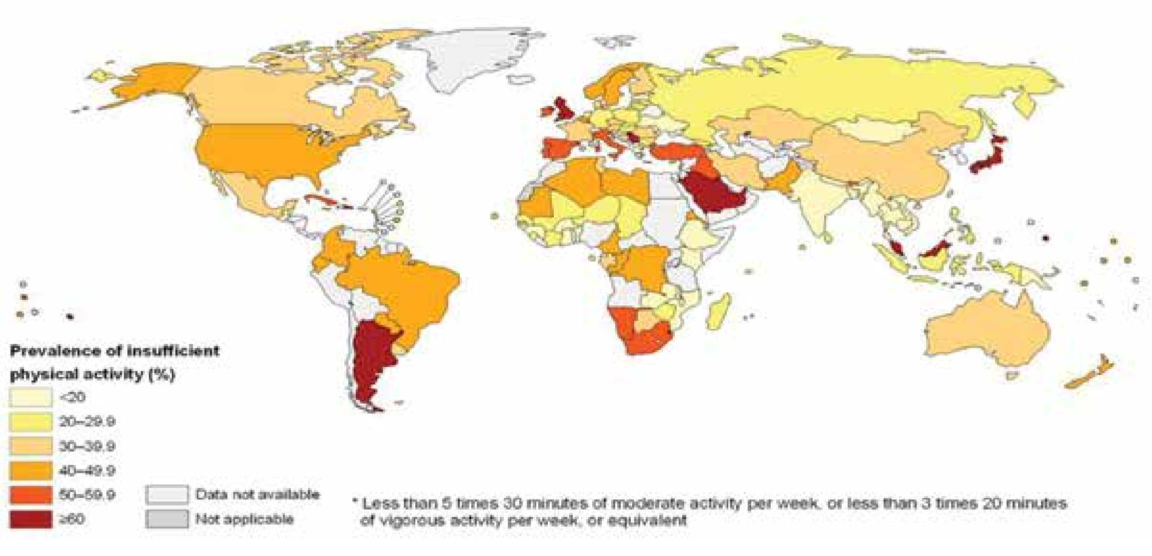


Figure 1: Prevalence of insufficient* physical activity, aged 15+, age standardized both sexes, 2008
Source: World Health Organization (2011). Map production: Public health Information and Geographic Information System (GIS) World Health Organization. © Copyright World Health Organization (WHO), 2015. All Rights Reserved.

Table 2: Global recommendations on physical activity for health

Recommendations for 5–17 years old	Recommendations for 18–64 years old	Recommendations for 65 years and above
1. Children and youth aged 5–17 should accumulate at least 60 minutes of moderate- to vigorous-intensity physical activity daily. 2. Amounts of physical activity greater than 60 minutes provide additional health benefits. 3. Most of the daily physical activity should be aerobic. Vigorous-intensity activities should be incorporated, including those that strengthen muscle and bone, at least three times per week. The benefits of being physically active outweigh the harms. Any existing risk can be reduced by a progressive increase in the activity level, especially in children and young people who are inactive. For activities that can pose risks of injuries, the use of protective equipment such as helmets should be encouraged.	1. Adults aged 18–64 should accumulate at least 150 minutes of moderate-intensity aerobic physical activity throughout the week or do at least 75 minutes of vigorous-intensity aerobic physical activity throughout the week or an equivalent combination of moderate- and vigorous-intensity activity. 2. Aerobic activity should be performed in bouts of at least ten minutes duration. 3. For additional health benefits, adults should increase their moderate-intensity aerobic physical activity to 300 minutes per week, or engage in 150 minutes of vigorous-intensity aerobic physical activity per week, or an equivalent combination of moderate- and vigorous-intensity activity. 4. Muscle-strengthening activities should be done involving major muscle groups on two or more days a week.	1. Older adults should accumulate at least 150 minutes of moderate-intensity aerobic physical activity throughout the week or do at least 75 minutes of vigorous-intensity aerobic physical activity throughout the week or an equivalent combination of moderate- and vigorous-intensity activity. 2. Aerobic activity should be performed in bouts of at least ten minutes duration. 3. For additional health benefits, older adults should increase their moderate-intensity aerobic physical activity to 300 minutes per week, or engage in 150 minutes of vigorous-intensity aerobic physical activity per week, or an equivalent combination of moderate-and vigorous-intensity activity. 4. Older adults, with poor mobility, should perform physical activity to enhance balance and prevent falls on three or more days per week. 5. Muscle-strengthening activities, involving major muscle groups, should be done on two or more days a week. 6. When older adults cannot do the recommended amounts of physical activity due to health conditions, they should be as physically active as their abilities and conditions allow.

Source: modified from WHO (2010).

MEASUREMENT OF PHYSICAL ACTIVITY

To monitor trends and evaluate public health or individual interventions aiming at increasing levels of physical activity (PA), reliable and valid measures of habitual physical activity are essential. Surveillance of physical activity can be done either through objective measurements (pedometer, accelerometer, double label water [DLW]) or through subjective assessments by means of questionnaires administered by trained personnel or telephone interview or self-administered questionnaires. The specific study type and design have an important bearing on the choice of method to measure physical activity (Table 3).

The selection of method to assess physical activity may be a trade-off between degree of validity and feasibility, but the method must be suitable for the aims of the study. Subjective methods of measuring physical activity are useful with large populations as they are inexpensive and easy to apply but have their limitations such as reliability and validity problems associated with recall of activity (Warren *et al.*, 2010).

Several questionnaires are been proposed in literature and a collection of self-reported measures and their associated validation studies were synthesized and published more than ten years ago (Pereira et al., 1997). The two most widely used standardized questionnaire instruments are the international physical activity questionnaire (IPAQ)[2] developed in 1997 as a result of various research projects and especially used in European surveys, and the global physical activity questionnaire (GPAQ)[3] developed in 2001 and used especially in developing countries.

The IPAQ is an instrument that was developed by the International Consensus Group in 1998–1999 to establish a standardized and culturally adaptable measurement tool across various populations in the world (Craig *et al.*, 2003). The IPAQ is designed to assess the levels of habitual PA for individuals ranging from young to middle-aged adults (i.e. 15–69 years old). Two versions of the

[2] http://www.ipaq.ki.se/ipaq.htm

[3] http://www.who.int/chp/steps/resources/GPAQ_Analysis_Guide.pdf

Table 3: Assessment of physical activity according to study type

Study type	Study outcomes	Appropriate tool
Surveillance systems and surveys	Monitoring trends Comparisons within population over time and between populations	Questionnaires that have demonstrated reliability and validity internationally, i.e. IPAQ, GPAQ
Observational large-scale cohort studies	Association analyses between exposure(s) and outcome(s)	Self-questionnaires that have been shown to be reliable and valid
Observational large-scale cohort studies in young people	Association analyses between exposure(s) and outcome(s)	Objective monitoring, i.e. accelerometers or combined heart rate and motion sensing
Interventions and randomized controlled trials	Treatment and intervention effects	Objective monitoring, i.e. accelerometers, heart rate monitoring and combined heart rate and motion sensing Doubly labelled water if investigating change in TEE or PAEE Pedometer if the intervention seeks to increase walking

Source: modified from: Warren *et al.* (2010).

IPAQ were developed, the short form and the long form. In the short version of the IPAQ, used primarily in studies of epidemiological surveillance, three specific activities are investigated that are carried out in the four domains. These specific activities are walking, the activity of medium-intensity and vigorous-intensity; the questionnaire also includes the time that is spent sitting, as an index of inactivity. The long form of the iPAQ is mainly used in research studies and evaluates in more detail each type of activity in each domain. The long form of IPAQ (IPAQ-L) measures frequency, duration and intensity of physical activity in the four domains of life: work, transport, domestic and garden, and leisure time. Studies have shown an acceptable validity and reliability of IPAQ for use in population-based studies of physical activity (Craig *et al.*, 2003; Deng *et al.,* 2008). Each of the two forms can be self-administered or by phone (Hagstromer, Oja and Sjöström, 2006; Hagstromer *et al.*, 2010). Physical activity estimated using the long version of IPAQ may be higher because the short version systematically underestimates physical activity level (Hallal *et al.,* 2004), since it consists of fewer questions (seven questions in the short version compared with 27 questions in the long version). One of the factors that most influences results obtained by this kind of questionnaire is the overestimation of time spent in a certain activity and for certain intensity (Rzewnicki, Vanden Auweele and De Bourdeaudhuij, 2003); moreover, the individual's ability and understanding as well as the age are other factors affecting self-administrated questionnaires results. However, the IPAQ-L is a self-assessment questionnaire (self-report) and people tend to overestimate the time spent in high-intensity activity and underestimate the time spent in sedentary activities (probably because they tend to respond in a socially desirable way) (Sallis and Saelens, 2000; Klesges e*t al.,* 1990). Administration by trained personnel in a face-to face interview limits this type of error (Hallal *et al.*, 2010).

The GPAQ was created by WHO as part of the STEPwise approach to surveillance (STEPS) programme for physical activity surveillance in developing countries. The STEPS is a simple, standardized method for collecting, analysing and disseminating data in WHO member countries. By using the same standardized questions and protocols, all countries can use STEPS information not only for monitoring within-country trends, but also for making comparisons across countries. The approach encourages the collection of small amounts of useful information on a regular and continuing basis. There are currently two primary STEPS surveillance systems,[4] the STEPwise approach to risk factor surveillance and the STEPwise approach to stroke surveillance.

It collects information on physical activity participation in three settings (or domains) as well as sedentary behaviour, comprising 16 questions. The domains are: (i) activity at work; (ii) travel

[4] http://www.who.int/chp/steps/en/

to and from places; and (iii) recreational activities. The GPAQ has been developed for face-to-face interviews conducted by trained interviewers. It had been tested in large-scale population-based surveys with the general adult population.

Both questionnaires are used for physical activity surveillance in general population, capture intensity, frequency and duration of overall physical activity and have similar validity and repeatability but, while IPAQ captures overall physical activity – vigorous, moderate, walking – and is not domain specific, GPAQ captures overall physical activity for each domain separately (work, transport, leisure time).

Using questionnaires the estimate of physical activity energy expenditure is made by using the compendium of physical activities (Ainsworth *et al.*, 1993, 2000, 2011). This compendium provides a classification of specific activities in metabolic equivalent of activity (MET) used to express exercise intensity. One MET represents the resting energy expenditure during quiet sitting and is commonly defined as 3.5 ml O2•kg–1•min–1 or ≈ 250 mL/min of oxygen consumed, which represents the average value for a standard person (70 kg). Obviously the oxygen consumption increases with activity intensity level, therefore the MET value increases with the intensity of physical activity (e.g. 1 MET = the rate of energy expenditure while at rest [sitting quiet], 2 MET = walking at 3 km/h would require twice the energy that an average person consumes at rest).

MEANING OF THE INDICATOR

FAO define sustainable diets as: ".... diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources" (FAO, 2010). Moreover, the Mediterranean diet refers not only to an eating pattern, but also to a healthy lifestyle where physical activity plays an important role in balancing energy intake, maintaining healthy body weight and providing many other health benefits (WHO, 2003). Physical activity, indeed, is a key component of the Mediterranean diet pyramid (Figure 2).

On the basis of these considerations, although there are doubts on considering physical activity as a nutritional indicator or a cofactor of nutritional status, it has been decided to consider it in the list of nutritional indicators of sustainability with the aim of maintaining a healthy lifestyle.

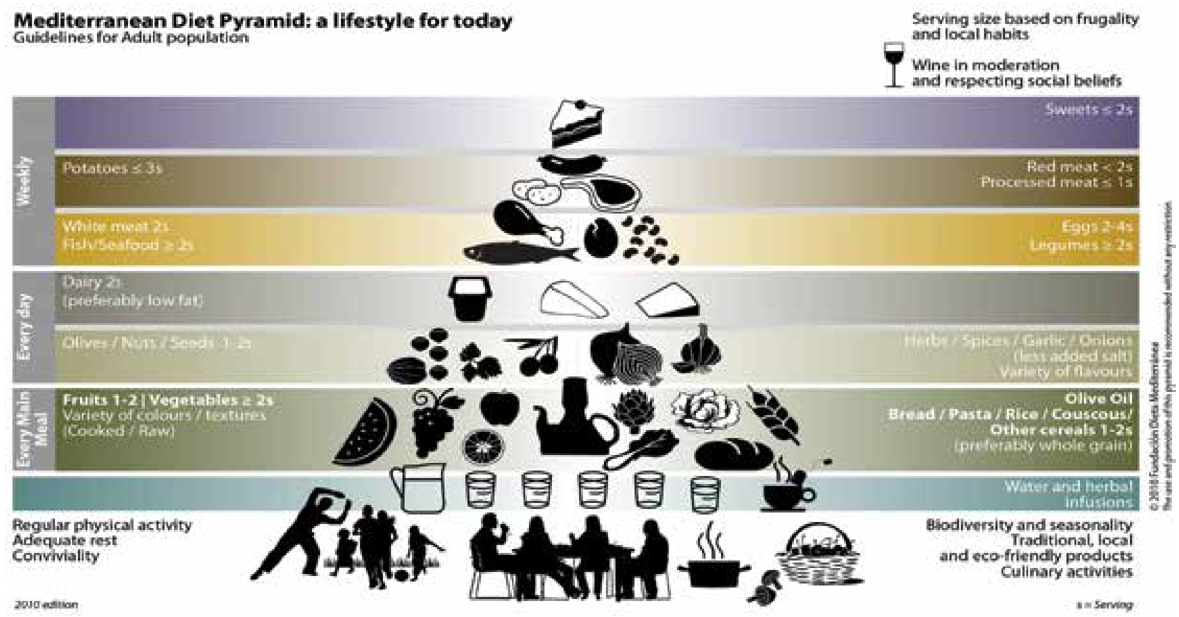


Figure 2: Mediterranean diet pyramid – a lifestyle for today
Source: modified from Bach-Faig, *et al.* (2011).

Several physical activity indicators have been proposed (WHO, 2009). On the basis of available data the physical inactivity prevalence has been selected as an indicator of physical activity, using the definition of not meeting any of the following criteria: at least 30 minutes of moderate-intensity activity per day on at least five days per week, or at least 20 minutes of vigorous-intensity activity per day on at least three days per week, or an equivalent combination.

DISCUSSION AND CONCLUSION

Physical inactivity, usually together with unhealthy food habits, is associated with development of many of the major non-communicable diseases in society, such as cardiovascular disease, some cancers, obesity, diabetes and osteoporosis. The physical activity level and pattern of a population is an important generic indicator in public health nutrition and several physical activity indicators have been proposed.

The problems in the selection of a physical activity indicator concern mainly the methodological aspect. For surveillance activity, the objective methods were rarely used: only a pedometer can be used but it is specifically designed to assess walking only; it is unable to record non-locomotor movements and to examine the rate or intensity of movement. On the other hand, an accelerometer is suitable for all populations and is an objective indicator of body movement (acceleration), but is an inaccurate assessment of a large range of activities, and the financial cost may prohibit assessment of large numbers of participants. Consequently, subjective methods are mainly used in the case of national and international surveys, but most of the available data may be difficult to interpret due to differences in the assessment methods of physical activity and consequently it is not possible to have a cross-country comparison. Moreover, it is necessary to underline that data on population-based physical inactivity may be limited in some countries.[5]

In the framework of the construction of an index of diet sustainability, the available data on physical inactivity can be used (i.e. the physical inactivity prevalence reported in the WHO Global InfoBase including surveys with clearly indicated methods based mainly on IPAQ, GPAQ or similar questionnaires). There is, however, a need for improved harmonization of methodologies in surveillance and intervention research, including analysis of existing datasets and field-testing of selected indicators in order to promote interinstitutional dialogue and to reach consensus on best indicators.

REFERENCES

Ainsworth, B.E., Haskell, W.L., Leon, A.S., Jacobs, D.R. Jr, Montoye, H.J., Sallis, J.F. & Paffenbarger, R.S. Jr. 1993. Compendium of physical activities: classification of energy costs of human physical activities. *Med. Sci. Sports Exerc.,* 25(1): 71–80.

Ainsworth, B.E., Haskell, W.L., Whitt, M.C., Irwin, M.L., Swartz, A.M., Strath, S.J., O'Brien, W.L., Bassett, D.R. Jr, Schmitz, K.H., Emplaincourt, P.O., Jacobs, D.R. Jr & Leon, A.S. 2000. Compendium of physical activities: an update of activity codes and MET intensities. *Med. Sci. Sports Exerc.*, 32(9 Suppl): S498–504.

Ainsworth, B.E., Haskell, W.L., Herrmann, S.D., Meckes, N., Basset,t D.R. Jr, Tudor-Locke, C., Greer, J.L., Vezina, J., Whitt-Glover, M.C. & Leon, A.S. 2011. Compendium of physical activities: a second update of codes and MET values. *Med. Sci. Sports Exerc.,* 43(8): 1575–1581.

Bach-Faig, A., Berry, E.M., Lairon D., Reguant J., Trichopoulou, A., Dernini, S., Medina, F.X., Battino, M., Belahsen, R., Miranda, G. & Serra-Majem, L. 2011. Mediterranean diet pyramid today. Science and cultural updates. *Public Health Nutrition*: 14(12A): 2274–2284.

Blair, S.N. 2009. Physical inactivity: the biggest public health problem of the 21st century. *Br. J. Sports Med.*, 43: 1–2.

Craig, C.L., Marshall, A.L., Sjöström. M., Bauman, A.E., Booth, M.L., Ainsworth, B.E., Pratt, M., Ekelund, U., Yngve, A., Sallis, J.F. & Oja, P. 2003. International physical activity questionnaire: 12-country reliability and validity. *Med. Sci. Sports Exerc*., 35(8): 1381–1395.

Deng, H.B, Macfarlane, D.J., Thomas, G.N., Lao, X.Q., Jiang, C.Q., Cheng, K.K. & Lam, T.H. 2008. Reliability and validity of the IPAQ-Chinese: the Guangzhou Biobank Cohort study. *Med Sci Sports Exerc*., 40: 303–307.

[5] https://apps.who.int/infobase/

FAO. 2010. *International Scientific Symposium "Biodiversity and Sustainable Diets: United Against Hunger".* Report of a Technical Workshop, 3–5 November 2010. Rome.

Gregg, E.W., Gerzoff, R.B., Caspersen, C.J., Williamson, D.F. & Narayan, K.M. 2003. Relationship of walking to mortality among US adults with diabetes. *Arch. Intern. Med.*, 163: 1440–1447.

Hagstromer, M., Ainsworth, B.E., Oja, P. & Sjostrom, M. 2010. Comparison of a subjective and an objective measure of physical activity in a population sample. *J. Phys. Act. Health*, 7: 541–550.

Hagströmer, M., Oja, P. & Sjöström, M. 2006. The International Physical Activity Questionnaire (IPAQ): a study of concurrent and construct validity. *Public Health Nut*r., 9: 755–762.

Hallal, P.C., Victora, C.G., Wells, J., Lima, R.C. & Valle, N.J. 2004 Comparison of short and full-length International Physical Activity Questionnaires. *J Phys Act Health* 1, 227–234.

Hallal, P.C., Simoes, E., Reichert, F.F., Azevedo, M.R., Ramos, L.R., Pratt, M. & Brownson, R.C. 2010. Validity and reliability of the telephone-administered international physical activity questionnaire in Brazil. J. *Phys. Act. Health*, 7(3): 402–409.

Klesges, R.C., Eck, L.H., Mellon, M.W,, Fulliton, W., Somes, G.W. & Hanson C.L. 1990. The accuracy of self-reports of physical activity. *Med. Sci. Sports Exerc*., 22: 690–697.

Pereira, M.A., FitzerGerald, S.J., Gregg, E.W., Joswiak, M.L., Ryan, W.J., Suminski. R.R., Utter, A.C. & Zmuda, J.M. 1997. A collection of physical activity questionnaires for health-related research. *Med. Sci. Sports Exerc.*, 29(6 Suppl.): S1–205.

Powell, K.E., Paluch, A.E. & Blair, S.N. 2011. Physical activity for health: What kind? How much? How intense? On top of what? *Ann. Rev. Public Health*., 32: 349–365.

Rzewnicki, R., Vanden Auweele, Y. &, De Bourdeaudhuij, I. 2003. Addressing overreporting on the International Physical Activity Questionnaire (IPAQ) telephone survey with a population sample. P*ublic Health Nutr.,* 6(3): 299–305

SACN (Scientific Advisory Committee on Nutrition). 2011. *Dietary reference values for energy*. London.

Sallis, J.F. & Saelens, B.E. 2000. Assessment of physical activity by self report: status, limitations, and future directions. *Res. Quart. Exerc. Sport,* 71: S1–S14.

Warburton, D.E.R., Nicol, C.W. & Bredin, S.S.D. 2006. Health benefits of physical activity: the evidence. *CMA*J, 174(6): 801–809.

Warren, J.M., Ekelund, U., Besson, H., Mezzani, A., Geladas, N. & Vanhees, L. 2010. Assessment of physical activity - a review of methodologies with reference to epidemiological research: a report of the exercise physiology section of the European Association of Cardiovascular Prevention and Rehabilitation. *Eur. J. Cardiovasc. Prev. Rehabil*., 17(2): 127–139.

WHO (World Health Organization) 2003. *Diet, nutrition and the prevention of chronic diseases*. Report of a Joint WHO/FAO Expert Consultation (available at http://www.who.int/dietphysicalactivity/publications/trs916/en/gsfao_introduction.pdf).

WHO. 2009. *Report of the Workshop on integration of data on physical activity patterns*. Report n°4 (available at http://www.euro.who.int/data/assets/pdf_file/0004/87430/E93705.pdf).

WHO. 2010. *Global recommendations on physical activity for health*. Geneva, Switzerland (available at http://www.who.int/dietphysicalactivity/factsheet_recommendations/en/).

WHO. 2014. Physical activity. Fact sheet 385 (available at http://www.who.int/mediacentre/factsheets/fs385/en/).

Zurlo, F., Ferraro, R.T., Fontvielle, A.M., Rising, R., Bogardus, C. & Ravussin, E. 1992. Spontaneous physical activity and obesity: cross-sectional and longitudinal studies in Pima Indians. *Am. J. Physiol*., 263: E296–E300.

THIRD SESSION: ASSESSING SUSTAINABLE DIETS IN THE CONTEXT OF SUSTAINABLE FOOD SYSTEMS

Sustainable diets and sustainable food systems

Vincent Gitz
Coordinator of the High Level Panel of Experts on Food Security and Nutrition, FAO

ABSTRACT

The High Level Panel of Experts (HLPE) was created in 2009 as part of the reform of the Committee on World Food Security (CFS), as the science–policy interface of CFS, to: assess and analyse the current state of food security and nutrition (FSN) and its underlying causes; and provide scientific and knowledge-based analysis and advice on specific policy-relevant issues. In 2014, the HLPE produced a report on food losses and waste in the context of sustainable food systems. On this occasion, it reflected on the very notion of sustainable food systems (SFS) and formalized a definition. Starting from this definition, this paper focus on the relationships between three key notions – sustainable diets, SFS and FSN – in order to understand how sustainable diets relate to sustainable food systems. The two notions are very linked, which can help their common assessment; the strength of the contribution of the diet to the sustainability of the food system is what characterizes the sustainability of the diet. And sustainable diets are not only an objective but an essential mean, a key driver, to achieve the transformation of food systems, which is needed to achieve SFS.

THE HLPE

First of all a few words about the High Level Panel of Experts on Food Security and Nutrition (HLPE), just to situate this intervention. The HLPE has been created as the science–policy interface of the Committee on World Food Security (CFS) to advise it and its stakeholders (governments, the private sector, civil society, international organizations, etc.), at its request, on topics related to food security and nutrition (FSN), and on priority areas of action to improve FSN. The HLPE works demand-driven, at the request of CFS. In 2014, the HLPE produced a report on food losses and waste in the context of sustainable food systems (HLPE, 2014a). On this occasion it had to reflect on the very notion of sustainable food systems and formalized a definition. It has also produced a note on critical and emerging issues for food security and nutrition (HLPE, 2014b), where it highlights the importance of adopting a food systems perspective as well as the links between food systems and nutrition.

FOOD SECURITY AND NUTRITION AS LINKED OF SUSTAINABLE FOOD SYSTEMS

So my approach starts from food security and nutrition, with a global and forward-looking perspective. Considerable changes in diets worldwide towards more animal-based products, driven by income growth and urbanization, and particularly in developing countries (see Figure 1), are causing global changes in food systems.

There is no need to insist here on the unsustainability of the global food system; it is now well recognized (Godfray *et al.*, 2010; Foresight, 2011; FAO, 2012a). Three symptoms of it deserve to be highlighted because they will be of use when thinking what sustainable food systems could mean:

- there are today more than 800 million hungry – while enough food is being produced;
- the majority of the hungry and poor are food producers;
- there are considerable impacts on natural resources and the environment.

Two trends of concern for the future need to be added:

- a projected considerable increase of demand, driven first and foremost by changing diets (including towards more animal-sourced products) and also (but to a lesser extent) by population growth – all of this in a context of persisting hunger;
- linked to this, considerable changes in food systems.

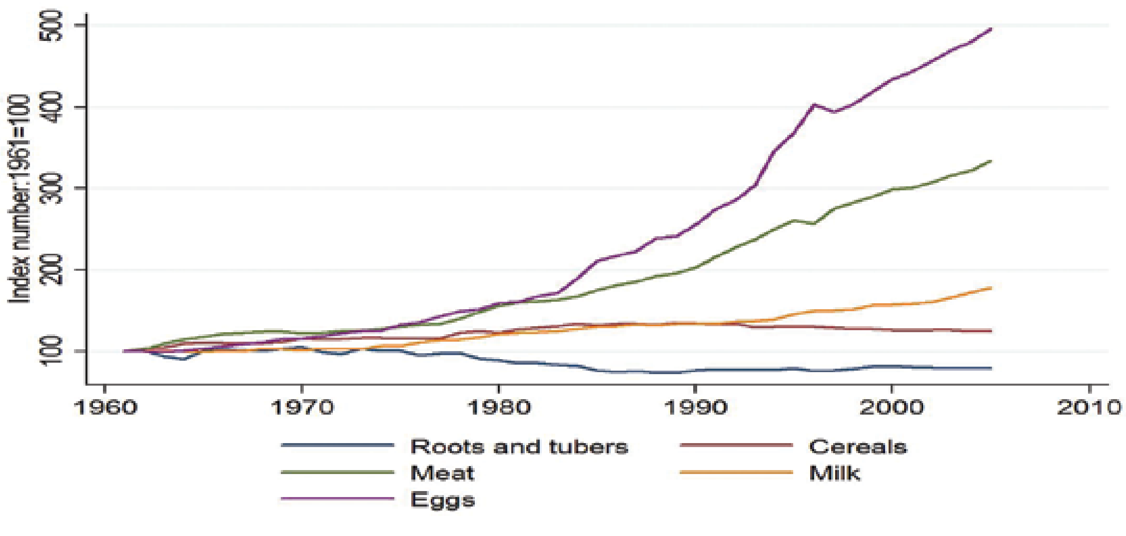


Figure 1: Dietary patterns in developing countries 1961–2005
Source: FAO (2009).

These two interrelated trends have been identified by the HLPE in its recent note to the CFS (HLPE, 2014b) as a critical and emerging issue for FSN, along with the need to identify pathways to sustainable food systems (SFS).

So, we could say that unsustainable diets lead to unsustainable food systems.

This presentation will focus on the relationships between three key notions (see Figure 2) that we believe can frame all the rest, help understand the situation, where to go and how to get there:

- Sustainable diets
- Sustainable food systems
- Food security and nutrition

And this will be important to understand how to best assess progress and results, which is the theme of the works of this session of the workshop.

In its report *Food losses and waste in the context of sustainable food systems*, released this year (2014), the HLPE formalized the link between the two concepts of food security and nutrition (FSN) and of sustainable food systems (SFS). It took as a starting point the generally assumed description of food systems, as adapted from a range of other definitions (e.g. Ericksen, 2008;

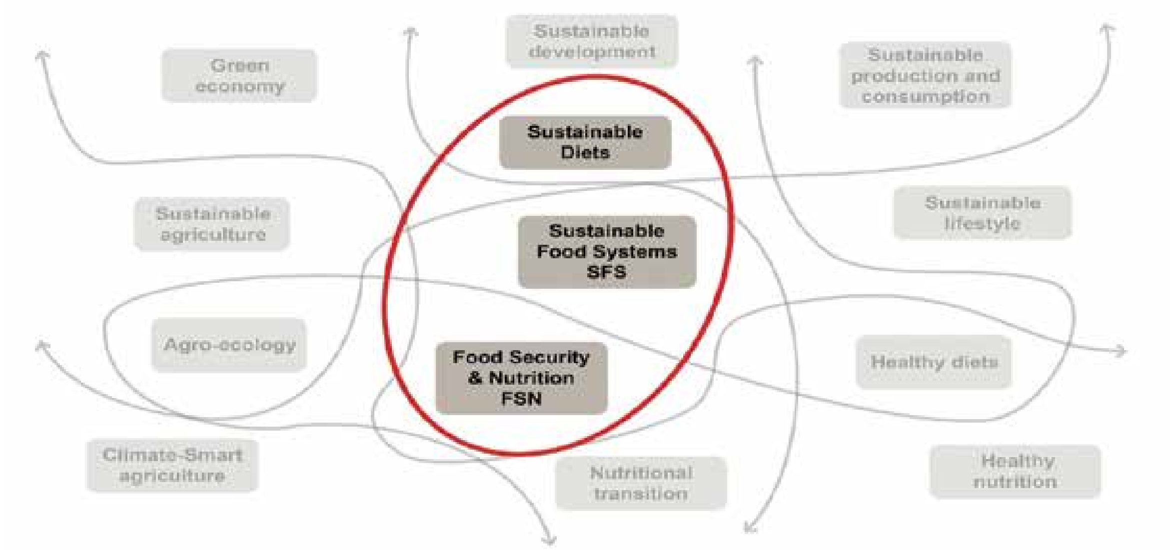


Figure 2: Sustainable diets, SFS and FSN

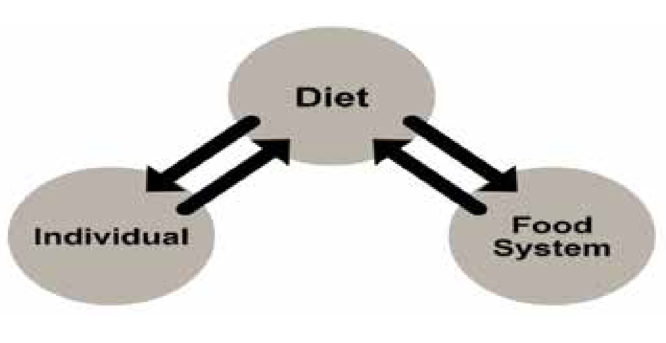


Figure 3: Diets, as a driver of individual nutrition and health and as a driver of food systems

Ericksen *et al.*, 2010; Ingram, 2011; IPCC, 2014) :

A food system gathers all the elements (environment, people, inputs, processes, infrastructures, institutions, etc.) and activities that relate to the production, processing, distribution, preparation and consumption of food, and the outputs of these activities, including socio-economic and environmental outcomes.

The HLPE, in line with the original broad approach of sustainability, defines "sustainable food systems" by their capacity to ensure the positive outcomes of a food system, food security, now and for future generations:

A sustainable food system (SFS) is a food system that ensures food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition of future generations are not compromised (HLPE, 2014a).

The bottom line is that there can be no FSN (short- and long-term) without SFS. Food security and nutrition (for all, worldwide) could be what ultimately characterizes sustainable food systems.

SUSTAINABLE DIETS AND SUSTAINABLE FOOD SYSTEMS

Diet is a notion that is person-centred. As defined by FAO/WHO/UNU (2001), it is the set of food, beverages and nutrients that are consumed by an individual or by a community of individuals during a certain period of time. However, when the question is "which diet to chose or to have", and the question of "optimal" diets, one has to bring into the picture elements that go beyond the diet "stricto-sensu", as well as the relationship of the individual to these elements (economic, social and cultural).

So how do we place sustainable diets in relation to SFS? If we take the 2010 definition of sustainable diets: "*those diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources*" (FAO, 2012b), and, keeping in mind the driving role of consumption, we could say that sustainable diets, with their double dimension of individual sustainability for health and of impact on global sustainability, are both a driver and an objective of sustainable food systems.

This has two important consequences to understand how sustainable diets relate to SFS:

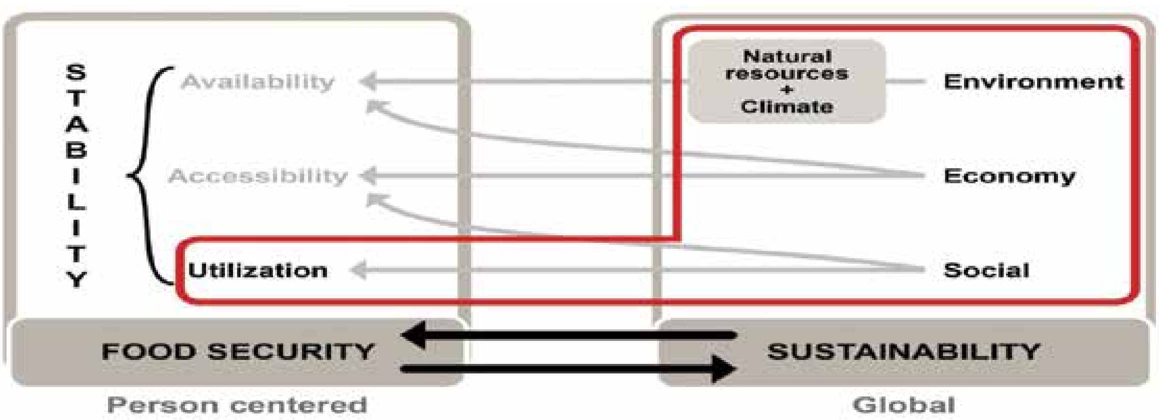


Figure 4: Food security and SFS

- First, the two notions are very linked, which can help their common assessment. The strength of the contribution of the diet to the sustainability of the food system is what characterizes the sustainability of the diet.
- Second, sustainable diets are not only an objective but an essential mean, a key driver, to achieve the transformation of food systems, which is needed to achieve SFS.

CHALLENGES TO ASSESS SUSTAINABLE DIETS IN THE CONTEXT OF SFS

So what could be indicators of sustainable diets? We have to make a distinction, according to the two dimensions of the definition of sustainable diets (Figure 5): on the one side, the nutrition and health dimension, assessed on people and, on the other side, the impact on the food system, measured at various levels, and its sustainability. Each dimension requires specific methodological approaches and tools.

Looking at the nutrition dimension involves mainly individual-level indicators, but comes with its challenges. It impacts – and to a great extent determines – the nutritional status of the person. One main challenge for assessment of nutrition and health impacts is how to make the link between the sum of individual diets, the global consumption of the population and the health status of a population, at country level, for example.

Looking at the impact on food systems brings different challenges. One has to first clarify what relates to the "diet" and what belongs to the "food system", as a prerequisite to understand the linkages between the two. Then, the status of the food system is the result of many drivers: different diets, environmental, economic and social issues at different levels from local to global, etc. Those diets that are uniquely linked to one specific food system (and vice versa) are becoming increasingly rare. In its sequence of articles about food, the *National Geographic Magazine* depicts some hunter-gatherer societies, with a very close link between a diet and a food system. But today, in one location – say at country level – diets are diverse and one could say that several dietary patterns "coexist". Therefore the food system is connected (and shaped by) a variety of diets. Together with the importance of imports, diets at one place are connected to food systems at other places. For instance 75 percent of the fish consumed in Italy is imported.[1] This shows how diets in Italy are connected to food systems elsewhere. Conversely, the "Italian food system" is also shaped by exports of high-quality produce, therefore by foreign diets.

When looking at the relationship between diets and food systems, one has to take into account that a food system, which includes all producers, food chains and processing going to export (such as the Italian food system, schematically presented in Figure 6), is shaped primarily by a sum of many different diets (including many abroad), but that, importantly, other drivers and external parameters operate on it. The food system is indeed shaped by energy and input prices, the cost of labour, agricultural policies, income and relative prices of foods, etc. In other words, other drivers than food consumption and diets *stricto-sensu* have an impact on the food system.

It is also important to recognize that the state of the food system conditions in turn the space of possible diets, and therefore the possibility to have a sustainable diet, given the available spectrum of consumption choices and incentives. The capacity for populations to be able to choose a sustainable diet, leading to "a healthy life for present and future generations", or "low environmental impact", is to be created, and is the result of the action of many, through a system.

Therefore, taking these relationships together, indicators of sustainable diets, in relation to the objective of SFS, would be, by nature, those measuring the "**strength of the contribution** of individual or collective dietary choices to the state of the food system (measured by indicators of the sustainability of food systems)". In other words, if one takes an indicator of SFS as a "state variable", then "how sustainable a diet is", is assessed by the derivative of this state variable (SFS) with respect to the set of variables describing the diet. A consequence is that the measurement of the sustainability of diets is by nature very multidimensional: it reflects the multidimensionality of the indicators of SFS, and adds

[1] http://www.globefish.org/fishery-aquaculture-country-profiles.html

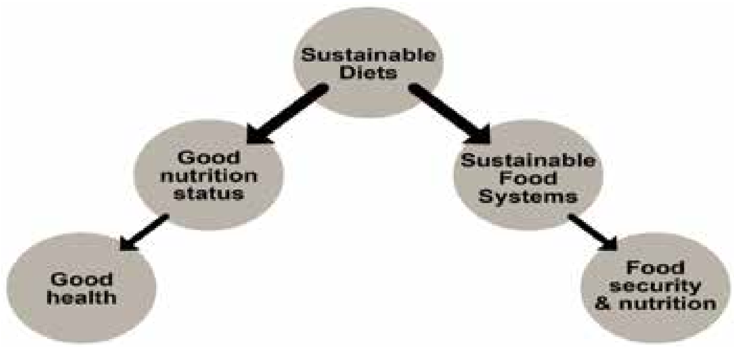


Figure 5: The two dimensions of sustainable diets as a driver of changes at individual level and system level

to it, as for each SFS indicator it needs to depict how the different components/variables describing the diet influence on them.

This is conforming to a conception of "sustainable diets" as those diets that most strongly act to "shape" the food system towards more sustainability, in its various dimensions, environmental, economic and social.

So what could be a way forward for this discussion?

1. Separate in the spectrum of indicators those that relate to the state of food systems from those that relate to sustainable diets. The first will be useful to inform the second, but are of a different nature.
2. In order to measure the sustainable diet indicators, which are indicators of "relation" between a diet and the system, adopt a two-way approach:
   - Starting from a diet, and the sum of diets, what are the impacts (direct and indirect) of diets and consumption choices, and their strength, on the sustainability of food systems. Which are the more direct and strongest ones? For a determinate diet, what are the strongest forces at play that characterize its effect on food security?
   - Conversely, starting from the food system, what are the key determinants of the social, economic or environmental performance, in a specific context. What role do consumption patterns and diets play within those? Where are the priorities or hotspots?

Finally, two additional methodological issues need to be mentioned.

First, the issue of the **degree of aggregation** to assess quantitatively sustainable diets in the real world. We have here to manage a tension between going towards the person, which is relevant for

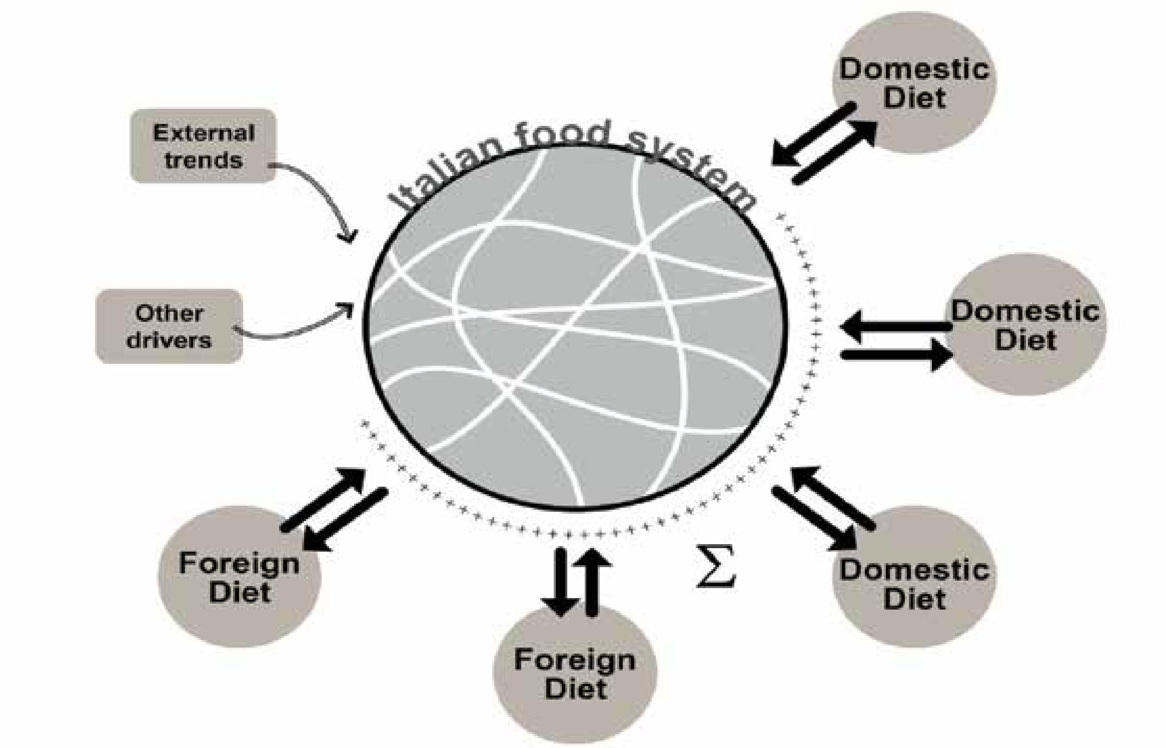


Figure 6: Linkages diets/food systems

the "human health part" of sustainable diets, versus going towards the system and integrating at broader scales, which is relevant for example for socio-cultural indicators (see Figure 5).

Finally, one critical issue is how to deal with the effect of **spatial integration**, from local to regional and global, when it comes to measuring the effect of one diet on one food system. With longer and longer food chains, growing imports and exports, and growing interconnection of food systems, diets are more likely to have remote impacts, which can be different than local impacts, and which will necessitate looking at the food system at global scale. The example of meat consumption in Europe is a good one, as it drives a good part of the soybean expansion in South America in order to provide feed. Another interesting example is the success of quinoa. How does the interest for quinoa in developed countries really contribute to sustainable diets, given all the dimensions of sustainability of food systems we talked about, locally and remote?

CONCLUSION

Currently we are rather in an unvirtuous circle, by which the evolution of diets, as explained in the introduction, are shaping and contributing to an increasingly unsustainable food system.

Diet(s) can be a good entry point to see what can be done individually and collectively to improve the system (and the margins of manoeuvre). Better knowledge of the **relationships** between diets and the sustainability of the food system, and proper tools and indicators taking into account the human and food systems dimensions of sustainable diets (and the three dimensions of sustainability), are very important to determine the priorities for action.

REFERENCES

Ericksen, P.J. 2008. What is the vulnerability of a food system to global environmental change? *Ecology and Society*, 13(2): 14.

Ericksen, P.J., Stewart, B., Dixon, J., Barling, D., Loring, P., Anderson, M., & Ingram, J. 2010. The value of a food system approach. In J. Ingram, P. Ericksen, & D. Liverman, eds. security, *Security and global environmental change*, pp. 25–45. London, Earthscan.

FAO. 2009. *The State of Food and Agriculture – Livestock in the balance*. Rome.

FAO. 2012a. *Greening the economy with agriculture*. Rome (available at http://www.fao.org/docrep/015/i2745e/i2745e00.pdf).

FAO. 2012b. *Sustainable diets and biodiversity; directions and solutions for policy, research and action*. Rome (available at http://www.fao.org/docrep/016/i3004e/i3004e.pdf).

FAO/WHO/UNU. 2001 *Human energy requirements*. Report of a joint FAO/WHO/UNU Expert Consultation. 17–24 October 2001. Food and Nutrition Technical Report Series. Rome.

Foresight. 2011. *Foresight. The future of food and farming.* Final Project Report. London, The Government Office for Science.

Godfray, H.C.J., Beddington, J.R., Crute, I.R., Haddad, L., Lawrence, D., Muir, J.F., Pretty, J., Robinson, S., Thomas, S.M. & Toulmin, C. 2010. Food security: the challenge of feeding nine billion people. *Science*, 327: 812–818.

HLPE. 2014a. *Food losses and waste in the context of sustainable food systems*. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security. Rome.

HLPE. 2014b. *Note on critical and emerging issues for food security and nutrition prepared for the Committee on World Food security*. Rome (available at http://www.fao.org/fileadmin/user_upload/hlpe/hlpe_documents/Critical_Emerging_Issues/HLPE_Note-to-CFS_Critical-and-Emerging-Issues_6-August-2014.pdf).

Ingram, J. 2011. A food systems approach to researching food security and its interactions with global environmental change. *Food Sec.,* 3: 417–431. doi:10.1007/s12571-011-0149-9.

IPCC. 2014. *Climate Change 2014: Impacts, adaptation, and vulnerability. Part A: Global and sectoral aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, C.B. Field, V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, & L.L. White, eds. Cambridge, UK, and New York, USA, Cambridge University Press.

WITHIN-SESSION SESSION: PERSPECTIVES FROM THE METERRANEAN DIET CASE STUDY

Towards the Med Diet Expo 2015 call: time to act
Sustainable food systems, food security and nutrition in the Mediterranean area

Sandro Dernini[1] and Roberto Capone[2]
[1]Department of Agriculture and Consumer Protection, FAO, Rome, Italy; Forum on Mediterranean Food Cultures, Rome.
[2] International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM), Bari, Italy

ABSTRACT

Food security, nutrition and sustainability have been increasingly debated in the context of sustainable food systems. The international policy debate on sustainable food consumption and production in recent years has also emerged in Europe. The European Commission has begun to address the scientific and methodological basis for identifying and measuring sustainable food and promoting the policy goal of a more efficient natural resource use. Over the past years, the interest for sustainable diets has also increased. The Mediterranean diet has started to be investigated by FAO and CIHEAM-Bari as a case study for the characterization and assessment of sustainable diets in the Mediterranean area. The non-adherence of current Mediterranean food consumption patterns to the Mediterranean diet model is particularly worrying. The FAO/CIHEAM joint case study, therefore, may also contribute to raising the debate on sustainable food systems, food security and nutrition in the Mediterranean area. The political momentum of the 2015 Expo of Milan is foreseen for the CIHEAM as an opportunity through the launching of the Med Diet EXPO call to further stimulate this debate as well as concrete actions towards the revitalization of the Mediterranean diet.

INTRODUCTION

The sustainability of food consumption and production has emerged on the international policy agenda in recent years. In July 2014, the High Level Panel of Experts on Food Security and Nutrition (HLPE) provided the following definitions for "sustainable food systems" and "food systems": "*A sustainable food system (SFS) is a food system that delivers food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition for future generations are not compromised*"; "*A food system gathers all the elements (environment, people, inputs, processes, infrastructures, institutions, etc.) and activities that relate to the production, processing, distribution, preparation and consumption of food and the outputs of these activities, including socio-economic and environmental outcomes*" (HLPE, 2014).

Food security, nutrition and sustainability have recently been increasingly discussed in the same context. Sustainability has started to be regarded as an integral part of food security planning, monitoring and evaluation in determining the long-term viability of a food system. But, getting the integration of food security as part of the sustainability agenda and vice versa is still a challenge since its benefits are long term. Sustainable diets, which are ecosystem-specific as defined in 2010 (FAO/Bioversity, 2012), with all their different elements, fit logically into this new general framework and they help articulate, in a more concrete and operational way, food security and sustainability (Berry *et al.*, 2015).

Food systems around the world are changing rapidly with profound implications for diets and food consumption outcomes (Lang and Barling, 2013), creating more production, consumption and socio-economic challenges (Garnett, 2013).

The European policy has also begun to address the scientific and methodological basis for identifying and measuring sustainable food and promoting the policy goal of a more natural-resource-efficient Europe (Barling, 2011). It has been forecasted that not only will future food and agricultural systems in Europe have to be as productive as at present or more productive, but they will also have to be more sustainable, through a radical change in food consumption and production (European Commission, 2011a). In the context of the development of a European "*Roadmap to a resource efficient Europe*" to transform Europe's economy into a sustainable one by 2050 (European Commission, 2011b), from July to October 2013, the European Commission held a public consultation on "the sustainability of food systems" aimed at exploring how we can move towards a more resource-efficient and sustainable food system. In the last years, the debate on food system sustainability and food security has also emerged in the Mediterranean debate, where one of the most important challenges, especially faced by southern and eastern Mediterranean countries, is still food and nutrition security (FAO, 2012; CIHEAM, 2014).

In this context, the Mediterranean diet has been foreseen as a driver for the improvement of the sustainability of food consumption and production in the Mediterranean area (CIHEAM/FAO, 2015). In the final declaration of the Ninth CIHEAM meeting of the Ministers of Agriculture-held in Malta on 27 September 2012, the role of the Mediterranean diet was underlined "*…as a driver of sustainable food systems within the strategies of regional development and on that of traditional local products, since quantitative food security must also be complemented by qualitative approaches*" (CIHEAM, 2012).

In 2011 FAO and UNEP formed a joint Sustainable Food Systems Programme to improve the efficiency of resource use and reduce the intensity of pollution in food systems from production to consumption, while at the same time addressing issues of food and nutrition security. CIHEAM and the FAO/UNEP Sustainable Food Systems Programme are playing a lead role to enhance the transition of the Mediterranean food systems towards more efficient sustainable consumption and production patterns.

MEDITERRANEAN DIET AS A SIGNIFICANT PART OF MEDITERRANEAN FOOD SYSTEMS

Food plays a central role in the social and cultural life of the Mediterranean area. The Mediterranean diet is an expression of the diversity of Mediterranean food cultures and it is equivalent to the Mediterranean cultural food system or Mediterranean culinary system (Medina, 2009). In this sense, the Mediterranean diet is a complex web of cultural aspects that depend on each other (Medina, 2011), and it must always be considered as a part of a significant social and cultural interdependent Mediterranean food system, and never as an independent item (Medina, 2015).

In the last decade, the Mediterranean diet has become the object of increasing studies on its sustainability, particularly on its lower environmental impact as a mainly plant-based dietary pattern, with a lower water footprint and lower greenhouse gas emissions compared with the current Western dietary pattern (Tukker *et al.*, 2011; Sáez Almendros *et al.*, 2013; Capone *et al.*, 2012, 2013, 2014; Tilman and Clark, 2014; van Dooren *et al.*, 2014; Pairotti *et al.*, 2014).

Since 2010, the Mediterranean diet, for its health and environmental benefits as well as because it involves a large number of countries and is also recognized by UNESCO as an intangible cultural heritage, has been identified by FAO and CIHEAM as a case study for the assessment of the sustainability of dietary patterns (FAO/CIHEAM, 2012).

From 2011 to 2013, through a series of joint CIHEAM/FAO international workshops and publications (CIHEAM/FAO, 2015; Dernini *et al.*, 2013; FAO/CIHEAM, 2012; Burlingame and Dernini, 2011), a preliminary draft of a country-specific and person-centered methodological approach has been developed together with a first, non-exhaustive, ensemble of indicators by taking into account the four sustainability dimensions of nutrition and health, environment, economy, society and culture, in the context of the sustainability of the Mediterranean agro-food systems.

To accomplish such a challenge, trends and projections in the Mediterranean area (UNEP/MAP/Plan Bleu, 2006, 2008, 2010, 2011; Plan Bleu, 2012; FAO, 2012; UNEP/MAP, 2005) were also analysed to identify priorities to be addressed for improving the sustainability of the diets and food consumption patterns in the Mediterranean area.

Then, in 2014, within a country-specific project "Quality products of Apulia", based on a quality certification scheme "Quality systems of agriculture and food products", CIHEAM-Bari started a pilot action to assess the sustainability of typical quality products of the Apulia region, Italy, which are the cornerstone of the regional Mediterranean diet and local food system (Lacirignola *et al.*, 2015).

In this quality framework project, consumer choice can play a leading role to orient food production towards sustainability, by selecting certain types of products according to their place of origin (DOC, IGP, DOP, Regime di qualità Prodotti di Puglia, etc.), process of production or producers, creating value especially for small producers. "Sustainable consumption and production" recognizes the role of consumers to promote sustainability, and sustainable production, by their consumption choices. To increase the sustainability of food systems, both production and consumption, supply and demand, have to be considered. To a certain extent, and still in many economies, consumption choices are bound to evolve in the, often restricted, product space that production offers (Meybeck and Gitz, 2014).

The pilot project in Apulia region is grounded in the context of the European Rural Development Policy,[1] within the revised Common Agriculture Policy (CAP) towards 2020, which recommends the following strategic aims: (i) viable food production; (ii) sustainable management of natural resources and climate action; and (iii) balanced territorial development (European Commission, 2010). In the Euro-Mediterranean Conference on Agriculture, held in Palermo in 2014, the need for a stronger sustainability of agrifood systems for the benefit of all citizens and of youth has been acknowledged towards a reinforced joint rural development, and in particular the benefits of the Mediterranean diet for local and regional development have been highlighted.

Despite increasing acknowledgements and popularity worldwide, the Mediterranean diet, recognized also by UNESCO as an intangible cultural heritage of humanity (UNESCO, 2010), is today endangered in all countries of the Mediterranean area. Current data show a *decline* in adherence to the Mediterranean diet pattern in Northern, Southern and Eastern Mediterranean countries (Garcia-Closas *et al.*, 2006; Alexandratos, 2006; Belahsen and Rguibi, 2006; da Silva *et al.*, 2009; Vareiro *et al.*, 2009; León-Muñoz *et al.*, 2012; Bonaccio *et al.*, 2013; Roccaldo *et al.*, 2014).

The Mediterranean region is passing through a "nutritional transition" in which problems of undernutrition coexist with overweight, obesity and food-related chronic diseases. This nutrition transition is alarming as it has negative impacts not only on health systems but also dramatic economic, social and environmental implications. Accurate nutritional policy and education can reverse these negative effects on health by promoting a traditional sustainable dietary model (Belahsen, 2014). These interdisciplinary issues are interdependent or related, directly or indirectly, to the sustainability of Mediterranean food consumption patterns, especially the decrease of adherence to the traditional Mediterranean diet (WHO, 2010).

The urbanization of society, the integration of women into the labour market, and changes in the distribution and availability of certain food products (imports, commercial innovation, and transformation of retail sales) are deeply modifying Mediterranean dietary and lifestyle patterns, as well as the structure of the Mediterranean food systems. (Florensa and Aragall, 2012). Such changes are disrupting the long-established ecological, social and economic equilibriums of the Mediterranean area (Boulier, 2012). Within the globalization process, the pressure from the

[1] Regulation (EU) No. 1305/2013 of the European Parliament and of the Council of 17 December 2013 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD).

agro-food market has changed the production methods, i.e. forced the abandonment of some crops, long-established livestock farming techniques and traditional crafts. This impact entails loss in the knowledge and practices that have contributed historically to the identity of the Mediterranean peoples and that have built a rich and complex food universe in the Mediterranean area (González Turmo, 2012).

The decline of the sustainability of the Mediterranean food systems was already forecast in the 2005 Mediterranean Strategy on Sustainable Development and the need to "*create a conducive regional environment to help countries develop policies and efficient procedures for the labelling and quality certification of Mediterranean food products and to promote the Mediterranean diet*" was pointed out (UNEP/MAP, 2005).

Therefore, the enhancement of typical quality regional foods is a necessary step towards the revitalization of the Mediterranean diet heritage in the context of its sustainable rural and territorial development. The Mediterranean diet, as a system rooted in respect for the territory, ensures the conservation and development of traditional activities and crafts linked to fishing and farming, thereby guaranteeing the balance between the territory and the people (CIHEAM/FAO, 2015).

CONCLUSIONS

This joint CIHEAM/FAO case study, as part of the further development of the FAO/UNEP Sustainable Food Systems programme, within the 10-Year Framework of Programmes on Sustainable Consumption and Production (10YFP), may contribute towards a broader understanding of the need to strengthen the Mediterranean diet as a component of Mediterranean food systems, and not just as an independent dietary pattern, within the enhancement of the sustainability of Mediterranean food systems and food security and nutrition in the Mediterranean area.

Therefore, there is a need to improve the debate on food sustainability and food security that is emerging at the international level and also with Mediterranean policy level recognition, through a multistakeholder approach, incorporating a broader coalition of public and private actors, active in the Euro-Mediterranean arena, in order to identify actions that link sustainable food consumption to its production.

Towards this need, by taking the political momentum of the EXPO of Milan on 14 May 2015, the CIHEAM, with a coalition of institutions, will launch the Med Diet EXPO call: Time to act to stimulate further this debate in the Mediterranean region and beyond , and also to identify and collect actions to move towards more sustainable Mediterranean food systems.

Coordinated actions are needed at local, national and regional levels. Multi-stakeholder partnerships geared to achieving food and nutrition security for all through sustainable food systems can be scaled up within sound regulatory frameworks. CIHEAM, in collaboration with FAO and other regional and international organizations (e.g. CGIAR-ICARDA, WHO/EM, UNEP-Blue Plan, etc.), could play a lead role in identifying and catalysing partnerships with other intergovernmental organizations, national governments, UN and EU agencies, the private sector and non-governmental organizations to foster transition towards more sustainable food consumption and production patterns in the Mediterranean region (Capone *et al.*, 2014).

The improvement of sustainable food security was pointed out at the 10th meeting of the CIHEAM Ministers Agriculture held in 2014, in Algiers, as a priority in the Mediterranean region. Such an exercise might involve projects on sustainable development in the rural areas, sustainable food systems, development and promotion of quality products or the Mediterranean diet (CIHEAM, 2014). The European Commission HORIZON 2020 strategy may also be an opportunity to drive it to implement framework methodologies for measuring the environmental impacts of food consumption and production, linking the need to rebalance the demand and the offer from the supply chain, through the development of a new action programme on food sustainability and food security and nutrition in the Mediterranean, with the Mediterranean diet heritage at its core, towards the development of "*country-based guidelines for improving the sustainability of food systems in the Mediterranean area*", to be context-specific and implemented by the member countries of CIHEAM, adapted to local situations.

REFERENCES

Caballero, B. 2005. A nutrition paradox - underweight and obesity in developing countries. *N. Engl. J. Med.,* 352(15): 1514–1515.

Alexandratos, N. 2006. The Mediterranean diet in a world context. *Public Health Nutrition*: 9(1A), 111–117.

Almendros, S.S., Obrador, B., Bach-Faig, A., Serra-Majem, L. 2013. Environmental footprints of Mediterranean versus Western dietary patterns: beyond the health benefits of the Mediterranean diet. *Environ Health*, 12(1): 118.

Barling, D. 2011. The challenges facing contemporary food systems: European policy and governance pathways to sustainable food consumption and production. *Agron Environ Soc.*, 1: 15–25.

Belahsen, R. & Rguibi, M. 2006. Population health and Mediterranean diet in southern Mediterranean countries. *Public Health Nutrition*, 9(8A): 1130–1135.

Belahsen, R. 2014. Cultural diversity of sustainable diets. Nutrition transition and food sustainability. *Proceedings of the Nutrition Society*, 73: 385–388.

Berry, E.M., Dernini, S., Burlingame, B., Meybeck, A. & Conforti, P. 2015. Food security and sustainability: can one exist without the other? *Public Health Nutrition.* DOI: 10.1017/S136898001500021X.

Boulier, F. 2012. Food security in the Mediterranean in 2030: From foresight to research priorities. *The Futures of Agriculture*. Brief No. 11 - English. Rome: Global Forum on Agricultural Research (GFAR).

Bonaccio, M., Di Castelnuovo, A., Costanzo, S., De Lucia, F., Olivieri, M.B., Donati, M.B., de Gaetano, G., Iacoviello, L., Bonanni, A. & Moli-sani Project Investigators. 2013. Nutrition knowledge is associated with higher adherence to Mediterranean diet and lower prevalence of obesity. Results from the Moli-sani study. *Appetite*, 68:139–146.

Burlingame, B. & Dernini, S. 2011. Sustainable diets: the Mediterranean diet example. *Public Health Nutrition,* 14(12A): 2285–2287.

Capone, R., Lamaddalena, N., Lamberti, L., Elferchichi, A. & El Bilali, H. 2012. Food Consumption Patterns and Sustainable Natural Resources Management in the Mediterranean Region. *Journal of Food Science and Engineering*, 2: 437–451.

Capone, R., Iannetta, M., El Bilali, H., Colonna, N., Debs, P., Dernini, S., Maiani, G., Intorre, F., Polito, A., Turrini, A., Cardone, G., Lorusso, F. & Virginia Belsanti, V. 2013. A preliminary assessment of the environmental sustainability of the current Italian detary pattern.: water footprint related food consumption. *J Food and Nutr Res.,* 1(4): 59–67.

Capone, R., El Bilali, H., Debs, P., Cardone, G., Driouech, N. 2014. Mediterranean food consumption patterns sustainability: Setting up a common ground for future research and action. *American Journal of Nutrition and Food Science*., 1(2): 37–52.

CIHEAM. 2012. *Final declaration. 9th meeting of the Ministers of Food, Agriculture and Fisheries of the Member Countries of CIHEAM*. Valletta. International Centre for Advanced Mediterranean Agronomic Studies.

CIHEAM. 2014. *Final declaration. 10th meeting of the Ministers of Food, Agriculture and Fisheries of the Members Countries of CIHEAM*. Algiers. International Centre for Advanced Mediterranean Agronomic Studies.

CIHEAM/FAO. 2015. *Mediterranean food consumption patterns: diet, environment, society, economy and health.* A White Paper Priority 5, Feeding Knowledge Programme, Expo Milan 2015. CIHEAM-IAMB, Bari/FAO, Rome.

Da Silva, R., Bach-Faig, A., Raido Quintana, B., Buckland, G., Vaz de Almeida, M.D., Serra-Majem, L. 2009. World variation of adherence to the Mediterranean diet, in 1961-1965 and 2000-2003. *Public Health Nutrition,* 12(9A): 1676–1684.

Dernini, S., Meybeck, A., Burlingame, B., Gitz, V., Lacirignola, C., Debs, P., Capone, R. El Bilali, H. 2013. Developing a methodological approach for assessing the sustainability of diets: The Mediterranean diet as a case study. *New Medit,* 3: 28–36.

European Commission. 2010. *The CAP towards 2020: Meeting the food, natural resources and territorial challenges of the future*. COM(2010) 672 fin, Bruxelles.

European Commission. 2011a. S*ustainable food consumption and production in a resource-constrained world.* Standing Committee on Agricultural Research (SCAR). The 3rd SCAR Foresight Exercise. Directorate-General for Research and Innovation, Bruxelles.

European Commission. 2011b. *The Roadmap to a Resource Efficient Europe.* (COM(2011) 571), Bruxelles.

FAO. 2012. *Regional Priority Framework for the Near East.* FAO Regional Office for the Near East, FAO. Cairo.

FAO/Bioversity. 2012. S*ustainable Diets and Bioversity. Directions and Solutions for Policy, Research and Action.* FAO. Rome.

FAO/CIHEAM. 2012. *Towards the development of guidelines for improving the sustainability of diets and food consumption patterns: the Mediterranean diet as a pilot study*. FAO. Rome.

Florensa, S. & Aragall, X. 2012. Mutations in Mediterranean societies. In *Mediterra* 2012, pp. 91–113, Paris, CIHEAM–SciencesPo Les Presses.

Garcia-Closas, R., Berenguer, A., Carlos, A. & Gonzalez, C. 2006. Changes in food supply in Mediterranean countries from 1961 to 2001. *Public Health Nutrition,* 9(1): 53–60.

Garnett, T. 2013. Food sustainability: problems, perspectives and solutions. *Proc. Nutr. Soc.*, 72: 29–39.

González Turmo, I. 2012. The Mediterranean diet: consumption, cuisine and food habits. In *Mediterra* 2012, pp. 115–132, Paris, CIHEAM–SciencesPo Les Presses.

HLPE. 2014. *Food Losses and Waste in the Context of Sustainable Food Systems*, Report of the High Level Panel of Experts of the World Food Security Commitee. Rome.

Lacirignola, C., Capone, R., Bottalico, F., El Bilali, H. & Debs, P. 2015. Sustainability of typical quality products for food and nutrition security in the Mediterranean: Lessons from the case of Apulia region in Italy. *CIHEAM Watch Letter 32*.

Lang, T. & Barling, D. 2013. Nutrition and sustainability: an emerging food policy discourse. *Proc Nutr Soc*; 72: 1–12.

León-Muñoz, L.M., Guallar-Castillón, P., Graciani, A., López-García, E., Mesas, A.E., Aguilera, M.T., Banegas, J.R. & Rodríguez-Artalejo F. 2012. Adherence to the Mediterranean diet pattern has declined in Spanish adults. *Journal of Nutrition*, 142 (10): 1843–1850.

Medina, F.X. 2009. Mediterranean diet, culture and heritage: challenges for a new conception. *Public Health Nutrition*, 12: 1618–1620.

Medina, F.X. 2011. Food consumption and civil society: Mediterranean diet as a sustainable resource for the Mediterranean area. *Public Health Nutrition*, 14(12A): 2346–2349.

Medina, F.X. 2015. Assessing sustainable diets in the context of sustainable food systems – socio-cultural dimensions. *In* Proceedings of the International Workshop – Assessing sustainable diets within the sustainability of food systems. Mediterranean diet, organic food: new challenges, pp. 55–60. A. Meybeck, S. Redfern, F. Paoletti, & C. Strassner, eds. Rome, FAO.

Meybeck, A. & Gitz, V. 2014. Signs to choose: voluntary stardards and ecolabels as information tools for consumers. *In* Voluntary standards for sustainable food systems: challenges and opportunities. Proceedings of a joint FAO/UNEP workshop. A. Meybeck & S. Redfern, eds. FAO. Rome.

Plan Bleu. 2012. 20 Years of sustainable development in the Mediterranean: review and outlook. *Blue Plan Notes,* 22 (available at www.planbleu.org/publications/8p22_20ans_dd_EN.pdf).

Pairotti, M.B., Cerutti, A.K., Martini, F., Vesce, E., Padovan, D., Beltramo, R. 2014. Energy consumption and GHG emission of the Mediterranean diet: a systemic assessment using a hybrid LCA-IO method. *Journal of Cleaner Production*, xxx: 1–10.

Roccaldo, R., Censi, L., D'Addezio, L., Toti, E., Martone, D., D'Addesa, D., Cernigliaro, A. & ZOOM8 Study Group. 2014. Adherence to the Mediterranean diet in Italian school children (The ZOOM8 Study). *Int. J. Food Sciences and Nutrition*, 65(5): 1–8.

Sáez Almendros, S., Obrador, B., Serra-Majem, L. & Bach-Faig, A. 2013. Beyond the health benefits of the Mediterranean Diet: environmental sustainability. *Environmental Health*, 12(118): 1–8.

Tilman, D., Clark, M. 2014. Global diets link environmental sustainability and human health. Nature, 515: 518–522.

Tukker, A., Goldbohm, R.A., de Koning, A., Verheijden, M., Kleijn, R., Wolf, O., Pérez-Domínguez, I. & Rueda-Cantuche, J.M. 2011. Environmental impact of changes to healthier diets in Europe. *Ecological Economics*, 70: 1776–1788.

UNEP/MAP. 2005. *Mediterranean Strategy For Sustainable Development: A Framework for Environmental Sustainability and Shared Prosperity*. Tenth Meeting of the Mediterranean Commission on Sustainable Development (MCSD), Athens.

UNEP/MAP/Plan Bleu. 2006. *A Sustainable Future for the Mediterranean. The Blue Plan's Environment and Development Outlook. Executive Summary*. Sophia Antipolis, France.

UNEP/MAP/Plan Bleu. 2008. *The Blue Plan's sustainable development outlook for the Mediterranean*. Sophia Antipolis, France.

UNEP/MAP/Plan Bleu. 2011. *Mediterranean Strategy for Sustainable Development Follow Up: Main Indicators.* Sophia Antipolis, France.

UNESCO. 2010. *Representative List of the Intangible Cultural Heritage of Humanity*. UNESCO, Paris.

van Dooren, C., Marinussen, M., Blonk, H., Aiking, H. & Vellinga, P. 2014. Exploring dietary guidelines based on ecological and nutritional values: a comparison of six dietary patterns. *Food Policy*, 44: 36–46.

Vareiro, D., Bach-Faig, A., Raidó Quintana, B., Bertomeu, I., Buckland, G., Vaz de Almeida, M.D. & Serra-Majem, L. 2009. Availability of Mediterranean and non-Mediterranean foods during the last four decades: comparison of several geographical areas. *Public Health Nutrition*, 12 (9A): 1667–1675.

WHO. 2010. *Regional strategy on nutrition 2010–2019*. World Health Organisation (WHO); Regional Committee for the Eastern Mediterranean; Fifty-seventh Session, Technical paper EM/RC57/4 (available at http://www.emro.who.int/docs/EM_RC57_4_en.pdf).

Assessment of the sustainability of Mediterranean agro-food products: preliminary insights from Apulia region, southeastern Italy

Cosimo Lacirignola, Roberto Capone, Francesco Bottalico, Hamid El Bilali and Philipp Debs
International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM), Mediterranean Agronomic Institute of Bari, Valenzano (Bari), Italy

ABSTRACT

In the framework of the *Agriculture & Quality* programme of Apulia region (southeastern Italy), in addition to the issues of quality, CIHEAM-Bari started a pilot project to promote the sustainability of the products with a regional voluntary quality scheme. Therefore, the products that adhere to the quality scheme should not only comply with the quality requirements defined by the technical specifications but also with sustainability requirements. The pilot project is one of the activities started after the international seminar organized by CIHEAM in collaboration with FAO on "*Sustainability of food systems in the Mediterranean Area*" in Malta in September 2012. The aim is to apply the methodology proposed in Malta to a well-defined territorial context (i.e. Apulia region) by developing the most appropriate indicators to assess the sustainability of Apulian products adhering to the quality scheme. This preliminary communication on the ongoing pilot project presents the methodological approach adopted, the sustainability criteria and themes identified and some indicators selected to assess the economic, environmental, socio-cultural and nutritional-health sustainability of Apulian quality agro-food products.

INTRODUCTION AND BACKGROUND

Agriculture & Quality is a programme of Apulia Region, which is technically and scientifically supported by the Italian seat of CIHEAM (*Centre International de Hautes Etudes Agronomiques Méditerranéennes*). Its main objective is the qualification and enhancement of typical food products of the Apulia region, through the creation of the quality scheme "Prodotti di Qualità Puglia" (Quality products of Apulia, PdQP). The voluntary quality scheme aims to ensure origin and quality of agro-food products from Apulia region by complying with the product technical specification of reference approved by the Apulia region authority.

In particular, in the framework of the programme, in addition to the issues of quality, CIHEAM-Bari has started a pilot project to assess and promote the sustainability of the products belonging to the quality scheme PdQP. The main objective of this pilot project is to ensure that the products that adhere to the quality scheme PdQP comply not only with the quality requirements defined by the technical specifications, but also with sustainability requirements. Specifically, the aim of this activity is to develop guidelines and a methodological approach (with appropriate indicators) to assess the environmental, economic, nutritional-health and socio-cultural sustainability of the Apulian quality typical products that are the cornerstone of the regional Mediterranean diet and food system.

This pilot project is one of the activities started after the international seminar organized by CIHEAM in collaboration with the FAO-Sustainable Food Systems Programme on "*Sustainability of food systems in the Mediterranean area*", held in Malta in September 2012, on the occasion of the Meeting of Ministers of Agriculture of Member Countries of the CIHEAM. In the seminar a methodological approach and a set of indicators to assess the four dimensions (economic, environmental, socio-cultural and nutritional-health) of the sustainability of the Mediterranean diet in different specific territorial contexts from the Mediterranean region (Lacirignola *et al.*, 2012) was presented. The proposed methodological approach has been further developed in the White Paper of the fifth thematic priority "*Mediterranean food consumption patterns: diet, environment, society, economy and health*" prepared by CIHEAM-Bari and the FAO-Sustainable Food Systems Programme for the Feeding Knowledge project in view of EXPO 2015 in Milan (Lacirignola *et al.*, 2015).

The pilot project is carried out in collaboration with the Italian Council for Agricultural Research and Economics (CREA) – Research Centre on Food and Nutrition, the Italian National Research Council (CNR), the Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA), the Forum on Mediterranean Food Cultures, the University of Bologna and the University of Naples Federico II.

The present paper aims at presenting the methodological approach adopted, the sustainability themes identified and some indicators selected to assess Apulian quality agro-food products sustainability.

METHODOLOGICAL APPROACH DEVELOPMENT

The starting building blocks for the elaboration of the methodological approach were the results of the international workshop on diets' sustainability held at CIHEAM-Bari in November 2011 and the conclusions of the international seminar held in Malta in September 2012 (Lacirignola *et al.*, 2012; Dernini *et al.*, 2013).

The main definition of sustainability consists of the integration of three pillars (WCED, 1987; United Nations, 2002, 2012): social, environmental and economic. In many cases these three pillars are not developed in the same way; the most developed pillar is very often the environmental one. For this reason, often the approach on sustainability is mainly environmental.

An agro-food system, to be sustainable, must, through time and generations, maintain and regenerate itself and must take into account the impact of production activities on the territory (meaning both the environment and the human community).

Being aware that sustainability is a complex concept, which arises from the interaction of multiple factors, Apulia Region chose to use the term "sustainability" only when all the three pillars are considered (environment, economy and society-culture), supplemented by the nutritional-health component, closely linked to food.

The environmental pillar includes biodiversity while the socio-cultural pillar includes also ethical aspects.

As for the thematic scope, the methodological approach can be applied to who demand, from the regional authorities, the use of the additional requirement "sustainability" for the products that adhere to the "Regional Quality Schemes" RQR or to other quality schemes recognized at EU level.

An agro-food product can be considered sustainable only if it is for each pillar of sustainability along the supply chain (production, processing, distribution, etc.) and for all its actors. Sustainability does not refer only to the actor that puts a finished product on the market, but must necessarily involve the entire supply chain starting from the production phase.

The methodological approach development was based on the adoption of a hierarchical approach (cf. FAO, 2013) i.e. from sustainability themes to indicators for each dimension/pillar.

Sustainability is evaluated separately for each of the four pillars (environmental, economic, socio-cultural and nutritional-health) and each pillar has the same importance as the others. For each pillar of sustainability some criteria have been identified and for each criteria one or more indicators will be identified, suitable and measurable at corporate level, for each agro-food supply chain. In addition, for each indicator, the standard methodologies of assessment will be indicated.

SELECTION OF SUSTAINABILITY THEMES AND CRITERIA

One of the main challenges for Apulian and Italian agro-food products is the ability to combine tradition and innovation, ensuring not only quality production, but also that it is sustainable from the economic, environmental, socio-cultural and nutritional-health point of view for the

Table 1: Identified sustainability themes and criteria

Pillar	Sustainability themes
Environment	Conservation of agro-biodiversity (genus, species, cropping system, ecosystem), natural and landscape diversity and associated biodiversity (ecological infrastructures) Adoption of sustainable agricultural practices Reducing environmental pollution: use of chemical inputs (fertilizers, pesticides, etc.) Reducing environmental impacts and improving resource use efficiency: water, energy, soil Responsible management and valorisation of production waste and by-products
Economy	Income: level and stability Labour and employment: entrepreneur family, members of local communities Investment Profitability of production factors (labour, land, etc.) Productivity of farm assets
Society and culture	Corporate social and ethical responsibility Women's labour involvement in production and management contexts at company level Social inclusion (most disadvantaged community groups) Good relationships with the local community Promotion of local identity and transmission of traditional knowledge to the young generation Training of workers and staff along the supply chain Training and inclusion of foreign workers Respect for animal welfare (for animal husbandry farms)
Nutrition and health	Food safety: compliance with hygiene-sanitary norms and rules Quality: high quality of raw materials, organoleptic properties Traceability Transparency regarding information on food labels: nutritional information and advice

consumer, the community and the supply chain. The agro-food supply chains have to generate positive impacts for the producers and the territory in which the products are grown/processed. To ensure obtaining a product that can be defined sustainable it is necessary to shift attention to the production processes of these products.

The selection of indicators should be considered just as a phase of the methodological approach development that includes the following tasks: justification of the choice of sustainability themes and indicators based on the concept of sustainability; description of indicators (cf. indicator sheets); and development of a method for the aggregation of indicators.

The selection of sustainability criteria and themes was based on the understanding of sustainability in the food industry for the pillar of interest (for example, what is environmental sustainability in the food sector?) and the characteristics that an agro-food product and/or a process should have in order to be considered sustainable (for example, what are the characteristics of a sustainable agro-food product from the economic point of view?).

The activities allowed identifying sustainability themes and criteria for each pillar as reported in Table 1.

DEVELOPMENT OF INDICATORS

The identified indicators must be well defined, relevant, specific, easily measurable at farm level, appropriate and easy to understand and communicate to all stakeholders, including farmers, politicians and consumers.

In line with SAFA – the Sustainability Assessment of Food and Agriculture Systems approach (FAO, 2013) – different types of indicators were considered: performance-based, practice-based and target-based (Box 1).

Most of the developed indicators refer to products (cf. product-based approach) but some of them refer to the producing farms/companies (cf. corporate-based approach) as they are not specific to single products and depend on the whole management of the agro-food company. The product-based approach was adopted for some sustainability themes of the environmental and nutrition-health pillars while the corporate-based approach was used mainly for some themes of the economic, socio-cultural and nutritional-health pillars.

Box 1: Types of used indicators

Performance-based (results-oriented or outcome) indicators: focused on the results of compliance with an objective and can measure the performance of an operation, identify trends and communicate results.
Practice-based (prescriptive or process) indicators: prescribe that the necessary tools and systems be in place to ensure best practices. The cause-effect between a given practice and a result is however never precise. One can assume that a practice may yield a desired result but with a substantial margin error.
Target-based indicators: these indicators focus on whether the company has plans, policies or monitoring, with targets and ratings based on steps towards implementing them.

Source: FAO (2013).

Table 2: Examples of proposed socio-cultural indicators

Dimension	Social	Cultural
Theme	Corporate social and ethical responsibility	Promotion of local identity and transmission of traditional knowledge to young generation
Subtheme	Woman labour involvement	Activities related to agricultural production as a means of promoting the local cultural identity
Indicator	Percentage of women in production and management roles at company level	Number of non-productive activities conducted yearly to promote local products as an expression of local identity

For each indicator a sheet was prepared including the following information: *definition of indicator; method of calculation* (in this area the necessary data to calculate the indicator and the method of data collection are also specified); *sustainability benchmark*; and *other useful information* (limits on the use of the indicator – for example validity only for fresh/non-processed products or only for plant origin products; link with other indicators; references; etc.).

The sustainability benchmark value, which will be defined for each indicator and for each supply chain, will express in a simple, objective and numerical way the threshold of sustainability beyond which a product, and/or the company that produces it, can be considered sustainable. This value will be defined taking into account the average performance of the Apulian agro-food enterprises.

Some examples of indicators developed using the hierarchical approach for the society-culture pillar are presented in Table 2.

CONCLUSIONS AND WAY FORWARD

The pilot project aims to apply the methodology proposed in Malta in 2012 to quality agro-food products of Apulia Region to assess their sustainability. As a pilot experience, the project aims to contribute to the further development of the methodological approach designed by addressing all the critical issues that arise from such an application. The work is ongoing for:

- refining the selection of indicators for the four sustainability dimensions/pillars;
- defining the weight to be assigned to each sustainability theme within each pillar;
- calculating contextualized sustainability benchmark values for all indicators;
- developing an appropriate rating/scoring system to ease the aggregation of indicators within sustainability dimensions;
- definition of a tool for visualization and communication of the degree of overall sustainability of each product; and
- validation of the developed methodological approach on specific typical quality products of Apulia region.

ACKNOWLEDGEMENTS

The authors would like to thank the following experts:

- Massimo Iannetta (ENEA), Generosa Calabrese (CIHEAM-Bari), Gaetano Ladisa (CIHEAM-Bari), Flavio Paoletti (CREA) and Milena Stefanova (ENEA) for their contribution to the selection of environmental sustainability criteria and themes.
- Giulio Malorgio (University of Bologna), Felice Adinolfi (University of Bologna), Fabian Capitanio (University of Naples Federico II) and Gianluigi Cardone (CIHEAM-Bari) for their contribution to the selection of economic sustainability themes.
- Mauro Gamboni (CNR), Silvana Moscatelli (CNR) and Sandro Dernini (Forum on Mediterranean Food Cultures) for their contribution to the selection of criteria and development of indicators regarding the socio-cultural sustainability pillar.
- Giuseppe Maiani (CREA), Angela Polito (CREA), Aida Turrini (CREA) and Sandro Dernini (Forum on Mediterranean Food Cultures) for their contribution to the selection of sustainability themes related to the nutrition-health pillar.

The authors would also like to thank Fabrizio De Castro, Vincenzo Lorusso and Luciana Pannarale for their technical support and assistance.

Thanks go also to Matteo Sisto for his valuable support during paper preparation.

REFERENCES

Dernini, S., Meybeck, A., Burlingame, B., Gitz, V., Lacirignola, C., Debs, P., Capone, R. & El Bilali, H. 2013. Developing a methodological approach for assessing the sustainability of diets: the Mediterranean diet as a case study. *New Medit.*, 3: 28–36 (available at http://www.iamb.it/share/img_new_medit_articoli/949_28dernini.pdf).

FAO. 2013. *Sustainability Assessment of Food and Agriculture systems – SAFA. Guidelines*. Version 3.0; December 2013. Rome.

Lacirignola, C., Capone, R., Dernini, S., El Bilali, H., Meybeck, A., Burlingame, B., Gitz, V., Debs, P., Cardone, G. & Driouech, N. 2015. *Mediterranean food consumption patterns: diet, environment, society, economy and health*. White Paper Priority 5 of Feeding Knowledge programme, Expo Milan 2015. CIHEAM-IAMB, Bari / FAO, Rome. In press.

Lacirignola, C., Dernini, S., Capone, R., Meybeck, A., Burlingame, B., Gitz, V., El Bilali, H., Debs, P. & Belsanti, V. 2012. Towards the development of guidelines for improving the sustainability of diets and food consumption patterns: the Mediterranean Diet as a pilot study. CIHEAM/FAO - *Options Méditerranéennes*, Series B: Studies and Research, N° 70; Bari. 67 p. (available at http://om.ciheam.org/om/pdf/b70 (en)/b70 (en).pdf).

United Nations. 2002. *Plan of Implementation of the World Summit on Sustainable Development (WSSD).* Johannesburg (available at http://www.un.org/esa/sustdev/documents/WSSD_POI_PD/English/WSSD_PlanImpl.pdf).

United Nations. 2012. *The future we want*. Outcome of the United Nations Conference on Sustainable Development (Rio+20) (available at https://rio20.un.org/sites/rio20.un.org/files/a-conf.216l-1_english.pdf.pdf).

WCED (World Commission on Environment and Development). 1987. *Our common future*. Report of the 1987 World Commission on Environment and Development. Oxford University Press, Oxford.

Perspectives from the Mediterranean diet case study: a view from the Southern Mediterranean rim

Rekia Belahsen
Laboratory of Biotechnology, Biochemistry and Nutrition
Training and Research Unit on Nutrition and Food Sciences, Chouaib Doukkali University School of Sciences, El Jadida, Morocco

ABSTRACT

The Mediterranean diet (MD) is a characteristic of the populations around the Mediterranean Sea. It is reported to have many beneficial effects on health, with nutrition disorders and associated mortality lower than in western diets.In the countries south of the Mediterranean Sea, a shift of the population from the MD is reported based on their lower fibre and higher saturated fat intakes compared with the traditional MD. These countries are increasingly at risk of developing the health problems already observed in the North. This is even more accelerated with nutritional transition ongoing South of the Mediterranean. Indeed, in all these countries problems of malnutrition were and are linked to several causes including infections, inadequate intakes of protein, energy and micronutrients. These problems affect all age categories. Maternal malnutrition was indeed reported as a risk factor for chronic diseases later in children because of the impact of nutritional deficiencies in pregnancy. To this may be added the problem of nutritional transition, the phenomenon leading to a shift from traditional diet and adoption of a simplified diet rich in sugar and fat. This makes these populations at risk of over nutrition health problems that were before characteristics of western countries.

The prevalence of these problems – obesity, cardiovascular diseases and cancers – and their increase in these countries indicates an erosion of the traditional diet and questions its sustainability. The protection and preservation of the MD can counter and minimize the increased disadvantages for health related to the problem of its erosion.

In the countries on the southern side of Mediterranean Sea, even if the populations share several common characteristics such as religion, geography and culture, there is a variability of diet based on the variability of its components in the different countries of the region, and even in the different regions in the same country. Preserving this variability contributes to limiting the erosion and ensuring sustainability of the MD. However, this variability is threatened because of the abandonment of traditional crops, and use and installation of monoculture with negative impacts including those on the environment and health.

One of the ways to limit this erosion is to revalorize or valorize foods that are no longer used or less used by these populations, especially those foods known for their respect for the environment, which can also contribute to food diversity and to preserve biodiversity. Nevertheless, there must be accompanying measures to the valorization of Mediterranean foods with the aim of avoiding perverse effects such as increased costs that could lead local population to use other cheap alternatives and also avoid exaggerated consumption and subsequent food waste.

INTRODUCTION

The Mediterranean diet (MD) is the dietary model characterizing the populations around the Mediterranean Sea. The MD is not a homogenous nutritional model. There are several

Mediterranean nations with varied history, cultures, traditions, incomes and dietary habits resulting in a wide variation of dietary patterns within the Mediterranean region (Simopoulos and Visioli, 2007).

Many beneficial effects of the MD have been reported. Among these effects is respect for the environment and the richness of biodiversity. It is also nutritionally healthy and is reported to be associated with lower nutrition disorders and mortality than the western diet. On the other hand, the MD has a beneficial role in the development of sustainable agriculture in the Mediterranean region. All of these beneficial effects make of MD a model for a sustainable diet (Burlingame and Dernini, 2010).

SHIFT OF MD AND IMPACT ON HEALTH

Obesity and non-communicable diseases

In the last decades, many studies have reported that the benefits of MD on health cited above are being lost because of a shift of the MD Many nutritional disorders observed before only in western countries are in increase in this area. These changes are observed in all Mediterranean countries including those in the Southern Mediterranean rim.

The prevalence of obesity is indeed reported in the northern Mediterranean adult population with the lowest prevalence of about 10 percent in Italy and the highest of more than 18 percent in Greece.[1] In the eastern Mediterranean countries, the prevalence of obesity is also high, affecting all age categories, andan increase of body mass index was observed between the years 1997 and 2009 in both sexes and in adults, children and adolescents (Nasreddine *et al.*, 2012).

Also, it is reported by WHO (2014) that non-communicable diseases are already responsible for 52 percent of deaths in the Eastern and Southern Mediterranean region. In Libya, for example, cardiovascular diseases (CVD) are prevalent in 43 percent, cancer in 14 percent and diabetes in 5 percent of the population. The impact of chronic diseases is also evident in Tunisia where deaths caused by CVD, cancer and diabetes were reported to be 47, 10 and 2 percent, respectively. In this country, overweight and obesity together are prevalent in about 50 percent of males and in more than 70 percent of women and are predicted to increase by 2030.[2] Different types of cancer are also prevalent in many countries of Mediterranean area including countries on the southern side of the Mediterranean Sea (WHO, 2014). The increased trends of overweight and obesity and the association of some types of cancer with obesity have led to the assumption that the largest increase in cancer incidence among the WHO regions in the next 15 years is likely to be in the Eastern Mediterranean region in females, males and children.

Erosion of MD and changes in food system

The increased prevalence of obesity, CVD and cancer problems in these countries indicates an erosion of the traditional MD and raises questions on its durability. To counter and reduce the disadvantages for health related to the erosion of MD is a big issue in the region and can only be done by preserving and protecting this model.

The reported shift from the MD in the population of countries south of the Mediterranean Sea is based on evidence of their lower intake of fibre and higher intake of saturated fat when compared with the traditional MD (Belahsen, 2014) reflecting alteration or even a decrease in the quality of diet in this region. In this area indeed, diet quality has not improved or has even worsened. In this way, Padilla, Capone and Palma (2010) have reported that no improvement of the Food Quality Index in the Southern Mediterranean area was seen between 1960 and 2000 and that it has even decreased in Eastern and Southern Mediterranean countries. In fact, in these countries, while the policy efforts are focused on agricultural production to meet sufficiency or to face global food shortages, little or no discussion has been devoted to the issue of food quality, which has effects on nutritional status and negative impact on environment.

[1] OECD Health Data 2010, Eurostat Statistics Database; WHO Global Infobase.

[2] http://www,who.int/chp/chronic_disease_report/en

On the other hand, as reported by FAO and illustrated by the case of Morocco for example, the trend of food availability between 1962 and 2000 showed a decrease in the consumption of barley, the traditional cereal that is replaced by an increased availability of wheat as a unique cereal and roots and tubers (FAO, 2001). Also, despite the locally high production of fruit and vegetables their consumption in the southern Mediterranean countries is insufficient[3] and in almost all of them it is lower than the 400g/day recommended by WHO.

In addition, the increase of food availability is reported by FAO in these southern countries, and associated with this there is a significant evolution of food energy supplies available for consumption that are now higher than body requirements. In parallel with the rise in food energy availability, there is a rise in body weight, as manifested by the obesity epidemic in different areas. It has been proposed to consider food energy intake higher than the requirementas food waste, in addition to its involvement in weight gain (Hall *et al.*, 2009).

Market globalization is another aspect of this change of dietary model in this region,which is associated with an evolvement from traditional diet to the ready-to-eat foods and restaurants that are in continuous development leading to a consumption of foods with high energy density and foods rich in sugar and fat (Haut-Commissariat au Plan, Morocco). The consequences of all these changes on nutritional status include problems of malnutrition in both its forms, undernutrition leading to energy and nutrient deficiencies and overnutrition, which is named the double burden of malnutrition in these countries of the region.

Double burden of malnutrition

The southern Mediterranean countries are facing a double burden of malnutrition. Indeed, the problems of malnutrition in all these countries were and are still linked to several causes including infections, inadequate intakes of protein, energy and micronutrients with prevalence of undernutrition problems and many nutrient deficiencies.

These problems affect all age categories and in the course of the life cycle are also associated with maternal malnutrition. The impact of nutritional deficiencies in pregnant women, during the development of the foetus, on the new-born is reported as a risk factor for chronic diseases later in children.

In the Mediterranean countries of North Africa, millions of children under five years of age are also still affected by moderate or severe stunting, underweight and wasting. Many international organizations have reported data showing that the number (in millions) and the prevalence (in percent) improvement was not important between 1990 and 2011. They passed from 28.6 (6.3 percent) in 1990, to 21.3 (5.0 percent) in 2010 and 21.0 (5.0 percent) in 2011; underweight passed from 11.3 (2.5 percent), 6.7 (1.6 percent) to 6.5 (1.5 percent) and wasting from 5.3 (1.2 percent), 8.0 (1.9 percent)to 6.5 (1.5 percent) and 8.2 (1.9 percent) in 1990, 2010 and 2011, respectively.[4]

Furthermore, **micronutrient** deficiencies are still being reported **including** iron, iodine, zinc, calcium, folic acid, vitamins A and D. The highest proportion of individuals affected is among children and women of childbearing age (Belahsen and Rguibi, 2006).

In addition to these are added problems linked to the phenomenon of **nutrition transition**, which is accompanying the global transition including demographic, epidemiologic, economic urbanization changes and a shift from the traditional diet to the adoption of a simplified diet rich in sugar and fat (Belahsen, 2014). The generated situation makes these populations at risk of health problems associated with poor nutritional status and emerging overnutrition problems that were before characteristics of western countries. Indeed, a rise of overweight is reported in the southern rim of Mediterranean Sea; it was estimated as 7.3 million (1.6 percent) in 1990, 12.8 (3.0 percent) in 2010 and 13.1 (3.1 percent) in 2011 among children under five years of age in North African countries.[4] Overweight and obesity are also present in adolescents of both sexes in the region. In

[3] FAOSTAT (available at http://faostat.fao.org/default.aspx).

[4] UNICEF/WHO/World Bank joint child malnutrition estimates 2012 (available at http://www.who.int/nutgrowthdb/estimates2012/en/).

males the estimated prevalence of overweight and obesity based on IOTF references are 9.3 and 4.1 percent in Algeria and16.4 and 9.6 percent in Libya, respectively. In females these prevalences are higher; they passed to 15.5 and 4.5 in Algeria; 26.6 and 10.0 percent in Libya (Nasreddine *et al.*, 2012). In adults overweight and obesity taken together, based on a body mass index value higher than 25, are reported among all region countries with a prevalence passing from 30.6 vs. 47.8 in Morocco to 64.5 vs 69.7 percent in Egypt in males and females respectively. The increased overweight and obesity is accompanied with the burden of non-communicable diseases such as hypertension, hypercholesterolemia and diabetes, which have also increased over the last two decades in all southern Mediterranean countries in the Middle East and North Africa (Musaiger, 2011).

On the other hand, because of the impact of the increasing trend of obesity and physical inactivity, breast cancer, which is the most frequent cancer in females, is considered by WHO to be of increased risk in the future in this region.[5]

DURABILITY OF DIET

In the past, all these nutritional and health problems mentioned above, and their associated mortality, were lower in the Mediterranean area compared with other regions of the world, and this result was associated with the reported beneficial effect of their diets on health. However, the increased prevalence of obesity, CVD and cancer problems in these countries indicates an erosion of the traditional Mediterranean diet raising the question of its durability (Belahsen, 2014) and invites reflection on the alternatives to this issue. It is about countering and minimizing the increased disadvantages to health linked to the problem of Mediterranean diet erosion, which can be done in part by protecting and preserving this diet.

HOW TO PRESERVE THE MD

In the countries on the southern side of the Mediterranean Sea, even if the populations share several common characteristics such as religion, geography and culture, there is a variability of the diet based on the variability of its components in the different countries of the region and even in the different regions of the same country. Preserving this variability contributes to limiting the erosion andto the sustainability of the Mediterranean diet in terms of diet diversity, production and preparation techniques, etc.

On the other hand, this variability is threatened because of the abandonment of seasonal traditional crops, and the use and installation of monoculture with negative impacts, including those on the environment and health.

One of the ways to limit this erosion is to revalorize or valorize the foods no longer used or less used by these populations.

Wild food plants are an example, which, by their respect for the environment, can also contribute to food diversity and to preserving biodiversity. An investigation in an agricultural province of Morocco has shown that edible wild plants continue to be a part of the eating habits of the local population especially in rural areas in Morocco, particularly in the winter season. These plants are consumed as an addition or a supplement to food cultivated plants (Tbatou *et al.*, submitted). However, there are no data on the description of their importance in the diet or their nutrient content. Also knowledge about their use is mainly held by parents and grandparents. Enhancing, promoting and encouraging sustainable consumption of these underused traditional products will prevent their disappearance.

NEED FOR ACCOMPANYING MEASURES FOR MD SUSTAINABILITY

One critique for valorizing Mediterranean foods is, however, the fact that this does not achieve the beneficial expected impacts. The reason is the overconsumption of these foods and the increase of their costs due to advertising their positive value in an absolute way. Diet valorization must

[5] www.who.int/healthinfo/bodgbd2002revised/en/index.html

therefore be accompanied by a non-absolute sensitization, to avoid the perverse effects. The consequent increase in their cost leads populations to use other food alternatives with the negative effects on health cited above. The other perverse effect is the exaggeration in the quantities consumed, which can lead to food waste and environment degradation.

REFERENCES

Belahsen, R.& Rguibi, M. 2006. Population health and Mediterranean diet in southern Mediterranean countries. *Public Health Nutr.*, 9(8A): 1130–1135.

Belahsen, R. 2014. Cultural diversity of sustainable diets. Nutrition transition and food sustainability. *Proceedings of the Nutrition Society*, 73: 385–388.

Burlingame, B. & Dernini, S., eds. 2010. *Sustainable diets and biodiversity. Directions and solutions for policy, research and action*. Proceedings of the International Scientific Symposium. FAO headquarters, Rome, 3–5 November 2010.Rome, FAO (available at http://www.fao.org/docrep/016/i3004e/i3004e.pdf).

FAO. 2001. T*he State of Food Insecurity in the World 2001*. Rome.

Hall, K.D., Guo, J., Dore, M. & C. 2009. The progressive increase of food waste in America and its environmental impact. *PLos One*, 4(11) (available at http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0007940).

Haut-Commissariat au Plan, Morocco. 2009. Enquêtes nationales sur les niveaux de vie des ménages: ENNVM 1998/1999 et ENNVM 2006/2007, La Vie eco N °4514, Juin 2009.

Musaiger, A.O. 2011.Overweight and obesity in Eastern Mediterranean Region: prevalence and possible causes. *J.Obes*. (available athttp://www.ncbi.nlm.nih.gov/pubmed/21941635).

Nasreddine, L., Naja, F., Chamieh, M.C., Adra, N., Sibai, A.M. & Hwalla, N. 2012. Prevalence (%) of obesity among Lebanese adults, children and adolescents (using both IOTF and CDC criteria) compared to those reported from selected countries of the Eastern Mediterranean region & worldwide. *BMC Public Health*,12: 798.

Padilla, M., Capone, R. & Palma, D. 2010. Sustainability of the food chain from field to plate:the case of the Mediterranean diet. In B. Burlingame & S. Dernini, eds. S*ustainable diets and biodiversity. Directions andsolutions for policy, research and action*. Proceedings of the International Scientific Symposium. FAO headquarters, Rome, 3–5 November 2010. Rome, FAO (available at http://www.fao.org/docrep/016/i3004e/i3004e.pdf).

Simopoulos, A.P. & Visioli, F., eds. 2007. More on Mediterranean diets. *World Rev. Nutr. Diet*, 97: I–XVIII.

Tbatou, M., Belahyan, A. & Belahsen, R. in press. Ethnobotanical study on wild edible plants in the countryside of El Jadida: sustaining the Moroccan traditional diet.

WHO (World Health Organization). 2014. *Noncommunicablediseases (NCD) country profiles*, 2014. Geneva, Switzerland.

Assessing sustainable diets in the context of sustainable food systems – socio-cultural dimensions

F. Xavier Medina
Universitat Oberta de Catalunya (UOC)/ICAF-Europe, Barcelona, Spain

ABSTRACT

In the developed countries, the large number of industrial processes and transformations of all kinds that food goes through before reaching the consumer generates in the latter a blind mistrust towards it. Actually, we can find an increasingly important movement from civil society, asking for more attention to be paid to local food and the sustainability of ecosystems and landscapes. In the Mediterranean basin, and from a local point of view and as a model of proximity consumption, Mediterranean food and diet can be a sustainable resource for the Mediterranean area. But this challenge requires a big effort and a very active and committed role of the public sector.

INTRODUCTION

Even if significant parts of the world's population (more than 800 million people, mostly in Africa and Asia; FAO, 2014) continue to have food consumption levels well below nutritional requirements, in the developed countries, well-provided with food, we can find a larger production and distribution of products at an industrial level and a more fluid access to a large amount of food by the public, at much more accessible prices.

In this sense, the large number of industrial processes and transformations of all kinds which food goes through before reaching the consumer generates in the latter a blind mistrust towards it. But we find also that such production, nowadays more industrialized than ever, has likewise seen itself affected in a different way: by generating different health problems (diseases, infections, etc.) related to their industrial production as well as, and consequently, by a growing mistrust among the population towards the food they consume. More and more often, people pursue going back to the origins that give them credibility and calmness when it comes to eating, and concepts such as "sustainable", "traditional", "local", "home-made", "organic" or "bio" succeed (Medina, 2011).

SUSTAINABLE DIETS IN THE FRAMEWORK OF SUSTAINABLE FOOD SYSTEMS

In a today very well-known paper, Gussow and Clancy (1986) suggested the term "sustainable diet" to describe a diet based on food chosen not only for health, but also sustainability (i.e. a certain capability of food maintenance into the foreseeable future). Gussow and Clancy concluded that consumers should, when possible, buy "locally produced foods". Such a movement would provoke implies less energy-intensive (transport) systems and support to local and regional agriculture.

Even if, immersed in the framework of the more and more massproduction of the agricultural systems and the food globalization process, this sustainable diet concept has been neglected by many developed countries in their public policies, we can also find an increasingly important movement from civil society, asking for more attention to be paid to local food and the sustainability of ecosystems and landscapes. At a supra-national level, in 2008, the Report of the FAO Regional Conference for Europe made important statements about sustainable diets: "that the goal of increased global food production, including biofuels, should be balanced against the need to protect biodiversity, ecosystems, traditional foods and traditional agricultural practices" (FAO, 2008; Burlingame and Dernini, 2011).

Until the present, the Mediterranean diet has been observed as a healthy model of medical behaviour. Nevertheless, and after its declaration as a Cultural Heritage of Humanity at UNESCO, the Mediterranean diet is actually being (and must be) observed as a part of Mediterranean culture, and opening the concept as an equivalent of the Mediterranean cultural food system or Mediterranean culinary system (Medina, 2009). In this sense, the Mediterranean diet is not simply a set of healthy nutrients, but a complex web of cultural aspects that depend on each other and lead from nutrition to the economy, through law, history, politics or religion. This point of view has to be highlighted in future discussions about the Mediterranean diet, its challenges and its future perspectives.

THE MEDITERRANEAN DIET AS A SUSTAINABLE FOOD SYSTEM

As Dernini (2008) points out, the Mediterranean diet as a whole life-style makes the cultural identities and diversity visible, providing a direct measure of the vitality of the culture in which it is embedded. The Mediterranean diet is an expression of a Mediterranean style of life in continuous evolution throughout time, and it is constantly recreated by communities and groups in response to changes in their environment and history. As a part of the different cultures, it provides a sense of identity and continuity for the Mediterranean societies.

As already pointed at the beginning of this paper, after the second half of the twentieth century, with modern agriculture and globalization of foods, concepts such as sustainable diets or human ecology have been neglected in favour of intensification and industrialization of agricultural systems. More recently, in the last three decades, the growing concern over food safety has motivated a renewed interest in organic foods (Herrin and Gussow, 1989) and locally produced and sustainable foods. This fact is particularly interesting in the Mediterranean area, where international movements such as Slow Food (but not only) are based on the defence of local production, biodiversity and sustainability, where both socio-cultural and biological aspects are included.

Nevertheless, the Mediterranean diet is still being considered politically as an independent item, and not as a part of a significant social and cultural Mediterranean food system. Health or food consumption is still considered separately from agricultural or fisheries production, economics (sales, import-export, etc.) or the maintenance of traditional structures of distribution or sale. In this framework, while good nutrition should be a goal of agriculture, it is imperative that concerns of sustainability are not lost in the process. Many dietary patterns can be healthy, but they can vary substantially, for example, in terms of their resource cost or their environmental impact.

As every food system in its own bio-social context, the Mediterranean diet is an outstanding resource, not yet fully acknowledged and enhanced within the Euro-Mediterranean Partnership (Medina, 2011; Dernini, 2008) for the achievement of an effective sustainable development in the Mediterranean area, as was already pointed out ten years ago in the report *Mediterranean Strategy on Sustainable Development*, issued in 2005 by the United Nations Environment Programme:[1]

> Mediterranean agricultural and rural models, which are at the origins of Mediterranean identity, are under increasing threat from the predominance of imported consumption patterns. This trend is illustrated in particular by the decline of the Mediterranean dietary model despite the recognized positive effects on health. The prospective scenario for the expected impacts of trade liberalization, climate change and the lack of efficient rural policies offers a gloomy picture in some southern and eastern Mediterranean countries, with the prospect of aggravated regional imbalances, deeper ecological degradation and persistent or accrued social instability... Create a conducive regional environment to help countries develop policies and efficient procedures for the labelling and quality certification of Mediterranean food products and to promote the Mediterranean diet.

[1] *Mediterranean Strategy for Sustainable Development: A Framework for Environmental Sustainability and Shared Prosperity*. 14th Ordinary Meeting of the Contracting Parties to the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean and its Protocols, UNEP/MAP, June 2005, Athens (available at http://www.planbleu.org/publications/smdd_uk.pdf).

CONCLUSIONS

The Mediterranean diet has been characterized, analysed and promoted through a variety of scientific and applied methods. It continues to be recognized and appreciated as a sustainable and culturally coherent diet in the Mediterranean region. But we must always consider the Mediterranean diet as a part of a significant social and cultural interdependent Mediterranean food system, and never as an independent item.

In this framework, the recognition in November 2010 of the Mediterranean diet as a World Immaterial Heritage by the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the start of the accession of different Mediterranean countries to this candidacy in 2013, can be an important future challenge for the Mediterranean local food production and manufacture. But, in this framework, an eventual definition of a sustainable Mediterranean diet should address sustainability of the whole food chain, while acknowledging the interdependencies of food production systems and food and nutrient requirements (Medina, 2011; Burlingame and Dernini, 2011).

This challenge requires a lot of efforts. And these efforts should focus primarily on coordination and generation mechanisms to expand and strengthen the collaboration network between backup food heritage structures; in any case, it is for governments involved to provide urgent adaptation to safeguarding the Mediterranean diet for the period we are going through. This major challenge involves also a large public commitment to safeguarding and promotion that cannot be neglected. In this framework, the active role of the public sector (not only, but mainly) is absolutely necessary (González-Turmo and Medina, 2012).

From a local Mediterranean point of view and as a model of proximity consumption, Mediterranean food and diet can be a sustainable resource for the Mediterranean area. In this context (and as every food system in their own bio-social context), the Mediterranean diet is an outstanding resource – locally produced in cultural coherent contexts – for the Mediterranean basin. But we must have also in mind that the Mediterranean diet is a complex web of cultural aspects that depend on each other, and we have to remember that every link in the chain must be protected, from the production to the dish and beyond.

REFERENCES

Baranski, M., Srednicka-Tober, D., Volakakis, N., Seal, C., Sanderson, R., Stewart, G.B., Benbrook, C., Biavati, B., Markellou, E., Giotis, C, Gromadzka-Ostrowska, J , Rembiałkowska, E., Skwarło-Sonta, K., Tahvonen, R., Janovská, D., Niggli, U., Nicot, P. & Leifert, C. 2014. Higher antioxidant and lower cadmium concentrations and lower incidence of pesticide residues in organically grown crops: a systematic literature review and meta-analyses. *Br. J. Nutr.*, 112(5): 794–811.

Burlingame, B. & Dernini, S. 2011. Sustainable diets: the Mediterranean diet as an example. *Pub. Health Nutr.*, 14(12A): 2285–2287.

Dernini, S. 2008. The strategic proposal to candidate the Mediterranean diet for inscription in the UNESCO List of Intangible Cultural Heritage. *Med. 2008. Mediterranean Yearbook. 2007 in the Euro-Mediterranean Space*. Barcelona, European Institute of the Mediterranean and Fundació CIDOB.

FAO. 2008. *Twenty-Sixth FAO Regional Conference for Europe*. Rome: FAO.

FAO. 2014. *The State of Food Insecurity in the World*. Rome.

González-Turmo, I. & Medina, F.X. 2012. Défis et responsabilités suite à la déclaration de la diète méditerranéenne comme patrimoine culturel immatériel de l'humanité (Unesco), *Revue d'Ethnoécologie*, 2 (available at http://ethnoecologie.revues.org/957).

Gussow, J.D. & Clancy, K.L. 1986. Dietary guidelines for sustainability. *J. Nutr Educ.*, 18: 1–5.

Herrin, M. & Gussow, J.D. 1989. Designing a sustainable regional diet. *J. Nutr. Educ.*, 21(6): 270–275.

Medina, F.X. 2009. Mediterranean diet, culture and heritage: challenges for a new conception. *Pub. Health Nutr.*, 12(9A): 1618–1620.

Medina, F.X. 2011. Food consumption and civil society: Mediterranean diet as a sustainable resource for the Mediterranean area. *Pub. Health Nutr.*, 14(12A): 2346–2349.

Nutrition and health: the Mediterranean diet paradigm

Antonia Trichopoulou
Hellenic Health Foundation, Athens, Greece (www.hhf-greece.gr)

ABSTRACT

Next to the evidence on the beneficial effect of the Mediterranean diet there is a similar volume of data on the detrimental effect of western diets. Ironically, Mediterranean populations have not been the major benefactors in the research on the effects of the Mediterranean lifestyle and populations in the regions, particularly the younger ones, are already following the wrong path. The price that the Mediterranean's are about to pay is big. Not only because the westernized diets followed by the young generations in the region have been associated with higher disease and mortality rates in northern Europe and the United States of America, but also because these food choices cannot support ecologically sustainable development in the way the Mediterranean diet does. Traditional foods, which form the backbone of the traditional Mediterranean diet, may provide the answer or parts of the answer. More generally, however, there is a need to highlight biodiversity, food production and food consumption as interconnected elements, with the purpose of promoting a broader assessment of the links between health, nutrition, local food products and sustainability, with traditional foods at the epicentre.

The international variation in the incidence of and mortality from most chronic diseases and the inability to explain the major fraction of it on the basis of genetic factors, pollution, infectious agents and other known disease determinants have pointed to nutrition as an important factor to disease causation. Indeed, hundreds of epidemiological and clinical studies have documented the role of diet in the occurrence of cardiovascular diseases, several forms of cancer and many other chronic diseases. During the last few decades, emphasis has shifted towards whole dietary patterns, as contrasted with specific foods and nutrients that may have minimal and even contradictory effects on specific disease and health conditions. Two general approaches have been used: de novo formulation of optimal dietary patterns and identification of "natural" long-used dietary patterns with ethnic roots and inherent, time-proven, ecological compatibility and environment-friendly sustainability. In the latter context, the traditional Mediterranean diet has emerged as a pattern that promotes good health. Indeed, in epidemiology, it is rare to have consistent evidence of the beneficial effects of an exposure as has been shown for the Mediterranean diet: a diet that promotes longevity, improves health-related quality of life and is ecologically sustainable and environmentally friendly (Trichopoulou *et al.,* 2014).

Yet, there is accumulating evidence that Mediterranean populations are deviating from their traditional eating habits. In a recent report presenting harmonized data for nutrition and health indices in Europe based on studies with wide population coverage, individuals in the Mediterranean region reported higher intakes of red meat and saturated fatty acids and lower intakes of plant products in comparison with their European counterparts (Elmadfa *et al.,* 2009). Publications presenting changes over time in the dietary habits of populations participating in the Seven Countries Study further support that the Mediterraneans are abandoning their traditional eating choices (Naska and Trichopoulou, 2014; Kafatos *et al.*, 1997; De Lorenzo *et al.*, 2001). Not disregarding methodological characteristics of the 1996 study that may limit direct comparisons with the 1960 data, results indicate a significant reduction in adherence to the Mediterranean diet. In the cross-sectional analysis of the Identification and prevention of Dietary – and lifestyle – induced health Effects In Children and infantS (IDEFICS) study, authors assessed adherence to the Mediterranean diet for 16 220 children aged 2–9 years old in eight European countries (Sweden, Germany, Hungary, Italy, Cyprus, Spain, Belgium and Estonia), using a Mediterranean Diet Score (Tognon *et al.,* 2003). More than half of the Swedish children (56.7 percent) reported close adherence to the Mediterranean diet, followed by the Italians (37.5 percent) and the Germans (35.1 percent). The lowest levels were observed in Cyprus, where 75.8 percent of children had score values below 3, indicating poor adherence to the traditional Mediterranean diet. In a representative sample of 554 Greek children and 358 adolescents, Kontogianni and colleagues assessed adherence to the Mediterranean diet using the KIDMED index. Only 11.3 percent of children and 8.3 percent of adolescents had an optimal score (≥8) (Kontogianni *et al.*, 2008).

At a time when other western countries experience a nutrition transition that favours the Mediterranean dietary pattern (Elmadfa *et al.*, 2009), traditional food choices in Italy, Greece and other Mediterranean regions are abandoned. This could be attributed to the globalization of the food supply, the overall improvement in socio-economic conditions in Europe that made food (especially of animal origin) more affordable and the urbanization of life, which primarily affects the younger generations.

The price that the Mediterranean's are about to pay is big. Not only because the westernized diets followed by the young generations in the region have been associated with higher disease and mortality rates in northern Europe and the United States of America (Akbaraly *et al.*, 2013; Sinha *et al.*, 2009), but also because these food choices cannot support ecologically sustainable development in the way the Mediterranean diet does. Being adjusted to the cultural, climatic and other environmental characteristics of the region, the Mediterranean diet is protective of and conducive to biodiversity and contributes to food and nutrition security, as well as to the health of present and future generations (Burlingame and Dernini, 2011; Trichopoulou, 2012). Unfavourable changes in disease rates will eventually increase the demand and the cost of health services – an issue of concern in an era of limited resources both at the individual and governmental level.

Is it, however, adequate to simply remind older generations of the health benefits of the Mediterranean diet and to re-introduce it to the younger ones? Apparently not, as it appears that the cost of following a Mediterranean diet is high, whereas the cost of a diet largely based on animal and refined products is easier to handle. Foods with most nutrients and least energy tend to be more expensive and when the household's budget shrinks (as is currently the case in the European Mediterranean countries), the first items dropped from the diet are the most costly options: fresh vegetables and fruit, unrefined cereals, olive oil and fish (Andrieu, Darmon and Drewnowski, 2006).

The question now is "how can we preserve the traditional Mediterranean diet as the dominant dietary pattern, at least in the populations that have in the past grown with it?" Traditional foods, which form the backbone of the traditional Mediterranean diet, may provide the answer or parts of the answer. The health effects of the Mediterranean diet, and indeed its identity, can be partly attributed to the traditional foods, which this diet integrates and which are critical components of this diet. They allow diet to remain a healthy, tradition-honored practice, rather than a composite of medical advice and recipes. Of course, specific differential emphasis and advice can and should be introduced (e.g. reduction of salt) but the approach would remain in the context of improving food habits, rather than substituting the diet with a set of medical recommendations. And sustainability is built-in inherently, as traditional diet is almost always environment friendly (Trichopoulou, 2012).

For the production of traditional foods, local products are generally used. Cultivation of local products contributes to a sustainable environment and employment of local people.

A multifaceted framework has been developed for the systematic investigation of traditional foods and recipes, an approach that could be useful in the study of other traditional foods, in other cultural settings (Vasilopoulou and Trichopoulou, 2009; Trichopoulou *et al.*, 2006).

The micronutrient content of traditional Greek foods in relation to professional recommendations showed that many of these foods have a rich micronutrient profile (Vasilopoulou, Dilis and Trichopoulou, 2013).

European law has recently provided a framework to promote the beneficial nutritional and health properties of foods by allowing the communication of scientifically supported claims, after a standard evaluation procedure. European Commission Regulation 1924 of 2006 is intended to minimize consumer misleading and promote healthy dietary choices. In this context, we have investigated the potential 194 traditional Greek foods to bear nutrition claims, by comparing their energy content and nutritional composition with the European recommendations on a wide range of nutritional components, including protein, total fat and fatty acids, sugars, salt, dietary fibre, and certain vitamins and minerals. The average number of nutrition claims per traditional food was 5, with a range between 0 and 14. Overall, about 1 024 nutrition claims were potentially relevant for the 194 traditional foods studied. From those, about half were made on vitamins and minerals. The European Regulation on nutrition and health claims made on foods may provide an important tool for the sustainment of Mediterranean traditional foods, since these foods frequently have distinct nutritional qualities. Toward this objective, compliance of the traditional foods with the current EU legislation on nutrition and health claims might offer considerable benefits.

The analyses of a weekly menu typical of the Greek variant of the Mediterranean diet and largely composed of traditional foods indicated that it meets the nutritional recommendations developed by the Scientific Committee for Food of the European Commission (Trichopoulou, Vasilopoulou and Georga, 2005).

Are there other traditional diets with similar environmental and perhaps health benefits? Most likely yes, and they should be treated as sustainable diets by the respective populations. I have talked specifically about the Mediterranean because of familiarity with it and also because, in my opinion, it is a dietary pattern that can easily be adopted by modern western societies.

More generally, however, there is a need to highlight biodiversity, food production and food consumption as interconnected elements, with the purpose of promoting a broader assessment of the links between health, nutrition, local food products and sustainability, with traditional foods at the epicentre.

REFERENCES

Akbaraly, T., Sabia, S., Hagger-Johnson, G., Tabak, A.G., Shipley, M.J., Jokela, M., Brunner, E.J., Hamer, M., Batty, G.D., Singh-Manoux, A. & Kivimaki, M. 2013. Does overall diet in midlife predict future aging phenotypes? A cohort study. *Am. J. Med.*, 126(5): 411–419 (available at http://dx.doi.org/10.1016/j.amjmed.2012.10.028.411e419.e3).

Andrieu, E., Darmon, N. & Drewnowski, A. 2006. Low-cost diets: more energy, fewer nutrients. *Eur. J. Clin. Nutr.*, 60: 434–436.

Burlingame, B. & Dernini, S. 2011. Sustainable diets: the Mediterranean diet as an example. *Public Health Nutr.*, 14(12A): 2285–2287 (available at http://dx.doi.org/10.1017/S1368980011002527).

De Lorenzo, A., Alberti, A., Andreoli, A., Iacopino, L., Serranò P. & Perriello, G. 2001. Food habits in a southern Italian town (Nicotera) in1960 and 1996: still a reference Italian Mediterranean diet? *Diabetes Nutr. Metab.,* 14(3): 121–125.

Elmadfa, I., Meyer, A., Nowak, V., Hasenegger, V., Putz, P., Verstraeten R., Remaut-BeWinter, A.M., Kolsteren, P., Dostálová, J., Dlouhý, P., Trolle, E., Fagt, S., Biltoft-Jensen, A., Mathiessen, J., Velsing Groth, M., Kambek, L., Gluškova, N. Voutilainen, S., Erkkilä, A., Vernay, M., Krems, C., Straßburg, A., Vasquez-Caicedo, A.L., Urban, C., Naska, A., Efstathopoulou, E., Oikonomou, E., Tsiotas, K., Bountziouka, V., Benetou, V., Trichopoulou, A., Zajkás, G., Kovács, V., Martos, E., Heavey, P., Kelleher, C., Kennedy, J., Turrini, A., Selga, G., Sauka, M., Petkeviciene, J., Klumbiene, J., Holm Totland, T., Andersen, L.F., Halicka, E., Rejman, K., Kowrygo, B., Rodrigues, S., Pinhão, S., Ferreira, L.S., Lopes, C., Ramos, E., Vaz Almeida, M.D., Vlad, M., Simčič, M., Podgrajšek, K., Serra Majem, L., Román Viñas, B., Ngo, J., Ribas Barba, L., Becker, W., Fransen, H., Van Rossum, C., Ocké, M., Margetts, B. 2009. European nutrition and health report 2009. *Ann. Nutr. Metab.*, 55(Suppl. 2): 1–40 (available at http://dx.doi.org/10.1159/000244607).

Kafatos, A., Diacatou, A., Voukiklaris, G., Nikolakakis, N., Vlachonikolis, J., Kounali, D., Mamalakis, G. & Dontas, A.S. 1997. Heart disease risk-factor status and dietary changes in the Cretan population over the past 30 years: the Seven Countries Study. *Am. J. Clin. Nutr.*, 65(6): 1882–1886.

Kontogianni, M.D., Vidra, N., Farmaki, A.E., Koinaki, S., Belogianni, K., Sofrona, S., Magkanari, F. & Yannakoulia, M. 2008. Adherence rates to the Mediterranean diet are low in a representative sample of Greek children and adolescents. *J. Nutr .*, 138(10): 1951–1956.

Naska, A. & Trichopoulou, A. 2014. Back to the future: the Mediterranean diet paradigm. *Nutr. Metab. Cardiovasc. Dis.*, 24(3): 216–219. doi: 10.1016/j.numecd.2013.11.007. Epub 16 December 2013.

Sinha, R., Cross, A.J., Graubard, B.I., Leitzmann, M.F. & Schatzkin, A. 2009. Meat intake and mortality: a prospective study of over half a million people. *Arch. Intern. Med.*, 169(6): 562–571 (available at http://dx.doi.org/10.1001/archinternmed.2009.6).

Tognon, G., Hebestreit, A., Lanfer, A., Moreno, L.A., Pala V, Siani A, Tornaritis, M., De Henauw, S., Veidebaum, T., Molnár, D., Ahrens, W. & Lissner L. 2013. Mediterranean diet, overweight and body composition in children from eight European countries: cross-sectional and prospective results from the IDEFICS study. *Nutr. Metab. Cardiovasc. Dis.*, 2013 Jul 17. 24(2): 205–213 (available at http://dx.doi.org/10.1016/j.numecd.2013.04.013. pii:S0939e4753(13)00115-4).

Trichopoulou, A. 2012. Diversity v. globalization: traditional foods at the epicentre. *Public Health Nutr.*, 15(6): 951–954.

Trichopoulou, A., Vasilopoulou, E. & Georga, K. 2005. Macro- and micronutrients in a traditional Greek Menu. In I. Elmadfa, ed. Diet diversification and health promotion. *Forum Nutr.*, 57, pp. 135–146, Basel, Karger

Trichopoulou, A., Vasilopoulou, E., Georga, K., Soukara, S. & Dilis, V. 2006. Traditional foods: why and how to sustain them. *Trends Food Sci. Technol.*, 17: 498–504.

Trichopoulou, A., Martínez-González, M.A., Tong, T.Y., Forouhi, N.G., Khandelwal. S., Prabhakaran, D., Mozaffarian, D. & de Lorgeril, M. 2014. Definitions and potential health benefits of the Mediterranean diet: views from experts around the world. *BMC Med.*, 12: 112. doi: 10.1186/1741-7015-12-112.

Vasilopoulou, E., Dilis, V. & Trichopoulou, A. 2013. Nutrition claims: a potentially important tool for the endorsement of Greek Mediterranean traditional foods. Mediterr. *J. Nutr., Metab.*, 6: 105–111. DOI 10.1007/s12349-013-0123-5.

Vasilopoulou, E. & Trichopoulou, A. 2009. The micronutrient content of traditional Greek foods. *Mediterr. J. Nutr. Metab.*, 2: 97–102.

Assessing diets, food supply chains and food systems sustainability: towards a common understanding of economic sustainability

Felice Adinolfi,[1] Roberto Capone[2] and Hamid El Bilali[2]
[1]University of Bologna, Italy
[2] International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM), Mediterranean Agronomic Institute of Bari, Valenzano (Bari), Italy

ABSTRACT

One of the main challenges impeding the promotion of sustainable food systems and diets is that related to sustainability assessment. Therefore, it is crucial to develop a shared scientifically-sound and easily applicable methodology for the analysis of sustainability. Economy is widely recognised as one of the three pillars of sustainability. The paper lists the main nutrition, health, environment, society, ethics and economy issues that should be considered for defining the economic sustainability of diets and provides insights for the assessment of the economic sustainability of healthy diets with a particular focus on the modelling of the economic effects of a switch to recommended diets and the analysis of the economic sustainability of food supply chains using different models and methods (e.g. input–output models, scenario analysis). The paper also highlights the importance of analysing the economic sustainability in relation to public policies especially those related to agriculture, food/nutrition and health. As a concrete case study, the paper provides a tentative list of indicators for assessing the economic sustainability of the food system in Apulia region (south-eastern Italy). For economic sustainability analysis many indicators can be used to describe current resource allocations and the impact of changes in food demand such as land use, production, prices, value of output, employment and trade. Economic objectives for sustainable food chains may include ensuring moderate food prices, achieving an equality point between food supply and demand, maintaining job posts, and optimising added value and return on investment. Economic modelling can be used to predict what might happen in case of a shift towards more healthy diets under different scenarios. The paper points out that the sustainability assessment focus (diet, food supply chain, food system) and geographical coverage should be clearly defined for the selection of appropriate economic indicators.

INTRODUCTION

Food consumption is variably influenced by a range of factors including food availability, food accessibility and personal food choice. These in turn may be influenced by geography, demography, disposable income, socio-economic status, urbanization, globalization, religion, culture, marketing and consumer attitude (Kearney, 2010). For most people, a key factor determining access to food is its affordability. This is dependent not only on food cost and price but also on the disposable income that can be spent on food (Ingram, 2011). In low-income countries, food consumption expenditures typically account for 50 percent or more of households' budgets. In lower middle-income countries the figure is about 40 percent (OECD, 2013). Many of those consumers classed as being in extreme poverty spend nearly 70 percent of their incomes on food (Rajiv, 2010). For them, there is little latitude to offset the price rise simply by spending more (von Braun, 2008).

For many Mediterranean consumers, income is a major barrier to freedom for a nutritious and sustainable food choice. The present food economy does not deliver enough food to major parts of the population, while market prices do not remunerate the costs that farmers should support to implement sustainable practices (Kickbusch, 2010). Pressures on food prices are exacerbated by volatile market dynamics and inadequate global coordination (Giovannucci *et al.,* 2012; Headey and Shenggen, 2010). A number of complex factors drive food prices including competition for natural resources especially land, population growth, rising affluence, urbanization, biofuels production and shifting dietary demand for livestock products (Cohen, 2002; Brown, 2012).

Price volatility has a strong impact on the poor and on food-importing countries. It also risks modifying diets, especially of the poorest as they tend to shift to cheaper, less preferred and poorer quality foods (HLPE, 2011). Economic analyses have shown that diets with a lower energy density – i.e. calories provided by whole grains and fresh produce – tend to be associated with higher food costs than calories from refined grains, added sugars and added fats (Rolls, Drewnowski and Ledikwe, 2005). Rising incomes and urbanization are driving a global dietary transition in which traditional diets are replaced by diets higher in refined sugars, refined fats, oils and meats (Tilman and Clark, 2014).

Food availability is fundamentally dependent on food production, but this can be local or distant. If distant, local food availability also depends on trade systems, and on packaging, transport and storage. This adds to the cost to the consumer, unless the cost of production at distance is so much less than locally so as to offset these additional costs (Ingram, 2011).

Berry *et al.* (2015) carried out an overview of the interrelationships between food security and food sustainability. They pointed out that sustainability should be considered as part of the long-term assessment of food security, as without integrating sustainability as an explicit food security dimension, today's policies could become the very cause of increased food insecurity in the future.

ISSUES FOR DEFINING THE ECONOMIC SUSTAINABILITY OF DIETS

Food consumption and production patterns are among the most important drivers of environmental pressures. With rising income and urbanization, dietary patterns are shifting. However, the role of eating patterns as important drivers for building sustainable agricultural and food systems has often been neglected by research and policy (Guyomard *et al.,* 2011). Diets are at the intersection of extremely diverse scientific disciplines. They are both the result and the driver of food systems. As such, they have to be looked at simultaneously from diverse points of view (Dernini *et al.*, 2013). This requires a huge amount of data, agreed methodologies and analytical tools. It requires also looking at dietary patterns not only from a nutritional point of view but also from environmental, economic, social and cultural perspectives, within a food system approach.

The assessment of the sustainability of dietary patterns is a critical development issue to counteract the emerging triple burden of undernutrition, overnutrition and micronutrient deficiencies in the Mediterranean region. The abandonment of the healthy Mediterranean diet pattern and the emergence of new lifestyles associated with socio-economic changes pose important threats for this intangible heritage as well as for the sustainability of Mediterranean food systems.

The concept of sustainable diets has been proposed to characterize dietary patterns and assess their sustainability in different agro-ecological zones (Burlingame and Dernini, 2012). FAO defines sustainable diets as *"those diets with low environmental impacts that contribute to food and nutrition security and to healthy lives for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable, nutritionally adequate, safe and healthy, while optimizing natural and human resources"* (FAO, 2010). According to Garnett (2014), while it is surely hard to disagree with this definition, it is very unclear what such a diet might look like on the plate. It also suggests that these multiple "goods" are synergistic, when inevitably there will be trade-offs

Dernini *et al.* (2013) presented a methodological approach to be used for assessing the sustainability of dietary patterns in different contexts. It identifies four main areas (environment, economy, society and culture, nutrition and health) to be considered and provides a first list of indicators. The Mediterranean diet is used as a model to assess food consumption patterns sustainability.

For some stakeholders, environment, economy and society (incorporating health and ethics) together constitute the "triple pillars of sustainability". According to the Food Climate Research

Figure 1: Main issues to consider in defining sustainable diets
Source: Garnett (2014).

Network (Garnett, 2014), many issues should be considered for defining diets sustainability. They relate to nutrition, health, environment, society and ethics but also economy and food supply (Figure 1). As far as economic sustainability is concerned, the main elements include markets and infrastructure, value added and jobs.

ASSESSMENT OF THE ECONOMIC SUSTAINABILITY OF HEALTHY DIETS

At the root of basic economic theory is the decision on the optimum allocation of scarce resources. In economic theory, it is assumed that resource (re)allocation is determined through the interaction of buyers and sellers in the operation of markets, in which price is the fundamental economic messenger.

Different stages can be considered for assessing the economic sustainability of more sustainable and healthier diets. These may include: determining the economic indicators to be used to assess diet economic sustainability; using those indicators to model economic outcomes regarding different economic issues under different scenarios; and assessing the economic feasibility and desirability of different economic outcomes, with a view to identifying potential public policy interventions and measures. To analyse the economic sustainability of more sustainable diets or the impact of a shift to healthier diets, many indicators can be used to describe current resource allocations and the impact of changes in demand (e.g. land use, production, prices, value of output, employment, trade).

However, the first step for healthy diets' economic sustainability assessment is the review of literature on the economic impact of changing diets. This encompasses literature regarding modelling the economic effects of a switch from the current to recommended healthy diets, analysing the sustainability of the food supply chain in economic terms, input–output economic models applied to food systems and investigating sustainability in relation to public food and health policies.

Table 1: Some literature sources on the economic effects of switching to healthier diets

Reference	Country	Objective	Main findings
Arnoult *et al.* (2010)	England and Wales	Quadratic programming techniques to model the land use, production and landscape effects of a shift to recommended diets.	Financial net margin of agriculture would rise, due to increased production of high market value and high economic margin crops. Some regions would be negatively affected and the effects of these changes would also be felt in upstream industries, such as animal feed suppliers.
Buzby, Wells, and Vocke (2006)	United States of America	Using ERS (Economic Research Service) Food Availability data and the ERS Food Guide Pyramid Servings data.	Consumers would need to increase daily fruit consumption by 132% to meet the new dietary recommendations. The additional demand could require US producers to more than double harvested fruit acreage from 3.5 million acres to 7.6 million acres (approx. 1.5 million ha to 3 million ha).
Conner *et al.* (2008)	United States of America (Michigan)	Estimate the gap between current and recommended fruit and vegetable consumption using USDA's Pyramid guidelines.	The analysis estimates that almost 2 000 jobs and USD200 million in new income would be created from the increased production of fruit and vegetables.
Lock *et al.* (2010)	United Kingdom and Brazil	Effects on trade of diets becoming healthier (reduction in consumption of meat and meat products).	Reduced consumption of animal products in some countries would have little or no effect on Brazil as exports could be reallocated elsewhere. But moving exports to a growing market would lead to lower price, affecting profitability. Reduction of meat consumption in high-income countries could intensify competition to supply meat to markets in other parts of the world and lead to a greater need to add value via processing.

Modelling the economic effects of a switch to recommended healthy diets

If society is to shift towards a more healthy diet, economic modelling can be used to predict what might happen to different types of economic activity (e.g. primary production, manufacturing, distribution, retailing, consumption) and different economic indicators (e.g. land use, prices, employment, trade) under different scenarios. During the last years, many scholars analysed the economic impacts and implications of switching to healthy diets and eating patterns (e.g. increase in consumption of fruits and vegetables, reduction of meat consumption) in many contexts, especially in developed countries. They used different models and techniques to analyse impacts on various aspects and sectors including agriculture and rural areas (Table 1).

Different types of approaches are used in economic sustainability studies such as: studies that provide statutory healthy eating guidelines, compare these to current consumption patterns and then model the economic effects of a switch from current to recommended diets; input–output models; more open-ended studies of scenario analysis nature (cf. what would happen if…); holistic sustainability of the food supply chain in economics terms.

ECONOMIC SUSTAINABILITY OF FOOD SUPPLY CHAINS

According to FAO (2012), a food chain is the sum of all processes involved in getting a specific food to consumers. The sum of all food chains makes up a food system. The main conceptual difference between a food system and a food chain is that the system is holistic, comprising a set of simultaneously interacting processes, whereas the chain is linear, involving a sequence of activities that must occur in order for people to obtain food.

Economic objectives for sustainable food chains may encompass achievement of an equality point between food supply and demand, ensuring moderate food prices, maintenance of job posts, maximization of added value and maximization of return on investment.

Yakovleva (2007) assessed the sustainability of the supply chain and applied it to the potato and chicken supply chains in the United Kingdom using three economic sustainability indicators: promotion of economic growth (GVA per workforce), encouragement of open and competitive economy (share of large enterprises) and changing consumption patterns (import dependency). The main finding of the study was that along the supply chain, the stage of food processing is the most economically efficient with 25 percent of added value of the entire food supply chain generated at this point.

Swenson (2006) used input–output models to examine the economic effect of four different scenarios with regard to increased production of, and different marketing strategies for fruit and vegetables in Iowa (United States of America). The research showed that, given the scenarios, there is the potential for substantial economic development to occur through import substitution. These gains are realized at the producer level as the amount of industrial output and value added per hectare increase markedly in fruit and vegetable production as compared with other types of agricultural products.

INDICATORS FOR ASSESSING FOOD SYSTEM ECONOMIC SUSTAINABILITY IN APULIA REGION

According to FAO (2012) and GECAF (2012), food systems encompass the ecosystem and all activities that relate to the production, processing, distribution, preparation and consumption of food. A food system involves multiple food chains operating at global, national and local levels. It operates within, and is defined by, social, economic and environmental contexts. Interactions between and within those contexts influence both activities and outcomes. Esnouf, Russel and Bricas (2011) distinguished various food systems types (domestic, local, territorial) and called for assessment of their sustainability. According to the High Level Panel of Experts on Food Security and Nutrition (HLPE) *"Sustainable food systems are food systems that ensure food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition of future generations are not compromised"* (HLPE, 2014).

The transformation of food systems towards sustainable diets is an essential part of the green economy. It offers vast economic and social opportunities (FAO, 2012). According to Edgar and Brown (2013), for a food system to be economically balanced it should provide economic opportunities that are balanced across geographic regions of the country and at different scales of activity, from local to global, for a diverse range of food system stakeholders, and afford farmers and workers in all sectors of the system a living wage. Economic viability is a necessary condition for sustainable agricultural and food systems. Profitability is a good place to begin. But economic viability is about more than profitability.

While the cost of treating the effects of malnutrition, whether in fiscal, economic or human terms, is high, the prevention of malnutrition is much less expensive. Investing in nutrition, therefore, is not only a moral imperative, it also makes good economic sense as it reduces health-care costs, improves productivity and economic growth, and promotes education, intellectual capacity and social development (FAO, 2012). Research has found that expanding local food systems in a community can increase employment and income (Martinez *et al.*, 2010). It also can have a positive impact on overall economic activity through import substitution and localizing processing activities.

Table 2: Some proposed indicators for assessing the Apulian food system economic sustainability

Indicators	Rationale	Sources
GVA per person from agriculture and comparison with Italy and EU	The economic sustainability of the agriculture sector requires that it is focused on the needs of consumers through the market, enhancing the incomes of competitive farm businesses.	ISTAT/EUROSTAT
Total factor productivity (TFP) of the food chain and comparison with the rest of national economy	United States of America	Using ERS (Economic Research Service) Food Availability data and the ERS Food Guide Pyramid Servings data.
Index of food products chosen relative to all food (inflation rate)	A sustainable food system requires that consumers have access to an affordable, healthy and varied diet.	ISTAT/analysis of regional food supply chain
Low income households' share of spending on food (as a % of total spending) and spending for selected food products	A sustainable food system should ensure that consumers have access to an affordable, healthy and varied diet. There is a focus on low-income households because they naturally have less money to spend on food.	ISTAT

That being said, many indicators can be proposed for assessing the economic sustainability of the food system in Apulia region (southeastern Italy). Table 2 includes a brief description of each proposed economic indicator, a rationale justifying its selection in relation to economic sustainability as well as some sources of data.

ECONOMIC SUSTAINABILITY IN RELATION TO PUBLIC POLICIES

The numerous food challenges faced by humanity put agricultural and food policy under scrutiny. Many questions are being asked about the adequacy and sustainability of both past and present public food policy. Previous food policies overlooked the importance of improving the sustainability of the food system. Transition towards sustainable food systems requires developing a set of comprehensive, coherent, integrated and holistic policies that deal with different spheres and areas of agriculture, environment, nutrition, health, economy, lifestyle, society and culture. Regulatory, economic/fiscal, information/communication and behavioural and technological instruments should be combined to mutually strengthen their effects and emphasize policy coherence and synergy. Achieving more sustainable food consumption implies promoting an integrated approach to different policies and ensuring functional links between policies. To reap the expected results, initiatives should involve the main food system actor categories.

There is nowadays a growing body of research being undertaken and policy debate taking place by various government institutions on the subject of sustainable diets. Many scholars analysed the economic impacts of food and health policies. Most of them focused on the economic costs of overweight and/or obesity, especially in terms of medical spending and savings that can be obtained by implementing appropriate health and nutrition policies (e.g. Allison, Zannolli and Narayan, 1999; Arterburn, Maciejewski and Tsevat, 2005; Barkin *et al.*, 2010; Thorpe *et al.,* 2004; Wyatt, Winters and Dubbert, 2006). Much of the literature on obesity is concerned with modelling the direct (health care) and indirect costs (e.g. productivity loss) of obesity-related illness. Many of the studies are carried out in the United States of America.

Obesity has emerged as the most serious health concern of the twenty-first century and is the leading cause of preventable death. Complications from obesity include cardiovascular risks, hypertension, type 2 diabetes and impaired glucose tolerance, obstructive sleep disorder and orthopaedic complications (Barness, Opitz and Gilbert-Barness, 2007). Once considered only a problem of high-income countries, obesity rates are rising globally and affect both developing and developed countries (FAO, 2012).

Barkin *et al.* (2010) predict the impact of obesity on the likely lifetime earnings of the millennial generation and consequences for employers and employees. Other papers examine the proportion of health-care spending that is attributable to obesity and methods of estimating the health and economic costs of obesity. Wolf (2002) lists various direct and indirect economic "outcomes" that she proposes researchers and clinicians collect to integrate into their weight management strategies. These include medical-care outcome measures such as inpatient days, inpatient costs, emergency room visits and procedures and costs, as well as lost-productivity outcome measures such as days of work lost, days of restricted activity and short- and long-term disability. Wellman and Friedberg (2002) estimate the economic cost of obesity in the United States of America as do Stein and Colditz (2004) who compare the cost of health care linked to obesity with the costs associated with smoking.

The cost of obesity is staggering. In North America, that cost is estimated at USD270 billion per year in the United States of America and USD30 billion a year in Canada alone. This total bill results from increased need for medical care, loss of worker productivity due to higher rates of death, loss of productivity due to disability of active workers, and loss of productivity due to total disability.[1] In Britain, obesity costs the National Health Service USD6.9 billion annually, and the wider economy USD6 billion.[2]

[1] www.usatoday.com/yourlife/health/medical/2011-01-12-obesity-costs-300-bilion_N.htm (in FAO, 2012).

[2] www.bbc.co.uk/news/health-14064561 (in FAO, 2012).

According to the Centre for Agricultural and Rural Development at Iowa State University, which completed a four-year research project in 2010 on the effects of agricultural policies on obesity: "*Government policies that affect agricultural commodity markets and prices also affect the prices and nutritional characteristics of food products and thus consumption choices and human nutrition outcomes. The effects of food and agricultural policies on human nutrition and obesity are not well understood… Nevertheless, presumptions about the relationships are implicit or explicit in public policy discussions (e.g., that cheap food leads to obesity) and may have important implications for policy choices that affect nutrition and the demand for food as well as farm income*".[3]

CONCLUDING REMARKS

The methodological insights presented in this paper require further development and validation. For the selection of appropriate economic indicators the sustainability assessment focus (diet, food supply chain, food system) and geographical coverage (local, territorial, regional, national) as well as data availability should be duly taken into consideration. It is also essential to consider the various sustainability dimensions and their complex interactions thus working across disciplines to develop comprehensive studies on diets and food consumption patterns. It is also important to foster dialogue among economists and between them and the wider scientific community on the economic sustainability of Mediterranean diets.

Enhancing the transition towards more sustainable food systems in the Mediterranean area requires a further development of holistic approaches within different spheres and arenas of agriculture, nutrition, health, economy, environment, culture and lifestyle. This is crucial for designing cross-sectoral policy instruments allowing the improvement of the sustainability of the diets and food systems. Governments have to determine what policy interventions are necessary to facilitate a shift towards more sustainable diets and food consumption patterns while mitigating potential undesirable outcomes (e.g. price inflation for some foods, unemployment in other food sectors, increased food deficit due to imports of recommended food products).

REFERENCES

Allison, D.B., Zannolli, R. & Narayan, K.M.V. 1999. The direct health care costs of obesity in the United States. *American Journal of Public Health*, 89(8): 1194–1199.

Arnoult, M.H., Jones, P.J., Tranter, R.B., Tiffin, R., Traill, W.B. & Tzanopoulos, J. 2010. Modelling the likely impact of healthy eating guidelines on agricultural production and land use in England and Wales. *Land Use Policy*, 27(4): 1046–1055.

Arterburn, D.E., Maciejewski, M. & Tsevat, J. 2005. Impact of morbid obesity on medical expenditures in adults. *International Journal of Obesity*, 29: 334–339.

Barkin, S.L., Heerman, W.J., Warren, M.D. & Rennhoff, C. 2010. Millennials and the world of work: the impact of obesity on health and productivity. *Journal of Business and Psychology*, 25(2): 239–245.

Barness, L.A., Opitz, J.M. & Gilbert-Barness, E. 2007. Obesity: genetic, molecular and environmental impacts . *Am. J. Med. Genet.*, Part A, 143A: 3016–3034.

Berry, E.M., Dernini, S., Burlingame, B., Meybeck, A. & Conforti, P. 2015. Food security and sustainability: can one exist without the other? *Public Health Nutrition*, 02/2015. DOI: 10.1017/S136898001500021X.

Brown, L. 2012. Full planet, empty plates: the new geopolitics of food scarcity. Chapter 1. Food: the weak link. Washington, DC, Earth Policy Institute.

Burlingame, B. & Dernini, S. 2012. *Sustainable diets and biodiversity: directions and solutions for policy, research and action*. Proceedings of the International Scientific Symposium "Biodiversity and Sustainable Diets - United Against Hunger", 3–5 November 2010. Rome, FAO (available at www.fao.org/docrep/016/i3004e/i3004e.pdf).

Buzby, J.C., Wells, H.F. & Vocke, G. 2006. *Possible implications for U.S. agriculture from adoption of select dietary guidelines*. Economic Research Service, USDA, Economic Research Report Number 31 (ERR-31).

[3] http://www.card.iastate.edu/food_nutrition

Cohen, J. 2002. World population in 2050: assessing the projections. *In* J.S. Little & R.K. Triest, eds. S*eismic shifts: the economic impact of demographic change*, pp. 83–113. Federal Reserve Bank of Boston Conference Series No. 46.

Conner, D.S., Knudson, W.A., Hamm, M.W. & Peterson, H.C. 2008. The food system as an economic driver: strategies and applications for Michigan. *Journal of Hunger & Environmental Nutrition*, 3/4: 371–383.

Dernini, S., Meybeck, A., Burlingame, B., Gitz, V., Lacirignola, C., Debs, P., Capone, R. & El Bilali, H. 2013. Developing a methodological approach for assessing the sustainability of diets: the Mediterranean diet as a case study. *New Medit.*, 3: 28–36 (available at http://www.iamb.it/share/img_new_medit_articoli/949_28dernini.pdf).

Edgar, C. & Brown, L. 2013. *A review of definitions of community food systems* (available at http://fyi.uwex.edu/cfsi/files/2012/10/CFS-definitions-5-21-13.pdf).

Esnouf, C., Russel, M. & Bricas, N. 2011. *duALIne – durabilité de l'alimentation face à de nouveaux enjeux.* Questions à la recherché. Rapport INRA-CIRAD (France).

FAO. 2010. *Biodiversity and sustainable diets: united against hunger*. Rome.

FAO. 2012. *Improving food systems for sustainable diets in a green economy*. FAO GEA Rio+20 Working Paper 4. Rome (available at http://www.fao.org/fileadmin/templates/ags/docs/SFCP/WorkingPaper4.pdf).

Garnett, T. 2014. *What is a sustainable healthy diet?* A discussion paper. Food Climate Research Network (FCRN), April 2014 (available at http://www.fcrn.org.uk/sites/default/files/fcrn_what_is_a_sustainable_healthy_diet_final.pdf).

GECAF (Global Environmental Change and Food Systems). 2012. *Glossary & acronyms* (available at www.gecafs.org/glossary/index.html).

Giovannucci, D., Scherr, S., Nierenberg, D., Hebebrand, Ch., Shapiro, J., Milder, J. & Wheelern, K. 2012. *Food and agriculture: the future of sustainability*. A strategic input to the Sustainable Development in the 21st Century (SD21) project. New York, USA, United Nations Department of Economic and Social Affairs, Division for Sustainable Development.

Guyomard, H., Darcy-Vrillon, B., Esnouf, C., Marin, M., Momot, A., Russel, M. & Guillou, M. 2011. *Eating patterns and food systems: critical knowledge requirements for policy design and implementation*. Paris, INRA (available at http://ccafs.cgiar.org/sites/default/files/assets/docs/guyomard_et_al_eating_patterns_and_food_systems.pdf).

Headey, D. & Shenggen, F. 2010. *Reflections on the global food crisis: how did it happen? how has it hurt? and how can we prevent the next one?* Research Monograph 165. Washington, DC, International Food Policy Research Institute.

HLPE. 2011. *Price volatility and food security*. A report by the High Level Panel of Experts (HLPE) on Food Security and Nutrition of the Committee on World Food Security. Rome.

HLPE. 2014. *Food losses and waste in the context of sustainable food systems*. High Level Panel of Experts (HLPE) on Food Security and Nutrition of the Committee on World Food Security. Rome.

Ingram, J.S.I. 2011. *From food production to food security: developing interdisciplinary, regional-level researc*h. PhD Thesis, Wageningen University.

Kearney, J. 2010. Food consumption trends and drivers. *Philosophical Transactions of the Royal Society*, Ser. B., 365(1554): 2793–2807.

Kickbusch, I. 2010. *The food system: a prism of present and future challenges for health promotion and sustainable development*. Promotion Santé Suisse, Bern.

Lock, K., Smith, R.D., Dangour, A.D., Keogh-Brown, M., Pigatto, G., Hawkes, C., Fisberg, R.M. & Chalabi, Z. 2010. Health, agricultural, and economic effects of adoption of healthy diet recommendations. *The Lancet*, 376/9753: 1699–1709.

Martinez, S., Hand, M., Da Pra, M., Pollack, S., Ralston, K., Smith, T., Vogel, S., Clark, Sh., Lohr, L., Low, S. & Newman, C. 2010. Local food systems: concepts, impacts and issues. Economic Research Report (ERR) 97, Economic Research Service, USDA, Washington D.C.

OECD (Organisation for Economic Co-operation and Development). 2013. *Global food security: challenges for the food and agriculture system*. Paris.

Rajiv, S. 2010. *Clinton Global Initiative Annual Meeting*. New York (available at http://www.usaid.gov/press/speeches/2010/sp100921.html).

Rolls, B.J., Drewnowski, A. & Ledikwe, J.H. 2005. Changing the energy density of the diet as a strategy for weight management. *Journal of the American Dietetic Association*, 105(5): 98–103.

Stein, C.J. & Colditz, G.A. 2004. The epidemic of obesity. *Journal of Clinical Endocrinology & Metabolism*, 89(6): 2522–2525.

Swenson, D. 2006. The economic impacts of increased fruit and vegetable production and consumption in Iowa: Phase II. Prepared for the Regional Food Systems Working Group, Leopold Center for Sustainable Agriculture, Economics Department - Iowa State University.

Thorpe, K.E., Florence, C.S., Howard, D.H. & Joski P. 2004. The impact of obesity on rising medical spending. *Health Affairs*, 23(6): 4480–4486.

Tilman, D. & Clark, M. 2014. Global diets link environmental sustainability and human health. *Nature*, 515: 518–522. doi:10.1038/nature13959.

von Braun, J. 2008. *Food and financial crises: implications for agriculture and the poor*. Washington, DC, International Food Policy Research Institute.

Wellman, N.S. & Friedberg, B. 2002. Causes and consequences of adult obesity: health, social and economic impacts in the United States. *Asia Pacific Journal of Clinical Nutrition*, 11: S705–S709.

Wolf, A.M. 2002. Economic outcomes of the obese patient. Obesity Research, 10: 58S–62S.

Wyatt, S.B., Winters, K.P. & Dubbert, P.M. 2006. Overweight and obesity: prevalence, consequences, and causes of a growing public health problem. *American Journal of the Medical Sciences*, 331(4): 166–174.

Yakovleva, N. 2007. Measuring the sustainability of the food supply chain: a case study of the UK. *Journal of Environmental Policy and Planning*, 9 (1): 75–100.

On the use of environmental life cycle indicators for sustainability assessment of Mediterranean diets

Massimo Iannetta[1] and Milena Stefanova[2]
[1] ENEA-Technical Unit "Sustainable Development and Innovation of Agro-industry Systems"
[2] ENEA-Technical Unit "Environmental Assessment Models, Methods and Technologies"

ABSTRACT

Recent trends in sustainability assessment of diets and food systems make use of life cycle (LC) indicators and life cycle assessment (LCA) methods. The main question of our work is: can the standard LCA toolbox be used for assessment studies regarding food system transformations that are characterized by traditional high-quality products on the supply side and Mediterranean diet pattern on the consumption side? In order to answer this question, we focus on a specific case study project carried out by the Apulia region and CIHEAM-Bari, with contributions from ENEA and other organizations, the aim of which is the promotion of high-quality traditional products from Apulia region. We present an analysis of the use of life cycle-based methodological tools in the context of food system sustainability, starting from the motivational perspectives behind such studies, identifying the "mental" models mapping the perspectives and the consequent mathematical implementations of such mental models. The case study under consideration has been positioned within the "system transformation" perspective. This perspective poses a number of non-trivial challenges on standard LCA tools; it is characterized by identification of sustainable patterns not only on the consumption side (Mediterranean diet pattern), but also on the supply side (e.g. different process implementation patterns). This paper extends the indicator balancing and scoring framework (IPI-SMeD) discussed in the CIHEAM/FAO international seminar (Malta, 2012) by presenting some initial guidelines on how to compute LC-based environmental indicators, which can provide significant evidence on differences in production patterns.

INTRODUCTION

At present the main challenge food systems are facing is the delivery of food and nutrition security for a growing population, at an environmental cost that respects the planetary boundaries of the Earth (FAO/Bioversity, 2012; Caraher and Coveney, 2003; Eriksen, 2007; Garnett, 2014; Padel, 2008). Therefore, the focus is being shifted towards *sustainable* food systems. At the same time, there is a growing recognition of the fact that food security and nutrition-related policies should take into account the whole food system and not only its consumption side, focusing only on nutritional outcomes of diet mixes (see Caraher and Coveney, 2003).

A recent concept for *sustainable diets* adopted during an international scientific symposium organized by FAO and Bioversity International (FAO/Bioversity, 2012) expresses this shift in changing concerns towards more sustainable food systems. The traditional Mediterranean diet has been selected as a first case study for the development of a methodology for sustainability assessments of diets (FAO/Bioversity, 2012; FAO/CIHEAM, 2012; Dernini *et al.*, 2013).

The concept of Mediterranean diet goes beyond food and refers to particular food systems and lifestyles, which were central for Mediterranean countries in the past, and which call for urgent attention at present due to a trend of erosion (Dernini, 2011). The food systems in the Mediterranean region have followed the overall trends observed in developed economies, with moving diet food diversity upstream, from rural systems, towards downstream, within the industrial processing and retail sectors (Dernini, 2011; Padilla, Capone and Palma, 2012). This shift in production methods had negatively affected environment and culture within the region, which poses the question of reversing the negative trends towards more sustainable food systems.

Distinguishing features of the Mediterranean diet are its socio-economic and environmental dimensions and its continuous evolution in balance with changing environmental, socio-economic and cultural conditions within the Mediterranean region. Diets that follow the Mediterranean diet pattern have also been recognized as healthy and as sources of balanced nutrition. This health–nutrition dimension has gained considerable attention in recent scientific literature (for a comprehensive list of references see Dernini *et al.*, 2013). The focus on health and the synthetic and effective way of communicating it through the Mediterranean diet pyramid (see Bach-Faig *et al.*, 2011) has resulted in less attention to its environmental, socio-cultural and economic features, in particular within studies related to sustainability of food and food systems. The way food is produced and consumed remains somehow at second place within such studies, while the focus is on the mix of products within diets (Duchin, 2005; Tukker *et al.*, 2009).

Building upon previous studies (FAO/CIHEAM, 2012; Dernini *et al.*, 2013; Garnett, 2014; Iannetta, 2012), this paper aims to provide further methodological insights for the sustainability assessment of diets, in order to capture the distinguishing characteristics of a Mediterranean diet of a well-defined territorial, socio-economic and environmental context. The focus is on life cycle assessment (LCA) environmental indicators and other similar methodological instruments (Blok *et al.*, 2013; ISO, 2006; Valdivia *et al.*, 2012), which had been examined in a critical way in correspondence with the above-mentioned methodological objectives. The analysis has been carried out in the framework of an ongoing pilot project "Assessment and Valorization of the sustainability of Quality Products typical of the Mediterranean diet of the Apulia Region in Italy". The project is carried out by CIHEAM-Bari and the Apulia region in collaboration with CREA, CNR, ENEA, the Forum on Mediterranean Food Cultures, the University of Bologna and the University of Naples Federico II.

FOOD SYSTEMS AND LIFE CYCLE ASSESSMENT

There are several ways of defining the concept of food system focusing on different aspects: activities, actors, relationships between actors, relationships and interactions between the food system on one side and the environmental and socio-economic context on the other (Caraher and Coveney, 2003; Eriksen, 2007; Garnett, 2014). However most considerations of what a food system is include a set of activities, starting from production of food raw materials (agricultural phase), raw materials processing (transformation phase), food packaging, distribution and retailing, as well as food consumption. Such a life cycle-oriented approach in defining food systems, from raw materials production up to consumption, calls for the use of life cycle-based methodologies and methods in sustainability evaluations of food systems and diets. LCA-based methodologies allow for systematic assessment of whole supply-consumption chains, in such a way as to avoid shifts of environmental burdens between different phases of the life cycle of a product. In fact, as a recent analysis of Pré Consultants shows, the food-related articles published in the *Journal of Life Cycle Assessment* since 2007 constitute a more or less stable figure of about 25 percent of all articles published in the journal (see Pré Consultants, 2014).

However, LCA-based methods for environmental (and recently also social and economic) assessments are applied in different ways according to the underlying perspective which determines the research questions of a study. Therefore, the interpretation of the results is not absolute, but needs to be considered in relation to the perspective from which an assessment has been conducted and the way research questions have been formulated. Within recent studies, three different perspectives on sustainable food systems have been identified (Garnett, 2014): efficiency, demand-restraint and system transformation perspectives. These perspectives express different points of view, conditioned by hidden moral frameworks and mental models of what sustainability means, which in their turn result in observing different aspects of the system under study, applying different modelling and formal techniques for analysis and drawing different conclusions about it (Watzlawick, 1984).

As underpinned in Garnett (2014), the dominant use of LCA aims at obtaining supply-side efficiency, through supply system optimization based on adoption of innovative technologies. This approach is followed by the various LCA-based standards and guidelines (see ISO, 2006; EC, 2013; European Food Sustainable Consumption & Production Round Table, 2013; WRI/WBCSD. 2011; etc.), which reflect the viewpoints of dominant stakeholders on the supply side of the food system (agricultural input businesses, farming unions, industrial food processors, food distributors and retailers). The underlying value-based assumption of this perspective is associating "good life" with material comfort and the belief that this can be achieved by technology-based optimization. As noted in Garnett (2014), since at present LCA is used prevalently in evaluating "supply-side" solutions to the food security problem, also the development of LCA-based tools has been strongly influenced by the basic values underlying the efficiency approach. In fact, such methodological instruments have been shaped and validated by important and influential stakeholder actors on the production side (see for example current trials with product environmental footprint (PEF) and organisation environmental footprint (OEF) standards, EC [2013]). Consequently the adoption of LCA-based instruments in studies with different goals from the technology-induced optimization on the supply side needs to be examined in a critical way before application.

A different approach to food security, identified in Garnett (2014), is the "demand-restraint perspective", where the focus is on the consumer side. It promotes more sustainable patterns of consumption, without necessarily examining the need to introduce also change in behaviour and in the relationships between stakeholders on the production side. However, a change of consumption patterns could induce some changes on the supply side leading to production mix change or change in shares between consumed food and non-food products (see for example Duchin, 2005; Heller, Keoleian and Willet, 2013; Vieux *et al.*, 2012).

The above two approaches to sustainable food security rely on the assumption that the relationships between stakeholders in the food system remain as they are today and both assume in advance a view of how the world should be in the future, provided that we have the food system of today. At conceptual level, the system and its elements are represented in terms of inputs and outputs. The stakeholders' relationships are ignored also in the mathematical formalization of life cycle inventory models resulting in systems of linear equations (expressing relations between process inputs and outputs) to be solved or in application of linear optimization methods in finding optimal configurations of the present system (see Figure 1).

MEDITERRANEAN DIETS AND THE SYSTEM TRANSFORMATION PERSPECTIVE

The main issues behind the present study are: Can the current non-sustainable trends of food systems in the Mediterranean region be reversed (Dernini, 2011)? Could a style of life, which has been recognized as an intangible cultural heritage (UNESCO, 2013) be preserved while continuing to evolve within changing contexts?

In order to be able to answer these questions, it is necessary to develop a methodology for sustainability assessment of diets, which can help in monitoring progress towards more sustainable trends (FAO/Bioversity, 2012; FAO/CIHEAM, 2012; Dernini *et al.*, 2013). The methodological perspective of the present study can be positioned predominantly within the "system transformation perspective", which reflects the question of reversing current non-sustainable trends of food systems in the Mediterranean region.

While it is clear that it is impossible to go back to the food systems that existed in Mediterranean countries in the past, it is still possible to aim at notional systems, which bear essential characteristics of the Mediterranean diets from corresponding countries or regions. Within the present case study, such a notional system is characterized by a Mediterranean diet pattern on the demand side (Bach-Faig *et al.*, 2011; Dernini *et al.*, 2013) and on the supply side by high-quality traditional products from the Italian region of Apulia (Regione Puglia – Assessorato alle Risorse Agroalimentari. 2006). These characteristics imply also a number of constraints, such as particular rural systems balanced with the natural environment, diversity in primary production and local varieties, fresh seasonal foods and less energy-intensive conservation methods, sharing of knowledge and food, extraneousness of food losses along all phases of the supply-consumption chains, and a multitude of social, economic and cultural aspects (FAO/Bioversity, 2012; FAO/CIHEAM, 2012; Dernini, 2011; Dernini *et al.*, 2013).

Assessment studies taking the system-transformation perspective on the sustainability issue are based on a conceptual model of the food system not in terms of input and output (see following section), but in terms of interactions and relationships between different system elements (e.g. stakeholders and other subsystems). Essentially this relates to some basic elements from the domain of "complex systems" (Barabási, 2002; von Bertalanffy, 1950). An analysis carried out from a system-transformation point of view focuses on system outcomes, rather than system outputs, and system outcomes go further than marketable products. Depending on the context, they can include delivery of lacking micronutrients, supply of environmental public goods, knowledge and information access, etc. Within such a perspective, single metrics (i.e. functional units), to which environmental indicators are related, could have little meaning. Moreover, the environmental impacts of a system cannot be understood without understanding how the system interacts with the context into which it is inserted. It is necessary to consider not only market-related mechanisms (see Zamagni *et al.*, 2006) of such contexts (which are sometimes considered within consequential LCAs, especially in relation to global markets, e.g. Tukker *et al.*, 2009), but also environmental, social, cultural, organizational and other more specific mechanisms at levels of less globalized contexts and which could be relevant for the type of question a study aims at.

The system-transformation perspective poses many challenges to LCA and at present no LCA-based methodology is able to consider them sufficiently even if there is an ongoing research effort in this direction (Blok *et al.*, 2013; Valdivia *et al.*, 2012; Zamagni *et al.*, 2006).

Some consistency issues that arise when using LCA tools in studies from a system-transformation perspective, and which apply in particular to the Mediterranean diet case study, are presented below.

Food systems functions

As mentioned above, LCA methodology is constructed around the notion of a single function of an economic system (typically a micro-level product system). Such a function could be connected to a desired outcome of the food system. A classical example is a food system outcome in terms of food availability on the market. Functional units expressing quantities of certain products implicitly or explicitly focus on this outcome. The corresponding studies mainly express the "efficiency perspective". When nutritional outcomes of the system are considered, then the functional units could become more complex, ranging from simple nutritional indicators, such as energy or protein content of food, up to more composite indices expressing overall nutritional qualities of single products, meals or also diets (see Heller, Keoleian and Willet, 2013). Such kinds of studies could be positioned as prevalently efficiency-oriented (Muñoz, Milà i Canalis and Fernández-Alba, 2010; Tukker *et al.*, 2009) or demand-restraint (Duchin, 2005; Heller, Keoleian and Willet, 2013; Vieux *et al.*, 2012), or even carrying elements of system transformation thinking (Vieux *et al.*, 2012).

In some cases, resource-related or environmental outcomes of the system become more important – in this case the preferred functional unit is on quantity of land used. Examples are studies assessing organic systems of production (Meier *et al.*, 2014).

The common feature between all these approaches to functional units is that they chose to look at a single system outcome and a single function. Such functions imply equivalence relations between system outcomes, which are defined on a set of food features considered to be important for a study. Which features are considered important, however, is often a consequence of the perspective from which the study has been conducted.

This point is particularly evident in comparison studies between agricultural practices or between food items and meals. Such comparisons could result in different conclusions (often contradictory) according to the set of features, which are defining the equivalence relations between food items. This set of features depends on the choice of functional unit. For example, the study in Flury, Büsser and Jungbluth (2013) compares ready-made with homemade lasagna Bolognese from an environmental point of view, where the functional unit is 1 kg of lasagna delivered at home.

Through the choice of this functional unit, the study assumes that industrial ingredients have equivalent counterpart of ingredients used at home, and the way the ingredients are mixed together is not a source of difference. Such a study would not only scandalize the *zdaura*[1] in Bologna for its lack of references to cultural and social values, but could puzzle also some attentive consumers who are not indifferent to the choice between fresh and conserved ingredients or the way such ingredients were produced.

System dynamics

The system-transformation perspective goes much further than the supply-side efficiency paradigm on which standard LCA is based – it considers explicitly consequences of change in behaviour of some system actors in response to changes of the behaviour of other system actors and subsequent feedbacks. Such cause–effect relations and feedbacks cannot be captured by the input–output system model adopted by attributional or consequential LCA methodologies.

For example, the increase of food waste at consumer phase could be related to decrease of food quality, rather than to whether the food was cooked at home or industrially prepared. Such types of issues have been raised, for example, by a bottom-up movement (see Coordinamento Commissioni Mense Scolastiche di Bologna. 2014) for improving the food quality in school canteens. Within this perspective, decrease of quality is examined in relation to organizational structure of the canteen service (e.g. in the case of Coordinamento Commissioni Mense Scolastiche di Bologna [2014], a single company serving large numbers of meals versus a distributed model, which was in place before). It is a dynamic perspective determined not by linear relations between input and output, but by the system behaviour and the way its components interact. Asking a question from such a dynamic perspective would result in a different design of the study in, for example, Flury, Büsser and Jungbluth (2013). Other questions studied in efficiency-oriented LCAs could be rephrased in a similar way, as for example those comparing imported and locally produced food (for more examples see Garnett, 2014).

Within studies carried out from system transformation point of view, it becomes necessary to calculate material, energy and other types of flows not with the help of fixed coefficients or emission factors (derived from observations of the current system), but as outcomes from system behaviour (see for example Tukker *et al.*, 2009, which clearly demonstrates the issue by not completing the analysis when considering global market dynamics). Remarkable examples are biologically mediated emissions (such as N_2O or NH_3 from agricultural soils), which are usually calculated with the help of statistically derived emission factors (European Monitoring and Evaluation Programme/European Environment Agency, 2013; IPCC, 2006) Using such emission factors or waste coefficients in studies, which for example compare intensive agricultural practices (on the base of which emission factors had been derived) with, for example, organic farming practices, could be considered simply wrong, even with reference to any possible perspective that led to asking the research question (see Meier *et al.*, 2014).

Ignoring system dynamics and interactions is also embedded in the practice of summing impacts along the life cycle of a product. Life cycle thinking is a strong point about LCA as it allows avoiding impact shifts between different phases of a product system. Even though LC-thinking has been implemented within LC inventories by using linear input–output models, it still reflects the need to carry out the analysis at a system level. However, LCA-indicators are calculated by summing impacts along phases, and this way of formalization of LC-thinking could be difficult to cope with in the case of questions posed from a system transformation perspective. In this way, efficiencies in one system could lead to better environmental performances in different but connected product systems. A typical example is the energy system, where better energy mixes in

[1] *Zdaura* is a word coming from the local dialect of the city of Bologna and refers to a housewife of a certain age, who since her youth has been dedicated to the house, and in particular to the preparation of strictly home-made traditional dishes and ingredients.

one country could determine better environmental performances of products imported from that country (Garnett, 2014).

TOWARDS AN OPERATIONAL METHODOLOGY FOR SUSTAINABILITY ASSESSMENT OF MEDITERRANEAN DIETS

The main study question of the present work is: can the existing LCA toolbox be adapted for assessment studies regarding food system transformations, which are characterized by traditional high-quality products on the supply side and the Mediterranean diet pattern on the consumption side? As we have seen, LCA tools are based on life cycle thinking, which could reflect the current shift of concern in considering human diets as an integral part of the food system and not simply related to nutritional outcomes. However, LC thinking has been implemented into various LCA-tools according to different underlying perspectives, which have shaped and influenced the methodological development in the LCA field (Garnett, 2014). Figure 1 shows a methodological development path, starting from value judgments and perspectives up to mathematical formalizations and subsequent software, which present a final step of turning methodological ideas and frameworks into operational methodology.

As explained in the previous section studies carried out from a system transformation perspective rely on conceptual models for complex systems. Within the LCA-toolbox at present there are no methodological tools implementing such a conceptual model, even if some tools for assessment of single system phases exist (Flichman, 2011). Therefore the goal is to develop a new methodology, which uses as much as possible useful elements from LCA-based instruments, while adapting them and integrating them with other methodological tools (Zamagni *et al.*, 2006). This methodology should capture distinguishing features of the Mediterranean diet and should allow for sustainability assessments of diets to be carried out from a system transformation perspective.

Methodological framework

The methodological framework presented here develops further the one in Iannetta (2012). Differently from LCA-oriented methodologies, it is based on the notion of food quality, rather than on food functions. We consider different types of food qualities, e.g. nutritional, environmental, social, cultural or economic qualities. This corresponds to a broader notion of food quality than the one based on only nutritional and sanitary standards. In this broad sense the concept for *food quality* reflects different outcomes of the food system (nutritional, cultural , ecological ,economic, etc.).

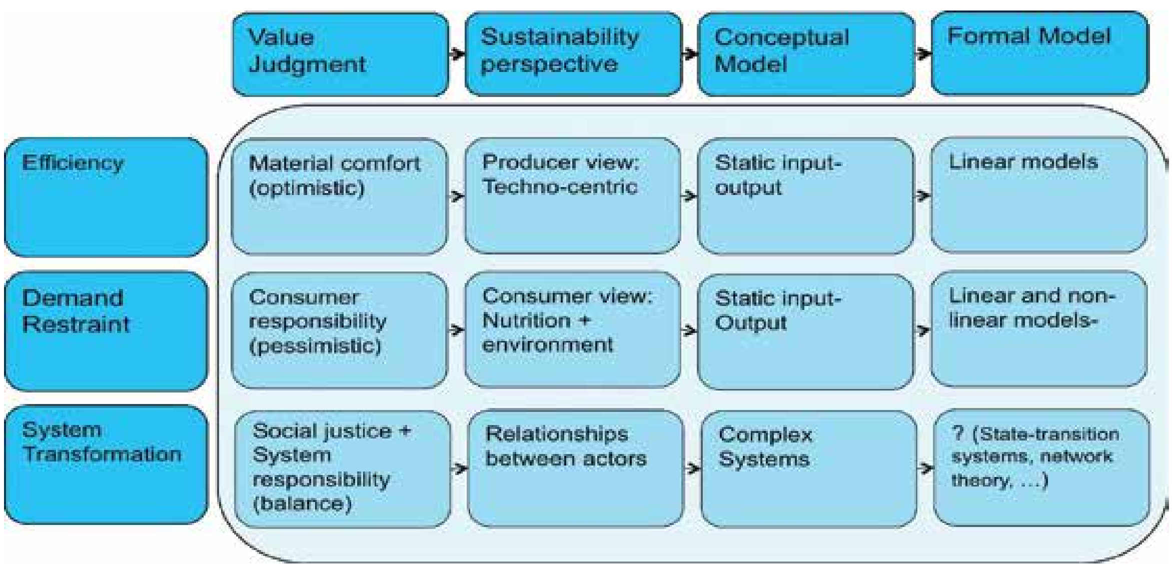


Figure 1: Paths for methodology development according to predominant perspective of a study

In this framework, indicators expressing different aspects (functions) determining the environmental quality of food are not presented in relation to a functional unit (as in LCA-based methodologies). Rather they are related to a reference quantity of food, which is not associated with any particular function or outcome of the food system. In this way multiple system functions are related to a common reference flow.

Figure 2 shows a schematic representation of the methodological framework for sustainability assessment of diets according to the guidelines in FAO/CIHEAM (2012) and Dernini *et al.* (2013). The guidelines identify four *thematic areas* corresponding to four types of food qualities: (i) environment and natural resources; (ii) economy; (iii) society and culture; and (iv) nutrition and health. For each area, an initial set of potential indicators has been identified and defined following a participatory process. The framework in Figure 2 adopts a balancing approach, based on a scoring system for balancing a number of indicators for environmental, economic, socio-cultural and nutritional aspects of the products within a specific context. The context is characterized by one or more agro-ecological zones from which the products consumed within the context are ultimately derived. The demand side is moreover characterized by diet patterns in terms of combinations of food items (products). The indicators are on the scale of single products, while the diet patterns are on the scale of the context under study, for example in our case the Apulia region.

The methodological framework is developed on four levels. Here it is illustrated with the help of the thematic areas identified in FAO/CIHEAM (2012) and Dernini *et al.* (2013), but it is more general and can be used irrespectively of chosen types of food qualities (level 2) and indicators (level 1) for each quality type. At the input layer (level 1), there is a set of indicators, which characterize a corresponding quality type for each product contributing to a diet.

The primary score in each thematic area (food quality layer) is estimated as the geometric mean of its own indicators (input layers):

$$\text{Quality\_x} = (\text{layer\_1} * \text{layer\_2} * \ldots * \text{layer\_xn})^{(1/xn)} \quad [1]$$

The first level, that of the basic data layers, isolates the rest of the system from the details of the data. The food quality layers (level 2) act as a buffer between the level 1 data layers and the derived

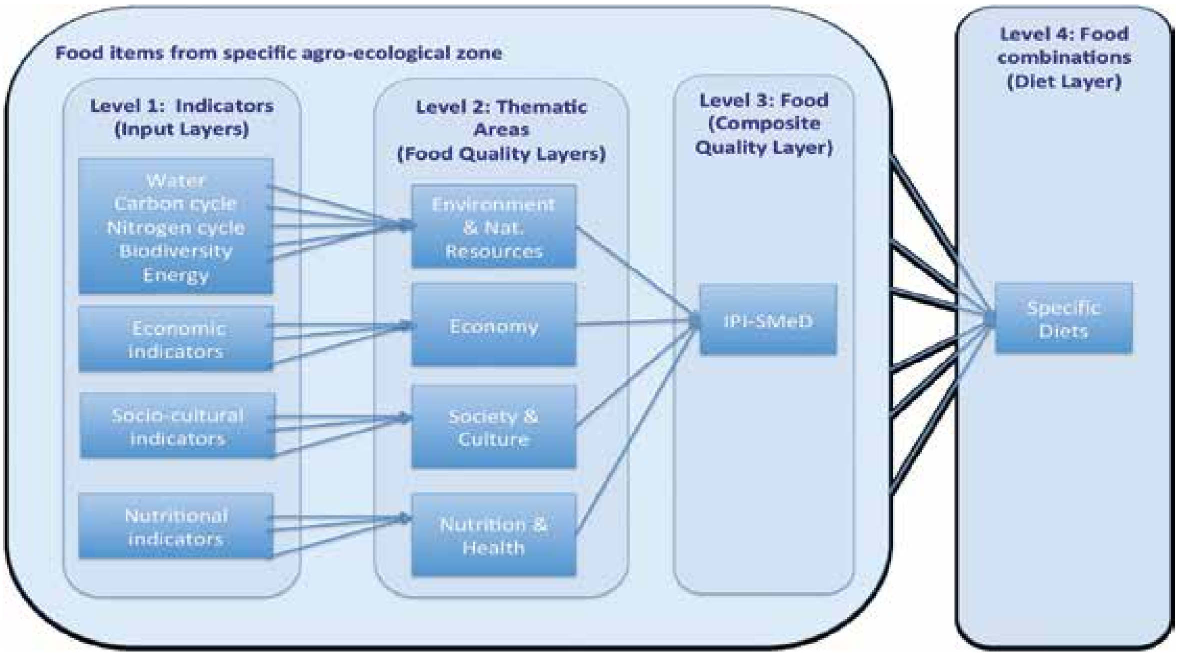


Figure 2: Expert system for evaluating the sustainability of (Mediterranean) diets by an integrated product index (IPI-SMed) in a specific agro-ecological zone
Source: adapted from Iannetta (2012).

IPI-SMeD composite index on food quality (level 3). With k qualities obtained from the above formula, the IPI-SMeD is estimated by:

$$\text{IPI-SMeD} = (\text{Quality\_1} * \text{Quality\_2} * \ldots * \text{Quality\_k})^{(1/k)} \quad [2]$$

In order to be able to make the above quantifications, it is necessary to bring the input indicators for each considered quality into a common scale. According to the factorial scaling technique, a score from a certain range (e.g. from 1 to 2) is assigned to each of the indicators, ranging from 1 (good conditions) to 2 (deteriorated condition). The scores are based on the influence that various parameters have on the considered issues at input layers (e.g. carbon cycle, water or energy use, etc.). The composite scores on the next levels have the same ranges. . Further details on the framework can be found in Iannetta (2012).

Towards calculation of environmental indicators

Within the methodological guidelines (FAO/CIHEAM, 2012; Dernini *et al.*, 2013) an initial set of environmental indicators has been proposed. Those include water, carbon and nitrogen footprints as well as LC-based energy use and biodiversity indicators for each product contributing to a Mediterranean diet. These indicators will be calculated for a "basket of products" representative for the current diet in Apulia region and for a basket of typical regional products for the Mediterranean diet.

A typical product is closely related to the territory and its natural, environmental, genetic (in terms of varieties) and socio-cultural resources. The notion of a typical product (Arfini, Belletti and Marescotti, 2010) implies different plant varieties and animal breeds from the conventional ones, as well as a multitude of different agronomic and food processing practices. Moreover, since typical productions are not done according to industrial standards imposed by large food industries or distributors, they could imply different forms of distribution to consumers. These issues pose additional challenges to LCA-tools to those mentioned in the section above: Mediterranean diets and the system transformation perspective.

In order to cope with consistency problems in using LCA within the system transformation perspective, we will first consider separate phases of food supply-consumption chains. Namely the following phases are considered:

- Primary production: agricultural phase (crop and livestock production)
- Processing and transformation
- Storage
- Transport
- Distribution
- Consumption

The LCA indicators, relevant for the context of Apulia region, will be recalculated with the help of existing LCA studies and databases, by considering also dynamic modelling instruments at each phase.

This point is illustrated below for the agricultural phase, where emissions from soils had been computed with the help of the agro-ecosystem model DNDC, which takes into account dynamic interactions between soil, plant and atmosphere systems.

The emissions of reactive nitrogen from soils in Figure 3 have been calculated for intensively cultivated Ethiopian mustard with three different levels of mineral nitrogen fertilization corresponding to a recommended dose for integrated production (N3) and, respectively, 25 percent (N2) and 50 percent (N1) reductions from this dose Canestrale *et al.*, 2012). The emissions are calculated both with the help of the agro-ecosystem model DNDC (Giltrap, Li and Saggar, 2010) and by using conventional emission-factors methods from IPCC and EMEP/EEA. This modelling experiment shows that emission-factor based methods are penalizing an optimal application of mineral fertilizer if compared with modelling tools. On the contrary, they are more crediting for overapplications of mineral fertilizer than modelling instruments. While this is only an illustrative example, which we did not check in a more systematic way, it is clear that the way emissions are calculated could influence

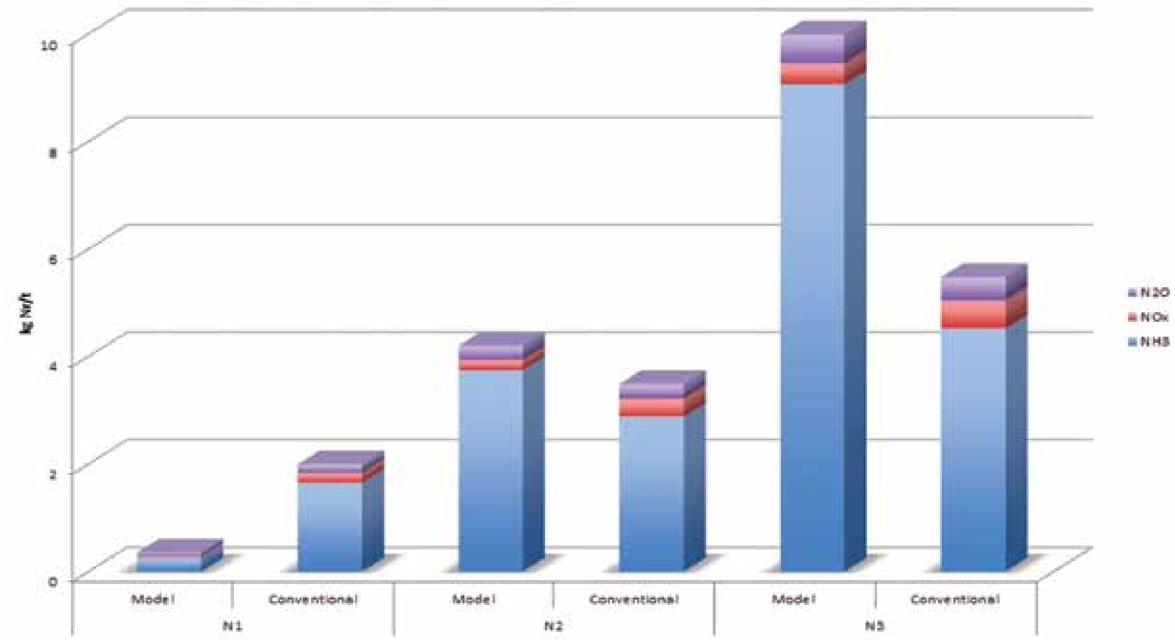


Figure 3: Comparison of reactive nitrogen emissions from soils
Model: emissions calculated with the help of the model DNDC; Conventional: emissions calculated with the help of IPCC and EMEP/EEA emission factor methods. N1, N2, N3: three different levels of mineral nitrogen fertilization.

the numeric values of indicators. Therefore it is necessary to define such methods that are both consistent and capture differences in production practices (Meier *et al.*, 2014).

DISCUSSION

This paper examines some critical aspects of using LCA-based methodological instruments in carrying out sustainability assessments of diets, when the goal of such assessment studies is to examine food system transformation alternatives. The proposed methodological approach is based on a changed focus from food functions to food qualities, which are defined in a very broad sense. The methodological approach is organized on four levels: (i) input indicators (for monitoring specific aspects for each considered quality of food items in a specific context); (ii) single quality level; (iii) composite food quality level; and (iv) diet level. The approach has been developed with reference to the Mediterranean diet, for which specific types of food qualities have been identified. An initial approach has been presented for the calculation of environmental indicators at separate phases of food supply and consumption chains. How to integrate such indicators over the whole chain is a question for further research. Surely it is necessary to avoid simple sums and consider interactions with the context. In fact, not all interactions resulting in emissions necessarily lead to negative impacts, it depends on the context. For example, balanced nutrient cycles or carbon cycles could have beneficial effects on biodiversity and climate. Indeed, certain types of agricultural systems are considered of high natural value or supplying ecosystem services and environmental public goods (Scottish Government, 2011).

ACKNOWLEDGMENTS

We would like to thank our colleague Nicola Colonna for many scientific discussions, support and feedback on the topics of the paper. We are also grateful to the team of CIHEAM-Bari for sharing with us experiences from the pilot project "Assessment and Valorization of the Sustainability of Quality Products, Typical of the Mediterranean Diet of the Apulia Region, Italy". Furthermore, we would like to thank Suzanne Redfern from FAO for her careful proofreading and help in finalizing the current paper.

REFERENCES

Baranski, M., Srednicka-Tober, D., Volakakis, N., Seal, C., Sanderson, R., Stewart, G.B., Benbrook, C., Biavati, B., Markellou, E., Giotis, C, Gromadzka-Ostrowska, J , Rembiałkowska, E., Skwarło-Sonta, K., Tahvonen, R., Janovská, D., Niggli, U., Nicot, P. & Leifert, C. 2014. Higher antioxidant and lower cadmium concentrations and lower incidence of pesticide residues in organically grown crops: a systematic literature review and meta-analyses. *Br. J. Nutr.*, 112(5): 794–811.

Arfini, F., Belletti, G. & Marescotti, A. 2010. *Prodotti tipici e denominazioni geografiche: strumenti di tutela e valorizzazione.* Edizioni Tellus.

Bach-Faig, A., Berry, E.M., Lairon, D., Reguant, J., Trichopoulou, A., Dernini, S., Medina, F.X., Battini, M., Belahsen, R., Miranda, G. & Serra-Majem, L. 2011. Medirerranean diet pyramid today. Science and cultural updates. *Public Health Nutrition*, 14(12A), 2274–2284.

Barabási, A.L. 2002. *Linked: the new science of networks*. Perseus Books Group.

Blok, K., Huijbregts, M., Roes, L., van Haaster, B., Patel, M., Hertwich, E., Wood, R., Hauschild, M.Z., Sellke, P. Antunes, P., Hellweg, S., Ciroth, A. & Harmelink, M. 2013. A novel methodology for the sustainability impact assessment of new technologies. Utrecht, FP7 Project PROSUITE (available at http://www.prosuite.org/).

Canestrale, R., Selmi, C., Zucchelli, M. & Altamura, V. 2012. *Risultati del progetto Filiere Colture Oleaginose per la Produzione di Olio per uso Industriale ed Energetico (annata 2010–2011)*. Regione Emilia-Romagna, CRPV.

Caraher, M. & Coveney, J. 2003. Public health nutrition and food policy. *Public Health Nutrition*, 7(5): 591–598.

Coordinamento Commissioni Mense Scolastiche di Bologna. 2014. *La mensa che vorremmo: Proposta innovativa per un capitolato rispettoso della salute dei nostri bambini e dell'ambiente* (available at http://osservatoriomensebologna.blogspot.it/p/documenti.html).

Dernini, S. 2011. The erosion and the renaissance of the Mediterranean diet: a sustainable cultural resource. *IEMED* (available at http://www.iemed.org/observatori/arees-danalisi/arxius-adjunts/qm-16-originals/derninisandro_erosion%20and%20the%20renaissance%20of%20Meddiet_qm16.pdf).

Dernini, S., Meybeck, A., Burlingame, B., Gitz, V., Lacirignola ,C., Debs, P., Capone, R. & El Bilali, H. 2013. Developing a methodological approach for assessing the sustainability of diets: the Mediterranean diet as a case study. *New MEDIT*.

Duchin, F. 2005. Sustainable consumption of food: a framework for analyzing scenarios about changes in diets. *Journal of Industrial Ecology*, 9(1–2): 99–114.

EC. 2013. *Commission Recommendation of 9 April 2013 on the use of common methods to measure and communicate the life cycle environmental performance of products and organizations: PEF and OEF guides* (available at http://ec.europa.eu/environment/eussd/smgp/index.htm).

Eriksen, P.J. 2007. Conceptualizing food systems for global environmental change research. *Global Environmental Change* 18 (2008) 234–245 (available at http://www.eci.ox.ac.uk/publications/downloads/ericksen07-foodsystems.pdf).

European Food Sustainable Consumption & Production Round Table. 2013. ENVIFOOD Protocol: Environmental Assessment of Food and Drink Protocol, v.1.0 (available at http://www.food-scp.eu/files/ENVIFOOD_Protocol_Vers_1.0.pdf).

European Monitoring and Evaluation Programme/European Environment Agency. 2013. *EMEP/EEA air pollutant emission inventory guidebook* (available at http://www.eea.europa.eu/publications/emep-eea-guidebook-2013/#).

FAO/Bioversity. 2012. *Sustainable diets and biodiversity: directions and solutions for policy, research and action*. Proceedings of the International Scientific Symposium "Biodiversity and sustainable diets united against hunger", 5–10 November 2010. Rome, FAO (available at http://www.fao.org/docrep/016/i3004e/i3004e00.htm).

FAO/CIHEAM. 2012. The sustainability of food systems in the Mediterranean area, towards the development of guidelines for improving the sustainability of diets and food consumption patterns in the Mediterranean area: international seminar (available at http://www.fao.org/docrep/016/ap101e/ap101e.pdf).

Flichman, G. ed. 2011. *Bio-economic models applied to agricultural systems*. Springer.

Flury, K., Büsser, S. & Jungbluth, N. 2013. *Ready-to-serve vs home-made lasagna: an LCA with a focus on food waste in different production chains*. ESU-services Ltd. commissioned by European Aluminium Foil Association e.V. (EAFA), Düsseldorf, DE and Zürich, CH (available at http://www.alufoil.org/tl_files/sustainability/ESU-ReadyMeal2013-ExecSum.pdf).

Garnett, T. 2014. Three perspectives on sustainable food security: efficiency, demand restraint, food system transformation. What role for life cycle assessment? *Journal of Industrial Ecology*, 73: 10–18.

Giltrap, D.L., Li, C. & Saggar, S. 2010. DNDC: A process-based model of greenhouse gas fluxes from agricultural soils. *Agriculture Ecosystems and Environment*, 136(3–4): 292–300.

Heller, M.C., Keoleian, G.A. & Willet, W.C. 2013. Toward a life cycle-based, diet-level framework for food environmental impacts and nutritional quality assessment: a critical review. *Environmental Science and Technology*, 47(22): 13632–13647.

Iannetta, M. 2012. Expert system for evaluating the sustainability of Mediterranean diets by an integrated product index (IPI-SMeD) in a specific agro-ecological zone. *Options Méditerranéennes*, Series B: Studies and Research, No. 70. CIHEAM.

IPCC (Intergovernmental Panel for Climate Change). 2006. IPCC guidelines for national greenhouse gas inventories: *Volume 4: Agriculture, forestry and other land use* (available at http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html).

ISO (International Organization for Standardization). 2006. ISO 14040:2006, *Environmental management – life cycle assessment – principles and framework*.

Meier, M.S., Stoessel, F., Jungbluth, N., Juraske, R., Schader, C. & Stolze, M. 2014. Environmental impacts of organic and conventional agricultural products – are the differences captured by life cycle assessment? *J. Environmental Management*, 149:193–208.

Muñoz, I., Milà i Canalis, L. & Fernández-Alba, A. 2010. Life cycle assessment of the average Spanish diet including human excretion. *Int. J. for Life Cycle Assesment*, 15: 794–805.

Neumayer, E. 2003. *Weak versus strong sustainability: exploring the limits of two opposing paradigms*. Elgar.

Padilla, M., Capone, R. & Palma, G. 2012. Sustainability of the food chain from field to plate: the case of the Mediterranean diet. *In* B. Burlingame and S. Dernini. *Sustainable diets and biodiversity: directions and solutions for policy, research and action*. Proceedings of the International Scientific Symposium "Biodiversity and sustainable diets united against hunger", 5–10 November 2010. Rome, FAO (available at http://www.fao.org/docrep/016/i3004e/i3004e00.htm).

Padel, R. 2008. *I padroni del cibo (Stuffed and starved: the hidden battle for the world food system).* Ed. Feltrinelli.

Pré Consultants. 2014. *Why food sustainability LCAs make up afFull 25% of all published LCAs* (available at http://www.pre-sustainability.com/why-25-of-LCAs-are-agriculture-related).

Regione Puglia – Assessorato alle Risorse Agroalimentari. 2006. *Atlante dei Prodotto Tipici Agroalimentari di Puglia.*

Scottish Government. 2011. *Developing high nature value farming and forestry indicators for the Scotland Rural Development Programme: Summary Report of the Technical Working Group on High Nature Value Farming and Forestry Indicators*. Edinburgh, Rural Analytical Unit, Rural and Environment Science and Analytical Services, Scottish Government (on behalf of the Technical Working Group) (available at http://www.scotland.gov.uk/Resource/Doc/355629/0120133.pdf).

Tukker, A., Bausch-Goldbohm, S., Verheijden, M., de Koning, A., Kleijn, R., Wolf, O. & Domiguez, I.P. 2009. *Environmental impacts of diet changes in the EU*. JRC Scientific and Technical Reports.

Valdivia, S., C. M. Ugaya, G. Sonnemann, G., J. Hildenbrand, A. Ciroth, M. Finkbeiner, W. Klöpffer, B. Mazijn, S. Prakash, M. Traverso, M., Vickery-Niederman, G. 2012, *Towards a life cycle sustainability assessment. Making informed choices on products*. United Nations Environment Programme.

Vieux, F., Darmon, N., Touazi, D. & Soler, L.G. 2012. Greenhouse gas emissions of self-selected individual diets in France: changing the diet structure or consuming less? *Ecological Economics*, 75: 91–101.

UNESCO. 2013. *Nomination file no. 00884 for inscription in 2013 on the Representative List of the Intangible Cultural Heritage of Humanity* (available at http://www.unesco.org/culture/ich/RL/00884).

von Bertalanffy, L. 1950.An outline of general system theory. *British Journal of Philosophy of Science*, 1(2): 164–195.

Watzlawick, P., ed. 1984. *The invented reality: how do we know what we believe we know?* (Contributions to constructivism). New York, USA, W.W. Norton.

WRI/WBCSD. 2011. *GHG Protocol: Product Life Cycle Accounting and Reporting Standard*. World Resources Institute and World Business Council for Sustainable Development (available at http://www.ghgprotocol.org/files/ghgp/public/Product-Life-Cycle-Accounting-Reporting-Standard_041613.pdf).

Zamagni, A., Buttol, P., Buonamici, R., Masoni, P., Guinée, J.B., Huppers, G., Heijungs, R., van der Voet, G.E., Ekvall, T. & Rydberg, T. 2006. *Blue paper on life cycle sustainability analysis*. CALCAS project deliverable (available at http://www.leidenuniv.nl/cml/ssp/publications/calcas_report_d20.pdf).

WITHIN-SESSION SESSION: PERSPECTIVES FROM THE ORGANIC SECTOR

Profiles of organic food consumers, first lessons from the French NutriNet-Santé Cohort Study: a step towards diet sustainability

Denis Lairon[1] and Emmanuelle Kesse-Guyot[2]
[1] Unité mixte de recherche NORT, Aix Marseille Université, France
[2] Equipe de Recherche en Epidémiologie Nutritionnelle, Centre d'Epidémiologie et Biostatistiques, Bobigny, France.

ABSTRACT

A global definition of sustainable diets was proposed during a FAO international conference held in 2010 (FAO/Bioversity, 2012): "Sustainable diets are those diets with low environmental impact which contribute to food and nutrition security and to a healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy, while optimizing natural and human resources." This now generally accepted definition contains a number of key words that highlight the directions for transition from the present agro-food system to a sustainable one (Lairon, 2012). In most industrialized countries, it is also widely recognized that current lifestyles and dietary patterns are not optimal for sustaining health (WHO, 2003, 2007), promoting growing rates of overweight and obesity, and in turn increasing prevalence of non-communicable chronic diseases. At the same time, 800 million people are still chronically undernourished and poverty dramatically affects the nutritional status of billions (www.fao.org).

THE AGRO-ECOLOGICAL CHALLENGE

In fact, in most countries, a fraction of farmers and the general population have long shown great concern about this question. Challenging the industrialization of the food production system gave rise since the 1970s to so-called "organic", "biological", "biodynamic" and "agro-ecological" production (www.ifoam.org). Such certified organic production has markedly increased during the last decade, up to 3–20 percent (mean 5.1 percent) of the agricultural area in European Union countries (www.agencebio.org). This has been largely driven by consumer attitudes, with a yearly increase of over 10 percent.

Coming back to the above definition of sustainable diets, one can anticipate that a diet based on organic products may better meet the definition of sustainability. Regarding the quality of organic foods, scientific literature (Benbrook and McCullum-Gomez, 2009; Dangour *et al.*, 2009; Lairon, 2010; Brandt *et al.*, 2011; Smith-Spangler, 2012; Baranski, 2014) has established that such foods have a high/better nutritional content in dry matter, magnesium (evenly iron, zinc), anti-oxidants, vitamin C and poly-unsaturated fatty acids (especially omega 3 fatty acids) but less protein in cereals. At the same time, organic foods show better safety thanks to drastically lower contamination by pesticide residues, much lower contamination by cadmium and reduced risk of antibiotic resistance, with comparable/lower mycotoxin levels or micro-organism contamination. Subjects having an organic food-based diet have a markedly reduced pesticide exposure (Curl, Fenske and Elgethun, 2003; Oates *et al.*, 2014). Thus, organic foods are reaching very high nutritional and safety value.

But another question arises: does consuming organic food represent a step towards sustainable food patterns? Until now, only small-scale studies described the profiles of organic consumers with the exception of a very recently published large cohort survey in Germany (Eisinger-Watzl *et al.*, 2015). We aimed to answer this important question and we had the opportunity to work within the framework of the French large ongoing Nutrinet-Santé Cohort Study (Hercberg, 2010), already including about 104 000 participants by the end of 2011. The data presented herein are a digest of the full paper published in 2013 (Kesse-Guyot *et al.*, 2013).

COHORT STUDY METHODS

We analysed data from the Nutrinet-Santé Study, a large Web-based prospective observational cohort launched in France in 2009 dedicated to investigating the relationship between nutrition and health/disease status (Hercberg, 2010). Briefly, the scheduled follow-up is ten years and recruitment for five years from 2009; the subjects are volunteers aged ≥ 18 years.

All information (socio-demographic and lifestyle data, dietary data, diseases, etc.), is collected through a dedicated secure HTML interface for Web-based validated questionnaires (www.etude-nutrinet-sante.fr). Registration of dietary data (three-day records) and all health outcomes was carried out by volunteers, with further validation. In addition, biochemical samples and clinical examination were performed on a subsample (about 20 000 subjects for blood and urine). An informed consent was filed by each participant and the study design has been approved by an ethics committee.

Two months after inclusion, participants were asked to provide information about organic products via an optional questionnaire as described in detail and published (Kesse-Guyot *et al.*, 2013). Participants were questioned about opinions on organic products and were asked to report frequency of consumption/use, or reasons for non-consumption of 18 types of organic products (fruit, vegetables, soya, dairy products, meat and fish, eggs, grains and legumes, bread and cereals, flour, vegetable oils and condiments, ready-to-eat meals, coffee/tea/herbal tea, wine, biscuits/chocolate/sugar/marmalade, other foods, dietary supplements, textiles and cosmetics). For each item, the eight possible responses were as follows: 1) most of the time; 2) occasionally; 3) never (too expensive); 4) never (product not available); 5) never ("I'm not interested in organic products"); 6) never ("I avoid such products"); 7) never (for no specific reason); and 8) "I don't know".

Statistical analyses and data treatments were carried out thanks to acknowledged methods (Kesse-Guyot *et al.*, 2013). Profiles of attitudes towards organic products were identified using multiple correspondence analysis and cluster analysis. Daily nutrient intakes were calculated from food consumption using a published nutritional composition table.

FIRST COHORT STUDY RESULTS

The data presented are based on questionnaires collected from June 2009 to December 2011 (Kesse-Guyot *et al.*, 2013). Among the 54 311 participants, the mean age was 43.7±14.4 and 77 percent were women, 64.5 percent had reached post-secondary degree and 49.8 percent were never-smokers.

We identified five clusters of participants (clusters 1 to 5) as illustrated in Figure 1. Two of these were composed of consumers of organic products (COP), including regular consumers (cluster 5: Regular COP) and occasional consumers (cluster 4: Occasional COP). Three other clusters grouped individuals who generally did not consume organic products due to the high cost (cluster 3), because they avoided such products (cluster 2) or because they were not interested in organic products (cluster 1).

Regular consumption of organic food was found associated with a higher education level, generally comparable income, lower BMI (body mass index), less report of restrictive diet, higher level of physical activity and no smoking. Thus, regular consumers of organic foods show generally healthier life-style profiles.

Daily nutrient intakes of organic product consumers (COPs)

Compared with participants with no interest in organic foods (cluster 1):

- the Regular COPs (cluster 5) showed comparable daily energy intakes (EI kcal/d: 2 200 men, 1 740 women) and EI from macronutrients but higher daily intakes ($p < 0.0001$) of:
  - polyunsaturated fatty acids (+12 percent in both genders),

– n-3 PUFA (+19 percent in men, +20 percent in women),
– fibres (+27 percent in men, +28 percent in women),
– beta-carotene (+28 percent in men, +33 percent in women),
– folic acid (+15 percent in men, +17 percent in women),
– vitamin C (+10 percent in men, + 13 percent in women),
– iron (+20 percent in men, +18 percent in women),
– magnesium (+18 percent in both genders),
and lower daily intakes ($p < 0.0001$) of:
– alcohol (–17 percent in men, –11 percent in women)
– cholesterol (–12 percent in men, –10 percent in women).

- the Occasional COP (cluster 4) showed profiles intermediate between never-consumers and Regular COP.

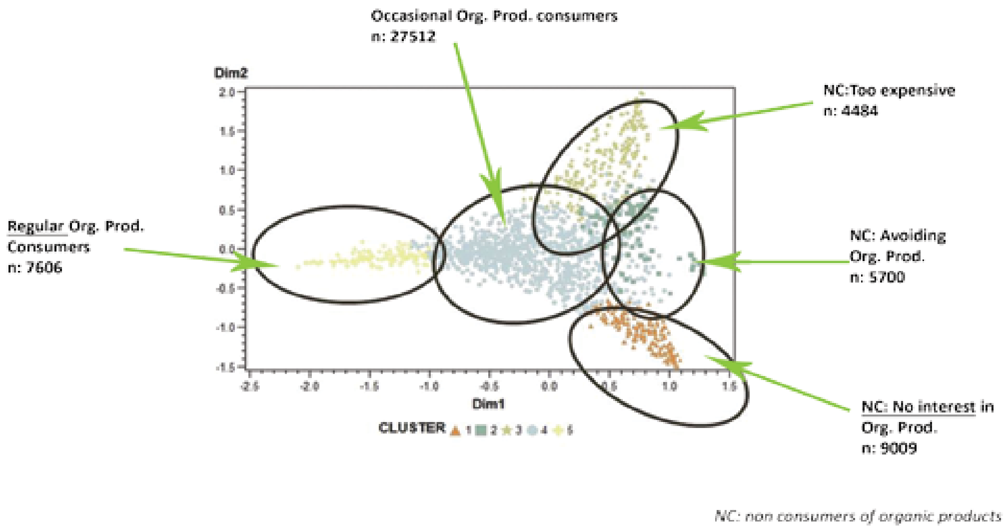


Figure 1: Consumer clustering

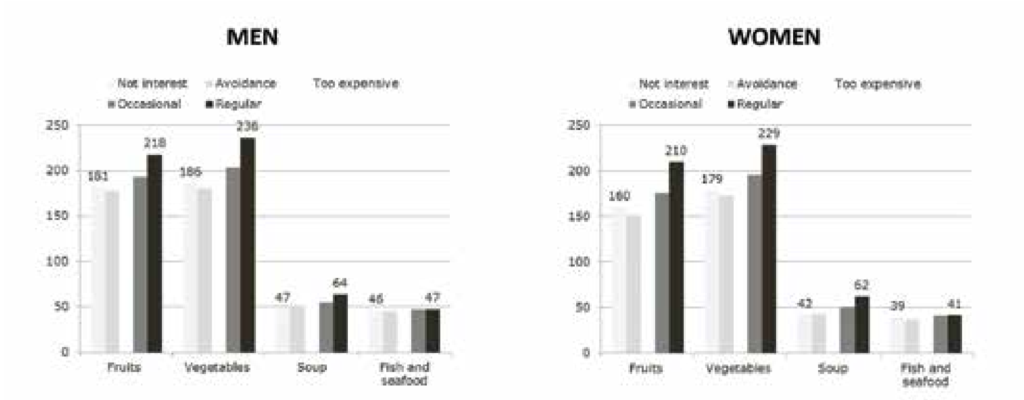


Figure 2. Food consumption*
*Values a:e mean consumption (g/d)
No interest, Avoidance, Too expensive: not a consumer of organic foods (with main reason).
Occasional and regular consumer of organic foods.

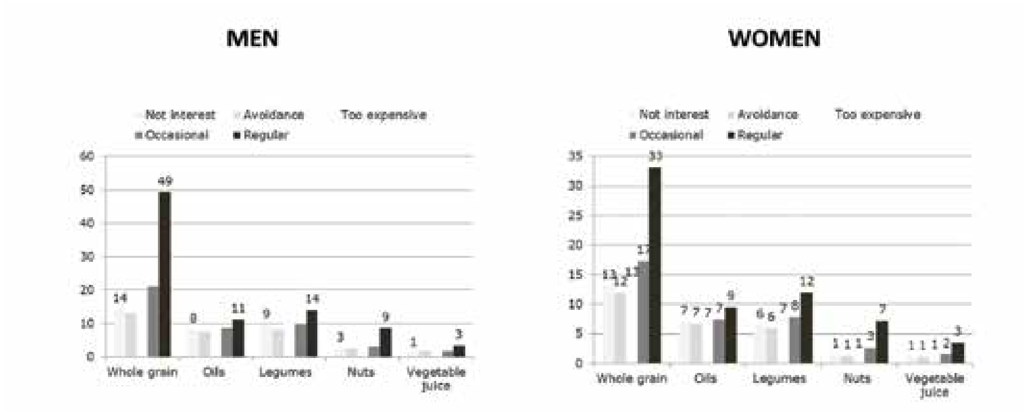


Figure 3; Food consumption*

*Values are mean consumption (g/d)

No interest, Avoidance, Too expensive: not a consumer of organic foods (with main reason).

Occasional and regular consumer of organic foods.

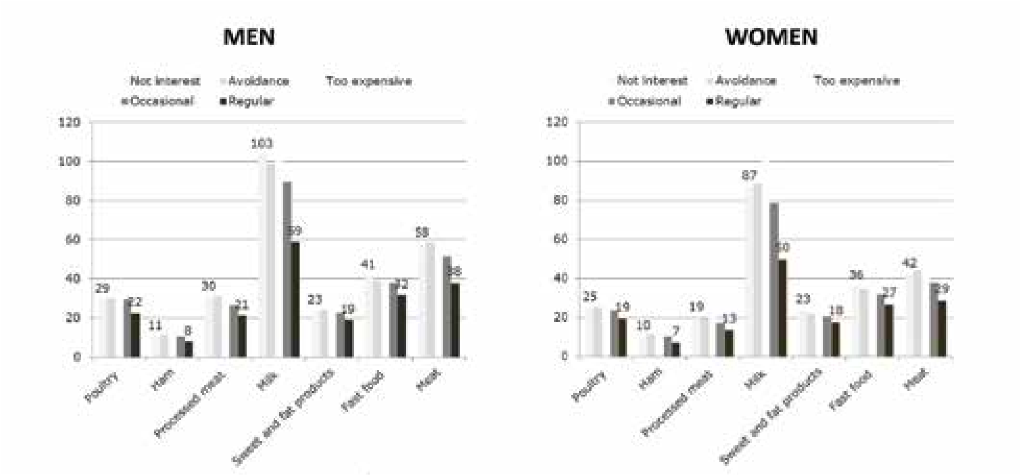


Figure 4: Food consumption*

*Values are mean consumption (g/d)

No interest, Avoidance, Too expensive: not a consumer of organic foods (with main reason).

Occasional and regular consumer of organic foods.

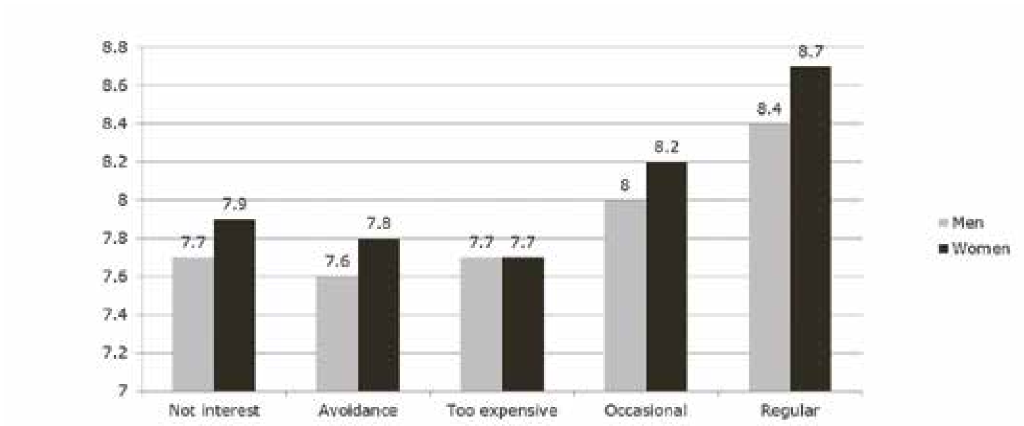


Figure 5: Adherence to nutritional guidelines*

*This score (PNNS score) includes 12 components for a maximum of 13.5 points:

- 8 refer to food serving recommendations (fruit and vegetables, starchy foods, whole grain products, dairy products, meat, eggs and fish, seafood, vegetable fat, water and soda),
- 4 refer to moderation in consumption (added fat, salt, sweets, alcohol).

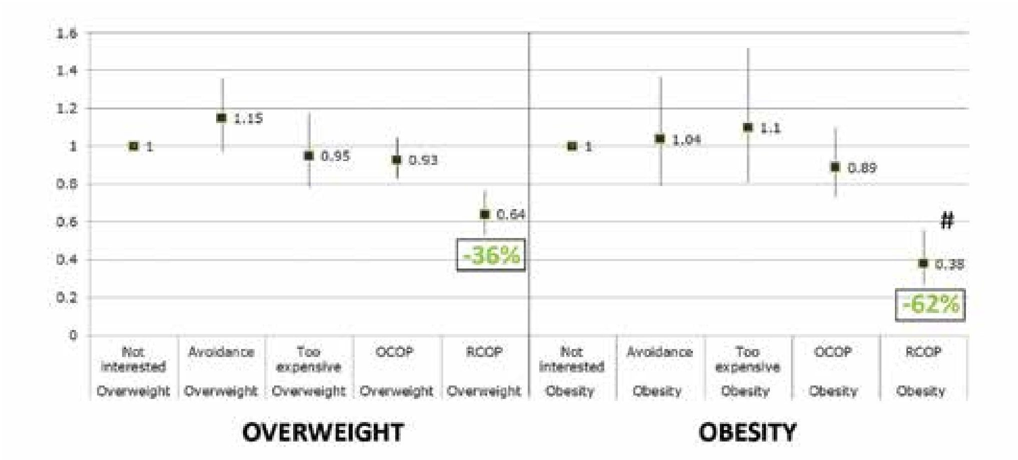


Figure 6: Association between cluster and corpulence among men*

*Values are odds ratios (polytomous logistic regression) adjusted for age, physical activity, education, smoking, energy intake, restrictive diet and mPNNS-GS.

Overweight, BMI 25-29.9; Obesity, BMI > 30

P-values for Wald test of the global effect between clusters <0.0001 (#)

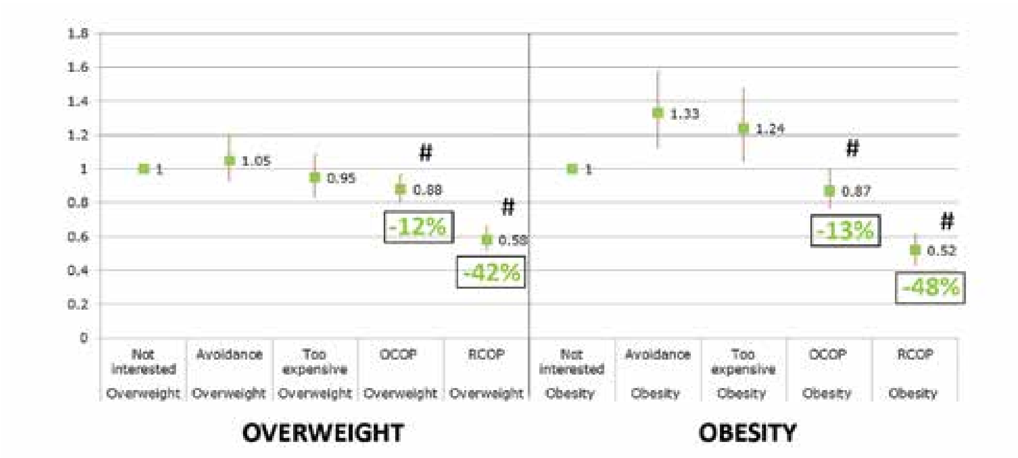


Figure 7: Association between cluster and corpulence among women*

*Values are odds ratios (polytomous logistic regression) adjusted for age, physical activity, education, smoking, energy intake, restrictive diet and mPNNS-GS.

Overweight, BMI 25-29.9; Obesity, BMI > 30

P-values for Wald test of the global effect between clusters <0.0001 (#)

Adherence to nutritional guidelines

A composite score of adherence to French nutritional guidelines PNNS (eight recommended food group servings, four food/nutrients to limit) was calculated for the five clusters of participants, separately in men and women. As shown in Figure 5, the Regular COPs, men or women, showed the highest scores, with a somewhat lower value for the occasional COPs, men or women, both being significantly higher that the scores obtained by the three clusters of non-consumers of OP.

Organic food consumption and corpulence

After adjustment for age, physical activity, education, smoking, energy intake, use of restrictive diet and the French Programme National Nutrition Santé (PNNS) dietary adequacy score, Regular COPs (cluster 5) showed a markedly lower probability of being overweight or obese: –36 percent and –62 percent in men and –42 percent and –48 percent in women, respectively (Figures 6 and 7). For Occasional COPs (cluster 4), women showed a 12 percent and 13 percent lower probability of being overweight or obese, respectively, whereas men no longer showed a reduced risk after such adjustments.

In conclusion, the first set of data obtained during the transversal analysis of this large-size cohort of French adult men and women indicates that regular consumers of organic products exhibit:

- specific socio-demographic characteristics (higher education level)

– with a more plant food-based dietary pattern, closer to the Mediterranean diet,
– with higher daily intakes of numerous nutrients and fibres,
– with a dietary pattern better fitting French nutritional recommendations,
– a generally healthier lifestyle,
– a much lower probability of being overweight and obese.

It is noteworthy to mention that a large adult consumer survey performed in Germany in 2008 and just published (Eisinger-Watzl *et al.*, 2015), indicated that organic food consumers, compared with non-buyers, showed more favourable food choices, are non-smokers, are more physically active, are more often of normal weight (less often overweight or obese), and more often classify their health status as very good or good: in brief, German organic food consumers adhere to a healthier lifestyle.

Thus, based on the convergent data of French and German cohort surveys, one can state that the present organic food consumers overall show a better compliance to the sustainable diet concept (based on FAO definition) with a more plant food-based dietary pattern, closer to the healthy Mediterranean diet pattern, a better nutrient intake, better food safety (fewer pesticide residues and cadmium contents), a better lifestyle (more physical activity, less smoking) and health potential (association with much less overweight and obesity rates), along with a minimization of energy/water uses and environmental impacts of agricultural production.

SUPPORT

The NutriNet-Santé Study is supported by the French Ministry of Health (DGS), the Institut de Veille Sanitaire (InVS), the Institut National de la Santé et de la Recherche Médicale (Inserm), the Institut National de la Recherche Agronomique (Inra), the Conservatoire National des Arts et Métiers (CNAM), the Institut National de Prévention et d'Education pour la Santé (INPES), the Fondation pour la Recherche Médicale (FRM) and Paris 13 University and the Agence Nationale pour la Recherche (ANR/ALID (Systèmes Alimentaires Durables) n° ANR-13-ALID-0001-08 : BioNutrinet project).

REFERENCES

Baranski, M., Srednicka-Tober, D., Volakakis, N., Seal, C., Sanderson, R., Stewart, G.B., Benbrook, C., Biavati, B., Markellou, E., Giotis, C, Gromadzka-Ostrowska, J, Rembiałkowska, E., Skwarło-Sonta, K., Tahvonen, R., Janovská, D., Niggli, U., Nicot, P. & Leifert, C. 2014. Higher antioxidant and lower cadmium concentrations and lower incidence of pesticide residues in organically grown crops: a systematic literature review and meta-analyses. *Br. J. Nutr.*, 112(5): 794–811.

Benbrook, C. & McCullum-Gomez, C. 2009. Organic vs conventional farming. *J. Am. Diet Assoc.*, 109: 809–811. S0002-8223(09)00306-X[pii];10.1016/j.jada.2009.03.019 [doi].

Brandt, K., Leifert, C., Sabderson, R. & Seal, C.J. 2011. Agroecosystem management and nutritional quality of plant foods: the case of organic fruits and vegetables. *Crit. Rev. Plant Sci.*, 30: 197.

Curl, C.L., Fenske, R.A. & Elgethun, K. 2003. Organophosphorus pesticide exposure of urban and suburban preschool children with organic and conventional diets. *Environ. Health Perspect*., 111(3): 377–382.

Dangour, A., Dodhia, S., Hayter, A., Aikenhead, A., Allen, E., Lock, K. & Uauy, R. 2009. *Comparison of composition (nutrients and other substances) of organically and conventionally produced foodstuffs: a systematic review of available literature* (available at http://www.nutriwatch.org/04Foods/fsa/nutrient.pdf).

Eisinger-Watzl, M., Wittig, F., Heuer, T. & Hoffmann, I. 2015. Customers purchasing organic food – do they live healthier? Results of the German National Nutrition Survey II. *European Journal of Nutrition & Food Safety*, 5(1): 59–71.

FAO/Bioversity. 2012. *Sustainable diets and biodiversity, directions and solutions for policy, research and action*. In B. Burlingame & S. Dernini, eds. Proceedings of FAO International Scientific Symposium Sustainable Diets and Biodiversity United Against Hunger, 3–5 November 2010. Rome.

Hercberg, S., Castetbon, K., Czernichow, S., Malon, A., Mejean, C., Kesse, E., Touvier, M. & Galan, P. 2010. The Nutrinet-Santé Study: a web-based prospective study on the relationship between nutrition and health and determinants of dietary patterns and nutritional status. *BMC Public Health*, 10: 242. doi: 1471-2458-10-242 [pii]; 10.1186/1471-2458-10-242.

Kesse-Guyot, E., Péneau, S., Méjean, C., Szabo de Edelenyi, F., Galan, P., Hercberg, S. & Lairon, D. 2013. Profiles of organic food consumers in a large sample of French adults: results from the Nutrinet-Santé cohort study. *PLoS One*, 8(10): e76998. doi: 10.1371/journal.pone.0076998.

Lairon, D. 2010. Nutritional quality and safety of organic food: a review. *Agron. Sustain. Dev*., 30: 33–41.

Lairon, D. 2012. Biodiversity and sustainable nutrition with a food-based approach., In B. Burlingame & S. Dernini, eds. *Sustainable diets and biodiversity, directions and solutions for policy, research and action*. Proceedings of FAO International Scientific Symposium Sustainable Diets and Biodiversity United Against Hunger, 3–5 November 2010. Rome.

Oates, L., Cohen, M., Braun, L., Schembri, A. & Taskova, R. 2014. Reduction in urinary organophosphate pesticide metabolites in adults after a week-long organic diet. *Environ. Res.*, 132: 105–111. doi: 10.1016/j.envres.2014.03.021.

Smith-Spangler, C., Brandeau, M.L., Hunter, G.E., Bavinger, J.C., Pearson, M., Eschbach, P.J., Sundaram, V., Liu, H., Schirmer, P., Stave, C., Olkin, I. & Bravata, D.M. 2012. Are organic foods safer or healthier than conventional alternatives?: a systematic review. *Ann. Intern. Med*., 157: 348–366. 1355685 [pii]; doi: 10.7326/0003-4819-157-5-201209040-00007.

WHO. 2003. *Diet, nutrition and the prevention of chronic diseases*. Report of a Joint WHO/FAO Export Consultation. WHO Technical Report Series 916. Geneva.

WHO. 2007. *The challenge of obesity in the WHO European Region and the strategies for response*, by F. Branca, H. Nikogosian & T. Lobstein. Geneva.

Putting it all together: how can the organic food system support sustainable diets and translate it into practice?

Carola Strassner,[1] Johannes Kahl[2] and Flavio Paoletti[3]
[1] MUAS - Münster University of Applied Sciences, Department of Home Economics and Nutritional Science – Facility Management, Germany
[2] University of Kassel, Witzenhausen, Germany
[3] Council for Agricultural Research and Economics, Research Center on Food and Nutrition, Rome, Italy

ABSTRACT

Representatives from the International Food Quality and Health Network (FQH) explored the organic food system as a case study and its potential support for sustainable diets. FQH experts contributed to the scientific debate at the workshop on how to address the question of sustainable diets within organic production/consumption concepts and achievements, and what contribution the organic part can provide to the ongoing discussions. This paper summarizes the contributions arising from the organic food system perspective. While organic agriculture can be taken as an example for sustainable food production, critical reflections were made on how organic consumption patterns may also be taken as an example for sustainable food consumption. The closing discussion at this workshop included deliberation about which organic-related measures might be useful in the sustainability assessment of diets. Two potential indicators considered more closely were for organic production (land use under organic cultivation in percentage) and for organic consumption (organic consumption per capita). Drawing on the definition of sustainable diets, the change of consumption patterns seems to be a crucial issue in the transformation to sustainable food systems. The consumption patterns of regular organic consumers seem to be close to the sustainable diet concept of FAO. Since diets play a central role in shaping food systems and food systems shape diets, the question of organic as a sustainable and healthy diet emerges as an essential topic to be addressed. Hence the organic support for a sustainable diet comes from the components: it has a definition, it has the principles, it has the standards, it has the metrics. Today it also has the data from more than 160 countries, and regulations are in force in more than 80 countries or regions. The organic food system shares with the Mediterranean diet putting the land (agri-cultura) back into the diet; it is the land from which the diet in toto is shaped. Therefore the organic food system provides the essential requirements of a sustainable diet.

INTRODUCTION

The interest in sustainable diets is steadily increasing; for active stakeholders from all agro-food sectors the broader and complex context of the sustainability of food systems is highly relevant for policy and practice (Lang, 2014). Defining a theoretical methodological framework for the assessment of the sustainability of diets presents many challenges. The definition reached in 2010 at the conference organized by FAO and Bioversity and the associated four dimensions (health and nutrition, environment, economic, socio-cultural) provide a starting point for a list of indicators serving assessment (Burlingame and Dernini, 2011).

The traditional Mediterranean diet, scientifically well-characterized as a healthy dietary pattern, appreciated for its lower environmental impact and acknowledged as a cultural heritage, is used as a model to assess sustainability of diets and food consumption patterns in the Mediterranean area, using indicators proposed by a Working Group (Dernini *et al.*, 2013).

Representatives from the International Food Quality and Health Network (FQH) explore the organic food system as a case study and its potential support for sustainable diets. FQH experts contribute to a scientific debate on how to address the question of sustainable diets within organic production/consumption concepts and achievements, and what contribution the organic part can provide to the ongoing discussions.

FROM THE ORGANIC ROOTS UNTIL TODAY

Flavio Paoletti from CREA - Research Centre for Food and Nutrition introduced the first of the two issues with a reminder of the context of our diets within food and agriculture systems and the global challenges compelling us to address the issues (Paoletti, 2015). Industrial food systems have proven successful in making more food available at a low price. Yet, notwithstanding that some progress has been recently observed, the number of undernourished and hungry people in the world remains unacceptably high (FAO, 2014; FAO/IFAD/WFP, 2014). At the same time, worldwide overweight and obesity are increasing among adults and, even more alarmingly, children (OECD, 2014). The huge amount of food produced is not equitably distributed and, furthermore, roughly one-third of the edible parts of food produced for human consumption are lost or wasted globally (FAO, 2011). In medium- and high-income countries, food is to a great extent wasted, meaning that it is thrown away even if it is still suitable for human consumption. The industrial food systems have developed a strong dependence on fossil energy and caused an undeniable negative effect on the environment (Tilman and Clark, 2014). Against the background of a looming 9.6 billion people on earth in 2050, many scientists argue for a further intensification of agricultural systems. The organic food system might offer an alternative approach towards real sustainability.

Ewa Rembiałkowska, Warsaw University, summarized the historical development of the organic food system. In Europe it is relatively young, about 90 years old, but developing very quickly. Rembiałkowska (2015) showed that the history of the organic movement has a clear and logical sequence: first came the philosophy and teachings, which were based on observation of nature and respect for natural laws. In turn, the organic pioneers transformed these principles into practical farming methods. After development in central Europe, organic agriculture was implemented in nearly all regions throughout the world. Today the organic system is a worldwide food system (Geier, 2007).

Johannes Kahl, FQH Chair, described the organic food system from the organic vision all the way through to the metrics. This includes a food system that raises incomes and increases food security and food safety at both ends; furthermore as one in which the environment is preserved while farmers and workers have fair access to the means of food production. Today, the system is described in the Codex Alimentarius (FAO/WHO, 1999) while the vision is laid down in international standards (e.g. IFOAM, 2008). Kahl (2015) showed that organic is defined through the principles of organic farming and food production. Organic food quality is defined through process- and product-related aspects. There are regulations in place in Europe (EC, 2007; EC, 2008), Japan (MAFF, 2007) and the United States of America (Ellsworth, 2011) both at the national and private standards levels, including a certification process. Indeed, 86 countries around the globe have organic legislation. Evaluation is performed through criteria, indicators and parameters that can be organic-specific. There is a clear connection between the regulation at farm and industry level and the impact on environment and food. In Europe, the organic logo is well recognized by the European consumer and is connected to a sustainable and healthy food system (Janssen and Hamm, 2012; Padel and Foster, 2005; Torjusen *et al.*, 2004).

ON THE DIMENSIONS OF SUSTAINABILITY

Considering the organic food system and sustainability, Christian Schader of FiBL explained the framework for Sustainability Assessment of Food and Agriculture (SAFA) systems used for farms and companies (Jawtusch *et al.,* 2013). Divided into four dimensions (environment, economy, social and governance) it covers 21 themes and 58 subthemes with defined objectives (FAO, 2013). Preliminary research shows that organic production impacts the entire food system and that organic agriculture can be part of efficiency, consistency and sufficiency strategies (Schader, Stolze and Niggli, 2015).

Sirli Pehme of the Estonian University of Life Sciences probed environmental impacts further using the life cycle perspective. As previous studies have shown, in general agriculture has the greatest contribution to environmental impacts of food products (Yan, Humphreys and Holden, 2011; Roy *et al.*, 2009) but most of the studies focus on the impacts as far as the farm gate. The environmental impacts of a diet could be formed as the sum of impacts of each component of the diet, using the life cycle assessment (LCA) approach, a tool to assess the potential environmental impacts and the use of resources through a product's life cycle (ISO, 2006). However, there is a lack of studies that include different processing technologies, distribution and consumption possibilities. The next stages can also have a significant impact, e.g. caused by energy consumption in processing, transport, food losses and consumer behaviour. To enable fair comparison of the environmental impacts of different diets, the selection of functional unit, i.e. the unit in which all impacts are reported, is essential (Pehme and Matt, 2015).

Learning from nutrition, economy, society and culture was presented by Carola Strassner, MUAS Germany. Key messages included the observation that there is no traditional, food-groups-based "organic diet" but that the consumption of organic food within a diet exhibits certain recurring characteristics, such as a shorter chain in terms of the degrees of separation to the primary producer (Dimitri and Green, 2000). Furthermore, there is growing evidence from profiling organic consumers, e.g. in Germany (Hoffmann and Spiller, 2010) or France (Kesse-Guyot *et al.*, 2013), of significantly different dietary choices made by such groups, specifically more healthful choices. Additionally, such data show better nutritional anthropometry measures and physical activity prevalence for organic consumers (Cordts *et al.*, 2013). Strassner hypothesized that the diet is economically fair and affordable, if the diet is sustainable according to the definition. An alternative indicator for the dimension of society and culture, which offers potential use for policy formulation, is the degree of training in household skills in schools. Indeed, education-linked measures such as food, health or nutrition literacy, and especially ecoliteracy (Semetsky, 2010; Capra, 2007), might offer some use (Strassner, 2015).

Denis Lairon gave a detailed presentation on the profiles of organic food consumers as studied in the French Nutrinet-Santé cohort comprising 54 311 adult participants (Hercberg *et al.,* 2010). The results were in astonishing agreement with those from the German study on organic consumers (Eisinger-Watzl *et al.,* 2015; Witting, Eisinger-Watzl and Hoffmann, 2011) using data from the National Nutrition Survey II as presented by Strassner. Regular consumers of organic products in both the French and the German cohorts exhibited:

- a better dietary pattern (more plant food-based);
- a diet fitting food-based and nutritional recommendations;
- markedly less overweight and obesity;
- a higher level of physical activity;
- a non-smoking routine.

Lairon (Lairon and Kesse-Guyot, 2015) showed that regular consumers of organic products have healthier life-style profiles – this is valid for the German cohort too – and thus a better compliance with the sustainable diet concept (more plant foods, better nutrition, better safety, better lifestyle and health (adiposity), to minimize energy/water uses and environmental impacts). Thus, regular consumers of organic products exhibit an overall plant-based diet and a healthier profile better fitting the sustainable diet definition (Box 1).

Nic Lampkin of the Organic Research Centre in the United Kingdom elaborated on the agro-ecology perspective of the organic food system showing that, like sustainability, also this term has different meanings to different people, ranging from a purely academic ecology focus to the social movement approach (Wezel *et al.*, 2009; Francis *et al.,* 2003; Gliessmann, 1998; Altieri, 1995). Lampkin considered the relationship between organic and agro-ecological principles, identifying

Box 1: Definition of sustainable diets

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

Source: FAO/Bioversity (2012).

areas of common ground and of difference. The question of how the agro-ecological underpinning of organic farming can be better reflected in organic regulations in future was addressed. He also spent some time on certification, underlining its value in helping translate the organic principles into practice through definition of relevant practices and technologies. Lampkin stressed that the concept of certification should be a foundation to support innovation, not a ceiling to constrain it. While it enables markets to reward producers for adopting specific practices, ensuring financial viability of systems, at the same time protecting consumers, it can lead to bureaucracy and institutionalization, disregarding delivery of the broader goals (Lampkin, 2015).

TWO CASE STUDIES PROVIDE INSIGHT INTO PRACTICE IN THE ORGANIC FOOD SYSTEM

Ivana Cavoski, Mediterranean Organic Agricultural Network (MOAN), linked the organic food system to the Mediterranean diet with work on organic durum wheat in the Mediterranean diet: old varieties and traditional bread making. The Mediterranean diet is characterized by an enormous food diversity where durum wheat is one of the bases, in the form of bread, pasta, couscous and bulgur. Different types of bread throughout the Mediterranean are made from durum wheat, including traditional flatbreads. Organic consumers tend to choose organic breads that are locally produced and handmade, and are processed with natural ingredients. Due to that, traditional sourdough fermentation becomes a very interesting biotechnology for bread making. Even though it produces a smaller loaf size, it is still very appealing to consumers because of its unique characteristics. Recently, there was a valorization of the old and local varieties of durum wheat particularly suitable for organic farming. Cavoski's presentation demonstrated that it is possible to bring traditions and cultural history successfully into modernity (Cavoski,Turk and Di Cagno, 2015).

Meanwhile, Anne-Kristin Løes of Bioforsk in Norway explained how organic food in public procurement was studied in schools, where meals are a most important public service for youth. iPOPY – innovative Public Organic food Procurement for Youth (2007–2010) was a market research study on how to increase the consumption of organic food in Europe by implementing organic food in school meals. Studies in Denmark, Finland, Italy, Norway and Germany showed highly variable conditions for school meals, ranging from complete, free meals (Finland) to packed, private lunches (Norway). To maximize organic consumption in schools, complete meals should be served, paid for by the public, with strong public involvement in general, with strong support for organic school food and an adapted supply chain (Løes and Nölting, 2011). In Finland, the organic proportion was low, but the well-established system has a high potential for significant organic consumption (Mikkola, 2008). In Italy, significant proportions of organic food were served, supported by public regulations, but hardly communicated (Spigarolo, Sarti and Giorgi, 2010; Bocchi *et al.,* 2008). Multiple embedding is required to establish a stable, high consumption of organic food in schools. The CORE-Organic I project iPOPY showed that organic food and farming are well suited to discuss and experience sustainability in practice (Roos and Mikkola, 2010). Analysis showed that an organic school policy promotes healthy eating: schools with a healthy food policy also support organic food (Løes, 2015).

CONCLUSION AND OUTLOOK

The underlying aim of the organic movement was and is still to create and develop further an alternative food system with focus on primary production (agriculture), but also including special value chains as well as distribution and recently also consumption. This is an approach towards developing a dietary pattern from field (agriculture) to fork (nutrition). The organic system may offer an example of comparing and combining both: sustainable food production and consumption patterns within one system. Since sustainability issues have been internationally discussed (Rio 1992, Rio +5, Rio +10, Rio +20, etc.), organic agriculture has been placed as an alternative way of production and discussed as a global best practice example. Therefore, during the last decade, many studies and reviews were performed investigating how organic agriculture and food production as well as parts of the value chains contribute to sustainable food production. In parallel, the market for organic food has grown exponentially worldwide. As a consequence, studies on consumer behaviour as well as consumption patterns were also carried out. However, until now organic production and consumption have never been brought together in a way describing the organic food system. Why may this be a very important challenge to do so? At this workshop the organic food system was presumed as an example for sustainable food systems. While organic agriculture can be taken as an example for sustainable food production, critical reflections were made on how organic consumption patterns may also be taken as example for sustainable food consumption. The closing discussion at this workshop included deliberation about which organic-related measures might be useful in the sustainability assessment of diets and the notion of characterizing organic value chains from a sustainability perspective on the basis of the dimensions discussed (health and nutrition, environment, economic, socio-cultural). Two potential indicators considered more closely were for organic production (land use under organic cultivation in percentage) and for organic consumption (organic consumption per capita). Drawing on the definition of sustainable diets above, the change of consumption patterns seems to be a crucial issue in the transformation to sustainable food systems. The consumption patterns of regular organic consumers seem to be close to the sustainable diet concept of FAO. Since diets play a central role in shaping food systems and food systems shape diets, the question of organic as a sustainable and healthy diet emerges as an essential topic to be addressed. Hence the organic support for a sustainable diet comes from the observation that the organic food system is a living laboratory. It has a definition, it has the principles, it has the standards, it has the metrics. The organic food system has been in practice for the last 100 years and covers environmental aspects, animal welfare standards and food quality as well as health issues. So today it also has the data from more than 160 countries, and regulations are in force in more than 80 countries or regions. The organic food system shares with the Mediterranean diet putting the land (agri-cultura) back into the diet; indeed, it is the land from which the diet *in toto* is shaped. Therefore the organic food system provides the essential requirements of a sustainable diet.

REFERENCES

Altieri, M.A. 1995. *Agroecology: the science of sustainable agriculture*. 2nd edition. Boulder, USA, Westview Press.

Bocchi, S., Spigarolo, R., Marcomini, N. & Sarti, V. 2008 Organic and conventional public food procurement for youth in Italy. *Bioforsk Report*, no. 42. State University of Milan, Faculty of Agriculture.

Burlingame, B. & Dernini, S. 2011. Sustainable diets: the Mediterranean diet as an example. *Public Health Nutrition*, 14(12A): 2285–2287.

Capra, F. 2007. Sustainable living, ecological literacy, and the breath of life. *Canadian Journal of Environmental Education*, 12(1): 9–18.

Cavoski, I. Turk J. & Di Cagno, R. 2015. Organic durum wheat in Mediterranean diet: old varieties and traditional bread making. *In* Proceedings of the International Workshop – Assessing sustainable diets within the sustainability of food systems. Mediterranean diet, organic food: new challenges, pp. 55–60. A. Meybeck, S. Redfern, F. Paoletti, & C. Strassner, eds. Rome, FAO.

Cordts, A., Wittig, F., Schulze, B., Eisinger-Watzl, M., Heuer, T., Spiller, A. & Hoffmann, I. 2013. A typology comparing male organic purchasers and male non-organic purchasers: Nutrition, health and buying behaviours. *Ernaehrungs Umschau international*, 60(3): 36–42. DOI 10.4455/eu.2013.009.

Dernini, S., Meybeck, A., Burlingame, B., Gitz, V., Lacirignola, C., Debs, P., Capone, R. & El Bilali, H. 2013. Developing a methodological approach for assessing the sustainability of diets: The Mediterranean diet as a case study. *New Medit.*, 12(3): 28–37.

Dimitri, C. & Greene, C. 2000. Recent growth patterns in the U.S. organic foods market. *Agriculture Information Bulletin*, pp. 1–21. Economic Research Service/USDA AIB-777.

EC. 2007. Council Regulation (EC) No 834/2007on organic production and labelling of organic products and repealing Regulation (EEC) No 2092/91. *Official Journal of the European Union*, L189: 1–23.

EC. 2008. Commission Regulation (EC) No 889/2008 of 5 September 2008, laying down detailed rules for the implementation of the organic regulation on organic production and labelling of organic products with regard to organic production, labelling and control. *Official Journal of the European Union*, L250: 1–84.

Eisinger-Watzl, M., Wittig, F., Heuer, T. & Hoffmann, I. 2015. Customers purchasing organic food - do they live healthier? Results of the German National Nutrition Survey II. EJNFS, 5(1): 59–71 Article no.EJNFS.2015.003.

Ellsworth, J. 2011. The history of organic food regulation. (2001 Third Year Paper) (available at http://nrs.harvard.edu/urn-3:HUL.InstRepos:8889458).

FAO. 2011. *Global food losses and food waste*, by J. Gustavsson, C. Cederberg, U. Sonesson, R. van Otterdijk & A. Meybeck. Rome.

FAO. 2013. *Sustainability Assessment of Food and Agriculture systems (SAFA)*. Rome (available at http://www.fao.org/nr/sustainability/sustainability-assessments-safa/en/).

FAO. 2014. *Statistical database FAOSTAT* (available at http://faostat3.fao.org).

FAO/Bioversity. 2012. *Sustainable diets and biodiversity*, by B. Burlingame. & S. Dernini, eds. Corporate authors: FAO, Rome, and Bioversity International, Rome. 309 p. ISBN-13: 978-92-5-107288-2.

FAO/IFAD/WFP. 2014. *The State of Food Insecurity in the World 2014. Strengthening the enabling environment for food security and nutrition*. Rome.

FAO/WHO. 1999. *Codex Alimentarius. Guidelines for the production, processing, labelling and marketing of organically produced foods*. GL 32-1999. Adopted 1999. Revisions 2001, 2003, 2004 and 2007. Amendments 2008, 2009 and 2010 (2001, rev. 2010). Rome, FAO, and Geneva, Switzerland, WHO.

Francis, C., Lieblein, G., Gliessman, S., Breland, T.A., Creamer, N., Harwood, R., Salomonsson, L., Helenius, J., Rickerl, D., Salvador, R., Wiedenhoeft, M., Simmons, S., Allen, P., Altieri, M., Flora, C. & Poincelot, R. 2003. Agroecology: the ecology of food systems. *Journal of Sustainable Agriculture*, 22: 99–118.

Geier, B. 2007. IFOAM and the history of the international organic movement. In W. Lockeretz, ed. *Organic farming: an international history*, pp. 175–186. Wallingford, UK, CABI. ISBN: 978-0-85199-833-6.

Gliessmann, S.R. 1998. *Agroecology: the ecology of sustainable food systems*. 2nd edition. CRC Press.

Hercberg, S., Castetbon, K., Czernichow, S., Malon, A., Mejean, C., Kesse, E., Touvier, M. & Galan, P. 2010. The Nutrinet-Santé Study: a web-based prospective study on the relationship between nutrition and health and determinants of dietary patterns and nutritional status. *BMC Public Health*, 10: 242. 1471-2458-10-242 [pii];10.1186/1471-2458-10-242 [doi].

Hoffmann, I. & Spiller, A. 2010. *Data interpretation based on the German National Nutrition Survey II (NVS II): An integrative analysis of behavioural and lifestyle-related factors for organic food consumption*. Auswertung der Daten der Nationalen Verzehrsstudie II (NVS II): eine integrierte verhaltens- und lebensstilbasierte Analyse des Bio-Konsums, Max-Rubner-Institut, Institut für Ernährungsverhalten, Karlsruhe and Georg-August-University Göttingen (available at http://orgprints.org/18055/ full study report in German with English summary).

IFOAM (International Federation of Organic Agriculture Movements). 2008. *Basic standards*. Bonn.

ISO (International Organisation for Standardisation). 2006. ISO-14040. *Environmental management – life cycle assessment – principles and framework*. Geneva, Switzerland.

Janssen, M. & Hamm, U. 2012. The mandatory EU logo for organic food: consumer perceptions. *British Food Journal*, 114: 335–362.

Jawtusch, J., Schader, C., Stolze, M., Baumgart, L. & Niggli, U. 2013. *Sustainability monitoring and assessment routine: results from pilot applications of the FAO SAFA Guidelines*. International Symposium on Mediterranean Organic Agriculture and Quality Signs related to the Origin, Agadir, Morocco, 2–4 December 2013.

Kahl, J. 2015. From vision to metrics: lessons from the organic food system. *In* Proceedings of the International Workshop – Assessing sustainable diets within the sustainability of food systems. Mediterranean diet, organic food: new challenges, pp. 55–60. A. Meybeck, S. Redfern, F. Paoletti, & C. Strassner, eds. Rome, FAO.

Kesse-Guyot, E., Péneau, S., Méjean, C., Szabo de Edelenyi, F., Galan, P., Hercberg, S. & Lairon, D. 2013. Profiles of organic food consumers in a large sample of French adults: results from the Nutrinet-Santé cohort study. *PLoS One*, 8(10): e76998. doi: 10.1371/journal.pone.0076998.

Lairon, D. & Kesse-Guyot, E. 2015. Profiles of organic food consumers, first lessons from the French NutriNet-Santé cohort study: a step towards diet sustainability. *In* Proceedings of the International Workshop – Assessing sustainable diets within the sustainability of food systems. Mediterranean diet, organic food: new challenges, pp. 55–60. A. Meybeck, S. Redfern, F. Paoletti, & C. Strassner, eds. Rome, FAO.

Lampkin, N. 2015. Organic food systems - an agro-ecological perspective. *In* Proceedings of the International Workshop – Assessing sustainable diets within the sustainability of food systems. Mediterranean diet, organic food: new challenges, pp. 55–60. A. Meybeck, S. Redfern, F. Paoletti, & C. Strassner, eds. Rome, FAO.

Lang, T. 2014 Sustainable diets: hairshirts or a better food future? *Development*, 57(2): 240–256. doi:10.1057/dev.2014.73.

Løes, A.-K. 2015. Organic food procurement in schools – iPOPY, a European case study. *In* Proceedings of the International Workshop – Assessing sustainable diets within the sustainability of food systems. Mediterranean diet, organic food: new challenges, pp. 55–60. A. Meybeck, S. Redfern, F. Paoletti, & C. Strassner, eds. Rome, FAO.

Løes, A-K. & Nölting, B. 2011. Increasing organic consumption by school meals – lessons learned in the iPOPY project. *Organic Agriculture*, 1: 91–110.

MAFF (Ministry of Agriculture, Forestry and Fisheries). 2007. *Overview of the organic Japanese agricultural standard system* (available at http://www.maff.go.jp/e/jas/specific/pdf/org01.pdf).

Mikkola, M. 2008 Organic and conventional public food procurement for youth in Finland. *Bioforsk Report*, no. 41. University of Helsinki, Ruralia Institute.

OECD (Organisation for Economic Co-operation and Development). 2014. *Obesity update* (available at http://www.oecd.org/els/health-systems/Obesity-Update-2014.pdf).

Padel, S. & Foster, C. 2005. Exploring the gap between attitude and behaviour: understanding why consumers buy or do not buy organic food. *British Food Journal*, 107: 606–625.

Paoletti, F. 2015. Contribution to sustainable diets from the organic sector: an introduction. *In* Proceedings of the International Workshop – Assessing sustainable diets within the sustainability of food systems. Mediterranean diet, organic food: new challenges, pp. 55–60. A. Meybeck, S. Redfern, F. Paoletti, & C. Strassner, eds. Rome, FAO.

Pehme, S. & Matt, D. 2015. How can the organic food system contribute to environmentally sustainable diets? *In* Proceedings of the International Workshop – Assessing sustainable diets within the sustainability of food systems. Mediterranean diet, organic food: new challenges, pp. 55–60. A. Meybeck, S. Redfern, F. Paoletti, & C. Strassner, eds. Rome, FAO.

Rembiałkowska, E. 2015. The organic food system in Europe. *In* Proceedings of the International Workshop – Assessing sustainable diets within the sustainability of food systems. Mediterranean diet, organic food: new challenges, pp. 55–60. A. Meybeck, S. Redfern, F. Paoletti, & C. Strassner, eds. Rome, FAO.

Roos, G. & Mikkola, M. 2010. Education about organic food and sustainability in Denmark, Finland, Italy and Norway. Findings from the iPOPY project. *Project Report*. No. 9 – 2010. Oslo, SIFO, National Institute for Consumer Research.

Roy, P., Nei, D., Orikasa, T., Xu, Q., Okadome, H., Nakamura, N. & Shiina, T. 2009. A review of life cycle assessment (LCA) on some food products. *J. Food Eng.*, 90: 1–10. doi:10.1016/j.jfoodeng.2008.06.016.

Schader, C., Stolze, M. & Niggli, U. 2015 How the organic food system contributes to sustainability. *In* Proceedings of the International Workshop – Assessing sustainable diets within the sustainability of food systems. Mediterranean diet, organic food: new challenges, pp. 55–60. A. Meybeck, S. Redfern, F. Paoletti, & C. Strassner, eds. Rome, FAO.

Semetsky, I. 2010. Ecoliteracy and Dewey's educational philosophy: implications for future leaders. *Foresight*, 12(1): 31–44.

Spigarolo, R., Sarti, V.& Giorgi, G. 2010. Organic and conventional public food procurement for youth in Italy. *Bioforsk Report*. Vol. 5 No. 109/2010; iPOPY discussion paper 4/2010. Bioforsk Organic Food and Farming, Tingvoll, Norway.

Strassner, C. 2015. How can the organic food system contribute to a sustainable diet. *In* Proceedings of the International Workshop – Assessing sustainable diets within the sustainability of food systems. Mediterranean diet, organic food: new challenges, pp. 55–60. A. Meybeck, S. Redfern, F. Paoletti, & C. Strassner, eds. Rome, FAO.

Tilman, D. & Clark, M. 2014. Global diets link environmental sustainability and human health. *Nature*, 515: 518–522.

Torjusen, H., Kjaernes, U., Sangstad, U. & Doherty Jensen, K. 2004. *European consumers' conceptions or organic food: a review of available research*. Professional report. Oslo, National Institute for Consumer Research (SIFO).

Wezel, A., Bellon, S., Dor'e, T., Francis, C., Vallod, D. & David, C. 2009. Agroecology as a science, a movement and a practice. A review. *Agronomy for Sustainable Development*. DOI: 10.1051/agro/2009004.

Wittig, F., Eisinger-Watzl, M. & Hoffmann, I. 2011. *Ernährungs- und Gesundheitsverhalten von Biokäufern. [Nutritional and health behaviour of consumer of organic food.]* Paper at: 11. Wissenschaftstagung Ökologischer Landbau, Gießen, 15–18 March 2011 (available at http://orgprints.org/17626/ short German paper with English summary).

Yan, M.-J., Humphreys, J. & Holden, N.M. 2011. An evaluation of life cycle assessment of European milk production. *J. Environ. Management*, 92: 372–379. doi:10.1016/j.jenvman.2010.10.025.

Understanding sustainable diets: from diets to food systems, from personal to global

Alexandre Meybeck
Department of Agriculture and Consumer Protection, FAO

ABSTRACT

Food systems are confronted with considerable challenges to ensure food security and nutrition for all, now and in the future. To address these challenges, the notions of sustainable diets and sustainable food systems are receiving increasing interest. These two notions are closely linked, but differ in focus and scope. Understanding the relationships between diets and food systems and how to consider each of them is key to assess and improve their sustainability. This paper builds upon the contributions to the international workshop on *Assessing sustainable diets within the sustainability of food systems* to propose a way forward for understanding what are sustainable diets and their contribution to sustainable food systems. It recalls the reasons for selecting the Mediterranean diet as a case study to assess the sustainability of diets and the objectives of such a work, and takes stock of progress made. It underlines some of the methodological issues raised by the differences of focus and scope between diets and food systems and proposes a framework to guide analysis. It acknowledges the potential contribution that the organic farming and food supply chain model could provide to the understanding of the relationships between consumption and production. It finally proposes distinguishing between sustainability characteristics of diets and a better clarification of their potential contributions to the sustainability of food systems in order to facilitate assessment and improvement of actual diets and food systems.

INTRODUCTION

Food systems are already exerting considerable pressure on the environment. According to FAO (2012a), food production needs to increase by 60 percent towards 2050 to respond to an increasing demand driven by population growth and changing dietary patterns. Concerns are increasingly being voiced that agriculture might, in the not too distant future, no longer be able to produce the food needed to sustain a still growing world population at levels required to lead a healthy and active life (Godfray *et al.*, 2010; Foresight, 2011; HLPE, 2011a; FAO, 2012a). At the same time, 2 billion people are malnourished, more than 800 million are still hungry and more than a billion are overweight and obese (FAO/IFAD/WFP, 2015). The global food system is unsustainable, and today's "unsustainable" diets are both a reason and a consequence of that. This recognition has given way to various studies comparing the potential impacts of diets, generally modelling environmental impacts, particularly GHG emissions and land use, of averaged standardized diets at global level (see for instance Erb *et al.*, 2009). It has also triggered interest in the notions of sustainable diet and sustainable food systems.

As defined in 2010, sustainable diets are "those diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources" (FAO, 2012b). Applying this definition concretely to actual diets encounters several methodological challenges, as shown by the experience of the Mediterranean diet as a case study. It requires assessing the sustainability of an actual diet from two totally different perspectives: from a nutrition perspective, to assess the potential effect on the individual's health, and from a broader sustainability perspective, to assess its impact on the sustainability of a food system, in all its dimensions: environmental, economic and social. This definition has been constructed on the assumption that diets and food systems are somehow linked, and in particular that they share the same spatial limits – with a broad equivalence between consumption and production spaces. Such an equivalence is true at global level (summing the potentially infinite number of diets that can compose it). It was to a great extent true in "traditional" food systems very much linked to a specific " traditional" diet. But it is no more to be found for most modern diets within a geographic area, bringing a second methodological challenge. The definition is finally constructed on the assumption that the diet within a particular "system" is the same for everybody, that consumption is homogenously distributed. This brings a third difficulty as the impact of distribution can be very diverse. It is the sum of diets that creates global demand and thus determines impacts on food systems. From this perspective it can be expressed by an average diet. On the contrary, from a nutrition and health perspective, it is all the individual diets that are important, rather than the average.

A prerequisite is to better understand the relationships between diets and food systems, in order to be able to concretely assess the sustainability of diets, intended as their contribution to the sustainability of food systems. Not because we need to accommodate one more concept but because it could help solve very concrete methodological difficulties in assessing impacts before further refining the modalities to calculate indicators and before attempting to assess actual, real diets. The High Level Panel of Experts on food security and nutrition has provided a definition of sustainable food systems as "food systems that deliver food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition for future generations are not compromised" (HLPE, 2014). As we will see, the analysis of the relationships between the concept of sustainable diets and of sustainable food systems provides a framework that can help design a way forward to assess both of them in concrete situations. It could also help understand some of the conditions/drivers of sustainable diets, which could enable the design of actions towards more sustainable diets (CIHEAM/FAO, 2015).

This paper builds upon the contributions to the international workshop on assessing sustainable diets within the sustainability of food systems to propose a way forward for understanding sustainable diets and their contribution to sustainable food systems. It recalls the reasons for selecting the Mediterranean diet as a case study and takes stock of progress made. It then considers some of the methodological challenges raised by the differences of focus and scope between diets and food systems and proposes a framework to guide analysis from concepts to actual diets and food systems. Perspectives from the organic sector can help to understand some of the relationships between consumption and production. It finally proposes distinguishing between sustainability characteristics of diets and a better clarification of their potential contributions to the sustainability of food systems in order to facilitate assessment and improvement of actual diets and food systems.

THE MEDITERRANEAN DIET AS A CASE STUDY

In 2011, FAO and CIHEAM, with many partners, initiated the development of a methodological approach for assessing the sustainability of diets, with the Mediterranean diet as a case study. It may be useful to recall here the reasons for selecting the Mediterranean diet as a case study.

A first group of reasons for interest is linked to the fact that the Mediterranean diet, as an archetypal model, has been well described and characterized. And it is important to underline that by Mediterranean diet we mean a model of diet, described from the diets practised in rural Mediterranean areas some 60 years ago. It is a model that has a historic and geographic reality as it was the standard diet of most of the rural Mediterranean communities. So, a first reason of interest is thus that it is a "real" historic diet. A second is that this model is shared by many different populations in both developed and developing Mediterranean countries, with of course local specific incarnations. A third reason is that this model still greatly influences actual Mediterranean diets, in spite of it being inherited from poor rural communities, which in itself is of major interest.

A second group of reasons pertains to the interest its characteristics raise, both from a public health and an environmental perspective. First of all, its positive impacts on nutrition and health are well described, assessed and recognized, with numerous scientific publications (Estruch *et al.,* 2013; Trichopoulou *et al.*, 2014; Gotsis *et al.*, 2014). Second, there is an increasing interest because of its positive impact on the environment, as compared with other types of diets, richer in animal products (Almendros *et al.*, 2013; Tilman and Clark, 2014; Tukker *et al.*, 2011). These two characteristics position the Mediterranean diet as a good candidate for a sustainable diet.

Third, linked to the reasons above, there is an important scientific community working on it, in very diversified disciplines with, very specifically, considerable pluridisciplinary work having been conducted towards the recognition of the Mediterranean diet as an intangible cultural heritage by UNESCO. The work conducted since 2011 is firmly positioned in these tracks. Finally, the Mediterranean diet, because of the reasons given above and also because of many other social, commercial and cultural reasons, is the object of much international interest, including outside the Mediterranean. Its main characteristics and some of its symbolic components, such as olive oil, are known and promoted all over the world. This makes the Mediterranean diet a good entry point for consumers worldwide to consider diet-related issues, in between their own practices, traditions, representations and values.

The work stream initiated in 2011 was grounded on some implicit "assumptions": the model of the Mediterranean diet is sustainable; actual diets in the Mediterranean area are not sustainable; returning to the model could be a way to make them sustainable, with the idea that showing the sustainability of the model would also be a way to promote its conservation. The objective was thus to develop a methodological approach that, starting from the model of the Mediterranean diet, would enable an assessment of the sustainability of actual diets in the Mediterranean area, to facilitate a diagnostic in order to raise awareness on critical issues and address them (Dernini and Berry, 2015).

It is important to underline that the Mediterranean model is here the starting point, the framework used to devise a methodology that is then to be used to consider and assess actual diets in Mediterranean countries, many of which are now no longer strictly implementing the model. In other words, the objective was to start from a model that is well known for its positive impacts on health and on the environment to develop a methodological approach to be used for assessing actual diets. The main stages of the development of a methodological approach for assessing the sustainability of diets, with the Mediterranean diet as a case study, have been summarized in the second session (for a description of the approach, see Dernini *et al.*, 2013). Four broad thematic areas were first identified: environment and natural resources (including agro-biodiversity); economy; society and culture; and nutrition, health and lifestyle. For each of them, potential indicators were identified, from existing series developed by international organizations and/or in the scientific literature. This list was then simplified, taking into account data availability as well as the need for a reduced number of indicators (both lists are available in Lacirignola *et al.*, 2012). A key question when attempting to calculate them concretely is to determine the scope on which to do it.

DIETS AND FOOD SYSTEMS: FOCUS AND SCOPE

At global level, the environmental sustainability of an archetypal average global diet can at very first hand be appraised by looking at how such a diet potentially impacts on the environmental sustainability of the food system, at least for some global common indicators. The need for a clarification of the relationships between diets and food systems emerges when trying to calculate concretely some of the indicators characterizing the environmental impact of a diet at lower levels, such as the national level. Most of the diets are no longer determined by what is locally produced, as it was for traditional food systems (see for instance Malassis, 1996). The connection between a diet and a geographic area has loosened with globalization. Also, there is increasingly a disconnection between the space of production and the space of consumption. And to a certain extent the very term Mediterranean diet is misleading. It is "geographic", localized, by name, while it is in fact increasingly using imported products, including from outside the Mediterranean area. Taking fish for instance, 75 percent of the fish consumed in Italy is imported.[1] It can also be followed outside the Mediterranean region.

This is why when we want to assess environmental impacts of a diet concretely we immediately get lost in scopes, scales and data. What is the environmental impact of the Italian diet? It is not the environmental impact of the Italian food production and consumption sector; there are exports, imports. These imports have different environmental impacts; how to get the information? And to what extent does diet (consumer choices) drive these differences? In other words, what is assessed at consumption level is not the sustainability of a food system but the contribution of the diet to the sustainability of food systems (Gitz, 2015). Impacts will be assessed through figures compiled on the production side. Unless there is total traceability of all products consumed, with for each of them total information on the specific impacts of their production, transformation, transport and conservation, impacts will be assessed using available, often generic, figures. Improving the understanding of the physical and economic relationships between production and consumption could gradually improve the assessment of the contribution of a determined diet to the sustainability of a determined food system.

The interpretation of some economic indicators, such as food prices, can also be particularly challenging. From a consumer perspective, the lower the better; it facilitates diversified and nutritious diets. However, low prices reduce the income of producers, who constitute, worldwide, the majority of the hungry and malnourished. Low prices also risk reducing capacity and willingness to invest in agriculture, a condition for future food production. On the other hand, high prices reduce poor net buyers' capacity to ensure a diversified and nutritious diet as well as other basic needs. High prices can also reveal high production costs and ultimately scarce productive capacities, a concern for the future, or high intermediate margins, and thus a lack of social sustainability. Such potential differences of interpretation call for a clarification, clearly separating food prices as an indicator at consumption level, an indicator of access, from its use and interpretation inside the food system at large, which requires breaking down the final consumption price in various components to better envision its relationships with economic and social dimensions of sustainability. Such distinctions of level of impacts inside food systems are also particularly important to better understand, conversely, the potential impacts of changing diets, through prices, on all stages of food systems (see Adinolfi, Capone and El Bilali, 2015). Food prices should therefore also be analysed in terms of their impacts on sustainability, with different approaches for diets and for food production, for instance. At consumption level, high food prices, assessed rather in relative terms, compared with available income of consumers and in particular of food consumers, and also relative prices of food items between themselves, impact negatively on the possibility of poor consumers to have a balanced and healthy diet. On the other hand, low food prices can have direct negative environmental impacts by not discouraging food waste (Gustavson *et al.*, 2011). They reduce investment capacity and thus economic sustainability. By driving the need for low production costs they also encourage low-cost practices that can be environmentally damaging and drive low income and wages for food producers and workers, with important social impacts. The contribution of food prices to the various dimensions of sustainability can thus be different when considering only diets or food systems as a whole, particularly when integrating a long-term perspective.

FROM CONCEPTS TO ACTUAL DIETS

The sections above show the need to clearly distinguish levels of analysis, from concepts and relations between them, to actual diets and food systems (Figure 1).

From a global and normative perspective, conceptual and forward looking, sustainable diets and sustainable food systems are clearly linked. Sustainable diets are both the objective and condition of sustainable food systems (right rectangle in Figure 1).

[1] http://www.globefish.org/fishery-aquaculture-country-profiles.html

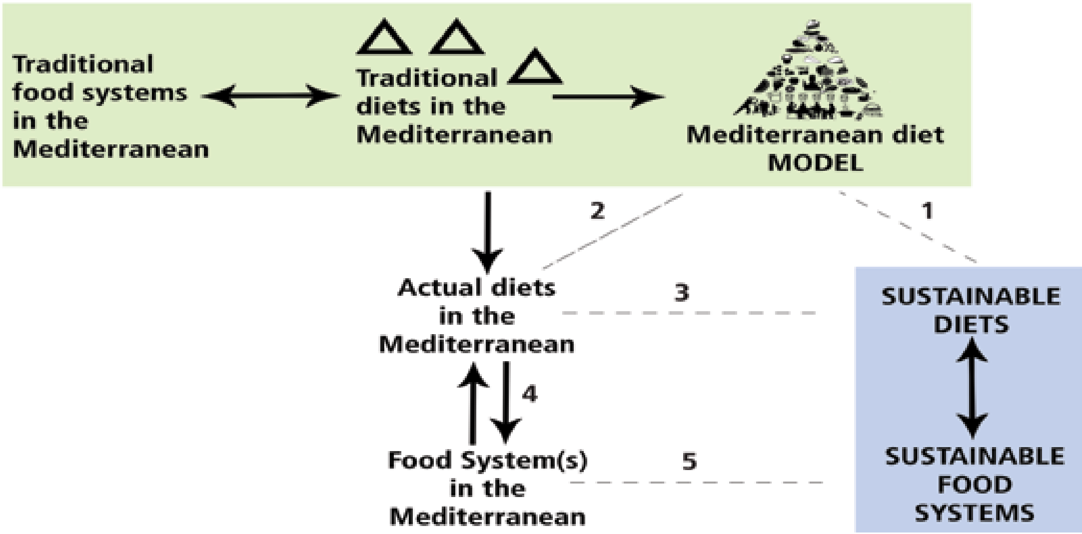


Figure 1: From concepts to actual diets

As mentioned above, the definition of a sustainable diet has been framed under the assumption that the considered diet is somehow homogenous, shared by a geographic community, and therefore that it shares the same geographical limits as its production area. To a certain extent this was verified in traditional food systems, and for the Mediterranean diet model, abstracted from traditional diets in the Mediterranean (rectangle above in Figure 1). This is why it can be considered as a case study of a sustainable diet (arrow 1). The work done in that respect aims to devise a methodological approach to consider actual diets in the Mediterranean in relation to the notion of a sustainable diet (arrow 3) using their relationship to the Mediterranean diet model (arrow 2) as a pathway. This approach, focused on the consumption side, covers well the health/ nutrition dimensions of the definition of sustainable diet. However, as shown above, to assess the environmental, economic and social dimensions would require looking specifically at the food system to which a diet is linked and to assess it from a sustainable food systems' perspective (arrow 5). Finally, the main question of interest in any food system could be the relationships between the diet and the food system (arrows 4) and how these determine the sustainability of the diet (arrow 3) and of the food system as a whole (arrow 5). Understanding these relationships and their dynamics could also be key to understanding drivers of change, including potential means to improve the sustainability of diets and food systems.

PERSPECTIVES FROM THE ORGANIC SECTOR

The organic movement provides a particularly interesting model of relationships between production and consumption. It started from a production model and has gradually given way to what could be considered as an alternative food system, advocated as such, with its own transformation and distribution enterprises. All of it is governed by specific certification rules, enacted or recognized by the states. Organic products are produced under certain conditions, certified as such, and recognized as such by consumers. In turn, consumers of organic products seem to share specific attitudes to food, with health and environment as the most commonly stated motives to buy organic (Shepherd, 2011; Kearney, 2010). They also display a more important degree of realization of these attitudes in actual behaviour, as shown by the increase in demand for organic products.

It seems, also, as shown by the study “Profiles of organic food consumers, first lessons from the French NutriNet-Santé Cohort Study: a step towards diet sustainability” (Lairon and Kesse-Guyot, 2015), that consumers of organic products, even occasionally, also share other food consumption characteristics, including less meat consumption, more fruits and vegetables, etc., which contribute to more sustainable diets, in the double acceptance of being more healthy and contributing to more sustainable food systems. These characteristics are in fact coherent with consumers of organic products' attitudes towards food. These results are particularly interesting. They seem to manifest that "attitudes" that are driving consumers' preference towards organic food could also play a role in driving behaviour towards more sustainable diets. If this is the case, it could well validate the idea that an information strategy on sustainable diets, or more specifically on the Mediterranean diet, can change not only the consumers' attitude but ultimately their behaviour. It also signals the "organic food system" as an interesting model to better understand drivers of sustainable consumption including in broader food systems. In spite of the specificities of regular consumers of organic products, what drives their attitudes towards food and ultimately their food choices could help understand what triggers behavioural changes towards more sustainable choices.

The organic sector, and its development, also shows how consumers' attitudes can drive choices towards products that bear specific "quality" attributes linked to their mode of production, perceived as more sustainable (Meybeck and Gitz, 2014). Such behaviour, in turn, drives the recognition, valorization and development of these modes of production, contributing to their economic, and often social, sustainability. This is why consumption of organic products and other types of products to which a sustainability characteristic is attached can be a valuable indicator to monitor sustainable consumption and diets. On the production side, the area cultivated under organic practices or other schemes contributing to sustainability can be both an indicator of sustainable production and of the impact of sustainable consumption on production.

DISCUSSION: HOW TO CONSIDER ACTUAL DIETS AND THEIR IMPACTS

When preparing the agenda of this international workshop we had in mind two main objectives: the first was to make progress on the selection of nutrition indicators for the assessment of a sustainable diet; the second was to better understand the relationships between diets and food systems in order to be able to better address some methodological issues in assessing the impacts of diets on food systems and also to get some insight on potential drivers of sustainable diets. We have gone a long way since the beginning of this work and this session was also an opportunity to take stock of the progress made and to agree on a way forward, including a potential list of issues to be further considered and on the ways to do so. As a result of this work, we have now a list, or a suite, of nutrition indicators, in relatively good shape (see Annex 1). This is particularly important to keep the focus on sustainable diets, on the impacts of food consumption on nutrition and health, because this is ultimately what a diet is about.

Given this experience we propose to better distinguish some methodological issues to be addressed when considering actual diets and their impacts.

First we need to be able to describe them. And here dietary models are particularly useful. They are useful as a research object in itself, simplifications of actual diets, constructing "archetypal models" that can be assessed and compared with other types of diets and as models against which to compare actual diets that, for historical and geographical reasons, are related to it. Second, as has been shown by numerous communications here, diets cannot be isolated from a food system; they drive it and are conditioned by it. Third, it is becoming increasingly difficult to establish a single homothetic relationship between a diet and a food system. Ultimately, the notion of diet can be linked to a community of consumers whereas most of the time its elements are coming from different places very often not identified.

We thus propose to adopt a broader approach considering diets in their relationships to/as part of food systems and to clearly distinguish characteristics to assess the sustainability of diets and food systems according to the focus and scope of the impacts to be assessed. The composition of the diet has two main categories of impacts: on the individuals consuming it and on the food system as a whole. The impacts on the individuals can be assessed by the nutritional characteristics of the foods consumed and/or, with a time lag, by the assessment of certain health characteristics known to be determined by food consumption. The composition of the diet drives the demand for and production of specific foods, with environmental, economic and social impacts. These can generally only be assessed using generic indicators and figures unless the origin of the products can be traced back and there are means to better assess specific impacts in the area of origin and along the food value chain.

There are finally the parameters that relate to drivers of food consumption choices and to their expression. And if we assume that sustainable diets are both an objective and a driver of sustainable food systems, understanding the drivers of food choices is of paramount importance to design ways to improve the sustainability of both diets and food systems. This leads to particular interest for two specific groups of parameters. The first covers those relating to consumption choices that go beyond an interest in diet composition and take into account characteristics such as quality, origin and mode of production. Such choices can have various impacts on all dimensions of sustainability. Moreover, as shown above, they can be the expression of attitudes that are also grounding some choices related to diet composition. The second covers economic, social and cultural parameters that, both inside and outside food systems, can drive food consumption choices.

Two multidisciplinary approaches – from the Mediterranean diet case study and from the organic sector – provide stimulating perspectives to better understand some potential drivers of change. The various sessions of this international workshop have presented some concrete ways to envisage links between food systems and diets; focused on consumers' health or on products or specific crop variety they provide easier entry points. Whatever their initial perspective, they all show that the link between consumption and production is never simple but always influenced by other factors pertaining to the food system, in which they are embedded, but also to the other connected systems (labour, transport, culture, etc.). As such they often manifest otherwise hidden drivers that can help understand some of the food systems' and diets' dynamics.

REFERENCES

Adinolfi, F., Capone, R. & El Bilali, H. 2015. Assessing diets, food supply chains and food systems sustainability: towards a common understanding of economic sustainability. *In* Proceedings of the International Workshop – Assessing sustainable diets within the sustainability of food systems. Mediterranean diet, organic food: new challenges, pp. 55–60. A. Meybeck, S. Redfern, F. Paoletti, & C. Strassner, eds. Rome, FAO.

Almendros, S.S., Obrador, B., Bach-Faig, A. & Serra-Majem, L. 2013. Environmental footprints of Mediterranean versus Western dietary patterns: beyond the health benefits of the Mediterranean diet. *Environ. Health*, 12(1): 118.

CIHEAM/FAO. 2015. *Mediterranean food consumption patterns: diet, environment, society,*

economy and health. A White Paper Priority 5 of Feeding Knowledge Programme, Expo Milan 2015. CIHEAM-IAMB, Bari/FAO, Rome.

Dernini, S., Meybeck, A., Burlingame, B., Gitz, V., Lacirignola, C., Debs, P., Capone, R. & El Bilali, H. 2013. Developing a methodological approach for assessing the sustainability of diets: The Mediterranean diet as a case study. *New Medit.*, 12(3): 28–37.

Dernini, S. & Berry, E.M. 2015. Mediterranean diet: from a healthy diet to a sustainable dietary pattern. *Frontiers in Nutrition*. 2: 15.

Erb, K-H., Haberl, H., Krausmann, F., Lauk, C., Plutzar, C., Steinberger, J.K., Müller, C., Bondeau, A., Waha, K. & Pollack, G. 2009. *Eating the planet: feeding and fuelling the world sustainably, fairly and humanely – a scoping study*. Commissioned by Compassion in World Farming and Friends of the Earth UK. Institute of Social Ecology and PIK Potsdam. Vienna. Social Ecology Working Paper No. 116.

Estruch, R., Ros, E., Salas-Salvadó, J., Covas, M.I., Corell, D., Arós, F., Gómez-Gracia, E., Ruiz-Gutiérrez, V., Fiol, M., Lapetra, J., Lamuela-Raventos, R.M., Serra-Majem, L., Pintó, X., Basora, J., Muñoz, M.A., Sorlí, J.V., Martínez, J.A. & Martínez-González, M.A. 2013. Primary prevention of cardiovascular disease with a Mediterranean diet. *N. Engl. J. Med.*, 368: 1279–1290.

FAO. 2012a. *World agriculture towards 2030/2050: the 2012 revision*, by N. Alexandratos & J. Bruinsma. ESA Working Paper No. 12-03, June, Rome (available at http://typo3.fao.org/fileadmin/templates/esa/Global_persepctives/world_ag_2030_50_2012_rev.pdf).

FAO. 2012b. *Sustainable diets and biodiversity; directions and solutions for policy, research and action* (available at http://www.fao.org/docrep/016/i3004e/i3004e.pdf).

FAO/IFAD/WFP. 2015. The State of Food Insecurity in the World 2015. *Meeting the 2015 international hunger targets: taking stock of uneven progress*. Rome, FAO.

Foresight. 2011. *The future of food and farming*. Final Project Report. London, The Government Office for Science.

Gitz, V. 2015. Sustainable diets and sustainable food systems diets. *In* Proceedings of the International Workshop – Assessing sustainable diets within the sustainability of food systems. Mediterranean diet, organic food: new challenges, pp. 55–60. A. Meybeck, S. Redfern, F. Paoletti, & C. Strassner, eds. Rome, FAO.

Godfray, H.C.J., Beddington, J.R., Crute, I.R., Haddad, L., Lawrence, D., Muir, J.F., Pretty, J., Robinson, S., Thomas, S.M. & Toulmin, C. 2010. Food security: the challenge of feeding nine billion people. *Science*, 327: 812–818.

Gotsis, E., Anagnotis, P., Mariolis, A., Vlachou, A., Katsiki, N. & Karagiannis, A. 2014. Health benefits of the Mediterranean diet: an update of research over the last 5 years. *Angiology*, 66(4): 304–318. DOI:10.1177/0003319714532169.

Gustavsson, J., Cederberg, C., Sonesson, U., van Otterdijk, R. & Meybeck, A. 2011. *Global food losses and food waste – extent, causes and prevention*, Rome, FAO (available at http://www.fao.org/docrep/014/mb060e/mb060e00.pdf).

HLPE. 2011. *Price volatility and food security*. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome.

HLPE. 2014. *Food losses and waste in the context of sustainable food systems*. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome.

Kearney, J. 2010. Food consumption trends and drivers. Phil. Trans. R. Soc. B, 365: 2793–2807.

Malassis, L. 1996. Les trois âges de l'alimentaire. *Agroalimentaria*, No.2. June.

Lacirignola, C., Dernini, S., Capone, R., Meybeck, A., Burlingame, B., Gitz, V., El Bilali, H., Debs, P. & Belsanti, V. 2012. Towards the development of guidelines for improving the sustainability of diets and food consumption patterns: the Mediterranean diet as a pilot study. *Options Méditerranéennes: Série B. Etudes et Recherches*, n. 70. Bari, CIHEAM/FAO.

Lairon, D. & Kesse-Guyot, E. 2015. Profiles of organic food consumers, first lessons from the French NutriNet-Santé Cohort Study: a step towards diet sustainability. *In* Proceedings of the International Workshop – Assessing sustainable diets within the sustainability of food systems. Mediterranean diet, organic food: new challenges, pp. 55–60. A. Meybeck, S. Redfern, F. Paoletti, & C. Strassner, eds. Rome, FAO.

Meybeck, A. & Gitz, V. 2014. Signs to choose: voluntary standards and eco-labels as information tools for consumers. In V*oluntary standards for sustainable food systems: Challenges and opportunities*, Proceedings of a workshop of the FAO/UNEP programme on Sustainable Food Systems. A. Meybeck & S. Redfern, eds. Rome, FAO.

Shepherd, R. 2011. *Foresight Project on Global Food and Farming Futures. Science Review: SR12. Societal attitudes to different food production models: biotechnology, GM, organic and extensification.* The UK Government Office for Science (available at http://www.bis.gov.uk/assets/foresight/docs/food-and-farming/science/11-558-sr12-societal-attitudes-to-foodproduction-models.pdf).

Tilman, D. & Clark, M. 2014. Global diets link environmental sustainability and human health. *Nature*, 515: 518–522.

Trichopoulou, A., Martínez-González, M.A., Tong, T., Forouhi, N.G., Khandelwa, S., Prabhakaran, D., Mozaffarian, D. & de Lorgeril, M. 2014. Definitions and potential health benefits of the Mediterranean diet: views from experts around the world. *BMC Medicine*, 12: 112.

Tukker, A., Goldbohm, R.A., de Koning, A., Verheijden, M., Kleijn, R., Wolf, O., Pérez-Domínguez, I. & Rueda-Cantuche, J.M. 2011. Environmental impact of changes to healthier diets in Europe. *Ecological Economics*, 70: 1776–1788.

A DRAFT DISCUSSION PAPER PREPARED FOR THE INTERNATIONAL WORKSHOP:
ASSESSING SUSTAINABLE DIETS WITHIN THE SUSTAINABILITY OF FOOD SYSTEMS
Mediterranean Diet, Organic Food: New Challenges

15–16 September 2014

Research Centre for Food and Nutrition, CREA, Rome

NUTRITIONAL AND HEALTH INDICATORS FOR ASSESSING SUSTAINABLE DIETS

The Mediterranean diet as a case study

SUSTAINABLE FOOD SYSTEMS PROGRAMME, FAO

Contents

Acknowledgements

This draft discussion paper has been prepared by Sandro Dernini and Alexandre Meybeck, Sustainable Food Systems Programme, FAO, based on an initial draft prepared by Elliot Berry, Hebrew University Hadassah Medical School, with contributions from the following co–authors:

Rekia Belahsen, Chouaib Doukkali University; Elliot Berry, Barbara Burlingame, Deakin University, Melbourne; Lorenzo M. Donini, CIISCAM/Sapienza University of Rome; Denis Lairon, INSERM/INRA/University Aix–Marseille; Lluis Serra Majem, University of Las Palmas de Gran Canaria; Antonia Trichopoulou, Hellenic Health Foundation/University of Athens; Giuseppe Maiani, Angela Polito and Aida Turrini, CREA - Research Centre for Food and Nutrition, Rome.

Theollowing experts are also acknowledged:

- Roberto Capone, CIHEAM–Bari for his overall contribution to the development of the methodological approach;
- Valeria del Balzo, Alessandro Pinto, Annamaria Giusti, CIISCAM/Sapienza University of Rome, and Federica Intorre, CREA - Research Centre for Food and Nutrition, for the identification of nutrition and health indicators;
- Massimo Iannetta, ENEA–Rome, and Eva Alessi, WWF–Italy, for the identification of environmental indicators;
- Giulio Malorgio, University of Bologna, and Philipp Debs and Hamid El Bilali, CIHEAM–Bari, for the identification of economic indicators;
- Mauro Gamboni and Silvana Moscatelli, CNR–Rome, for the identification of socio–cultural indicators.

A special thanks to Suzanne Redfern, Sustainable Food Systems Programme, FAO, for the editing and layout of this document.

1. Introduction

1.1 SUSTAINABLE DIETS AS OBJECTIVE AND DRIVER OF SUSTAINABLE FOOD CONSUMPTION AND PRODUCTION

Food consumption and production trends and patterns are among the most important drivers of environmental pressures (Vanham, Mekonnen and Hoeskstra, 2013; Kastner *et al.,* 2012; Tukker *et al.,* 2011; EC, 2011; Garnett, 2013; Popp, Lotze-Campen and Bodirsky, 2010; Ingram, Ericksen and Liverman, 2010; Friel *et al.,* 2009; Carlsson-Kanyama and Gonzalez, 2009; EC/JRC, 2009; Lundqvist, de Fraiture and Molden, 2008).

The challenge of feeding the growing world population, which is expected to reach 9 billion people in 2050, requires new strategies to ensure global sustainable food security (FAO, 2009, 2011; Godfray *et al.,* 2010). Today, the main challenge for the food and agriculture sector is to provide simultaneously enough food, in quantity and quality, to meet nutritional needs and to conserve the natural resources for present and future generations (UNCSD, 2012).

There is rising evidence of the cost of diets on the environment, society and public health nutrition (Heller, Keoleian and Willet, 2013; O'Kane, 2012; Burke Delaney, 2012; Clonan and Holdsworth, 2012; Haines *et al.,* 2009; Holdsworth, 2010; Hawkesworth *et al.,* 2010; Lock *et al.,* 2010).

Food systems around the world are changing rapidly, with profound implications for diets and nutritional outcomes, and within the context of the food systems transformation towards more sustainable food consumption and production patterns (HLPE, 2014a; FCRN, 2014; Garnett, 2013), the interest for sustainable diets is markedly increasing as an emerging issue, bridging agriculture, nutrition, food security and sustainability (IOM, 2014; ODI, 2014; Johnston, Fanzo and Cogill, 2014; Capone *et al.,* 2014a,b; WRI, 2013; Lang and Barling, 2013; Buttriss and Riley, 2013; Esnouf, Russel and Bricas, 2013; FAO, 2013, 2012; UNEP, 2012; CGIAR, 2012; Dangour *et al.,* 2012, Lawrence, Lyons and Wallington, 2010; Pinstrup-Andersen and Herforth, 2008).

The notion of "sustainable diets" started to be explored in the early 1980s (Gussow and Clancy, 1986) to recommend diets that would be healthier for the consumers as well as for the environment. In the last decade, the interest for sustainable diets has been further raised by a growing body of scientific evidences of the non-sustainability of current dietary trends (Van Dooren *et al.,* 2014; Masset *et al.,* 2014; Macdiarmid, 2013; Saxe, Larsen and Mogensen, 2013; Wilson *et al.,* 2013; Macdiarmid *et al.,* 2012; Smith and Gregory, 2012; Berners-Lee *et al.,* 2012; Vieux *et al*., 2013; WWF, 2013; Scarborough *et al.,* 2012; Pluimers and Blonk, 2011; Guyomard *et al.,* 2011; Garnett, 2013; SDC, 2009, 2011; Marlow *et al.,* 2009; Stehfest *et al.,* 2009). However, there is no evidence that high nutritional quality is always associated with low greenhouse gas emissions (Vieux *et al.,* 2012).

In 2010, in Rome, at FAO headquarters, participants at the international symposium on 'Biodiversity and Sustainable Diets: United against Hunger', organized by FAO and Bioversity International, reached an agreement on the following definition of sustainable diets: *Sustainable diets are those diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources* (FAO/Bioversity, 2012).

The sustainable diets' concept highlights the role of sustainable consumption as a driver of sustainable production. This relationship was at the basis of the 10YFP on Sustainable Consumption and Production adopted at the Rio+20 Conference (UNCSD, 2012). It requires an intersectoral effort to reverse the simplification of diets, the degradation of ecosystems, and the erosion of biodiversity. This can be achieved through sustainable food consumption and production linked to sustainable diets, acknowledging the interdependencies of food production and food consumption with food requirements and nutrient recommendations (FAO/Bioversity, 2012).

This further requires reshaping food systems towards sustainable diets (UN, 2014). The world is producing enough food to feed all of its population. Yet almost one billion people go hungry and two billion are malnourished, lacking the essential micronutrients they need to lead healthy lives. Globally, the number of overweight/obese people has reached more than 1.4 billion adults. These figures show profound imbalances in consumption and diets (FAO, 2013).

Food consumption is variably affected by a whole range of factors including food availability, food accessibility and food choice, which in turn may be influenced by geography, demography, disposable income, socio-economic status, urbanization, globalization, religion, culture, marketing and consumer attitude (Kesse-Guyot *et al.,* 2013a; FAO, 2012; Kearney, 2010; de Boer, Hooglan and Boersema, 2007). It will require a better understanding of the drivers of food consumption changes (HLPE, 2014b).

There is a large geographic variation in patterns of food consumption and production that influences their environmental impacts and requires solutions and guidelines tailored to these different geographic conditions, with local, national, regional and international levels of application. There are still many challenges towards the development of guidelines for assessing the diets' sustainability (Van Dooren *et al*., 2014; Heller, Keoleian and Willet, 2013; Swedish National Food Agency, 2013; WWF. 2013; Esnouf, Russel and Bricas, 2013; Health Council of the Netherlands, 2011).

Developing methodologies that describe and characterize diets at various levels, identifying types of diets and assessment of their impacts would provide a more holistic understanding of food consumption. This would increase value to give food and food choices highlighting nutritional, economic, social and cultural dimensions.

1.2 THE MEDITERRANEAN DIET AS A CASE STUDY FOR SUSTAINABLE DIETS

1.2.1 THE MEDITERRANEAN DIET

The Mediterranean diet is more than just a diet; it represents a lifestyle, a social cultural expression of the different Mediterranean food cultures that has been acknowledged in 2010 by UNESCO as an intangible cultural heritage of humankind (UNESCO, 2010). The Mediterranean diet is closely related to the Mediterranean lifestyles, and deeply influenced by cultural and economic modifications during the last decades.

The Mediterranean diet results from a highly diversified heritage, which makes it diverse in various countries. Food traditions vary from country to country in the Mediterranean area and as a consequence it is necessary to take into consideration different local realities with specific environmental, economic, social and cultural traits. As a result, the Mediterranean diet should be considered in *continuous evolution*, related closely to the particular historical and environmental mosaic that is the Mediterranean region.

The concept or notion of the Mediterranean diet began to be studied in the 1950's as a model of a healthy diet (Keys, 1970) which reduced morbidity and mortality. This developed in the 2000's to a model of sustainable diet (Gussow, 1995) which also considers the overall impact on the ecosystem (Burlingame and Dernini, 2011), and, then recognized as an intangible cultural heritage acknowledged by UNESCO (UNESCO, 2010), see Figure 1.

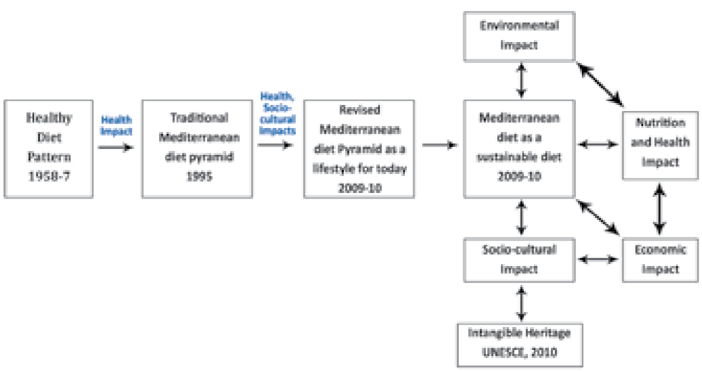


Figure 1: The evolution of concepts surrounding the Medeterranean diet
Source: Dernini and Berry, 2015.

There is not one single Mediterranean diet, but rather a number of variations on a basic dietary pattern adapted to diverse country's cultures. The term "*Mediterranean diet*" implies the existence of some common dietary characteristics in

Mediterranean countries such as: high amounts of olive oil and olives, fruits, vegetables, cereals (mostly unrefined), legumes, nuts and fish; moderate amounts of dairy products (preferably cheese and yoghurt); and low quantities of meat and meat products. Wine in moderation is acceptable when it is not contradictory to religious and social norms (Willet *et al.,* 1995; Trichopoulou and Lagiou, 1997; Bach-Faig *et al.,* 2011).

The Mediterranean diet has been well scientifically characterized, since the pioneer Seven Countries Study by Ancel Keys (Keys, 1970), as a healthier dietary pattern (Estruch *et al.,* 2013; Trichopoulou *et al.,* 2014; Gotsis *et al.,* 2014; Kesse-Guyot *et al.,* 2013b; Maillot *et al.,* 2011; Kastorini *et al.,* 2011; Vernele *et al.,* 2010; Sofi *et al*., 2010; Trichopoulou *et al.,* 2009; Bosetti, Pelucchi and La Vecchia, 2009; Babio *et al.,* 2009; Serra-Majem *et al.,* 2009, Serra-Majem, Roman and Estruch, 2006; Martinez-Gonzalez *et al.,* 2009; Trichopoulou, Bamia and Trichopoulos, 2009, 1995; Willett *et al.,* 1995; Nestle, 1995). It has further started being analysed in many studies and appreciated for its lower environmental impact (Van Dooren *et al.,* 2014; Pairotti *et al.,* 2014; Capone *et al.,* 2014a,b; Sáez-Almendros *et al.,* 2013; Tukker *et al.,* 2011; Pluimers and Blonk, 2011; EC/JRC, 2009; Baroni *et al.,* 2007; Duchin, 2005; Gussow, 1995).

Because of these characteristics, and because it concerns a large number of countries, the Mediterranean diet has been selected by FAO as a pilot case study on which to develop and validate methods and indicators for sustainable diets (Burlingame and Dernini, 2011; FAO/CIHEAM, 2012).

The Mediterranean diet has nutritional, economic, environmental and socio-cultural characteristics that make it particularly relevant as a case study for characterizing sustainable diets in different agro-ecological zones. The study of the Mediterranean diet as a sustainable diet model should contribute to clarify what is required for an environmentally sustainable food system and more eco-friendly food-based dietary guidelines.

But despite the well-documented health and environmental benefits of the Mediterranean diet, current data show a decline in adherence to it in Northern, Southern and Eastern Mediterranean countries, because of multifactorial influences – life style changes, globalization of food markets, economic and socio-cultural factors (Bonaccio *et al*., 2014; Leon-Munoz *et al.,* 2012; Da Silva *et al.,* 2009; Vareiro *et al.,* 2009; Padilla, 2008; Garcia-Closas, Berenguer and Gonzalez, 2006; Alexandratos, 2006; Belahsen and Rguibi, 2006; IOTF, 2005). This decline has caused an increasing process of erosion of the Mediterranean diet heritage, which needs to be counteracted through promoting its adherence and enhancement as a practical, sustainable cultural resource (Dernini, 2011; Medina, 2011).

Various dietary scores of adherence to the Mediterranean diet have been published (Trichopoulou *et al.,* 1995, 2009; Fidanza *et al.,* 2004; Martínez-González *et al.,* 2002; Sanchez-Villegas *et al.,* 2002; Serra-Majem *et al.,* 2004; Gerber, 2006) and extensively reviewed (Bach *et al.,* 2006; Koularba and Panagiotakos, 2009; Sofi *et al.,* 2008, 2010, 2013; Milà-Villarroel *et al.,* 2011; Issa *et al.,* 2011). Several dietary guidelines for specific Mediterranean populations have been developed and associated with pyramidal graphic representation, such as for the Spanish population (Aranceta and Serra-Majem, 2001), for the Greek population (Supreme Scientific Health Council, Ministry of Health and Welfare of Greece. 1999) and for the Italian population (Ministero della Salute, 2004; del Balzo *et al.,* 2012).

The first traditional Mediterranean diet pyramid was presented in 1993 at the international conference on Mediterranean diets held at the Harvard School of Public Health in Boston (Willett *et al.,* 1995), and was compared with the 1992 food guide pyramid issued by the US Department of Agriculture in preparation for the 1995 *Dietary Guidelines for Americans*. Then, in 1994, it was copyrighted by Oldways Preservation & Exchange Trust (Willett *et al.,* 1995).

In 2009 and 2010, the Mediterranean diet pyramid was revised, without any copyright provision, through a participatory consensus position process that conceived the pyramid as a simplified mainframe capable of adaptation to the different country-specific variations related to the various geographical, socio-economic and cultural contexts of contemporary Mediterranean lifestyles (Bach-Faig *et al.,* 2011; Dernini *et al.,* 2012).

This new revised Mediterranean diet pattern was presented as an example of a sustainable diet, in which nutrition, local food production, biodiversity, culture and sustainability are strongly interconnected, with a lower impact on the environment. The concepts of seasonality, fresh and locally grown products, culinary activities, biodiversity, traditional, local and eco-friendly products, of variety of colours for fruits and vegetables were introduced together with the concepts of main meals, frugality, moderation, conviviality and physical activity.

The revision of the Mediterranean diet pyramid was developed through the joint efforts of experts in nutrition, anthropology, sociology and agriculture, most of them also participating in the development of this discussion document, by taking into consideration all the scientific evidence for the health benefits of the Mediterranean diet and its protective effects against chronic diseases, as well as contemporary lifestyles and environmental constraints.

1.2.2 METHODOLOGICAL APPROACH FOR THE ASSESSMENT OF THE SUSTAINABILITY OF THE MEDITERRANEAN DIET.

Much evidence is available on the constituents of healthy diets (WHO, 2003), and many countries have adopted dietary recommendations to encourage healthy consumption patterns (WHO, 2004). Food-based dietary guidelines from different countries contain similar broad messages based on principles of nutrition science. National dietary guidelines, however, often contain unique features that were designed by national experts to address the priorities of each individual country. Nevertheless, evidence to assess whether national agricultural and food systems are providing the correct balance of foods, or whether populations are consuming recommended dietary patterns, is extremely limited (Hawkesworth *et al.,* 2010).

Considering together the various sustainability dimensions and scales, and their complex interactions, in the context of the Mediterranean area, requires joint collaboration across disciplines to develop and strengthen studies on diets and food consumption patterns.

The development of a first methodological approach for the assessment of the sustainability of the Mediterranean diet was initiated in 2010 by FAO (FAO, 2010), and further developed in 2011 and 2012, through collaboration between FAO and CIHEAM-Bari (FAO/CIHEAM, 2012), which allowed finalizing a methodological framework (Dernini *et al.,* 2013), as follows:

1. Identification of four priority areas for assessing sustainability of diets:
    a) nutrition and health;
    b) environment;
    c) economy;
    d) socio-cultural factors.
2. Identification of an ensemble or suite of appropriate indicators for the above four priority areas and related selection criteria, to be applied at individual, household and country level.
3. Selection of one or more Mediterranean countries in which to test and further refine this methodological approach for assessing, at individual, household and country levels, the sustainability of the diet and its conformity to the Mediterranean diet model.
4. Identification of food groups and serving sizes in the selected countries, using recent food consumption surveys, supplemented from food balance sheet data.
5. Assessment of current food consumption patterns in selected Mediterranean countries by using available food consumption surveys and food balance sheets/supply utilization account. Assessment of their adherence (Bach *et al.,* 2006; Koularba and Panagiotakos, 2009; Sofi *et al.,* 2008, 2010, 2013; Milà-Villarroel *et al.,* 2011) to the new revised Mediterranean diet pyramid (Baich-Faig *et al.,* 2011) as a reference framework to be adapted to each country.
6. Calculation of a value/score using the data gathered for each indicator.
7. Combination of all scores into a scale and analysis of trends over relevant time series. Assessment from this set of indicators/scores of the relationship between current dietary patterns, adherence to the Mediterranean diet pattern and the sustainability of food consumption at the country level.

According to FAO, *an indicator generally comprises elements (a cut-off value, a frame of reference, a mode of expression, etc.) which allow a relatively universal appreciation of the information it supplies and also facilitates comparison in time and space* (FAO, 2005).

To select the most effective indicators, the following criteria have to be considered:

1. *Relevant to the question being asked* with the objective to select the best indicator currently available to answer the question.
2. *Understandable* i.e. clear, simple and unambiguous.
3. *Graphically representable*.
4. *Readily interpretable* i.e. clear which direction the indicator should develop to lead to greater sustainability.
5. *Relevant* in most Mediterranean countries i.e. not restricted to an element that is limited to a few countries.
6. *Monitorable* i.e. based on data that are readily available, or could be made available at a reasonable cost-benefit ratio and with regularity/repeatability within the time frame of the policy cycle.
7. *Reliable and consistent,* i.e. data collection and analysis methodologies should preferably be consistent between countries and, at the very least, be consistent within a given country from year to year.
8. *Representative*, i.e. can be taken to represent current food consumption and production trends (Watson *et al.,* 2010).

Using the above mentioned criteria and given considerations to the set of indicators provided by the UK Department for Environment, Food and Rural Affairs for enabling and encouraging people to eat a healthy, sustainable diet (DEFRA, 2009), and by taking into account the four dimensions (health and nutrition, environment, econom, and socio-cultural factors) of the sustainable diets (FAO, 2010), a first, preliminary list of 74 potential sustainability indicators was compiled in 2011 (Annex 1), which, because of limited available data resources, was reduced to a list of 20 more manageable indicators (Annex 2), which were revised and extended again in 2012 as a list of 24 indicators, as reported in Table 1 (page 6).

Then, a second list of indicators, Table 2 (page 6), was extracted in part from the previous larger list (Table 1 and Annex 1) and was more recently brought into discussion, with the purpose to integrate some of them within the final ensemble of nutrition and health indicators.

Table 1: Proposed indicators to assess the sustainability of the Mediterranean diet

Thematic area	Proposed indicators
A. Nutrition and health	A1. Diet–related morbidity/mortality A2. Fruit and vegetable consumption/intake A3.Vegetable/animal protein consumption ratio A4. Dietary energy supply/intake A5. Dietary diversity score A6. Dietary energy density score A7. Nutrient density/quality score A8. Food biodiversity composition and consumption A9. Nutritional anthropometry A10. Physical inactivity prevalence
B. Environment	B1. Water footprint B2. Carbon footprint B3. Nitrogen footprint B4. Biodiversity
C. Economy	C1. Food consumer price index (FCPI): cereals, fruit, vegetables, fish and meat C2. Cost of living index (COLI) related to food expenditures: cereals, fruit, vegetables, fish and meat C3. Distribution of household expenditure per groups: food C4. Food self–sufficiency: cereals, fruit and vegetables C5. Intermediate consumption in the agricultural sector: nitrogen fertilizers C6. Food losses and waste
D. Society and culture	D1. Proportion of meals consumed outside home D2. Proportion of already prepared meals D3. Consumption of traditional products (e.g. proportion of product under PDO or similar recognized traditional foods) D4. Proportion of mass media initiatives dedicated to the knowledge of food background cultural value

Source: FAO/CIHEAM (2012).

Table 2. Other proposed indicators for nutrition and health

B1	Food composition
B2	Food energy density
B3	Frugality
B4	Household food security
B5	Level of food processing
B6	Local food system and seasonality
B7	Mediterranean diet adherence
B8	Nutrient profile
B9	Organic and eco–friendly consumption
B10	Global nutritional index

2. First ensemble of nutrition and health indicators for assessing the sustainability of the Mediterranean diet

Because of the lack of time available for preparing this first draft, it was not feasible to integrate the second list of indicators, reported in Table 2. Some of them were considered not a priority or redundant, others difficult to measure. Some of these indicators were instead thought potentially important for incorporation in the ensemble of nutrition and health indicators, despite not being purely nutrition and health indicators but more socio-cultural or environmental or economic ones, because of their close relations with food choices or food consumption – key drivers for the MD as well as for sustainable diets and their assessment. Such integration will require further development and discussion.

In this first draft, therefore, only the first ten nutrition and health indicators of the Table 1 were further developed and fully reported in this document, as follows:

A1. DIET-RELATED MORBIDITY/MORTALITY STATISTICS

a. Definition

This indicator monitors the occurrence of cardiovascular diseases, type II diabetes, hypertension, osteoporosis, neurodegenerative diseases, and some types of cancer as a proxy for healthy diets.

b. Methodology

DALYs lost for nutrition related factors: high blood pressure, high cholesterol (total and LDL), high blood sugar (insulin resistance and or diabetes).

Prevalence of individuals having physician-diagnosed obesity, cardiovascular diseases (hypertension, CHD), type II diabetes, osteoporosis, cancers (possibly linked to obesity: oesophagus, pancreas, colon and rectum, breast, endometrium, prostate, kidney, thyroid, gallbladder).

c. Background

The prevalence of obesity has increased worldwide and is a source of concern since the negative consequences of obesity start as early as in childhood. Nutrition-related chronic diseases are increasing leading to disabilities and death globally and in developing countries, including Mediterranean countries. The epidemiology of non-communicable diseases, such as cardiovascular diseases (hypertension, CHD and stroke), diabetes and cancer, gastrointestinal diseases (in particular NAFLD and NASH), respiratory diseases (OSAS and restrictive lung ventilatory dysfunction), mental illness and immune impairment, functional impairment (with increased disability), and the risk factors for these diseases (mainly obesity) are closely related to food consumption, dietary patterns, nutrition and lifestyles.

In fact the excess of body fat (particularly visceral obesity), represented in obesity, and is associated with metabolic abnormalities and inflammatory status. In fact the adipose tissue can now be considered as an endocrine organ orchestrating crucial interactions with vital organs and tissues such as the brain, the liver, the skeletal muscle, and the heart and blood vessels themselves. Inflammation is also associated to obesity and central adiposity and anaemia or iron deficiency coexisting in countries in nutrition transition. Moreover obesity related comorbidity and disability, together with psychological issues, impacts all aspects of an individual's quality of life. Finally reports present alarming figures for the prevalence of this phenomenon, accounting for 63 percent of the 57 million total deaths in 2008 (WHO, 2011).

Finally there is to be noted that over- and undernutrition frequently coexist. In developing countries the transition phase is characterised by a high prevalence of both malnutrition (still not eradicated) and obesity (depending on the shift in dietary consumption and energy expenditure that coincides with economic, demographic, and epidemiological changes leading to a transition from traditional diets high in cereal and fiber to more Western pattern diets high in sugars, fat, and animal-source food) (Popkin, 1993; Hawkes, 2006). Moreover, even in "developed" countries and also in obese subjects, there are signs and symptoms due to malnutrition (sarcopenic obesity; mineral-vitamin deficits in obese subjects (Schweiger *et al.,* 2010) and in immigrants; calorie-protein malnutrition in elderly subjects).

d. Data sources

National surveys, WHO world health statistics.

e. Limitations of the indicator

Some pathologies can be undiagnosed or underreported in some countries. Data could not be available for the same age group. If data are not available, mortality prevalence will be used.

f. Addional information

Barone, D.A. & Krieger, A.C. 2013. Stroke and obstructive sleep apnea: a review. *Curr. Atheroscler Rep*. 2013 July; 15(7): 334. doi: 10.1007/s11883-013-0334-8.

Bastien, M., Poirier, P., Lemieux, I. & Després, J.P. 2014. Overview of epidemiology and contribution of obesity to cardiovascular disease. *ProgCardiovasc Dis*., Jan–Feb; 56(4): 369–381. doi: 10.1016/j.pcad.2013.10.016.

Corrado, R.L., Torres, D.M. & Harrison, S.A. 2014. Review of treatment options for nonalcoholic fatty liver disease. *Med Clin North Am.,* 98(1): 55–72. doi: 10.1016/j.mcna.2013.09.001.

Correja Horvath, J.D., Dias de Castro, M.L, Kops, N., Kruger Malinoski, N. & Friedman, R. 2014. Obesity coexists with malnutrition? Adequacy of food consumption by severely obese patients to dietary reference intake recommendations. *Nutr. Hosp.*, 29(2): 292–299.

Diaz-Melean, C.M., Somers, V.K., Rodriguez-Escudero, J.P., Singh, P., Sochor, O., Llano, E.M. & Lopez-Jimenez, F. 2013. Mechanisms of adverse cardiometabolic consequences of obesity. *Curr. Atheroscler Rep.* , 15(11): 364. doi: 10.1007/s11883-013-0364-2.

Gartner, A., El Ati, J., Traissac, P., Bour, A., Berger, J., Landais, E. El Hsaïni, H., Ben Rayana, C. & Delpeuch, F. 2014. A double burden of overall or central adiposity and anemia or iron deficiency is prevalent but with little socioeconomic patterning among Moroccan and Tunisian urban women. *The Journal of Nutrition*, 144(1): 87–97.

Hawkes, C. 2006. Uneven dietary development: linking the policies and processes of globalization with the nutrition transition, obesity, and diet-related chronic diseases. *Global Health*, 2(4): 1–18.

Klop, B., Elte, J.W. & Cabezas, M.C. 2013. Dyslipidemia in obesity: mechanisms and potential targets. *Nutrients*, 12,5(4): 1218–1240. doi: 10.3390/nu5041218.

Popkin, B.M. 1993. Nutritional patterns and transitions. *Population and Development Review*, 19(1): 138–157.

Schweiger, C., Weiss, R., Berry, E.M. & Keidar, A. 2010. Nutritional deficiencies in bariatric surgery candidates. *Obesity Surgery*, 20: 193–197.

Taylor, V.H., Forhan, M., Vigod, S.N., McIntyre, R.S. & Morrison, K.M. 2013. The impact of obesity on quality of life. *Best Pract Res ClinEndocrinolMetab.,* 27(2): 139–146. doi: 10.1016/j.beem.2013.04.004.

WCRF. 2007. *Report on food, nutrition, physical activity and the prevention of cancer: a global perspective*. Geneva, Switzerland.

WHO. 2003. *Diet, nutrition and the prevention of chronic diseases*. Report of the Joint WHO/FAO Expert Consultation. Geneva, Switzerland.

WHO. 2009. *Global health risks, mortality and burden of disease attributable to selected major risks (*available at http://www.who.int/healthinfo/global_burden_disease/GlobalHealthRisks_report_full.pdf).

WHO. 2011. *The global burden of noncommunicable diseases*. Geneva, Switzerland.

WHO. *Obesity and overweight.* Factsheet N311 (available at http://www.who.int/mediacentre/factsheets/fs311/en/).

A2. FRUIT AND VEGETABLES, INCLUDING LEGUMES, CONSUMPTION/INTAKES

a. Definition

This indicator is the measure of the consumption (g/cap/day) of fruit and vegetables, including *legumes*, directly applicable to assessing adherence to the Mediterranean diet, and as a proxy for a healthy diet and specific micronutrient intakes.

b. Methodology

Measure the consumption (g/cap/day) of fruit, vegetables and legumes.

c. Background

The existing scientific evidence regarding a primary role for fruits and vegetables in preventing degenerative diseases, as well as in alleviating several micronutrient deficiencies especially in less developed countries, is consistent and reliable. Nutrition policies have strongly promoted the consumption of a diet containing at least 400 g/day of fresh fruit and vegetables (excluding potatoes and other starchy tubers) as a nutritional goal for health promotion (WHO, 2003). In fact, a high intake of fruit and vegetables (FV), including legumes, has been shown to be associated with reduced risk of a number of chronic diseases, including cardiovascular diseases (CHD and stroke in particular), metabolic diseases (type 2 diabetes and dyslipidemia) and obesity. Moreover, epidemiological evidence strongly suggests that consumption of dietary phytochemicals found in vegetables and fruit can decrease cancer incidence. More and more evidence suggests that the health benefits of fruits, vegetables, legumes, whole grains and other plant foods are attributed to the synergy or interactions of fibre bioactive compounds, and other nutrients in whole foods. Therefore, consumers should obtain their nutrients, antioxidants, bioactive compounds and phytochemicals from a balanced diet with a wide variety of fruits and vegetables (of different colours), whole grains and other plant foods for optimal nutrition, health and well-being, rather than from dietary supplements.

d. Data sources

National surveys, FAO food balance sheets.

e. Limitations of the indicator

Data obtained from food balance sheets do not reflect the effective food intake, because they relate to the food quantities theoretically available for consumption; the amount of food consumed may be lower than that reported in food balance sheets, due to the degree of losses of edible food and nutrients in the household, e.g. during storage, in preparation and cooking, as plate waste or quantities fed to domestic animals and pets, or thrown away. However, when national dietary surveys are not available, the food balance sheets provide relevant data by which to compare several countries and different time periods.

f. Addional information

Agudo, A. 2005. *Measuring intake of fruit and vegetables*. Background paper, WHO, Geneva, Switzerland.

Abdull Razis, A.F. & Noor, N.M. 2013. Cruciferous vegetables: dietary phytochemicals for cancer prevention. *Asian Pac. J. Cancer Prev*., 14(3): 1565–1570.

Bouchenak, M. & Lamri-Senhadji, M. 2013. Nutritional quality of legumes, and their role incardiometabolic risk prevention: a review. *J. Med. Food*, 16(3): 185–198. doi: 10.1089/jmf.2011.0238.

Hartley, L., Igbinedion, E., Holmes, J., Flowers, N., Thorogood, M., Clarke, A., Stranges, S., Hooper, L. & Rees, K. 2013. Increased consumption of fruit and vegetables for the primary prevention of cardiovascular diseases. *Cochrane Database Syst Rev*., 6: CD009874. doi: 10.1002/14651858.CD009874.pub2.

Liu, R.H. 2013. Health-promoting components of fruits and vegetables in the diet. *Adv. Nutr.,* 4(3): 384S–92S. doi: 10.3945/an.112.003517.

Martin, C., Zhang, Y., Tonelli, C. & Petroni, K. 2013. Plants, diet, and health. *Ann. Rev. Plant Biol*., 264: 19–46. doi: 10.1146/annurev-arplant-050312-120142.

Nicklett, E.J. & Kadell, A.R. 2013. Fruit and vegetable intake among older adults: a scoping review. *Maturitas*, 275(4): 305–312. doi: 10.1016/j.maturitas.2013.05.005.

Rees, K., Hartley, L., Flowers, N., Clarke, A., Hooper, L., Thorogood, M. & Stranges, S. 2013. 'Mediterranean' dietary pattern for the primary prevention of cardiovascular disease. *Cochrane Database Syst Rev.*, 12 August: CD009825. doi: 10.1002/14651858.CD009825.pub2.

Ros, E. & Hu, F.B. 2013. Consumption of plant seeds and cardiovascular health: epidemiological and clinical trial evidence. *Circulation*, 128(5): 553–565. doi: 10.1161/CIRCULATIONAHA.112.001119.

WHO. 2003. *Diet, nutrition and the prevention of chronic diseases*. Report of the Joint WHO/FAO Expert Consultation. Geneva, Switzerland.

Woodside, J.V., Young, I.S. & McKinley, M.C. 2013. Fruit and vegetable intake and risk of cardiovascular disease. *ProcNutr Soc.*, 72(4): 399–406. doi:10.1017/S0029665113003029.

A3. VEGETABLE/ANIMAL PROTEIN CONSUMPTION RATIOS

a. Definition

This indicator is a ratio of the relative intakes of protein from plant and animal sources, assessing adherence to an optimal dietary pattern, and a proxy for environmental impact of diets.

b. Methodology

The methodology is a straightforward calculation of the ratio of plant (cereals, vegetables, pulses, fruit) and animal (meat, fish, eggs, dairy products) proteins in the diet using existing data. Adherence to an optimal ratio, including the Mediterranean diet, can be judged by simple comparison, and the trend can be monitored over the time series of available data, regardless of the data source.

c. Background

Dietary protein can be expressed in different ways, with four major dimensions for consideration: source, quality, quantity and impact. Source can be presented at several levels of aggregation, from the classic classification of kingdoms (plant, animal), to finer divisions, e.g. terrestrial and aquatic, through to the most disaggregated taxonomic levels of subspecies, variety, cultivar and breed, reflecting biodiversity.

The most basic classification for dietary protein, with the most available data, is a simple division into plant and animal sources. This classification is a useful proxy for nutritional quality, as the amino acid patterns of animal-source foods are better suited to human requirements; while, on the contrary, as a somewhat useful proxy for environmental sustainability, where in terms of GHG emission and land/water use, plant sources perform better than animal sources.

d. Data sources

FAOSTAT food balance sheets and commodity balances provide data for domestic availability of a food, and food component in the case of protein. The contributing data include the sum of production and imports, with exports and non-food use subtracted. New modules to the FAOSTAT family of databases, including land use, emission, pesticide, fertilizer and irrigation, will provide more data on environmental sustainability when analysed with protein ratio data. Food consumption studies, national nutrition surveys, household budget surveys, etc, will be available in some countries to augment FAO data.

e. Limitations of the indicator

FAOSTAT data from food balance sheets and commodity balances reflect domestic availability of foods, not consumption or production *per se*. While these data have proven useful historically for assessing nutritional adequacy of diets, they may significantly misrepresent sustainability issues. For example, livestock production has a greater role in GHG emission than livestock consumption. If meat is imported rather than domestically produced, the calculation of environmental impact may be skewed if using food balance or commodity balance data sets. Similarly, national nutrition surveys do not address the issue of production. Food losses and waste are not accounted for in these datasets, which will affect the calculations and their interpretation. Additionally, the advantages of using plant:animal protein ratio as opposed to plant:animal dietary energy ratio or plant:animal ratio in grams per person per day need to be elaborated and justified.

f. Addional information

Alonso, A.I., Beunza, J.J., Bes-Rastrollo, M., Pajares, R.M. & Martínez-González, M.A. 2006. Vegetable protein and fiber from cereal are inversely associated with the risk of hypertension in a Spanish cohort. *Arch. Med. Res.*, 37(6): 778–786.

Carlsson-Kanyama, A. & Gonzalez, A.D. 2009. Potential contributions of food consumption patterns to climate change. *Am. J Clin. Nutr*., 89: 1704S–1709S.

Kritchevsky, D. 1979. Vegetable proteins and atherosclerosis. *Journal of the American Oil Chemists' Society*, 3: 135–140.

Macdiarmid, J.I., Kyle, J., Horgan, G.W., Loe, J., Fyfe, C., Johnstone, A. & McNeill, G. 2012. Sustainable diets for the future: can we contribute to reducing greenhouse gas emissions by eating a healthy diet? *Am. J. Clin. Nutr.*, 96: 632–639.

Masset, G., Soler, L.G, Vieux, F. & Darmon, N. 2014. Identifying sustainable foods: the relationship between environmental impact, nutritional qualityand prices of foods representative of the French diet. *J. Acad. Nutr. Diet*, 114: 862–869.

Sellmeyer, D.E., Stone, K.L., Sebastian, A. & Cummings, S.R., for the Study of Osteoporotic Fractures Research Group. 2001. A high ratio of dietary animal to vegetable protein increases the rate of bone loss and the risk of fracture in postmenopausal women. *Am. J. Clin. Nutr.*, 73: 118–122.

Vallianou, N.G., Bountziouka, V.P., Georgousopoulou, E., Evangelopoulos, A.A., Bonou, M.S., Vogiatzakis, E.D., Barbetseas, J.D., Avgerinos, P.C. & Panagiotakos, D.B. 2013. Influence of protein intake from haem and non-haem animals and plant origin on inflammatory biomarkers among apparently-healthy adults in Greece. *J. Health Popul. Nutr.*, 31(4): 446–454.

Yoon, G.A. & Hwang, H.J. 2006. Effect of soy protein/animal protein ratio on calcium metabolism of the rat. *Nutrition*, 22(4): 414–418.

A4. DIETARY ENERGY SUPPLY/INTAKES

a. Definition

This indicator is a quantitative or semi-quantitative measure of the amount of energy (kJ or kcal) in the diet. Using food balance sheets, supply utilization accounts or household budget surveys, dietary energy supply (kcal/capita/day) is a population-based proxy for consumption. Using dietary intake survey data (e.g. food diaries, dietary recalls), actual consumption is estimated. For actual consumption only, it can also be a proxy for frugality. Dietary energy intake is an indicator reflecting energy input which should be related to physical energy expenditure and as a result, with body mass index.

b. Methodology

Estimate of the per capita amount of energy (kcal or kJ) in food available for human consumption, during the reference period. Per capita dietary energy supply (DES) is expressed in kcal per capita per day. Per capita supplies represent only the average supply available for each individual in the total population and do not indicate what is actually consumed by individuals. From nutritional surveys, better estimates of food energy intake per capita (but somewhat underestimated due to home food wastes) can be determined. Lowest and upper dietary energy requirements have been elaborated at national and international levels, for different population categories (FAO, 2011). This relates to under- and overnutrition. Energy expenditure should also be recorded.

c. Background

The aetiologies implicated in obesity and related comorbidities are multifactorial and include genetic and environmental factors (Sarra-Majem and Bautista-Castaño, 2013). Evidence suggests that a large percentage of obesity cases involve a clear environmental component linked to sedentary lifestyles and dietary habits that lead to positive energy balance and, as a result, the gradual, relentless accumulation of fatty tissue. Diverse epidemiological studies describe a direct relationship between an increased body mass index, when correlated with an increase in fat mass, and mortality (Gupta, Krueger and Lastra, 2012).

On the contrary, based on its known benefits to cardiometabolic health, including modest calorie restriction in a combined lifestyle programme, the Mediterranean diet is likely to improve heart health and prevent subsequent cardiovascular events both in normal weight and in overweight/obese individuals (Paullaf *et al*., 2013). Calorie restriction may represent, both in animal and human models, an important way to counteract ageing effects by reducing the ageing-related functional decline and by preventing the occurrence of age-related diseases (Bales and kraus, 2013; Chung *et al*., 2013). In particular, calorie restriction may modulate deleterious chronic inflammation at molecular levels and the impact of epigenetic chromatin and histone modifications at the ultimate control sites of gene expression (Martin-Montalco and de Cabo, 2013; Kowaltowski, 2011).

The traditional Mediterranean diet is typified by a certain frugality, while the present dietary pattern is characterized more by energy-dense foods, a low intake of saturated animal fats contrasting with a high, but reasonable, intake of mono or polyunsaturated fatty acids, complex carbohydrates, fresh vegetables and fruit and nuts rich in antioxidant vitamins, together with fish and wine.

It should be considered that in all Mediterranean countries, certain portions of the population can suffer from either undernutrition or overnutrition, based on energy intake criterion

d. Data sources

National surveys, household budget surveys, FAO food balance sheets – tailored macropanel.

e. Limitations of the indicator

Difficult to estimate with reasonable accuracy and difficult to interpret without information on physical activity.

f. Addional information

Bales, C.W. & Kraus, W.E. 2013. Caloric restriction: implications for human cardiometabolic health. *J. Cardiopulm. Rehabil. Prev.*, 33(4): 201–208. doi: 10.1097/HCR.0b013e318295019e.

Chung, K.W., Kim, D.H., Park, M.H., Choi, Y.J., Kim, N.D., Lee, J., Yu, B.P. & Chung, H.Y. 2013. Recent advances in calorie restriction research on aging. *ExpGerontol*., 48(10): 1049–1053. doi: 10.1016/j.exger.2012.11.007.

FAO. 2001. *Human energy requirements.* Report of a joint FAO/WHO Expert Consultation. Rome.

FAO. 2011. *Guidelines for measuring household and individual dietary diversity*. FAO, Rome.

Gupta, D., Krueger, C.B. & Lastra, G. 2012. Over-nutrition, obesity and insulin resistance in the development of B-cell dysfunction. *Curr. Diabetes Rev*., 8(2): 76–83.

Kowaltowski, A.J. 2011. Caloric restriction and redox state: does this diet increase or decrease oxidant production? *Redox Rep*., 16(6): 237–241. doi: 10.1179/1351000211Y.0000000014.

Martin-Montalvo, A. & de Cabo, R. 2013. Mitochondrial metabolic reprogramming induced by calorie restriction. *Antioxid. Redox Signal*, 19(3): 310–320. doi: 10.1089/ars.2012.4866. Epub 2012 15 October.

Pallauf, K., Giller, K., Huebbe, P. & Rimbach, G. 2013. Nutrition and healthy ageing: calorie restriction or polyphenol-rich "MediterrAsian" diet? *Oxid. Med. Cell Longev.*, Article ID 707421. doi: 10.1155/2013/707421.

Serra-Majem, L. & Bautista-Castaño, I. 2013. Etiology of obesity: two "key issues" and other emerging factors. *Nutr. Hosp*., Suppl 5: 32–43. doi:10.3305/nh.2013.28.sup5.6916.

A5. DIETARY DIVERSITY SCORE

a. Definition

This indicator is a qualitative measure of food consumption that reflects household access to a variety of foods, and is also a proxy for nutrient adequacy of the diet of individuals.

b. Methodology

It can be constructed using one or more indices centered on the Mediterranean diet (Bach *et al.,* 2006) as a function of the characteristics of the study population and the epidemiological target.

c. Background

Food-based dietary guidelines (FBDG) aim to address the nutritional requirements at the population level in order to prevent diseases and promote a healthy lifestyle. Overall diet quality measurements have been suggested as a useful tool to assess diet-disease relationships. Diet quality indices can be used to assess the compliance with these FBDG.

The comparative study highlights the similarities and differences between the different tools aimed at analysing food consumption through dietary diversity scores. The choice of indicator for food diversity or quality assessment and surveillance will vary depending on user needs.

The Mediterranean model is correlated with a lower prevalence of degenerative chronic diseases. These health effects are related to the biochemical and nutritional characteristics of the plant-based eating pattern (e.g. antioxidant capacity, low inflammation status) that are considered protective against cell damage and related metabolic complications. An ample source of molecules with antioxidant and anti-inflammatory actions, among which omega-3 fatty acids, oleic acid, and phenolic compounds characterise the Mediterranean model.

The variety of the diet is the prerequisite to obtaining the benefits in terms of health attributed to the Mediterranean model.

d. Data sources

National surveys, FAO food balance sheets.

e. Limitations of the indicator

f. Addional information

Argyropoulou, A., Aligiannis, N., Trougakos, I.P. & Skaltsounis, A.L. 2013. Natural compounds with anti-ageing activity. *Nat. Prod. Rep.*, 30(11): 1412–1437. doi: 10.1039/c3np70031c.

Bach, A., Serra-Majem, L., Carrasco, J.L., Roman, B., Ngo, J., Bertomeu, I. & Obrador, B. 2006. The use of indexes evaluating the adherence to the Mediterranean diet in epidemiological studies: a review. *Public Health Nutr.*, 9(1A): 132–146.

Falciglia, G.A., Horner, S.L., Liang, J., Couch, S.C. & Levin, L.S. 2009. Assessing dietary variety in children: development and validation of a predictive equation. *J. Am. Diet Assoc.*, 109(4): 641–647. doi: 10.1016/j.jada.2008.12.012.

Fransen, H.P. & Ocké, M.C. 2008. Indices of diet quality. *Curr. Opin. Clin. Nutr. Metab. Care*, 11(5): 559–565. doi: 10.1097/MCO.0b013e32830a49db.

Hashemi Kani, A., Alavian, S.M., Esmaillzadeh, A., Adibi, P. & Azadbakht, L. 2013. Dietary quality indices and biochemical parameters among patients with non alcoholic fatty liver disease (NAFLD). *Hepat. Mon.,* 13(7): e10943. doi: 10.5812/hepatmon.10943. eCollection 2013.

Kennedy, G., Berardo, A., Papavero, C., Horjus, P., Ballard, T., Dop, M., Delbaere, J. & Brouwer, I.D. 2010. Proxy measures of household food consumption for food security assessment and surveillance: comparison of the household dietary diversity and food consumption scores. *Public Health Nutr.*, 13(12): 2010–2018. doi: 10.1017/S136898001000145X.

Kourlarba, G. & Panagiotakos, D.B. 2009. Dietary quality indices and human health: a review. *Maturitas*, 62: 1–8.

Puchau, B., Zulet, M.A., de Echávarri, A.G., Hermsdorff, H.H. & Martínez, J.A. 2009. Dietary total antioxidant capacity: a novel indicator of diet quality in healthy young adults. *J. Am. Coll.Nutr.,* 28(6): 648–656.

Steyn, N.P., Nel, J., Labadarios, D., Maunder, E.M. & Kruger, H.S. 2014. Which dietary diversity indicator is best to assess micronutrient adequacy in children 1 to 9 y? *Nutrition*, 30(1): 55–60. doi: 10.1016/j.nut.2013.06.002.

Vyncke, K., Cruz Fernandez, E., Fajó-Pascual, M., Cuenca-García, M., De Keyzer, W., Gonzalez-Gross, M., Moreno, L.A., Beghin, L., Breidenassel, C., Kersting, M., Albers, U., Diethelm, K., Mouratidou, T., Grammatikaki, E., De Vriendt, T., Marcos, A., Bammann, K., Börnhorst, C., Leclercq, C., Manios, Y., Dallongeville, J., Vereecken, C., Maes, L., Gwozdz, W., Van Winckel, M., Gottrand, F., Sjöström, M., Díaz, L.E., Geelen, A., Hallström, L., Widhalm, K., Kafatos, A., Molnar, D., De Henauw, S. & Huybrechts, I. 2013. Validation of the Diet Quality Index for Adolescents by comparison with biomarkers, nutrient and food intakes: the HELENA study. *Br. J. Nutr.*, 109(11): 2067–2078. doi: 10.1017/S000711451200414X.

A6. DIETARY ENERGY DENSITY SCORE

a. Definition

This indicator measures the amount of energy in 100 g, or one kg, of diet as a proxy for healthy dietary patterns.

Share of energy supply provided by food groups other than cereals and starchy roots I, including liquid foods and alcohol, in the total dietary energy supply (DES).

b. Methodology

No agreed method (at least eight!).
Amount of energy in 100 g of diet.

c. Background

A growing body of laboratory-based, clinical and epidemiological data suggests that low-energy-dense diets are associated with better diet quality, lower energy intakes and body weight. Dietary protein, fibre, glycemic index and energy density influence, at least in short-term studies, energy intake. Moreover, an excess of foods high in energy density, yet which provide little vitamin and mineral intake at each meal, may negatively influence energy balance. The literature was reviewed in a study (Pérez-Escamilla *et al.*, 2012) concerning 17 studies (seven RCT, one non-RCT, and nine cohort studies) in adults and six cohort studies in children and adolescents. WHO in 2003 recommended reducing the energy density of the diet as a viable strategy to stem the global obesity epidemic. The 2010 Dietary Guidelines Advisory Committee for the American population confirmed that strong and consistent evidence in adults indicates that dietary patterns relatively low in energy density improve weight loss and weight maintenance. In addition, the Committee concluded that there was moderately strong evidence from methodologically rigorous longitudinal cohort studies in children and adolescents to suggest that there is a positive association between dietary energy density and increased adiposity.

However, diets with a lower energy density tend to be associated with higher food costs. Economic analyses have shown that calories provided by whole grains, fresh produce and lean meat were more expensive than calories from refined grains, added sugars and added fats. As a result, changes in consumer behaviour need to be accompanied by appropriate changes in food and nutrition policies.

d. Data sources

National surveys, FAO food balance sheets.

e. Limitations of the indicator

Data obtained from food balance sheets do not reflect the effective food intake, because they relate to the food quantities theoretically available for consumption; the amount of food consumed is lower than those reported in food balance sheets, due to the degree of losses of edible food and nutrients in the household, e.g. during storage, in preparation and cooking, as plate waste or quantities fed to domestic animals and pets, or thrown away. However, when national dietary surveys are not available the food balance sheets provide a good surrogate data by which to compare several countries and different time periods.

f. Addional information

McCrory, M.A., Burke, A. & Roberts, S.B. 2012. Dietary (sensory) variety and energy balance. *Physiol, Behav.*, 107(4): 576–583. doi: 10.1016/j.physbeh.2012.06.012.

Pérez-Escamilla, R., Obbagy, J.E., Altman, J.M., Essery, E.V., McGrane, M.M., Wong, Y.P., Spahn, J.M. & Williams, C.L. 2012. Dietary energy density and body weight in adults and children: a systematic review. *J. Acad. Nutr. Diet*, 112(5): 671–684. doi: 10.1016/j.jand.2012.01.020.

Rebello, C.J., Liu, A.G., Greenway, F.L. & Dhurandhar, N.V. 2013. Dietary strategies to increase satiety. *Adv. Food Nutr. Res.,* 69: 105–182. doi:10.1016/B978-0-12-410540-9.00003-X.

Roberts, S.B., Urban, L.E. & Das, S.K. 2014. Effects of dietary factors on energy regulation: Consideration of multiple- versus single-dietary-factor models. *Physiol. Behav.*, p. ii: S0031–9384(14)00215-7. doi: 10.1016/j.physbeh.2014.04.024.

Rolls, B.J. 2009. The relationship between dietary energy density and energy intake. *Physiol. Behav.*, 97(5): 609–615. doi: 10.1016/j.physbeh.2009.03.011.

Rolls, B.J., Drewnowski, A. & Ledikwe, J.H. 2005. Changing the energy density of the diet as a strategy for weight management. *Journal of the American Dietetic Association*, 105(5): 98–103.

Schwingshackl, L. & Hoffmann, G. 2013. Comparison of effects of long-term low-fat vs high-fat diets on blood lipid levels in overweight or obese patients: a systematic review and meta-analysis. *J. Acad. Nutr. Diet*, 113(12): 1640–1661. doi: 10.1016/j.jand.2013.07.010.

WHO. 2003. *Diet, nutrition and the prevention of chronic diseases*. Report of the Joint WHO/FAO Expert Consultation. Geneva, Switzerland.

A7. NUTRIENT DENSITY/QUALITY SCORE

a. Definition

The quality of given foods and of a whole diet can be defined by a high content in necessary nutrients, fibre and protective compounds, along with a low content in items to reduce or avoid – such as salt, sugar and saturated fat. The nutrient profile concept implies that it is possible to discriminate between foods according to their contribution to a healthy diet. Various scores have been raised to evaluate either the nutrient density of foods or the nutrient quality/adequacy of diets.

b. Methodology

Scores have been developed to evaluate the nutrient density of foods aiming at food profiling.

Nutrient density scores have been proposed: they could refer to either 100 g, 100 kcal/kJ or cost/kg or L of a given food. Also, various scores have been proposed to evaluate the nutrient quality or adequacy of global diets, especially the mean adequacy ratio(MAR). The MAR was initially described as a truncated index of the percent of daily recommended intakes for eight nutrients, including energy and protein. The last adaptation of MAR was based on the mean percentage of the recommended intakes for 23 key nutrients (available in a food-composition database).

c. Background

Various nutrient density scores have been proposed, referring to either 100 g, 100 kcal or cost of foods. Another recent score (agreed by the French food safety agency) is composed of SAIN (score of nutritional adequacy of individual foods based on recommended intakes), including a limited number of key nutrients (proteins, fibre, vitamin C, calcium and iron), along with a LIM score referring to recommended values for three nutrients (sodium, added sugar and saturated fat), the intakes of which should be limited in a healthy diet. The combination of these two scores provides four food rankings from the worst to the highest.

Various scores have been proposed to evaluate the nutrient quality or adequacy of diets. The MAR has been used to estimate the nutrient adequacy of the total diet. The MAR has been repeatedly shown to be positively associated with other indexes of diet quality, notably those estimating dietary diversity or variety (28, 30–34). Positive relationships with health indicators have been also reported (35, 36). The last adaptation of MAR was based on the mean percentage of the recommended intakes for 23 key nutrients (available in a food-composition database) included in the MAR score.

d. Data sources

National surveys and cohorts, food balance sheets.

e. Limitations of the indicator

All scores designed to evaluate the nutritional quality or nutrient density of either individual foods or whole diet have advantages and limitations. They must be taken into account depending on the precise context and objective considered. In all cases, accurate food intakes and nutrient-based food databases must be available.

f. Addional information

Azais-Braesco, V., Goffi, C. & Labouze, E. 2006. Nutrient profiling: comparison and critical analysis of existing systems. *Public Health Nutr.*, 9: 613–622.

Darmon, N., Vieux, F., Maillot, M., Volatier, J.L. & Martin, A. 2009.Nutrient profiles discriminate between foods according to their contribution to nutritionally adequate diets: a validation study using linear programming and the SAIN,LIM system. *Am. J. Clin. Nutr.,* 89: 1227–1236.

European Parliament/Council of the European Union. 2006. Regulation (EC) no 1924/2006 of the European Parliament and of the Council of 20 December 2006 on nutrition and health claims made on foods. *Off. J. Eur. Union*, L404: 9–25.

FAO. 2011. *Guidelines for measuring household and individual dietary diversity*. FAO, Rome.

Kant, A.K. 1996.Indexes of overall diet quality: a review. *J. Am. Diet Assoc*., 96(8): 785–791.

Maillot, M., Darmon, N., Vieux, F. & Drewnowski, A. 2007. Low energy density and high nutritional quality are each associated with higher diet costs in French adults. *Am. J. Clin. Nutr*., 86: 690–896.

A8. FOOD BIODIVERSITY COMPOSITION AND CONSUMPTION

a. Definition

Biodiversity covers diversity within species, between species and of ecosystems; synonyms: biological diversity, ecological diversity. For the purposes of human nutrition, biodiversity refers to foods identified at the taxonomic level below species (e.g. cultivar, breed) or by local varietal name, and wild, neglected and/or underutilized species. Biodiversity is distinctly different from “dietary diversity”, which reflects intake at the level of aggregate food groups.

b. Methodology

Indicator 1, Food composition: a count of the number of foods

- at variety/ cultivar/ breed level for common foods;
- species level for wild/indigenous/underutilized foods with at least one value for component found in published and unpublished resources.

Indicator 2, Food consumption:

- the taxonomic diversity of foods, as for food composition. Additional information will be reported on:
  - study (scope, date, number and description of subjects, geographical/ethnic coverage, instrument used; reference, total number of studies examined);
  - food (number of foods reported, food list);
- number of surveys with at least one reported food counting for biodiversity.

c. Background

The biodiversity indicators were deemed necessary in order to understand, quantify, and monitor the role of biodiversity in human nutrition, and the impact of biodiversity-related nutrition interventions and initiatives. They were developed as one of the important activities under the Cross-cutting Initiative on Biodiversity for Food and Nutrition (CBD, 2004, 2006ab), and within the framework of the Biodiversity Indicator Partnership (BIP, 2013), and they are monitored by FAO with a regular reporting schedule (FAO/INFOODS, 2013a).

d. Data sources

FAO/INFOODS compile data and report periodically (FAO/INFOODS, 2013b).

For Indicator 1, composition, data are obtained by searching peer-reviewed journals using the search engines Scopus and Science Direct, and through a call for data conducted via INFOODS (International Network of Food Data Systems). These data are then compiled in a Biodiversity Food Composition Database (Charrondiere *et al.*, 2012; FAO/INFOODS, 2013b).

Food consumption data from all surveys contribute to Indicator 2, including national nutrition surveys, market surveys, ethno-biological investigations and inventory studies. All published and unpublished available resources are searched including peer-reviewed journals, official international/regional/national/subnational survey reports, conference presentations and published, including posters, abstracts published from meetings and theses.

e. Limitations of the indicator

The development and reporting on the indicators are recent, and only two to three time points are available. The usefulness of the indicators should be assessed in the future, and judged against market survey data, as well as nutritional outcomes. For the moment, the results represent a reflection of the attention being paid to biodiversity by researchers designing food composition studies and dietary surveys.

f. Addional information

AFROFOODS. 2009. *Call for action from the door of return for food renaissance in Africa* (available at http://www.fao.org/fileadmin/templates/food_composition/documents/pdf/AFROFOOD_CALL_and_APPEL.pdf).

BIP. (Biodiversity Indicators Partnership). 2013. *Homepage* (retrieved 13 December 2013 from http://www.bipindicators.net/).

Burlingame, B., Charrondiere, U.R. & Mouille, B. 2009. Food composition is fundamental to the cross-cutting initiative on biodiversity for food and nutrition. *Journal of Food Composition and Analysis*, 22(5): 361–365.

CBD. 2004. *COP 7 Decision VII/32.* Seventh Meeting of the Conference of the Parties to the Convention on Biological Diversity, Kuala Lumpur, Malaysia, 9–20 February 2004 (available at http://www.cbd.int/decision/cop/default.shtml?id=7769).

CBD. 2006a. C*OP 8 Decision VIII/23.* Eighth Meeting of the Conference of the Parties to the Convention on Biological Diversity, Curitiba, Brazil, 20–31 March 2006 (available at http://www.cbd.int/agro/food-nutrition/default.shtml).

CBD. 2006b. *Agricultural biodiversity: a cross-cutting initiative on biodiversity for food and nutrition* (available at https://www.cbd.int/decision/cop/default.shtml?id=11037).

Charrondiere, U.R., Stadlmayr, B., Rittenschober, D., Mouille, B., Nilsson, E., Medhammar, E., Olango, T., Eisenwagen, S., Persijn, D., Ebanks, K., Nowak, V., Du, J. & Burlingame, B. 2012. FAO/INFOODS Food Composition Database for Biodiversity. *Food Chemistry*, 140: 408–412.

Englberger, L., Aalbersberg, W., Fitzgerald, M., Marks, G. & Chand, K. 2003. Provitamin A carotenoid content of different cultivars of edible pandanus fruit. *Journal of Food Composition and Analysis*, 16: 237–247.

Englberger, L., Aalbersberg, W., Schierle, J., Marks, G.C., Fitzgerald, M.H., Muller, F., Jekkein, A., Alfred, J., Vander Velde, N. 2006. Carotenoid content of different edible pandanus fruit cultivars of the Republic of the Marshall Islands. *Journal of Food Composition and Analysis,* 19: 484–494.

FAO. 2008. *Expert Consultation on Nutrition Indicators for Biodiversity – 1. Food Composition*. Rome (available at ftp://ftp.fao.org/docrep/fao/010/a1582e/a1582e00.pdf).

FAO. 2010. *Expert Consultation on Nutrition Indicators for Biodiversity – 2. Food Consumption.* Rome (available at http://www.fao.org/docrep/014/i1951e/i1951e00.htm).

FAO. 2013. *Review of key issues on biodiversity and nutrition*. Commission on Genetic Resources for Food and Agriculture, CGRFA–14/13/8. Rome.

FAO/INFOODS. 2013a. *FAO/INFOODS Report on the Nutrition Indicators for Biodiversity – Global Progress Report*. Rome, FAO (available at: http://www.fao.org/docrep/019/i3559e/i3559e.pdf).

FAO/INFOODS. 2013b. *FAO/INFOODS Food composition database for biodiversity version 2.1 – BioFoodComp2.1*. Rome, FAO (available at: http://www.fao.org/infoods/infoods/food-biodiversity/en/).

Huang, A.S., Tanudjaja, L. & Lum, D. 1999. Content of alpha-, betacarotene, and dietary fiber in 18 sweetpotato varieties grown in Hawaii. *Journal of Food Composition and Analysis*, 12: 147–151.

Toledo, A. & Burlingame, B. 2006. Biodiversity and nutrition: a common path toward global food security and sustainable development. *Journal of Food Composition and Analysis*, 19(6–7): 477–483.

A9. NUTRITIONAL ANTHROPOMETRY

This indicator is based on the BMI and waist circumference (WC) ,which is used in a wide variety of contexts as a simple method to assess how much an individual's body weight departs from what is normal or desirable for a person of his or her height and the metabolic risk due to abdominal obesity.

a. Definition

BMI in both men and women as a measure of underweight (< 18.5 kg/m^2) or different levels of overweight (25–29.9; 30–34.9; 35–39.9 ≥ 40 kg/m^2).

WC in both men and women as a measure of visceral adiposity (> 88 cm in women and 102 cm in men). Increased waist circumference also can be a marker for increased risk, even in people of normal weight associated also with insulin resistance.

As already stated in A1 indicator, over- and undernutrition frequently coexist weight loss, real to ideal weight ratio, and specific nutritional assessment tools (MNA, JANUS) may be useful to detect the presence of malnutrition.

b. Methodology

DHS – ICF Macro, DHS, MICS, WHO Global Database, Data locally available.
Undernutrition.
Indicator description: prevalence of individuals having a body mass index (BMI) <18.5 kg/m^2 calculated from self-reported weight and height.
Overweight or obesity
Indicator description: Prevalence of individuals having a body mass index (BMI) ≥25.0 kg/m^2 calculated from self-reported weight and height and/or W > 88 cm in women and 102 cm in men.

Classification of overweight and obesity by BMI, waist circumference and associated disease risk

			Disease risk* relative to normal weight and waist circumference	
	BMI (kg/m^2)	**Obesity class**	**Men 102 cm or less Women 88 cm or less**	**Men > 102 cm Women > 88 cm**
Underweight	< 18.5		–	–
Normal	18.5–24.9		–	–
Overweight	25.0–29.9		Increased	High
Obesity	30.0–34.9	I	High	Very high
	35.0–39.9	II	Very high	Very high
Extreme obesity	40.0 +	III	Extremely high	Extremely high

* Disease risk for type 2 diabetes, hypertension and CVD. http://www.nhlbi.nih.gov/health/public/heart/obesity/lose_wt/bmi_dis.htm

c. Background

Overweight and obesity are increasing worldwide and in developing countries, including Mediterranean countries. Overweight and obesity are defined in terms of BMI cut-off points (see table). Obesity is strongly associated with a number of chronic diseases, including diabetes mellitus, hypertension and cardiovascular diseases and increases the risk of mortality from these condition. The fundamental cause of obesity and overweight is an energy imbalance between calories consumed and calories expended. Globally, there has been an increased intake of energy-dense foods that are high in fat, salt and sugars but low in vitamins, minerals and other micronutrients and a decrease in physical activity due to the increasingly sedentary nature of many forms of work, changing modes of transportation and increasing urbanization. In many countries, recently it is possible to observe a decrease of underweight and an increase of overweight. Large disparities exist among different socio-economic classes and between urban and rural areas. It is important for policy-makers to have accurate information not only about obesity at national level, but also about how obesity varies across different populations and by socio-economic and demographic factors.

Many low- and middle-income countries are now facing a "double burden" of disease. While they continue to deal with the problems of infectious disease and undernutrition, they are experiencing a rapid upsurge in non-communicable disease risk factors such as obesity and overweight, particularly in urban settings. It is not uncommon to find undernutrition and obesity existing side-by-side within the same country, the same community and the same household.

The term "body mass index" (previously called the Quetelet Index from the nineteenth century) was firstly proposed in the July edition of 1972 in the *Journal of Chronic Diseases* by A Keys, which found the BMI to be the best proxy for body fat percentage among ratios of weight and height. It provides a simple numeric measure of a person's thickness or thinness. In different epidemiological studies, BMI was correlated with increased morbidity and mortality in all age classes, both in males and females, in different settings (free-living, hospitalized or institutionalised subjects), in different populations all over the world. Despite its limits in defining body composition, in particular in over- and undernutrition, it is still considered to be the screening tool with the best value for cost.

d. Data sources

National surveys, WHO.

e. Limitations of the indicator

Individuals tend to overestimate (by self-reporting) their height and underestimate their weight, leading to underestimation of BMI and of the prevalence of overweight and obesity. Self-reported national surveys might be subject to such systematic error resulting from non-coverage (e.g. lower telephone coverage among populations of low socioeconomic status), nonresponse (e.g. refusal to participate in the survey or to answer specific questions) or measurement (e.g. social desirability or recall bias). Data could be not available for some countries. For these reasons direct measurements are preferred.

f. Addional information

http://www.cdc.gov/nchs/data/nhanes/nhanes3/cdrom/nchs/manuals/anthro.pdf

http://www.fao.org/fileadmin/templates/food_composition/documents/Nutrition_assessment/c2.pdf

http://www.measuredhs.com

http://www.childinfo.org/mics.html

http://www.who.int/bmi/index.jsp

WHO. 1995. *Physical status: the use and interpretation of anthropometry.* Geneva, Switzerland.

A10. PHYSICAL ACTIVITY/PHYSICAL INACTIVITY PREVALENCE

a. Definition

Physical activity is defined as any bodily movement produced by skeletal muscles that requires energy expenditure. The term "physical activity" should not be mistaken with "exercise". Exercise, is a subcategory of physical activity that is planned, structured, repetitive, and purposeful in the sense that the improvement or maintenance of one or more components of physical fitness is the objective. Physical activity includes exercise as well as other activities which involve bodily movement and are done as part of playing, working, active transportation, house chores and recreational activities.

Due to differences in estimating physical activity, a global database for comparable estimates between countries-has been created. As physical activity indicator has been used the Physical inactivity prevalence defined as percentage of individuals not meeting any of the following criteria: at least 30 minutes of moderate-intensity activity per day on at least 5 days per week, or at least 20 minutes of vigorous-intensity activity per day on at least 3 days per week, or an equivalent combination (WHO Global Infobase).

b. Methodology

- STEPS instrument (GPAQ) Attributable DALYs from Physical Inactivity
- International Physical Activity Questionnaire-Short Form (IPAQ-SF):
- Physical inactivity prevalence:

c. Background

Sedentary lifestyles have become a worldwide phenomenon due to changing social and economic patterns all over the world. Sedentary lifestyles are associated with increased obesity, type 2 diabetes and cardiovascular disease. Insufficient physical activity is the fourth leading risk factor for mortality. Approximately 3.2 million deaths and 32.1 million DALYs (representing about 2.1 percent of global DALYs) each year are attributable to insufficient physical activity. People who are insufficiently physically active have a 20 to 30 percent increased risk of all-cause mortality compared to those who engage in at least 30 minutes of moderate intensity physical activity most days of the week. Globally in 2008, 31 percent of adults aged 15+ were insufficiently active (men 28 percent and women 34 percent). To monitor trends and evaluate public health or individual interventions aiming at increasing levels of physical activity, reliable and valid measures of habitual physical activity are essential. Several routine instruments are available to measure physical activity (self-report questionnaires, indirect calorimetry, direct observation, heart rate telemetry and movement sensors). However, due to the limitations of these methods, for physical activity there is currently no gold-standard criterion.

Different questionnaires have been proposed to evaluate physical activity levels. The International Physical Activity Questionnaire-Short Form (IPAQ-SF) has been recommended as a cost-effective method to assess physical activity (Lee, 2011).

The WHO developed a Global Activity Questionnaire (GPAQ), mainly applied in STEPS (STEPwise approach to non-communicable disease risk factor surveillance) surveys (http://www.who.int/chp/steps/en/) conducted in developing countries. The two questionnaires are comparable in terms of reliability and validity (WHO, 2010).

d. Data sources

National surveys, WHO Global Infobase.

e. Limitations of the indicator

Data on population-based physical inactivity may be limited in some countries. Most of the available data may be difficult to interpret due to differences in the way physical inactivity is measured.

f. Addional information

http://www.who.int/dietphysicalactivity/pa/en/index.html

http://www.who.int/chp/steps/instrument/en/index.html

http://www.who.int/healthinfo/global_burden_disease/GlobalHealthRisks_report_full.pdf

WHO Global Infobasehttps://apps.who.int/infobase/

Boon, R.M., Hamlin, M.J., Steel, G.D., & Ross, J.J. 2010. Validation of the New Zealand physical activity questionnaire (NZPAQ-LF) and the international physical activity questionnaire (IPAQ-LF) with accelerometry. *British Journal of Sports Medicine*, 44: 741–746. doi: 10.1136/bjsm.2008.052167.

Freedson, P.S. & Miller, K. 2000. Objective monitoring of physical activity using motion sensors and heart rate. *Research Quarterly for Exercise and Sport*, 71: S21–S30.

Jiang, C.Q., Thomas, G.N., Lam, T.H., Schooling, C.M., Zhang, W., Lao, X.Q., Adab, P., Leung, G.M. & Cheng, K.K. 2006. Cohort profile: the Guangzhou Biobank Cohort Study, a Guangzhou-Hong Kong-Birmingham collaboration. *International Journal of Epidemiology*, 35: 844–852. doi: 10.1093/ije/dyl131.

Knuth, A.G., Bacchieri, G., Victora, C.G. & Hallal, P.C. 2010. Changes in physical activity among Brazilian adults over a 5-year period. *Journal of Epidemiology and Community Health*, 64: 591–595. doi: 10.1136/jech.2009.088526.

Hu, F.B., Li, T.Y., Colditz, G.A., Willett, W.C. & Manson, J.E. 2003. Television watching and other sedentary behaviors in relation to risk of obesity and type 2 diabetes mellitus in women. *Journal of American Medical Association*, 289: 1785–1791. doi: 10.1001/jama.289.14.1785.

Montoye, H.J., Kemper, H.C.G., Saris, W.H.M. & Washburn, R.A. 1996. *Measuring physical activity and energy expenditure*. Champaign, Human Kinetics.

Terwee, C.B., Mokkink, L.B., van Poppel, M.N.M., Chinapaw, M.J.M., van Mechelen, W. & de Vet, H.C.W. 2010, Qualitative attributes and measurement properties of physical activity questionnaires: a checklist. *Sports Medicine*, 40: 525–537. doi: 10.2165/11531370-000000000-00000.

US Department of Health and Human Services. 2001. *The Surgeon General's call to action to prevent and decrease overweight and obesity*. US Department of Health and Human Services, Public Health Services, Office of the Surgeon General.

Warren, T.Y., Barry, V., Hooker, S.P., Sui, X., Church, T.S. & Blair, S.N. 2010. Sedentary behaviors increase risk of cardiovascular disease mortality in men. *Medicine and Science in Sports and Exercise*, 42: 879–885. doi: 10.1249/MSS.0b013e3181c3aa7e.

Welk, G.J. 2002. *Physical activity assessments for health-related research*. Champaign, Human Kinetics.

WHO. 2010. *Review of physical activity surveillance data sources in European Union Member States*, Report no 6. Copenhagen, Denmark.

3. Revision of the first ensemble of nutrition and health indicators for assessing the sustainability of the Mediterranean diet

From October 2014 to April 2015, the discussion on the first ensemble of nutrition and health indicators was continued by the working group. As its outcome, a revised set of indicators was produced and then assembled by Lorenzo M. Donini to be published in a scientific journal.

Experts: Donini Lorenzo M[1,10], Dernini Sandro[2,10], Berry Elliot[9,10], Lairon Denis[3,10], Serra-Majem Lluis[4,10], Trichopoulou Antonia[8], Maiani Giuseppe[7], Polito Angela[7], Amiot Marie-Josèphe[3,10], Burlingame Barbara[5], Belahsen Rekia[6], Turrini Aida[7], Intorre Federica[7], del Balzo Valeria[1,10], Giusti Anna-Maria[1,10].

[1] *Sapienza University of Rome, Italy*
[2] *Food and Agriculture Organization of the United Nations, Rome, Italy*
[3] *Aix Marseille University, INRA 1260, INSERM 1062, Marseille, France*
[4] *University of Las Palmas de Gran Canaria and CIBER OBN, Instituto de Salud Carlos III, Las Palmas, Spain*
[5] *Deakin University, Melbourne, Australia*
[6] *Chouaib Doukkali University, El Jadida, Morocco*
[7] *Council for Agricultural Research and Economics-Research Center on Food and Nutrition, Rome, Italy*
[8] *Hellenic Health Foundation, Athens, Greece*
[9] *Hebrew University-Hadassah, Jerusalem, Israel*
[10] *CIISCAM-International Inter-university Center for Mediterranean Food Culture studies*

A1. Diet-related morbidity/mortality statistics
A2. Fruit and vegetable consumption/intakes
A3. Vegetable/animal protein consumption ratios
A4. Average dietary energy adequacy
A5. Dietary diversity score
A6. Dietary energy density score
A7. Nutrient density of diet
A8. Food biodiversity composition and consumption
A9. Nutritional Anthropometry
A10. Physical activity/Physical inactivity prevalence
A11. Adherence to the Mediterranean dietary pattern
A12. Rate of Local/regional foods and seasonality
A13. Rate of eco-friendly food production and/or consumption

A1. DIET-RELATED MORBIDITY/MORTALITY STATISTICS

a. Definition

This indicator monitors mortality and morbidity (occurrence of cardiovascular events, type 2 diabetes, dyslipidemia, hypertension, osteoporosis, neurodegenerative diseases, and some types of cancer) as a proxy for the consumption of healthy diets.

b. Methodology

Parameters considered are:

- prevalence of individuals having physician-diagnosed obesity, cardiovascular diseases (CHD, stroke), type II diabetes, dyslipidemia, osteoporosis, neurodegenerative diseases, obesity-related cancers
- disability-adjusted life year (DALY) as a measure of overall disease burden expressed of years lost due to illness, disability or early death associated with nutrition related factors: high blood pressure, high cholesterol (total and LDL), high blood sugar (insulin resistance and or diabetes).

c. Background

The prevalence of obesity has increased worldwide and is a source of concern since the negative consequences of obesity start from childhood. Nutrition-related chronic diseases are increasing leading to disabilities and deaths in both industrialized and developing countries, including Mediterranean countries (WHO 2003; WCRF, 2007). The epidemiology of non-communicable diseases, such as cardiovascular diseases (CHD and stroke), diabetes and cancer, gastrointestinal diseases (in particular non-alcoholic fatty liver disease [NAFLD] and non-alcoholic steato-hepatitis [NASH]), respiratory diseases (obstructive sleep apnea syndrome [OSAS] and restrictive lung ventilatory dysfunction), mental illness and immune impairment, functional impairment (with increased disability), and the risk factors for these diseases (mainly obesity and the metabolic syndrome factors, abdominal obesity, hypertension, dyslipidemia, insulin-resistance as well as inflammation) are closely related to food consumption, dietary patterns, nutrition and lifestyles (Bastien *et al.*, 2014).

The excess of body fat (particularly visceral obesity) is associated with metabolic abnormalities and inflammatory status. In fact adipose tissue can now be considered as an endocrine organ orchestrating crucial interactions with vital organs and tissues such as the brain, liver, skeletal muscle, heart and blood vessels themselves. Inflammation is also associated with obesity and central adiposity and anaemia or iron deficiency coexisting in countries in nutrition transition. Moreover, obesity-related comorbidity and disability, together with psychological issues, impact on all aspects of an individual's quality of life (Kushner and Foster, 2000). Reports present alarming figures for the prevalence of this phenomenon, accounting for 63 percent of the 57 million total deaths in 2008 (WHO, 2011).

Finally there is to be noted that over- and undernutrition frequently coexist. In developing countries the nutritional transition is characterized by the double burden of a high prevalence of both malnutrition (still not eradicated) and obesity (depending on the shift in dietary consumption and energy expenditure that coincides with economic, demographic and epidemiological **changes leading to a transition from traditional diets high in cereal and fib**res to Western dietary patterns high in sugars, fat, and animal-source foods) (Gartner, 2004; Popkin, 1993; Hawkes, 2006). Moreover, even in "developed" countries and also in obese subjects, signs and symptoms can be found due to malnutrition (sarcopenic obesity; mineral-vitamin deficits in obese subjects and in immigrants; calorie-protein malnutrition in elderly subjects) (Driemeyer *et al.*, 2014).

d. Data sources

National surveys, WHO World Health Statistics (WHO Web sites).

e. Limitations of the indicator

Some pathologies can be undiagnosed or underreported in some countries. Data may not be available for the same age groups. If data are not available, mortality prevalence will be used.

f. Additional information

http://www.who.int/healthinfo/global_burden_disease/GlobalHealthRisks_report_full.pdf
http://www.who.int/mediacentre/factsheets/fs311/en/

Klop, B., Elte, J.W, & Cabezas, M.C. 2013. Dyslipidemia in obesity: mechanisms and potential targets. *Nutrients*., 5(4): 1218–1240. doi: 10.3390/nu5041218.

Kushner, R.F. & Foster, G.D. 2000. Obesity and quality of life. *Nutrition,* 16: 947–952.

Popkin, B.M. 1993. Nutritional patterns and transitions. *Population and Development Review,* 19(1): 138–157.

Taylor, V.H, ., Forhan, M., Vigod, S.N., McIntyre, R.S. & Morrison, K.M. 2013. The impact of obesity on quality of life. *Best Pract. Res. Clin. Endocrinol. Metab.,* 7(2): 139–146. doi: 10.1016/j.beem.2013.04.004.

WCRF. 2007. Report on Food, nutrition, physical activity and the prevention of cancer: a global perspective.

WHO. 2003. *Diet, nutrition and the prevention of chronic diseases*. Report of the Joint WHO/FAO Expert Consultation, Geneva.

WHO. 2011. *The global burden of non-communicable diseases*. Geneva.

Barone, D.A. & Krieger, A.C. 2013. Stroke and obstructive sleep apnea: a review. *Curr. Atheroscler. Rep.,* 15(7): 334. doi: 10.1007/s11883-013-0334-8.

Bastien, M., Poirier, P., Lemieux, I. & Després, J.P. 2014. Overview of epidemiology and contribution of obesity to cardiovascular disease. *Prog. Cardiovasc. Dis.,* 56(4):369–81. doi: 10.1016/j.pcad.2013.10.016.

Corrado, R.L., Torres, D.M. & Harrison, S.A. 2014. Review of treatment options for non-alcoholic fatty liver disease. *Med. Clin. North Am.,* 98(1): 55–72. doi: 10.1016/j.mcna.2013.09.001.

Diaz-Melean, C.M., Somers, V.K., Rodriguez-Escudero, J.P., Singh, P., Sochor, O., Llano, E.M. & Lopez-Jimenez, F. 2013. Mechanisms of adverse cardiometabolic consequences of obesity. *Curr. Atheroscler. Rep.,* 15(11): 364. doi: 10.1007/s11883-013-0364-2.

Driemeyer, Correja, Horvath, J., Dias de Castro, M.L., Kops, N., Kruger, Malinoski, N. & Friedman, R. 2014. Obesity coexists with malnutrition? adequacy of food consumption by severely obese patients to dietary reference intake recommendations. *Nutr. Hosp.,* 229(2): 292–299.

Gartner, A., El Ati, J., Traissac, P., Bour, A., Berger, J., Landais, E., El Hsaïni, H., Ben Rayana, C., Delpeuch, F. 2014. A double burden of overall or central adiposity and anemia or iron deficiency is prevalent but with little socioeconomic patterning among Moroccan and Tunisian urban women. *The Journal of Nutrition*, 144(1): 87–97.

Hawkes, C. 2006. Uneven dietary development: linking the policies and processes of globalization with the nutrition transition, obesity, and diet-related chronic diseases. *Global Health,* 2.4: 1–18.

A2. FRUIT AND VEGETABLE CONSUMPTION/INTAKES

a. Definition

This indicator is the measure of the consumption (g/capita/day) of fruit and vegetables, including pulses, nuts and seeds (Nishida *et al*., 2004), directly applicable to assessing adherence to MD, and as a proxy for a healthy diet and specific micronutrient intakes.

b. Methodology

Parameter considered:

- measure of the consumption (supply, availability, intake) of fruit and vegetables (g/capita/day), including pulses, nuts and seeds.

c. Background

The existing scientific evidence regarding a primary role for fruits and vegetables in preventing degenerative diseases, as well as in alleviating several micronutrient deficiencies especially in less developed countries, is consistent and trustworthy. Consumption of fruits and vegetables reduces the risk of cardiovascular disease convincingly. Their consumption is also associated with a decreased risk of colorectal cancer, type 2 diabetes, weight gain.

An additional daily serving of fruits or vegetables decreases the risk of CVD by about 4 percent (meta-analysis of Dauchet [2006] and He [2007]), a decrease of 20 percent for five servings equivalent to 400 g. The consumption of a greater variety of fruits and vegetables of different plant families (green leafy vegetables, fruits and vegetables rich in carotenoids, berries) has been associated with the reduction of cardiovascular diseases (Joshipura *et al*., 2009;,; Oude Griep *et al.*, 2010, 2011; Larsson *et al.,* 2013). Nutrition policies have strongly promoted the consumption of a diet containing at minimum 400 g/day of fruit and vegetables (excluding potatoes and other starchy tubers) as a nutritional goal for health promotion (WHO, 2003). Moreover, the diversity of fruit and vegetable contributes to the consumption of a wide variety of constituents of interest (fibres, vitamins, diverse phytochemicals such as polyphenols, glucosinolates, etc.) in the prevention of chronic diseases.

More and more evidence suggests that the health benefits of fruits, vegetables, whole grains and other plant foods are attributed to the additive or synergistic effects between fibres, vitamins, minerals and other phytochemicals, recognized to be healthy bioactive, in higher quantities in whole foods. Therefore, consumers could reach easier their daily nutrient requirements, and have other healthy beneficial bioactive compounds with a balanced diet composed of a wide variety of fruits, vegetables, whole grains and other plant foods for optimal nutrition, health and well-being, rather than from dietary supplements. Five portions of fruit and vegetable a day represent a public health version to promote eating fruit and vegetable (NOO, 2010) although others recommend >7 portions a day (Oyebode, 2014). Pulses, nuts, and seeds are separately indicated by the FAO/WHO Committee as at least 30 g/day/capita within the at least 400 g/day/capita of fruit and vegetables (Nishida *et al.,* 2004) (Table 1).

d. Data sources

National individual dietary surveys (IDS), household budget surveys (HBS), FAO food balance sheets (FBS).

e. Limitations of the indicator

Data obtained from food balance sheets do not reflect the effective food intake, because they relate to the food quantities available to the consumer (but not necessarily consumed). Thus, the amount of food consumed is usually lower than that reported in food balance sheets (Cialfa *et al.,* 1991), due to the degree of losses of edible food and nutrients in the household/catering, e.g. during storage, in preparation and cooking, as plate waste or quantities fed to domestic animals and pets, or thrown away. However, when national individual dietary surveys are not available, the HBS and/or FBS provide good indicators by which to compare several countries and different time periods.

Although it is not specified in official documents, considering the high proportion of waste often present in preparations of plant foods, it should be specified that the weight of 400 g daily refers to edible product net of waste (EURODIET, 2001; WHO, 2003; Nishida, 2004).

When using national supply data the reference value could be increased to take into account that goods include inedible parts. Moreover, 500 g/day are also recommended in some dietary guidelines (e.g. http://www.fao.org/nutrition/education/food-based-dietary-guidelines/regions/countries/finland/en/) and for ischaemic heart disease prevention (Tse *et al.,* 2011; Willet, 2006).

f. Additional information

Cialfa, E., Turrini, A. & Lintas, C. 1991. A national food survey. Food balance sheets and other methodologies: a critical overview. *In* I. Macdonald, ed. *ILSI monographs - Monitoring dietary intakes*, chap. 4, pp. 24–44.

EURODIET. 2001. Nutrition and diet for healthy lifestyles in Europe. A.G. Kafatos, AG (coordinator) (available at http://ec.europa.eu/health/archive/ph_determinants/life_style/nutrition/report01_en.pdf).

Nishida, C., Uauy, R., Kumanyika, S. & Shetty, P. 2004. The Joint WHO/FAO Expert Consultation on diet, nutrition and the prevention of chronic diseases: process, product and policy implications. *Public Health Nutrition,* 7(1A): 245–250.

NOO (National Obesity Observatory). 2010. *Review of dietary assessment methods in public health*. Solutions for Public Health, UK.

Oyebode, O., Gordon-Dseagu, V., Walker, A. & Mindell, J.S. 2014. *Fruit and vegetable consumption and all-cause, cancer and CVD mortality: analysis of Health Survey for England data*. JECH Online First, published on 31 March 2014 as 10.1136/jech-2013-203500.

Tse, H-F., Lip, G.Y. & Coats, A.J.S., eds. 2011. Diets and ischaemic heart disease. In *Oxford Desk Reference: Cardiology,* chap. 5.2, pp. 139–212.

WHO. 2003. *Diet, nutrition and the prevention of chronic diseases*. Report of the Joint WHO/FAO Expert Consultation, Geneva (available at http://www.who.int/dietphysicalactivity/publications/trs916/download/en/).

Willet, W.C. 2006. The Mediterranean diet: science and practice. *Public Health Nutrition*, 9: 105–110.

A3. PLANT AND ANIMAL PROTEIN CONSUMPTION RATIOS

a. Introduction

Plant-based diets have long been associated with lower risk of cardiovascular diseases (Kritchevsky, 1979), certain cancers, hypertension (Alonso *et al.,* 2006), obesity, inflammation and metabolic stresses. In many cases, it is thought that the non-haem proteins of plant origin are responsible, at least in part, for the benefits. Metabolic studies have shown that intake of haem protein is associated with higher inflammation markers due to the fact that it contains more iron than non-haem protein (Vallianou *et al.,* 2013), and a number of clinical studies demonstrate that animal protein is more cholesterolemic and atherogenic than vegetable protein. Moreover, diets that are rich in animal foods and lower in plant foods, typical of industrialized countries, lead to a higher net acid load that has a negative effect on calcium balance (Sellmeyer *et al.,* 2001). In metabolically stressed patients, both inadequate and excessive protein can cause problems.

In many developing countries with high prevalences of malnutrition and food insecurity, animal source proteins are relied upon as a dependable and sustainable solution for improving diet quality. Introducing animal-source foods to largely plant-based diets has been shown to reduce the prevalence of stunting in children and other manifestations of malnutrition (WHO, 2003).

As a crude generalization, production systems for animals require much more land area, water and energy inputs, and produce more greenhouse gas (GHG) emissions than production systems for most food plants (Macdiarmid *et al.,* 2012). Thus, animal-source proteins have a higher environmental impact than plant-based proteins (Carlsson-Kanyama and Gonzales, 2009).

Therefore developing countries will strive to decrease the plant:animal protein ratio, while developed countries with high prevalences of non-communicable disease and overweight/obesity will strive to increase the ratio. Regardless, the epidemiology of protein intake forms a bell-shaped curve, with the lowest and the highest levels contributing to the greatest risk for human health. For environmental sustainability, the plot is a straight line, i.e. the higher the intake the greater the threat to environmental sustainability.

The optimal dietary protein ratio needs to be agreed as a basic assumption for this indicator, ideally with the traditional Mediterranean diet (MD) as the standard. The ratio is likely to be at least 4:1, plant to animal. From this, dietary patterns can be assessed for sustainable diets, with the understanding that protein-related sustainability and nutrition-related goals, both for populations and individuals, will be different across the spectrum of countries and regions (Masset *et al*., 2014).

b. Definition

This indicator is a ratio of the relative intakes of protein from plant and animal sources, assessing adherence to an optimal dietary pattern, and a proxy for environmental impact of diets.

c. Methodology

Parameter considered:

- ratio of plant (cereals, vegetables, pulses, fruit) and animal (meat, fish, eggs, dairy products) proteins in the diet using existing data.

Adherence to an optimal ratio, including the MD, can be judged by simple comparison, and the trend can be monitored over the time series of available data, regardless of the data source.

d. Background

Dietary protein can be expressed in different ways, with four major dimensions for consideration: source, quality, quantity and impact. Source can be presented at several levels of aggregation, from the crude classification of kingdoms (plant, animal), to finer divisions, e.g. terrestrial and aquatic, through to the most disaggregated taxonomic levels of subspecies, variety, cultivar and breed, reflecting biodiversity.

The most basic classification for dietary protein, with the most available data, is a simple division into plant- and animal-source. This classification is a useful proxy for nutritional quality, as the amino acid patterns of animal-source foods are better suited to human requirements, and a somewhat useful proxy for environmental sustainability, at least in terms of GHG emission and land/water use, with plant source performing better than animal source.

e. Data sources

FAOSTAT food balance sheets and commodity balances provide data for domestic availability of a food, and food component in the case of protein (FAO, 2015). The contributing data include the sum of production and imports, with exports and non-food use subtracted. New modules to the FAOSTAT family of databases, including land use, emission, pesticide, fertilizer and irrigation, will provide more data on environmental sustainability when analysed with protein ratio data. Food consumption studies, national nutrition surveys, household budget surveys, etc. will be available in some countries to augment or replace FAOSTAT data.

f. Limitations of the indicator

FAOSTAT data from food balance sheets and commodity balances reflect domestic availability of foods, not consumption or production *per se*. While these data have proven useful for assessing nutritional adequacy of diets, with a long history of use, they may significantly misrepresent sustainability issues. For example, livestock production has a greater role in GHG emission than livestock consumption. If meat is imported rather than domestically produced, the calculation of environmental impact may be skewed if using food balance or commodity balance datasets. Similarly, national nutrition surveys do not address the issue of production. Food losses and waste not accounted for in the datasets will affect the calculations and interpretation. Additionally, the advantages of using plant:animal protein ratio, as opposed to plant:animal dietary energy ratio or plant:animal ratio in grams per person per day, need to be elaborated.

g. Additional information

Alonso, A., Beunza, J.J., Bes-Rastrollo, M., Pajares, R.M.& Martínez-González, M.A. 2006. Vegetable protein and fiber from cereal are inversely associated with the risk of hypertension in a Spanish cohort. *Arch. Med. Res.,* 37(6): 778–786.

Carlsson-Kanyama, A. & Gonzalez, A.D. 2009. Potential contributions of food consumption patterns to climate change. *Am. J. Clin. Nutr*., 89: 1704S–1709S.

FAO. 2015. FAOSTAT http://faostat3.fao.org/browse/FB/*/E. Accessed 20 April 2015.

Kritchevsky. D. 1979. Vegetable proteins and atherosclerosis. *Journal of the American Oil Chemists' Society,* 3: 135–140.

Macdiarmid, J.I., Kyle, J., Horgan, G.W., Loe, J., Fyfe, C., Johnstone, A. & McNeill, G. 2012. Sustainable diets for the future: can we contribute to reducing greenhouse gas emissions by eating a healthy diet? *Am. J. Clin. Nutr.,* 96: 632–639.

Masset, G., Soler, L.G., Vieux, F. & Darmon, N. 2014. Identifying sustainable foods: the relationship between environmental impact, nutritional quality and prices of foods representative of the French diet. *J. Acad. Nutr. Diet*, 114: 862–869.

Sellmeyer, D.E., Stone K.L., Sebastian, A. & Cummings. S.R. for the Study of Osteoporotic Fractures Research Group. 2001. A high ratio of dietary animal to vegetable protein increases the rate of bone loss and the risk of fracture in postmenopausal women. *Am. J. Clin. Nutr.,* 73: 118–122.

Vallianou, N.G., Bountziouka, V.P., Georgousopoulou, E., Evangelopoulos, A.A., Bonou, M.S., Vogiatzakis, E.D., Barbetseas, J.D., Avgerinos, P.C., & Panagiotakos, D.B. 2013. Influence of protein intake from haem and non-haem animals and plant origin on inflammatory biomarkers among apparently-healthy adults in Greece. *J. Health Popul. Nutr.,* 31(4): 446–454.

WHO. 2003. Diet, nutrition and the prevention of chronic diseases: report of a joint WHO/FAO expert consultation, Geneva.

World Bank. 2015. Global Consumption Database (available at http://datatopics.worldbank.org/consumption/).

Yoon, G.A. & Hwang, H.J. 2006. Effect of soy protein/animal protein ratio on calcium metabolism of the rat. *Nutrition*, 22(4): 414–418.

A4. AVERAGE DIETARY ENERGY ADEQUACY

a. Definition

The indicator expresses the dietary energy supply (DES) as a percentage of the average dietary energy requirement (ADER) in the country. Each country's or region's average supply of calories for food consumption is normalized by the average dietary energy requirement estimated for its population, to provide an index of the adequacy of the food supply in terms of calories. This indicator was proposed by FAO as new approach for the measurement of food security (FAO, 2013).

b. Methodology

Parameters considered:

- DES (kcal/capita/day): average supply available for each individual in the total population (it does not indicate what is actually *consumed* by individuals);
- ADER (kcal/capita/day): the amount of food energy needed to balance energy expenditure in order to maintain body size, body composition and a level of necessary and desirable physical activity consistent with long-term good health.

c. Background

The aetiologies implicated in obesity and related comorbidities are multifactorial and include geneticXenvironmental factors (Serra-Majem and Bautista-Castaño, 2013). Evidence suggests that a large percentage of obesity cases involve a clear (toxic) environmental component linked to sedentary lifestyles and dietary habits that lead to positive energy balance and, as a result, the gradual, relentless accumulation of fatty tissue. Diverse epidemiological studies describe a direct relationship between an increased body mass index, when correlated with an increase in fat mass, and mortality (Gupta, Krueger and Lastra, 2012).

On the contrary, based on its known benefits to cardiometabolic health, including modest calorie restriction in a combined lifestyle programme, the Mediterranean diet is likely to improve heart health and prevent subsequent cardiovascular events both in normal weight and in overweight/obese individuals (Paullaf *et al*., 2013). Calorie restriction may represent, both in animal models and humans, an important way to counteract ageing effects by reducing the ageing-related functional decline and by preventing the occurrence of age-related diseases (Bales and Kraus, 2013; Chung *et al*., 2013). In particular, calorie restriction may modulate deleterious chronic inflammation at molecular levels and the impact of epigenetic chromatin and histone modifications at the ultimate control sites of gene expression (Martin-Montalco and de Cabo, 2013; Kowaltowski, 2011).

The dietary energy intake represents the metabolizable energy content of food (expressed as kcal or kJ) provided by the four macronutrient categories (i.e. carbohydrate, protein, fat and alcohol) and together with the total energy expenditure defines the energy balance. Data on food consumption can be derived from national individual dietary surveys (IDS), food balance sheets (FBS) or household budget urvey (HBS), each method having well-documented weaknesses. Notwithstanding IDS are one of the most accurate (and costly) methods for obtaining data on food consumption, the per capita DES, providing continuous and comparable information for large-scale population studies, can be however considered as a population-based proxy for consumption. However, as a nutritional and health indicator of a sustainable diet, it could be better to use the average dietary supply adequacy. This indicator was proposed by FAO as new approach for the measurement of food security (FAO, 2013). It embraces requirements, i.e. also energy expenditure, and consequently considers the energy balance that has to be maintained in order to avoid under- or overnutrition conditions, measures the adequacy of the national food supply in terms of calories and helps understanding whether undernourishment is mainly due to insufficient food supply or to bad distribution.

d. Data sources

Data can be downloaded from http://www.fao.org/economic/ess/ess-fs/ess-fadata/en/#. Otherwise DES can be obtained from national individual dietary surveys, household budget surveys, food balance sheets and ADER from national energy requirements, FAO human energy requirements.

e. Limitations of the indicator

National individual dietary surveys using food diaries or dietary recalls estimate the actual consumption (i.e. the dietary energy intake), provide the best evidence on food consumption and constitute the best method for assessing energy intake and more generally dietary patterns and evaluating diet-disease associations. Being expensive and labour-intensive, these surveys are undertaken only in a limited number of countries, often at regional or local level or in specific population groups; furthermore, it is difficult to accomplish comparability at the international level, because the assessment methods are variable, self-reported and consequently subject to considerable measurement errors. In order to overcome these problems, the per capita dietary energy supply (DES) can be used instead of the dietary energy intake. Data on DES can be gathered from FBS and HBS. FBS and HBS overestimate energy intake, although not in a linear way: while FBS includes eating out, HBS does not; food losses and waste should be considered. In order to reduce the impact of possible errors in estimated DES, due to the difficulties in properly accounting of stock variations in major food, the indicator is calculated as an average over three years (for example, 2010–2012, 2011–2013, 2012–2014).

ADER is a reference for adequate nutrition in the population. The recommended level of dietary energy intake for a population group is the mean energy requirement of the healthy, well-nourished individuals who constitute that group. The estimates of requirements are derived from measurements of a collection of individuals of the same age, gender, body size, presumed body composition and physical activity, and are grouped to give the average energy requirements for a class of people or a population group. These requirements are used together to predict the requirements of other individuals with similar characteristics, but on whom measurements have not been made. Consequently, application of these results to any one individual for clinical or other purposes may lead to errors of diagnosis and improper management (FAO, 2001). On the other hand, data on the size of the consumed food portion that influence energy intake need to be evaluated (Rolls *et al*.,2002), as positive relationships between portion size and energy intake have been demonstrated in adults (Diliberti *et al.,* 2004; Ello-Martin *et al.,* 2006, Lioret *et al.*, 2009).

f. Additional information

Bales, C.W. & Kraus, W.E. 2013. Caloric restriction: implications for human cardiometabolic health. *J. Cardiopulm. Rehabil. Prev.*, 33(4): 201–208. doi: 10.1097/HCR.0b013e318295019e.

Chung, K.W., Kim, D.H., Park, M.H., Choi, Y.J., Kim, N.D., Lee, J., Yu, B.P. & Chung, H.Y. 2013. Recent advances in calorie restriction research on aging. *Exp. Gerontol.*, 48(10): 1049–1053. doi: 10.1016/j.exger.2012.11.007.

Diliberti, N., Bordi, P.L., Conklin, M.T., Roe, L.S. & Rolls, B.J. 2004. Increased portion size leads to increased energy intake in a restaurant meal. *Obes. Res.,* 12:, 562–568.

Ello-Martin, J.A., Ledikwe, J.H. & Rolls, B.J. 2005. The influence of food portion size and energy density on energy intake: implications for weight management. *Am. J. Clin. Nutr.,* 82: 236S–241S.

FAO. 2001. *Human energy requirements.* Report of a joint FAO/WHO Expert Consultation. Rome.

FAO. 2013. *Statistical Yearbook*. Rome.

Gupta, D., Krueger, C.B. & Lastra, G. 2012. Over-nutrition, obesity and insulin resistance in the development of B-cell dysfunction. *Curr. Diabetes Rev.*, 8(2): 76–83.

Kowaltowski, A.J. 2011. Caloric restriction and redox state: does this diet increase or decrease oxidant production? *Redox Rep.*, 16(6): 237–241. doi: 10.1179/1351000211Y.0000000014.

Lioret, S., , J-L Volatier, J-L., Lafay, L., Trouvier, M. & Maire, B. 2009. Is food portion size a risk factor of childhood overweight?. *EJCN,* 63: 382–391.

Martin-Montalvo, A. & de Cabo, R. 2013. Mitochondrial metabolic reprogramming induced by calorie restriction. *Antioxid. Redox Signal*, 19(3): 310–320. doi: 10.1089/ars.2012.4866. Epub 2012 15 October.

Pallauf, K., Giller, K., Huebbe, P. & Rimbach, G. 2013. Nutrition and healthy ageing: calorie restriction or polyphenol-rich "MediterrAsian" diet? *Oxid. Med. Cell Longev.*, Article ID 707421. doi: 10.1155/2013/707421.

Rolls, B.J., Morris, E.L. & Roe, L.S. 2002. Portion size of food affects energy intake in normal-weight and overweight men and women. *Am. J. Clin. Nutr.*, 76: 1207–1213.

Serra-Majem, L. & Bautista-Castaño, I. 2013. Etiology of obesity: two "key issues" and other emerging factors. *Nutr. Hosp*., Suppl 5: 32–43. doi:10.3305/nh.2013.28.sup5.6916.

A5. DIETARY DIVERSITY SCORE

a. Definition

Dietary diversity is a qualitative measure of the household access and consumption of a wide variety of foods. It is an indicator that reflects the households' diet quality and is also a proxy for the adequacy of nutrient intake of the diet for individuals (FAO, 2007; Hoddinott and Yohannes, 2002; USDA, 1996). This concept is based on the fact that the needs in nutrients are not covered by a single food but by a diet composed of several foods.

It is associated with household socio-economic status and food security (energy availability at the household level). A greater dietary diversity was also reported to protect different households against the double burden of malnutrition known in countries in nutrition transition (Deleuze Ntandou Bouzitou, Fayomi and Delisi, 2005; Savy *et al.*, 2005; Bezerra and Sichieri, 2011).

b. Methodology

Parameters considered:

- dietary diversity scores (DDS) defined as the number of food groups consumed over a reference period:
  - individual dietary diversity score (IDDS): used as proxy of the nutritional quality of individual diet has for aim to assess the adequacy of nutrient intake;
  - dietary diversity score at the household level (HDDS) is used, on the other hand, as proxy of the socio-economic level of the household and intends to reflect, the economic ability of a household to consume a variety of foods;
- dietary variety score (DVS) (Drewnowski *et al.*, 1996) corresponding to the number of foods consumed among a list of foods;
- US healthy food diversity index (Vadiveloo *et al*., 2014) a tool for the simultaneous measurement of dietary variety, quality and proportionality at individual level.

c. Background

Food-based dietary guidelines (FBDG) aim to address the nutritional requirements at population level in order to prevent diseases and promote a healthy lifestyle. Overall diet quality measurements have been suggested as a useful tool to assess diet–disease relationships. Diet quality indices can be used to assess the compliance with these FBDG.

The comparative study highlights the similarities and differences between the different tools aimed at analysing food consumption through dietary diversity scores. The choice of indicator for food diversity or quality assessment and surveillance will vary depending on user needs. Households' food availability in the last decades is increasing, with industrial foods replacing and shifting the diverse to monotone traditional foods (Levy-Costa *et al.*, 2005) associated with an increase of many health problems.

Note that the variety of the diet is the prerequisite to obtaining the benefits in terms of health attributed to the Mediterranean model (Bach *et al*., 2006; Argyropoulou *et al*., 2013; Fransen and Ocké, 2008). A higher diversity index was reported to be protective from the risk of cardio-vascular diseases, diabetes type II and hypertension and cancer in American male (DeKoning *et al*., 2011; Vadiveloo *et al.*, 2015). It has been shown that higher US HFD index values were inversely associated with indicators of body adiposity in both sexes, indicating that greater healthful food variety may protect against excess adiposity (Vadiveloo *et al.*, 2015). Both types of scores DDS and DVS are based on the same principle, but depend on the level of disaggregation of the food groups and even the definition of a food. Both types of scores allow a rapid approach, easy and inexpensive, to measure changes of the diet quality at household and individual levels (Steyn *et al.*, 2014; HashemiKani *et al.*, 2013; Vyncke *et al.*, 2013). The questionnaire filling and data analysis are simple and quick. They have been linked to socio-economic characteristics of individuals or households. In most cases, these indexes have been studied in relationship with individuals' nutritional status, assessed by anthropometric measurements. The indexes have been studied in relation to their relationships with states of health and in this case they are developed mainly in industrialized countries (Kennedy *et al.*, 2010; Puchau *et al.*, 2009; Falciglia *et al.*, 2009). The US healthy food diversity (HFD) index has been developed to measure dietary variety, dietary quality and proportionality according to the 2010 Dietary Guidelines for Americans (DGA) US HFD can range between 0 (poor) and 1 - 1/n, where n is the number of foods. This score is maximized by consuming a variety of foods in proportions recommended by the 2010 DGA. It is positively correlated with nutrient-dense foods including whole grains, fruits, orange, vegetables and low-fat dairy and negatively correlated with added sugars and lean meats. Moreover, it is positively correlated with the mean probability of adequacy for 13 nutrients among 15 tested.

The health problems concerned essentially disorders associated with overweight/obesity, cardiovascular diseases and cancers. Although having the ambition to reflect the overall quality of the diet, these indexes are more or less complex, mixing or not quantity to the quality aspects based on thresholds or recommendations. Indeed, the construction of these diversity indexes has sometimes incorporated frequency of food consumption and the number of portions of some food groups, according to dietary recommendations (Kourlarba and Panagiotakos, 2009;. Kant *et al.,* 1991, 2000; Wahlqvist *et al.,* 1989; Miller *et al.,* 1992; Fernandez *et al.,* 1996; Hatloy *et al.,* 2000; Lowik *et al.,* 1999; Le Torheim *et al.,* 2004).

d. Data sources

Usually specific questionnaires are administered. The use of national individual dietary surveys (IDS), household budget surveys (HBS) and FAO food balance sheets (FBS) needs to be experimented.

e. Limitations of the indicator

Even if there is a preference for the dietary diversity scores based on food groups, the issues of the number and the choice of these food groups have not yet been resolved. The selection of food groups can be guided by the objectives for which the scores are used.

For example, if the score of diversity is used to identify populations at risk of micronutrient deficiency, the classification used should distinguish foods groups depending on their content in micronutrients. In this case, it is obvious that comparisons between studies or countries are more difficult.

Moreover it has to be considered that the diversity scores have been designed specifically for developing countries without regularly carried out national statistics about this topic.

f. Additional information

Argyropoulou, A., Aligiannis, N., Trougakos, I.P. & Skaltsounis, A.L. 2013. Natural compounds with anti-ageing activity. *Nat. Prod. Rep.*, 30(11): 1412–1437. doi: 10.1039/c3np70031c.

Bach, A., Serra-Majem, L., Carrasco, J.L., Roman, B., Ngo, J., Bertomeu, I. & Obrador, B. 2006. The use of indexes evaluating the adherence to the Mediterranean diet in epidemiological studies: a review. *Public Health Nutr.,* 9(1A): 132–146.

Bezerra, I.N. & Sichieri, R. 2011. Household food diversity and nutritional status among adults in Brazil. *International Journal of Behavioral Nutrition and Physical Activity*, 8: 22.

DeKoning, L., Chiuve, S.E., SE, Fung, T.T., , Willett, W.C., Rimm, E.B. & Hu, F.B. 2011. Diet-quality scores and the risk of type 2 diabetes in men. *Diabetes Care*, 34: 1150–1156.

Deleuze Ntandou Bouzitou, G., Fayomi, B. & Delisl, H. 2005. *Cahiers Santé*, 15(4) October-November-December.

Drewnowski, A., Henderson, S.A., Shore, A.B. ***et al.*** D1996. Diet quality and dietary diversity in France: implications for the French paradox. *Journal of American Dietetic Association,* 96(7): 663–669.

Falciglia, G.A., Horner, S.L., Liang, J., Couch, S.C. &, Levin, L.S. 2009. Assessing dietary variety in children: development and validation of a predictive equation. *J. Am. Diet Assoc.,* 109(4): 641–647. doi: 10.1016/j.jada.2008.12.012.

FAO. 2007. *Guide pour la mesure de la diversité alimentaire au niveau des individus et des ménages*. Rome.

Fernandez, E., D'Avanzo, B., Negri, E. ***et al.*** 1996. Diet diversity and the risk of colorectal cancer in northern Italy. *Cancer Epidemiology, Biomarkers and Prevention,* 5(6): 433–436.

Fransen, H.P. & Ocké, M.C. 2008. Indices of diet quality. *Curr. Opin. Clin. Nutr. Metab. Care.,* 11(5): 559–565. doi: 10.1097/MCO.0b013e32830a49db.

HashemiKani, A., Alavian, S.M., Esmaillzadeh, A., Adibi, P. &, Azadbakht, L. 2013. Dietary quality indices and biochemical parameters among patients with non alcoholic fatty liver disease (NAFLD). *Hepat. Mon.,* 13(7): e10943. doi: 10.5812/hepatmon.10943. eCollection 2013.

Hatloy, A., Hallund, J., Diarra, M.M. ***et al.*** 2000. Food variety, socioeconomic status and nutritional status in urban and rural areas in Koutiala (Mali). *Public Health Nutrition,* 3(1): 57–65.

Hoddinott, J. & Yohannes ,Y. 2002. *Dietary diversity as a household food security indicator.* Projet d'Assistance technique en Alimentation et Nutrition, Académie pour le Développement de l'Education, Washington, DC (available at www.fantaproject.org/publications/dietdiversity1.shtml).

Kant, A.K., Block, G., Schatzkin, A. ***et al.*** 1991. Dietary diversity in the US population, NHANES II, 1976-1980. *Journal of American Dietetic Association,*; 91(12): 1526–1531.

Kant, A.K., Schatzkin, A., Graubard, B.I. ***et al.*** 2000. A prospective study of diet quality and mortality in women. *Journal of the American Medical Association,* 283(16): 2109–2115.

Kennedy, G., Berardo, A., Papavero, C., Horjus, P., Ballard, T., Dop, M., Delbaere, J. & Brouwer, I.D. 2010. Proxy measures of household food consumption for food security assessment and surveillance: comparison of the household dietary diversity and food consumption scores. *Public Health Nutr.,* 13(12): 2010–2018. doi: 10.1017/S136898001000145X.

Kourlarba, G. & Panagiotakos, D.B. 2009. Dietary quality indices and human health: a review. *Maturitas*, 62: 1–8.

Le Torheim, F., Ouattara, M.M., Diarra, F,D., Thiam, I., Barikmo, A., Hatly, A. & Oshaug, A. 2004. Nutrient adequacy and dietary diversity in rural Mali: association and determinants. *European Journal of Clinical Nutrition*, 58: 594–604.

Levy-Costa, R.B., Sichieri, R., Pontes, N. . & Monteiro, C.A. 2005. Household food availability in Brazil: distribution and trends (1974-2003). *Rev. Saúde Pública*, 39: 530–540.

Lowik, M.R., Hulshof, K.F. & Brussaard, J.H. 1999. Food-based dietary guidelines: some assumptions tested for The Netherlands. *British Journal of Nutrition,* 81 Suppl. 2: S143–S149.

Miller, W.L, Crabtree, B.F. & Evans, D.K. 1992. Exploratory study of the relationship between hypertension and diet diversity among Saba Islanders. *Public Health Reproduction*, 107(4): 426–432.

Puchau, B., Zulet, M.A., de Echávarri, A.G., Hermsdorff, H.H. & Martínez, J.A. 2009. Dietary total antioxidant capacity: a novel indicator of diet quality in healthy young adults. *J. Am. Coll. Nutr.,* 28(6): 648–656.

Savy, M., Martin-Prevel, Y., Sawadogo, P., Kameli. & Delpeuch, F. 2005. Use of variety/diversity scores for diet quality measurement: relation with nutritional status of women in a rural area in Burkina Faso. *European Journal of Clinical Nutrition*, 59: 703–716.

Steyn, N.P., Nel, J., Labadarios, D., Maunder, E.M. & Kruger, H.S. 2014. Which dietary diversity indicator is best to assess micronutrient adequacy in children 1 to 9 y? *Nutrition*, 30(1): 55–60. doi: 10.1016/j.nut.2013.06.002.

USDA (US Department of Agriculture). 1996. *Food guide pyramid*. Washington, DC.

Vadiveloo, M., Dixon, L.B,, Mijanovich, T.,, Elbel, B. & Parekh, N. 2015. Dietary variety is inversely associated with body adiposity among US adults using a novel food diversity index. *J. Nutr.*, 145(3): 555–563.

Vadiveloo, M., Dixon, L.B., Mijanovich, T., Elbel, B. & Parekh, N. 2014. Development and evaluation of the US Healthy Food Diversity index. *Br. J. Nutr.,* 112: 1562–1574.

Vyncke, K., Cruz Fernandez, E., Fajó-Pascual, M., Cuenca-García, M., De Keyzer, W., Gonzalez-Gross, M., Moreno, L.A., Beghin, L., Breidenassel, C., Kersting, M., Albers, U., Diethelm, K., Mouratidou, T., Grammatikaki, E., De Vriendt, T., Marcos, A., Bammann, K., Börnhorst, C., Leclercq, C., Manios, Y., Dallongeville, J., Vereecken, C., Maes, L., Gwozdz, W., Van Winckel, M., Gottrand, F., Sjöström, M., Díaz, L.E., Geelen, A., Hallström, L., Widhalm, K., Kafatos, A., Molnar, D., De Henauw, S. & Huybrechts. I. 2013. Validation of the diet quality index for adolescents by comparison with biomarkers, nutrient and food intakes: the HELENA study. *Br. J. Nutr.*, 109(11): 2067–2078. doi: 10.1017/S000711451200414X.

Wahlqvist, M.L., Lo, C.S. & Myers, K.A. 1989. Food variety is associated with less macrovascular disease in those with typeII diabetes and their healthy controls. *Journal of the American College of Nutrition*, 8(6): 515–523.

A6. DIETARY ENERGY DENSITY SCORE

a. Definition

This indicator measures the amount of energy (kcal or kJ) in a given weight (g, 100 g, kg) of diet as a proxy for healthy dietary patterns

b. Methodology

Parameter considered:

- dietary energy density (kcal/g) calculated by dividing total dietary energy by the edible weight of foods and caloric beverages consumed. The primary data are:
  - the mean amounts of various foods/beverages or foods groups consumed daily;
  - the energy provided by weight unit of the foods/beverages or foods groups as provided by food composition databases. It will be expressed as the amount of energy (kcal or kJ) in 100 g or one kilo of daily diet.

c. Background

A growing body of laboratory-based, clinical and epidemiological data suggests that low-energy-dense diets are associated with better diet quality, lower energy intakes and body weight. Dietary protein, fibre, glycaemic index and energy density influence, at least in short-term studies, energy intake. Moreover, an excess of foods displaying high energy density, providing low vitamin and mineral intake at each meal, may negatively influence energy balance. The literature was reviewed in a study (Pérez-Escamilla *et al.*, 2012) concerning 17 studies (seven RCT, one non-RCT and nine cohort studies) in adults and six cohort studies in children and adolescents. WHO in 2003 recommended reducing the energy density of the diet as a viable strategy to stem the global epidemic obesity. The 2010 Dietary Guidelines Advisory Committee for the American population confirmed that strong and consistent evidence in adults indicates that dietary patterns relatively low in energy density improve weight loss and weight maintenance. In addition, the Committee concluded that there was moderately strong evidence from methodologically rigorous longitudinal cohort studies in children and adolescents to suggest that there is a positive association between dietary energy density and increased adiposity.

However, diets with a lower energy density tend to be associated with higher food costs. Economic analyses have shown that calories provided by whole grains, fresh products and lean meat were more expensive than calories from refined grains, added sugars and added fats. As a result, changes in consumer behaviour need to be accompanied by appropriate changes in food and nutrition policies.

d. Data sources

National individual dietary surveys, household budget surveys (HBS), FAO food balance sheets (FBS).

e. Limitations of the indicator

Individual dietary surveys (IDS) provide the most accurate figures for actual daily food consumption. Data obtained from food balance sheets do not reflect the effective food intake, because they relate to the food quantities theoretically available for consumption; the amount of food consumed is lower than those reported in food balance sheets, due to the degree of losses of edible food and nutrients in the household, e.g. during storage, in preparation and cooking, as plate waste or quantities fed to domestic animals and pets, or thrown away. Depending on data sources and studies, the level of accuracy and units used can vary.

Also, the data obtained even from national dietary surveys do not reflect the portion size. Indeed there is evidence that larger portion size of energy dense and nutrient poor foods is involved in the increase of overweight and obesity that accompany the changes in dietary patterns in children and adults (Ello-Martin *et al.,* 2006; Lioret *et al*., 2009).

f. Additional information

Drewnowski, A., Monsivais, P., Maillot, M. & Darmon, N. 2007. Low-energy-density diets are associated with higher diet quality and higher diet costs in French adults. *J. Acad. Nutr. Diet,* 107: 1028–1032.

Ello-Martin, J.A., Ledikwe, J.H. & Rolls, B.J. 2005. The influence of food portion size and energy density on energy intake: implications for weight management. *Am. J. Clin. Nutr.,* 82: 236S–241S.

Lioret, S., Volatier, J-L., Lafay, L. Trouvier, M. & Maire, B. 2009. Is food portion size a risk factor of childhood overweight?. *EJCN*, 63: 382–391.

McCrory, M.A., Burke, A. & Roberts, S.B. 2012. Dietary (sensory) variety and energy balance. *Physiol, Behav.,*107(4): 576–583. doi: 10.1016/j.physbeh.2012.06.012.

Pérez-Escamilla, R., Obbagy, J.E., Altman, J.M., Essery, E.V., McGrane, M.M., Wong, Y.P., Spahn, J.M. & Williams, C.L. 2012. Dietary energy density and body weight in adults and children: a systematic review. *J. Acad. Nutr. Diet*, 112(5): 671–684. doi: 10.1016/j.jand.2012.01.020.

Rebello, C.J., Liu, A.G., Greenway, F.L. & Dhurandhar, N.V. 2013. Dietary strategies to increase satiety. *Adv. Food Nutr. Res.,* 69: 105–182. doi:10.1016/B978-0-12-410540-9.00003-X.

Roberts, S.B., Urban, L.E. & Das, S.K. 2014. Effects of dietary factors on energy regulation: consideration of multiple- versus single-dietary-factor models. *Physiol. Behav.*, p. ii: S0031– 9384(14)00215-7. doi: 10.1016/j.physbeh.2014.04.024.

Rolls, B.J. 2009. The relationship between dietary energy density and energy intake. *Physiol. Behav.*, 97(5): 609–615. doi: 10.1016/j.physbeh.2009.03.011.

Rolls, B.J., Drewnowski, A. & Ledikwe, J.H. 2005. Changing the energy density of the diet as a strategy for weight management. *Journal of the American Dietetic Association*, 105(5): 98–103.

Schwingshackl, L. & Hoffmann, G. 2013. Comparison of effects of long-term low-fat vshigh-fat diets on blood lipid levels in overweight or obese patients: a systematic review and meta-analysis. *J. Acad. Nutr. Diet*, 113(12): 1640–1661. doi: 10.1016/j.jand.2013.07.010.

WHO. 2003. *Diet, nutrition and the prevention of chronic diseases*. Report of the Joint WHO/FAO Expert Consultation. Geneva, Switzerland.

A7. NUTRIENT DENSITY OF DIET AND FOODS

a. Definition

The nutrient density of a composite diet is the amount of various necessary nutrients and fibres present in a given daily diet expressed in weight (or evenly in energy).

b. Methodology

Parameters considered:

- for a daily diet:
  - mean adequacy ratio (MAR) based on the mean percentage of the recommended intakes for 29 key needed nutrients, alone or in combination with the mean excess ratio (MER) for nutrients to limit;

- for general purpose:
  – the amount of every nutrient present in a unit of a given food/beverage or food group as provided by food composition databases;
  – nutrient density scores referring to either 100 g, 100 kcal/kJ or cost/ kg or L of a given food (ex simplified SAIN/LIM scoring, (Masset *et al*., 2014).

Some publications cited in the reference list provide examples of calculations and interpretations (Maillot *et al.,* 2007; Vieux *et al*., 2014).

c. Background

The quality of given foods and of a whole diet can be defined by a high content in necessary nutrients, fibres and protective compounds, along with a low content in items to reduce or avoid – such as salt, sugar and saturated fat. The nutrient profiling concept implies that it is possible to discriminate between foods according to their contribution to a healthy diet. This concept is extended to evaluate the amount of nutrients provided by a whole daily diet.

The MAR has been used to estimate more exhaustively the nutrient adequacy of the total diet. The MAR has been used to estimate the nutrient adequacy of the total diet, on a per capita and daily basis. The last adaptation of MAR was based on the mean percentage of adequacy of intakes vs recommended intakes for 23 key nutrients (proteins, fibres, fatty acids [3], vitamins [10], minerals [8)]. These nutrients and fibre contents are available in a food-composition database and the per capita daily intakes are calculated from the daily amount/portion of each food or food group consumed). MAR has been repeatedly shown to be positively associated with other indexes of diet quality, notably those estimating dietary diversity or variety, but is negatively associated with dietary energy density. Positive relationships with health indicators have also been also reported.

The Mean Excess Ratio (MER): it is the mean percent of maximal recommended values for three nutrients to limit (Na, SFA, free sugar), on a par capita and daily basis. Its calculation is as for MAR.

A combination of the MAR and the MER could be an optimal option.

At the food product level, the SAIN, LIM nutrient profiling model was proposed by the French food safety agency (ANSES, formerly AFSSA) (Agence française de sécurité sanitaire des aliments, 2008; Darmon *et al*., 2009). This model is based on two previously published indicators: the nutrient density score (NDS), based on qualifying nutrients (i.e. positive nutrients), and the LIM score, based on disqualifying nutrients (i.e. the nutrient to be limited) (Darmon *et al*., 2005; Maillot *et al*., 2007). The SAIN uses five basic nutrients (protein, fibre, calcium, vitamin C and iron), and the LIM includes three nutrients (saturated fatty acids, added sugars and sodium). Vitamin D is used as an optional nutrient for calculating the SAIN; it replaces one of the five basic nutrients if the content/recommendation ratio for vitamin D is greater than one of the ratios for basic nutrients. The combination of these two scores provides four food rankings from the worst to the highest. It especially allows comparison of all categories of foods, even the more complex ones (e.g. snacks, prepared meals, pastries), which are not subject to any specific recommendation because they do not belong to a well-defined group of foods. Salted snacks and sweets display a low SAIN/LIM, whereas fruit and vegetables have a high SAIN/LIM.

Another system is the UK Of-com incorporating on a single scale the following components composition per 100 g of food: saturated fat, sodium, total sugar and energy as the negative nutrients; protein, fibre and fruit, vegetable and nut content as the positive nutrients. The score of Of-com ranges from 1 to 100 and higher scores indicated a healthier food/drink. (Rayner *et al.,* 2009).

In a recent work, the SAIN/LIM and Of-com systems were used in order to identify foods with compatible sustainability dimensions (Masset *et al*., 2014) suggesting that the very low level of snacks and sweetened beverages should be an indicator of sustainable healthy diet.

d. Data sources

National individual dietary surveys, household budget surveys (HBS), FAO food balance sheets (FBS) (see indicator A2 for a comprehensive description).

e. Limitations of the indicator

All scores designed to evaluate the nutrient density of either individual foods or whole diet have advantages and limitations. They must be taken into account depending on the precise context and objective considered. The limitations are: (i) the need for accurate and quantitative dietary intake data and food composition databases; (ii) comparisons between countries are limited by possibly different daily recommended intakes (energy, nutrients and fibre); and (iii) comparisons between studies need to use the same nutrients and total number of nutrients.

It has to be considered that the MAR normally should be 29, but because of the lack of composition tables usually the number is less. In France, for example, 23 includes the different lipids.

f. Additional information

Azais-Braesco, V., Goffi, C. & Labouze, E. 2006. Nutrient profiling: comparison and critical analysis of existing systems. *Public Health Nutr*., 9: 613–622.

Drewnowski, A. & Fulgoni, V.L. 3rd 2014. Nutrient density: principles and evaluation tools. *Am. J. Clin. Nutr.,* 99(5 Suppl): 1223S–1228S. doi: 10.3945/ajcn.113.073395. Epub 2014 Mar 19.

Darmon, N., Vieux, F., Maillot, M., Volatier, J.L. & Martin, A. 2009.Nutrient profiles discriminate between foods according to their contribution to nutritionally adequate diets: a validation study using linear programming and the SAIN, LIM system. *Am. J. Clin. Nutr.,* 89: 1227–1236.

European Parliament/Council of the European Union. 2006. Regulation (EC) No. 1924/2006 of the European Parliament and of the Council of 20 December 2006 on nutrition and health claims made on foods. *Off. J. Eur. Union*, L404: 9–25.

FAO. 2011. *Guidelines for measuring household and individual dietary diversity.* Rome.

Kant, A.K. 1996. Indexes of overall diet quality: a review. *J. Am. Diet Assoc.,* 96(8): 785–791.

Madden, J.P., Goodman, S.J. & Guthrie, H.A. 1976. Validity of the 24-hr. recall. Analysis of data obtained from elderly subjects. *J. Am. Diet Assoc.,* 68:143–147.

Maillot, M., Darmon, N., Vieux, F. & Drewnowski, A. 2007. Low energy density and high nutritional quality are each associated with higher diet costs in French adults. *Am. J. Clin. Nutr.,* 86: 690–896.

Masset, G., Soler, L.G., Vieux, F. & Darmon, N. 2014. Identifying sustainable foods: the relationship between environmental impact, nutritional quality, and prices of foods representative of the French diet. *J. Acad. Nutr. Diet,*114: 862–869.

Pérez-Escamilla, R., Obbagy, J.E., Altman, J.M., Essery, E.V., McGrane, M.M., Wong, Y.P., Spahn, J.M. & Williams, C.L. 2012. Dietary energy density and body weight in adults and children: a systematic review. *J. Acad. Nutr. Diet,* 112(5): 671–684. doi: 10.1016/j.jand.2012.01.020.

Rayner, M., Scarborough, P. & Lobstein, T. 2009. *The UK Of-com Nutrient Profiling Model.* Oxford, UK, British Heart Foundation Health Promotion Research Group.

Scarborough, P., Rayner, M. & Stockley, L. 2007. Developing nutrient profile models: a systematic approach. *Public Health Nutr.,* 10(4): 330–336.

Vieux, F., Soler, L.G., Touazi, D. & Darmon, N. 2013. High nutritional quality is not associated with low greenhouse gas emissions in self-selected diets of French adults. *Am. J. Clin. Nutr.,* 97(3):569-83. doi: 10.3945/ajcn.112.035105. Epub 2013 Jan 30.

Rolls, B.J., Drewnowski, A. & Ledikwe, J.H. 2005. Changing the energy density of the diet as a strategy for weight management. *Journal of the American Dietetic Association*, 105(5): 98–103.

WHO. 2003. *Diet, nutrition and the prevention of chronic diseases.* Report of the Joint WHO/FAO Expert Consultation. Geneva, Switzerland.

A8. FOOD BIODIVERSITY COMPOSITION AND CONSUMPTION

a. Introduction

"Eat a variety of foods" has long been the first rule in national and international food-based dietary guidelines. The nutrition community, however, is only recently appreciative of the relevance of "biodiversity" to this message. Until recently it was considered acceptable to judge dietary diversity as food-group diversity (e.g. dietary diversity score) and generic food diversity. However, it is known that the nutrient content differences within species can be significant, varying by factors of 1 000 or more in some cases (Huang, Tanudjaja and Lum, 1999; Englberger *et al*., 2003, 2006). These facts, coupled with the dramatic loss in food biodiversity in recent decades, provided a strong case for examining biodiversity in the context of human nutrition and sustainable diets (Toledo and Burlingame, 2006).

Through a series of international conferences and consultations, two nutrition indicators for biodiversity were developed and are now being monitored: Indicator 1 on food composition (FAO/INFOODS, 2008; Burlingame, Charrondiere and Mouille, 2009) and Indicator 2 on food consumption (FAO/INFOODS, 2010). These indicators are used to assess the extent to which food biodiversity is being documented for purposes of human nutrition. In 2008, the baseline report counted 5 519 foods for Indicator 1. In the following years, between 835 and 5 186 foods were added annually (FAO/INFOODS, 2013a). Researchers throughout the world are submitting their data to the FAO/INFOODS Food Composition Database for Biodiversity (2013b), which serves as an international repository. These data are freely available, widely disseminated and frequently cited.

Indicator 2 is a count of the number of biodiverse foods reported in food consumption or similar surveys (FAO/INFOODS, 2010). In 2009, the baseline report counted 3 119 foods. In the subsequent two reporting periods, 1 827 and 1 375 foods were added. A secondary survey indicator was developed as a count of the number of food consumption and similar surveys taking biodiversity into consideration in their design and/or reporting, with at least one reported food meeting the criteria for Indicator 2 (FAO/INFOODS, 2013a).

The indicators have proved useful in stimulating the production, collection and dissemination of biodiversity data for food composition and consumption. They are also advocacy tools for effectively raising awareness of the importance of biodiversity for nutrition and providing documentation of the ever-increasing knowledge of biodiversity and human nutrition. They are also thought to be useful as a proxy for environmental sustainability of diets and resilience of local food systems (FAO, 2013; AFROFOODS, 2009).

b. Definition

Biodiversity covers diversity within species, between species and of ecosystems; synonyms are: biological diversity, ecological diversity. For the purposes of human nutrition, biodiversity refers to foods identified at the taxonomic level below species (e.g. cultivar, breed) or by local varietal name, and wild, neglected and/or underutilized species. Biodiversity is distinctly different from “dietary diversity”, which reflects intake at the level of aggregate food groups.

c. Methodology

Parameters considered:

- Food composition: A count of the number of foods
  - at variety/cultivar/breed level for common foods
  - at species level for wild/indigenous/underutilized foods

  with at least one value for component found in published and unpublished sources.
- Food consumption:
  - the taxonomic diversity of foods, as for food composition, reported in food consumption/dietary intake surveys. Data collected and reported include:
    - the study instrument (e.g. diet history, food frequency) with details (scope, date, number and description of subjects, geographical/ethnic coverage; reference, total number of studies examined);
    - the qualifying biodiverse foods reported (number of foods, food lists);
  - the number of surveys with at least one reported food counting for biodiversity.

d. Background

The biodiversity indicators were deemed necessary in order to understand, quantify and monitor the role of biodiversity in human nutrition, and the impact of biodiversity-related nutrition interventions and initiatives. They were developed as one of the important activities under the Cross-cutting Initiative on Biodiversity for Food and Nutrition (CBD, 2004, 2006ab), and within the framework of the Biodiversity Indicator Partnership (BIP, 2013), and they are monitored by FAO with a regular reporting schedule (FAO/INFOODS, 2013a).

e. Data sources

FAO/INFOODS compile data and report periodically (FAO/INFOODS, 2013b). For food composition, data are obtained by searching peer-reviewed journals using the search engines Scopus and Science Direct, and through a call for data conducted via INFOODS (International Network of Food Data Systems). These data are then compiled in a Biodiversity Food Composition Database (Charrondiere *et al*., 2012; FAO/INFOODS, 2013b).

For food consumption, data are obtained from all surveys, including national nutrition surveys, market surveys, ethno-biological investigations and inventory studies. All published and unpublished available resources are searched including peer-reviewed journals, official international/regional/national/subnational survey reports, conference presentations and published matter, including posters), abstracts published from meetings and theses.

f. Limitations of the indicators

The development and reporting on the indicators is recent, and only two to three time points are available. The usefulness of the indicators should be assessed in the future, and judged against market survey data as well as nutritional outcomes. For the moment, the results represent a reflection of the attention being paid to biodiversity by researchers designing food composition studies and dietary surveys. Monitoring and reporting on the biodiversity indicators is the responsibility of FAO/INFOODS. It is a time-consuming activity and, for the 2014–2015 biennium, FAO has put few or no resources into the continuation of this effort.

g. Additional information

AFROFOODS. 2009. *Call for action from the door of return for food renaissance in Africa* (available at http://www.fao.org/fileadmin/templates/food_composition/documents/pdf/AFROFOOD_CALL_and_APPEL.pdf).

BIP (Biodiversity Indicators Partnership). 2013. Homepage (available at http://www.bipindicators.net/, accessed 13 December 2013).

Burlingame, B., Charrondiere, U.R. & Mouille, B. 2009. Food composition is fundamental to the cross-cutting initiative on biodiversity for food and nutrition. *Journal of Food Composition and Analysis,* 22(5): 361–365.

CBD (Convention on Biological Diversity). 2004. *COP 7 Decision VII/32*. Seventh Meeting of the Conference of the Parties to the Convention on Biological Diversity, Kuala Lumpur, Malaysia, 9–20 February 2004 (available at http://www.cbd.int/decision/cop/default.shtml?id=7769).

CBD. 2006a. *COP 8 Decision VIII/23*. Eighth Meeting of the Conference of the Parties to the Convention on Biological Diversity, Curitiba, Brazil, 20–31 March 2006 (available at http://www.cbd.int/agro/food-nutrition/default.shtml).

CBD. 2006b. *Agricultural biodiversity: a cross-cutting initiative on biodiversity for food and nutrition* (available at https://www.cbd.int/decision/cop/default.shtml?id=11037).

Charrondiere, U.R., Stadlmayr, B., Rittenschober, D., Mouille, B., Nilsson, E., Medhammar, E., Olango, T., Eisenwagen, S., Persijn, D., Ebanks, K., Nowak, V., Du, J. & Burlingame, B. 2012. FAO/INFOODS Food Composition Database for Biodiversity. *Food Chemistry,* 140: 408–412.

Englberger, L., Aalbersberg, W., Fitzgerald, M., Marks, G. & Chand, K. 2003. Provitamin A carotenoid content of different cultivars of edible pandanus fruit. *Journal of Food Composition and Analysis*, 16: 237–247.

Englberger, L., Aalbersberg, W., Schierle, J., Marks, G.C., Fitzgerald, M.H., Muller, Fred, Jekkein, A., Alfred, J. & Vander Velde, N. 2006. Carotenoid content of different edible pandanus fruit cultivars of the Republic of the Marshall Islands. *Journal of Food Composition and Analysis*, 19: 484–494.

FAO. 2013. *Review of key issues on biodiversity and nutrition*. Commission on Genetic Resources for Food and Agriculture, CGRFA-14/13/8. Rome.

FAO/INFOODS. 2008. *Expert Consultation on Nutrition Indicators for Biodiversity - 1. Food Composition.* Rome (available at ftp://ftp.fao.org/docrep/fao/010/a1582e/a1582e00.pdf).
FAO/INFOODS. 2010. *Expert Consultation on Nutrition Indicators for Biodiversity – 2. Food consumption*. Rome (available at http://www.fao.org/docrep/014/i1951e/i1951e00.htm).
FAO/INFOODS. 2013a. *FAO/INFOODS Report on the Nutrition Indicators for Biodiversity – Global Progress Report.* Rome (available at http://www.fao.org/docrep/019/i3559e/i3559e.pdf).
FAO/INFOODS. 2013b. *FAO/INFOODS Food composition database for biodiversity version 2.1 - BioFoodComp2.1*. Rome (available at http://www.fao.org/infoods/infoods/food-biodiversity/en/).
Huang, A.S., Tanudjaja, L. & Lum, D. 1999. Content of alpha-, betacarotene and dietary fiber in 18 sweet potato varieties grown in Hawaii. *Journal of Food Composition and Analysis*, 12: 147–151.
Toledo, A. & Burlingame, B. 2006. Biodiversity and nutrition: a common path toward global food security and sustainable development. *Journal of Food Composition and Analysis,* 19(6–7): 477–483.

A9. NUTRITIONAL ANTHROPOMETRY

a. Definition

This indicator is based on the body mass index (BMI) and the waist circumference (WC) which are used in a wide variety of contexts as simple methods to assess how much an individual's body weight departs from what is normal or desirable for a person of his or her height (WHO 1995).

BMI in both men and women represents a measure of underweight (<18.5 kg/m²) or different levels of overweight (25–29.9, 30–34,9, 35–39,9 ≥40 kg/m²).

WC in both man and women represents a measure of visceral adiposity (>88 cm in women and 102 cm in men). Increased waist circumference can be a marker for increased risk, even in people of normal weight associated with insulin resistance.

Over- and undernutrition frequently coexist. Weight loss, real to ideal weight ratio, and specific nutritional assessment tools (Mini Nutritional Assessment [MNA], Just a Nutritional Score [JANUS]) (Guigoz *et al.,* 1996; Donini *et al*., 2014) may be useful to detect the presence of malnutrition.

b. Methodology

Parameters considered:

- Undernutrition: prevalence of individuals having a BMI <18.5 kg/m² calculated from self-reported weight and height.
- Overweight or obesity: prevalence of individuals having a BMI ≥25.0 kg/m² calculated from self-reported weight and height and/or WC >88 cm in women and 102 cm in men.

Classification of overweight and obesity by BMI, waist circumference and associated disease risks

			Disease risk* relative to normal weight and waist circumference	
	BMI (kg/m²)	Obesity class	Men 102 cm or less Women 88 cm or less	Men > 102 cm Women > 88 cm
Underweight	< 18.5		-	-
Normal	18.5–24.9		-	-
Overweight	25.0–29.9		Increased	High
Obesity	30.0–34.9	I	High	Very high
	35.0–39.9	II	Very high	Very high
Extreme obesity	40.0 +	III	Extremely high	Extremely high

* Disease risk for type 2 diabetes, hypertension and CVD (http://www.nhlbi.nih.gov/health/public/heart/obesity/lose_wt/bmi_dis.htm).

c. Background

Overweight and obesity are increasing worldwide and in developing countries, including Mediterranean countries. Overweight and obesity are defined as abnormal or excessive fat accumulation that may impair health. Obesity is strongly associated with a number of chronic diseases, including diabetes mellitus, cancers, hypertension and cardiovascular diseases and increases the risk of mortality from these conditions. The fundamental cause of obesity and overweight is an energy imbalance between calories consumed and calories expended. Globally, there has been an increased intake of energy-dense foods that are high in fat, salt and sugars but low in vitamins, minerals and other micronutrients and a decrease in physical activity due to the increasingly sedentary nature of many forms of work, changing modes of transportation and increasing urbanization. In some countries recently it is possible to observe a decrease of underweight and an increasing of overweight. Large disparities exist among different socio-economic classes and between urban and rural areas. It is important for policy-makers to have accurate information not only about obesity at national level, but also about how obesity varies across different populations and by socio-economic and demographic factors (Yusuf *et al.,* 2004; Haslam and James, 2005; Kushner, 2007).

Many low- and middle-income countries are now facing a "double burden" of disease. While they continue to deal with the problems of infectious disease and under-nutrition, they are experiencing a rapid upsurge in non-communicable disease risk factors such as obesity and overweight, particularly in urban settings. It is not uncommon to find undernutrition and obesity existing side-by-side within the same country, the same community and the same household (Jaacks *et al*., 2015; Wojcicki, 2014).

The term "body mass index" (previously called the Quetelet Index from the nineteenth century) was firstly proposed in the July edition of 1972 in the *Journal of Chronic Diseases* by A. Keys, which found the BMI to be the best proxy for body fat percentage among ratios of weight and height. It provides a simple numeric measure of a person's thickness or thinness (Keys *et al.,* 1972). In different epidemiological studies BMI was correlated with increased morbidity and mortality in all age classes, both in males and females, in different settings (free-living, hospitalized or institutionalized subjects), in different populations all over the world. Despite its limits in defining body composition, in particular in over- and undernutrition, it is still considered to be the screening tool with the best value for cost (National Heart, Blood and Lung Institute, 1998; Douglas *et al.,* 2014; Flegal *et al.,* 2013).

Together with an increased BMI, excess abdominal fat is considered a risk factor for developing heart and vascular diseases, as well as other obesity related diseases (metabolic syndrome) or Alzheimer's disease. A study published in the *European Heart Journal* in April 2007 showed that waist circumference and waist-hip-ratio were predictors of cardiovascular events (de Koning *et al.,* 2007; Carey, 1998; Razay, 2006).

d. Data sources

WHO Global Database. Data locally available through national surveys.[1]

e. Limitations of indicator

Individuals tend to overestimate their height and underestimate their weight, leading to underestimation of BMI and of the prevalence of overweight and obesity. Moreover anthropometric measurements have to be performed by skilled personnel according to a standardized procedure.

Self-reported national surveys might be subject to systematic error (lower reported weight and higher reported height) resulting from non-coverage (e.g. lower telephone coverage among populations of low socio-economic status), non-response (e.g. refusal to participate in the survey or to answer specific questions) or measurement (e.g. social desirability or recall bias). Data could be not available for some countries.

[1] http://www.cdc.gov/nchs/data/nhanes/nhanes3/cdrom/nchs/manuals/anthro.pdf
http://www.fao.org/fileadmin/templates/food_composition/documents/Nutrition_assessment/c2.pdf
http://www.measuredhs.com
http://www.childinfo.org/mics.html
http://www.who.int/bmi/index.jsp

f. Additional information

Kushner, R. 2007. *Treatment of the obese patient (contemporary endocrinology).* Totowa, USA, Humana Press. 158 p.

Carey, D.G.P. 1998. Abdominal obesity. *Current Opinion in Lipidology*. 9(1): 35–40.

Lawrence de Koning, L., Merchant, A.T., Pogue, J. & Anand, S.S. 2007. Waist circumference and waist-to-hip ratio as predictors of cardiovascular events: meta-regression analysis of prospective studies. *European Heart Journal*, 28 (7): 850–856.

Donini, L.M., Ricciardi, L.M,. Neri, B., Lenzi, A. & Marchesini, G. 2014. Risk of malnutrition (over and under-nutrition): Validation of the JaNuS screening tool. *Clin. Nutr.*, 33: 1087–1094.

Douglas, B.K.I., dos-Santos-Silva, F.H., Leon, D.A. & Smeeth, L. 2014. Body-mass index and risk of 22 specific cancers: a population-based cohort study of 5·24 million UK adults. *Lancet*, 384(9945): 755–765.

Flegal, K.M., Kit, B.K., Orpana, H. & Graubard, B.I. 2013. Association of all-cause mortality with overweight and obesity using standard body mass index categories a systematic review and meta-analysis. *The Journal of the American Medical Association,* 309(1): 71–78.

Guigoz, Y., Vellas, B. & Garry, P.J. 1996. Assessing the nutritional status of the elderly: The Mini Nutritional Assessment as part of the geriatric evaluation. *Nutr. Rev.,* 54: S59–ß65.

Haslam, D.W. & James, W.P. 2005. Obesity. *Lancet*, 366(9492): 1197–1209.

Jaacks, L.M., Slining, M.M. & Popkin, B.M. 2015. Recent underweight and overweight trends by rural-urban residence among women in low- and middle-income countries. *J. Nutr.*, 145(2): 352–357.

Keys, A., Fidanza, F., Karvonen, M.J., Kimura, N. & Taylor, H.L. 1972. Indices of relative weight and obesity. *J. Chronic Dis*., 25(6): 329–343.

Kushner, R. 2007. *Treatment of the obese patient (contemporary endocrinology)*. Totowa, USA. Humana Press. 158 p.

National Heart, Lung, and Blood Institute. 1998. *Executive summary. Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults: the evidence report* (available at http://www.ncbi.nlm.nih.gov/books/NBK2008/).

Razay, G. 2006. Obesity, abdominal obesity and Alzheimer's disease. *Dementia & Genetic Cognitive Disorders*, 22(2): 173–176.

WHO (World Health Organization). 1995. *Physical status: the use and interpretation of anthropometry*. Geneva, Switzerland.

Wojcicki, J.M. 2014. The double burden household in sub-Saharan Africa: maternal overweight and obesity and childhood undernutrition from the year 2000: results from World Health Organization Data (WHO) and Demographic Health Surveys (DHS). *BMC Public Health,* 14: 112.

Yusuf, S., Hawken, S., Ounpuu, S., Dans, T., Avezum, A., Lanas, F., McQueen, M., Budaj, A., Pais, P., Varigos, J., Lisheng, L. & INTERHEART Study Investigators. 2004. Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study. *Lancet*, 364(9438): 937–952.

A10. PHYSICAL ACTIVITY/PHYSICAL INACTIVITY PREVALENCE

a. Definition

As physical activity is a key determinant of energy expenditure, it is fundamental to energy balance and weight control. Although there are doubts on considering it as a nutritional indicator or a cofactor of nutritional status, the Working Group decides to consider it in the list of nutritional indicators of sustainability. Anyway, it is important to underline that the MD and a more in general diet needs to be considered a lifestyle and the regular practice of physical activity is a key component of it.

Physical activity is defined as any bodily movement produced by skeletal muscles that require energy expenditure. The term "physical activity" should not be mistaken with "exercise". Exercise, is a subcategory of physical activity that is planned, structured, repetitive, and purposeful in the sense that the improvement or maintenance of one or more components of physical fitness is the objective. Physical activity includes exercise as well as other activities that involve bodily movement and are done as part of working, active transportation, house chores and recreational activities (SACN, 2011).

Several physical activity indicators have been proposed (WHO, 2009). On the basis of available data the physical inactivity prevalence has been selected as an indicator of physical activity, using the definition of not meeting any of the following criteria: at least 30 minutes of moderate-intensity activity per day on at least five days per week, or at least 20 minutes of vigorous-intensity activity per day on at least three days per week, or an equivalent combination (WHO Global Infobase).

b. Methodology

Parameters considered:

- attributable DALYs from Physical Inactivity;
- physical activity questionnaires (e.g. WHO Global Physical Activity Questionnaire (GPAQ); International Physical Activity Questionnaire (IPAQ), etc.).

c. Background

Sedentary lifestyles have become a worldwide phenomenon due to changing social and economic patterns all over the world. Sedentary lifestyles are associated with increased obesity, type 2 diabetes and cardiovascular disease. Insufficient physical activity is the fourth leading risk factor for mortality. Approximately 3.2 million deaths and 32.1 million DALYs (representing about 2.1 percent of global DALYs) each year are attributable to insufficient physical activity. People who are insufficiently physically active have a 20 percent to 30 percent increased risk of all-cause mortality compared with those who engage in at least 30 minutes of moderate intensity physical activity most days of the week (Blair, 2009). Globally in 2008, 31 percent of adults aged 15+ were insufficiently active (men 28 percent and women 34 percent) (WHO Global Infobase). To monitor trends and evaluate public health or individual interventions aiming at increasing levels of physical activity, reliable and valid measures of habitual physical activity are essential. Physical activity can be measured either through objective measurements (pedometer, accelerometer, double label water [DLW]) or through subjective assessments by means of questionnaires administered by trained personnel or telephone interview or self-administered questionnaires. The specific study type and design has an important bearing on the choice of method to measure physical activity. Subjective methods of measuring physical activity are useful with large populations as they are inexpensive and easy to apply but have their limitations as reliability and validity problems associated with recall of activity (Warren *et al.,* 2010).

Different questionnaires have been proposed to evaluate physical activity level (e.g. International Physical Activity Questionnaire – Short Form [IPAQ-SF] [Craig *et al*., 2003; Deng HB *et al.,* 2008; Hagstromer *et al.,* 2006; Hagstromer *et al.,* 2010], Minnesota Leisure-time Physical Activity Questionnaire [MLTPAQ]). The WHO Global Physical Activity Questionnaire (GPAQ), was developed by WHO as part of WHO STEPS Instrument, for physical activity surveillance in developing countries (Bull *et al.,* 2009, www.who.int/chp/steps).

d. Data sources

National surveys, WHO Global Infobase

e. Limitations of indicator

It is difficult to use questionnaires that are comparable across cultures. All the questionnaires dealing with physical activity present some limitations, in particular considering the shorter forms and the versions to be used without personal interview (Pereira *et al*., 1997). Moreover, data on population-based physical inactivity may be limited in some countries. As an indicator should be, by the way, "monitorable", it should be based on the data that are readily available, but most of the available data may be difficult to interpret due to differences in the way physical inactivity is measured.

The use of objective methods such as pedometers is becoming more feasible, especially with the use of mobile technology and Apps that provide such information. However, at the moment, for surveillance activity, the objective methods were rarely used and there are no available data. Moreover, the pedometer is specifically designed to assess walking only; it is unable to record non-locomotor movements and to examine the rate or intensity of movement. On the other hand, the accelerometer is suitable for all populations and is an objective indicator of body movement (acceleration), but is an inaccurate assessment of a wide range of activities, and the financial cost may prohibit assessment of large numbers of participants.

Finally, considering the cost-benefit ratio, the Working Group suggests promoting the collection of using harmonized methodologies, such as the same physical activity questionnaire in all countries (i.e. GPAQ) supported by pedometer or accelerometer.

f. Additional information

Blair, S.N. 2009. Physical inactivity: the biggest public health problem of the 21st century. *Br. J. Sports Med.,* 43: 1–2.

Bull, F.C., Maslin, T.S. & Armstrong, T. 2009. Global physical activity questionnaire (GPAQ): nine country reliability and validity study. *J. Phys. Act. Health*, 6(6): 790–804.

Craig, C.L., Marshall, A.L., Sjöström. M., Bauman, A.E., Booth, M.L., Ainsworth, B.E., Pratt, M., Ekelund, U., Yngve, A., Sallis, J.F. & Oja, P. 2003. International physical activity questionnaire: 12-country reliability and validity. *Med. Sci. Sports Exerc*., 35(8): 1381–1395.

Deng, .HB., Macfarlane, D.J., Thomas, G.N., Lao, X.Q., Jiang, C.Q., Cheng, K.K. & Lam, T.H. 2008. Reliability and validity of the IPAQ-Chinese: the GuangzhouBiobank Cohort study. *Med. Sci. Sports Exerc.,* 40: 303–307.

Hagstromer, M., Ainsworth, B.E., Oja, P.& Sjostrom, M. 2010 .Comparison of a subjective and an objective measure of physical activity in a population sample. *J. Phys. Act. Health*., 7: 541–550.

Hagströmer, M., Oja, P. & Sjöström, M. 2006. The International Physical Activity Questionnaire (IPAQ): a study of concurrent and construct validity. *Public Health Nutr*., 9: 755–62.

Pereira, M.A., FitzGerald, S.J., Gregg, E.W., Joswiak, M.L., Ryan, W.J., Suminski, R.R., Utter, A.C. & Zmuda, J.M. 1997. A collection of Physical Activity Questionnaires for health-related research. *Med. Sci. Sports Exerc.,* 29(6 Suppl): S1–205.

SACN (Scientific Advisory Committee on Nutrition). 2011 *Dietary reference values for energy*. London.

Warren, J.M., Ekelund, U., Besson, H., Mezzani, A., Geladas, N. & Vanhees, L. 2010. Assessment of physical activity - a review of methodologies with reference to epidemiological research: a report of the exercise physiology section of the European Association of Cardiovascular Prevention and Rehabilitation. *Eur. J. Cardiovasc. Prev. Rehabil.,* 17(2): 127–139.

WHO (World Health Organization). 2009. *Report of the Workshop on integration of data on physical activity patterns*. Report No. 4 (available at http://www.euro.who.int/__data/assets/pdf_file/0007/87433/E93707.pdf).

WHO. *Global Infobase* (available at https://apps.who.int/infobase/).

A11. ADHERENCE TO THE MEDITERRANEAN DIETARY PATTERN

a. Definition

Adherence to the traditional Mediterranean diet (MD), or to diets that resemble the Mediterranean pattern, has been expressed through indexes or scores, defined a priori, which operate by combining conceptually and computationally the dietary components that capture the essence of this dietary pattern.

b. Methodology

Parameter considered:

- Mediterranean diet score (MDS) (it ranges from 0 – minimal adherence to the traditional Mediterranean diet – to 9 – maximal adherence):
  - for the five components that are representative of the MD and are presumed to be consumed in large quantities (vegetables, legumes, fruits and nuts, cereal and fish), a value of 1 is assigned to people whose consumption is at or above the components' sex-specific medians based on the considered sample, and 0 otherwise;
  - a sixth component of the score is the ratio of monounsaturated lipids to saturated lipids, reflecting the principal role of olive oil consumption in the traditional Mediterranean diet: a value of 1 is assigned to people whose consumption is at or above the sample-specific median of this lipid ratio and 0 otherwise;

– for the following two components that are presumed to be consumed in low/moderate quantities in the MD (all meats and all dairy products, which are rarely non-fat or low-fat in Mediterranean countries), people with a consumption below the median are granted with a value of 1, and people whose consumption is at or above the median are penalized with a value of 0;
– for alcohol, a value of 1 is assigned to men who consume between 10 and 50 g of ethanol per day and to women who consume between 5 and 25 g per day, expressing the moderate ethanol consumption in the MD.

c. Background

The Mediterranean diet has been hypothesized to be associated with better health some decades ago (Keys, 1980). The operational definition of this pattern, which was a necessity in order to assess its role on various outcomes in analytical epidemiologic studies, appeared in the literature in 1995 through the MDS proposed by Trichopoulou and colleagues and was subsequently updated (Trichopoulou *et al.,* 1995; Trichopoulou *et al.,* 2003). Trichopoulou *et al.,* 2005).

The MDS is based on sample medians and, therefore, its score is highly dependent on the specific characteristics of the sample. This fact may represent a limitation for the transferability of results to other samples. An alternative that was proposed is to build MD indexes according to absolute/normative cut-off points for the consumption of specific food groups (pre-defined servings/day or servings/week) (Sofi, 2013; Tognon, 2013).

The MDS was found to be associated with a considerable reduction of overall mortality among the elderly, as well as among the general population. Since then, other researchers have proposed several variations of MDS that were also shown to be associated with health outcomes such as cardiovascular diseases, cancer and overall mortality.

Other variations of MDS are also available in the literature, as well as other indices such as the Mediterranean Adequacy Index and the Italian Mediterranean Index. (Alberti-Fidanza and Fidanza, 2004). Irrespective of how adherence to the MD is computed, all scores share some common ground; they are all based on the above-indicated dietary components that capture the essence of this dietary profile. Some indexes have taken into account some food groups more precisely. Among children and adolescents, adherence to the Mediterranean diet is usually assessed through the KIDMED index (Serra-Majem, 2004), which comprises 16 "yes" or "no" questions combining principles sustaining the Mediterranean dietary patterns for adults (e.g. eating fruit, vegetables and pulses regularly; using olive oil at home), together with general dietary guidelines for children (for instance, to always have breakfast). Next to the KIDMED index, other scores have also been proposed in the literature to assess adherence to the Mediterranean diet among children and adolescents (Tognon, 2013).

These, newer MD indexes (Bach, 2006) were based on more complex algorithms as compared with the original one by:

- adding or removing nutritional components;
- expressing the nutritional components in different ways (e.g. in servings per day rather than in grams per day);
- using a wider range of values for the MD scale (e.g. by using quintiles for the individual MD components rather than using the median value to discriminate between those with high vs low consumptions).

The above-indicated indexes were estimated in their majority from information collected through detailed food frequency questionnaires (FFQ) or repeated measures of 24-hour recall dietary questionnaires, which are not easy to deal with especially from the general public. There is a need, therefore, to examine whether adherence to the MD can be captured with more crude instruments such as Web-based questionnaires, since the latter are fashionable and friendly ways to obtain information for lifestyle factors from the general population (http://www.credits4health.gr/). A second issue is to evaluate whether simple MD scores perform equally well as more complex forms, in capturing the adherence to MD.

d. Limitations

The previous-indicated approach has been very valuable in order to express the whole of a dietary pattern, and specifically of the MD. The limitation of the approach is that usually cut-off points used in most scores are sample-dependent, making the interpretation of any identified association of this pattern with health outcomes difficult to generalize. Second, since many MD indexes exist, a natural question is whether some work better than others with respect to capturing the adherence to MD, as well as to identifying associations of this diet with a specific health outcome. To decide, however, which of these numerous MD indexes is "optimal" is rather difficult since such a decision would require an evaluation of the predictive ability of the various indexes with respect to different outcomes using one population, and then validation of the results to different populations. The issue becomes even more complicated due to the population-specific and not universal cut-off values that have been used for discriminating the low/high consumptions for each of the MD components, as described previously. Notwithstanding the scientific value of such an approach, any "optimal" MD scale should be also characterized by its simplicity in the construction of the index as well as in the use of this index widely in public health as well as in clinical practice. Such an investigation would be very important for future studies that wish to assess the association of MD with health.

e. Additional information

Agnoli, C., Krogh, V., Grioni, S., Sieri, S., Palli, D., Masala, G., Sacerdote. C., Vineis, P., Tumino, R., Frasca, G., Pala, V., Berrino, F., Chiodini, P., Mattiello, A. & Panico, S. 2011. A priori-defined dietary patterns are associated with reduced risk of stroke in a large Italian cohort. *J. Nutr.,* 141(8): 1552–1558. http: //dx.doi.org/10.3945/jn.111.140061.

Alberti-Fidanza, A. & Fidanza, F. 2004. Mediterranean adequacy index of Italian diets. *Public Health Nutr.,* 7(7): 937–941.

Bach, A., Serra-Majem, L., Carrasco, J.L., Roman, B., Ngo, J., Bertomeu, I. & Obrador, B. 2006. The use of indexes evaluating the adherence to the Mediterranean diet in epidemiological studies: a review. *Public Health Nutr.,* 9: 132–146.

Bach-Faig, A., Berry, E.M., Lairon, D., Reguant, J., Trichopoulou, A., Dernini, S., Medina, F.X., Battino, M., Belahsen, R., Miranda, G. & Serra-Majem, L. 2011. Mediterranean Diet Foundation Expert Group: Mediterranean diet pyramid today. *Public Health Nutr.,* 14: 2274–2284.

Dominguez, L.J., Bes-Rastrollo, M., de la Fuente-Arrillaga, C., Toledo, E., Beunza, J.J., Barbagallo. M. & Martinez-Gonzalez, M.A. 2013. Similar prediction of total mortality, diabetes incidence and cardiovascular events using relative- and absolute-component Mediterranean diet score: the SUN cohort. *Nutr. Metab. Cardiovasc. Dis.,* 23: 451–458.

Estruch, R., Ros, E., Salas-Salvado, J., Covas, M.I., Corella, D., Aros, F., Gómez-Gracia, E., Ruiz-Gutiérrez, V., Fiol, M., Lapetra, J., Lamuela-Raventos, R.M., Serra-Majem, L., Pintó, X., Basora, J., Muñoz, M.A., Sorlí, J.V., Martínez, J.A., Martínez-González, M.A. & PREDIMED Study Investigators. 2013. Primary prevention of cardiovascular disease with a Mediterranean diet. *N. Engl. J. Med.,* 368: 1279–1290.

Issa, C., Darmon, N., Salameh, P., Maillot, M., Batal, M, & Lairon, D. 2011. A Mediterranean diet pattern with low consumption of liquid sweets and refined cereals is negatively associated with adiposity in adults from rural Lebanon. *Int. J .Obesity*, 35: 251–258.

Keys, A. 1980. S*even countries: a multivariate analysis of death and coronary heart disease.* Cambridge, USA, Harvard University Press.

Martinez-Gonzalez, M.A., Fernandez-Jarne, E., Serrano-Martinez, M., Wright, M. & Gomez-Gracia, E. 2004. Development of a short dietary intake questionnaire for the quantitative estimation of adherence to a cardio protective Mediterranean diet. *Eur. J. Clin. Nutr.,* 58: 1550–1552.

Naska, A. & Trichopoulou, A. 2014. Back to the future: the Mediterranean diet paradigm. *Nutr. Metab. Cardiovasc. Dis.*, 216–219. doi: 10.1016/j.numecd.2013.11.007. Epub 16 Dec. 2013.

Serra-Majem, L., Ribas, L., Ngo, J., Ortega, R., Garcia, A., Perez, C. & Aranceta, J. 2004. Food, youth and the Mediterranean Diet in Spain. Development of KIDMED, Mediterranean Diet Quality Index in children and adolescents. *Public Health Nutr.,* 7(7): 931–935.

Sofi, F., Macchi, C., Abbate, R., Gensini, G.F. & Casini, A. 2014. Mediterranean diet and health status: an updated meta-analysis and a proposal for a literature-based adherence score. *Public Health Nutr.,* 17(12): 2769–2782. doi: 10.1017/S1368980013003169. Epub 2013 Nov 29.

Tognon, G., Hebestreit, A., Lanfer, A., Moreno, L.A., Pala, V., Siani, A., Tornaritis, M., DeHehauw, S., Veidebaum, T., Molnár, D., Ahrens, W. & Lissner, L. 2013. Mediterranean diet, overweight and body composition in children from eight European countries: cross-sectional and prospective results from the IDEFICS study. *Nutr. Metab. Cardiovasc. Dis.,* 24(2): 205–213.

Trichopoulou, A., Costacou, T., Bamia, C. & Trichopoulos D. 2003. Adherence to a Mediterranean diet and survival in a Greek population. *N. Engl. J. Med.,* 348(26): 2599–2608.

Trichopoulou, A., Kouris-Blazos, A., Wahlqvist, M.L., Gnardellis, C., Lagiou, P., Polychronopoulos, E., Vassilakou, T., Lipworth, L. & Trichopoulos, D. 1995. Diet and overall survival in elderly people *BMJ*, 311(7018): 1457–1460.

Trichopoulou, A., Martínez-González, M.A., Tong, T.Y., Forouhi, N.G., Khandelwal, S., Prabhakaran, D., Mozaffarian, D. & de Lorgeril, M. 2014. Definitions and potential health benefits of the Mediterranean diet: views from experts around the world. *BMC Med*., 12: 112. doi: 10.1186/1741-7015-12-112 (available at http://www.credits4health.gr/).

Trichopoulou, A., Orfanos, P., Norat, T., Bueno-de-Mesquita, B., Ocké. M.C., Peeters, P.H., van der Schouw, Y.T., Boeing, H., Hoffmann, K., Boffetta, P., Nagel, G., Masala, G., Krogh, V., Panico, S., Tumino, R., Vineis, P., Bamia, C., Naska, A., Benetou, V., Ferrari, P., Slimani, N., Pera, G., Martinez-Garcia, C., Navarro, C., Rodriguez-Barranco, M., Dorronsoro, M., Spencer, E.,A., Key, T.J., Bingham, S., Khaw, K-T., Kesse, E., Clavel-Chapelon, F., Boutron-Ruault, M-C., Berglund, G., Wirfalt, E., Hallmans, G., Johansson, I., Tjonneland, A., Olsen, A., Overvad, K., Hundborg, H.H., Riboli, E. & Trichopoulos, D. 2005. Modified Mediterranean diet and survival: EPIC-elderly prospective cohort study. *BMJ*, 330: 991.

Willett, W.C., Sacks, F., Trichopoulou, A., Drescher, G., Ferro-Luzzi, A., Helsing, E. & Trichopoulos, D. 1995. Mediterranean diet pyramid: a cultural model for healthy eating. *Am. J. Clin. Nutr.*, 61: 1402S–1406S.

A12. LOCAL/REGIONAL FOODS AND SEASONALITY

a. Definition

The term "local food system" (or "regional food system") is used to describe a method of food production and distribution that is geographically localized, rather than national and/or international. Food is grown (or raised) and harvested close to consumers' homes, then distributed over much shorter distances than is usual in the conventional globalized industrial food system with long-distance transportation. In general, local/regional food systems are associated with the sustainable agriculture concept, but not systematically. In particular, it is based on purchases at short distance from the producer (from a few to 100 km or miles) and directly from the producer or with one intermediate between the consumer and producer.

Production "in season" means that minimum artificial conditions are used to grow the products (essentially plant products: vegetables and fruits), without heated greenhouses in the local agro-environmental conditions., and no long-term cold storage).

b. Methodology

Parameters considered:

- the distance between consumer purchase location and producing area; it is usually considered that it should be at maximum 150 km (around 100 miles);
- the number of intermediates between producer and consumer with zero when direct from producer, one when one intermediate is present (one can be considered as a cut point for discrimination);

- the consumer choice:
  - directly to local/regional producers (on-farm, farmer's market/shop, food baskets made of local foods) as a share of total food purchases;
  - share of fresh vegetables or fruits consumed coming from open field or unheated greenhouse cultivation;
- the duration between fruit harvest (known or estimated from agriculture statistics of the concerned growing location or country) and purchase of fresh fruit, as a direct reflect of distance from seasonal production (and cold storage duration).

c. Background

It is important to consider that consuming local/regional foods, essentially grown in season, and/or without cold storage, were the basis of the traditional Mediterranean food systems during millennia. The trend for drastic changes from that context started in the 1950s.

In that line, consuming local and seasonal foods is part of the new international recommendations on the Mediterranean diet (2011).

The term "local food system", or "regional food system", is used to describe a method of food production and distribution that is geographically localized, rather than national and/or international (http://www.sustainabletable.org/254/local-regional-food-systems; Kneafsey *et al.,* 2013). It refers also to short food supply chains (Kneafsey *et al.,* 2013). Food is grown and harvested, as well as processed, close to consumer homes, then distributed over much shorter distances than is usual in the conventional global industrial food system. In general, local/regional food refers to food produced near the consumer (i.e. food grown or raised within a reasonable distance from a consumer).

However, there is not yet a universally agreed-upon definition for the geographic component of what "local" or "regional" means (http://www.sustainabletable.org/254/local-regional-food-systems; Kneafsey *et al.,* 2013). A 2008 survey found that half of consumers surveyed described "local" as "made or produced within a hundred miles" (of their homes), while another 37 percent described "local" as the ability to eat "locally". This also varies depending on the production capacity of the region considered: ex agriculturally productive year-round vs arid or colder regions. About 150 km (100 miles or even 50 miles in United States of America, or 100 km in Europe) from home seems to be a reasonable limit to identify local/regional foods, but could depend on the area context.

Local/regional foods are usually purchased on farms, at farmers' market or at farmers' shops or distributed by a single local intermediate (such as food baskets or pick-up points in cities). Consuming local foods is associated with consumption of vegetables and fruits with a very short delay between harvest and intake, allowing very fresh and mature foods, with an optimal taste and flavour as well as the highest nutrient content, especially vitamin C and antioxidants (Kneafsey *et al.,* 2013; Azzini *et al*., 2012). Economical, social and environmental positive aspects have also been identified but some are still under discussion (Coley *et al*., 2009; Duram and Oberholtzer, 2010; Pretty *et al.,* 2005: Van Hauwermeiren *et al.*, 2007).

A complementary and more focused aspect is the seasonality of food production. Indeed, under the present industrial agro-food system, only a limited part of fresh food produced is grown and thus consumed in season. An important part of fresh vegetables and some fruits (for example strawberries) are grown out of season under heated greenhouses in many countries. For others (i.e. potatoes, most fruits), long-term cold storage allows consumption during a large part of the year. This has important negative impacts (energy use, agriculture intensification, loss of biodiversity). Growing in season (open field or unheated greenhouses) and consuming fresh foods (i.e. vegetables, parts of fruits) is a way to cut most of these negative impacts, along with having foods with optimal taste, flavour and nutrient content.

d. Data sources

The information necessary to assess these indicators can be only obtained from dedicated studies where such specific questions are addressed. This is the case in some national human cohorts surveys or more local/regional consumption studies. The growing interest in such consumption approaches will stimulate more investigations in this domain.

d. Limitations

The parameters to use are still under debate and need further testing. The present availability of data can be restricted to a limited number of studies, but this figure is expected to markedly improve in the next future.

e. Additional information

Azzini, E., Durazzo, A., Polito, A., Venneria, E., Stella Foddai, M., Zaccaria, M., Mauro, B., Intorre, F. & Maiani, G. 2012. Biodiversity and local food products in Italy. In *Sustainable diets and biodiversity.* Proceedings of FAO International Scientific Symposium Sustainable diets and Biodiversity united against hunger: Rome, 3–5 November 2010. FAO Rome, FAO.

Coley, D., Howard, M. & Winter, M. 2009. Local food, food miles and carbon emissions: A comparison of farm shop and mass distribution approaches. *Food Policy,* 34: 150–155.

Duram, L. & Oberholtzer, L. 2010. A geographic approach to place and natural resource use in local food systems. *Renewable Agriculture and Food Systems*, 25(2): 99–108.

Kneafsey, M., Venn, L., Schmutz, U., Balazs, B., Trenchard, T., Eyden-Wood, T., Bos, E., Sutton, G. & Blackett, M. 2013. *Short food supply chains and local food systems in the EU. A State of play of their socio-economic characteristics.* JRC scientific and policy reports (available at http://ipts.jrc.ec.europa.eu/publications/pub.cfm?id=6279).

Pretty, J.N., Bal,l A.S,, Lang. T. & Morison, J.I.L. 2005. Farm costs and food miles: an assessment of the full cost of the UK weekly food basket. *Food Policy,* 30(1): 1–19.

Van Hauwermeiren, A., Coene, H., Engelen, G. & Mathisjs, E. 2007. Energy lifecycle inputs in food systems: a comparison of local versus mainstream cases. *Journal of Environmental Policy & Planning*, 9(1): 31–51.

A13. ORGANIC/ECO-FRIENDLY PRODUCTION AND CONSUMPTION

a. Definition

Nowadays, most agro-food productions based on agro-ecological principles are called "organic" and are certified and labelled at national and continental levels (Willer and Lernoud, 2013/2014).

These well-characterized, controlled and certified methods of food productions exclude the use of chemical fertilizers, pesticides, GMOs and intensive animal husbandry.[2] These methods are acknowledged to better protect the environment, biodiversity and potentially, health consumers.

b. Methodology

Parameters considered:

- the percentage of consumers buying organic foods and the frequency of consumption;
- organic food consumption in percentage of total food amount or money per capita (e.g. Bionutrinet cohort survey in France – http://bionutrinet.etude-nutrinet-sante.fr).
- the percentage of the organic market volume
- the percentage of land use under organic certification

c. Background

During FAO international conference held in 2010 (FAO, 2012) a global definition of sustainable diets was proposed. Numerous keywords present there are in fact at the basis of the past and present agro-ecological systems. Indeed, in most countries, a small fraction of farmers and the general population have long shown great concern about this question. Indeed, facing the changes that have taken place in the food production system in the twentieth century, refusal of chemical fertilizers, pesticides and intensive animal husbandry since the 1970s, gave rise to so-called

[2] Codex Alimentarius, 2010; http://www.ifoam.org/en/ifoam-standard; EC, 2007, 2008; http://www.maff.go.jp/e/jas/specific/criteria_o.html; http://www.usda.gov/wps/portal/usda/usdahome?navid=ORGANIC_CERTIFICATIO

"organic", "biological", "biodynamic" and "agro-ecological" production, depending on the options and/or the country. These alternative production systems are now being recognized because of their highly nutritive and safe products (Lairon, 2010; Smith-Spangler *et al*., 2012; Brandt *et al.,* 2011; Baranski *et al.,* 2014; Oates *et al.,* 2014), along with low environmental impacts (Mondelaers *et al*., 2009; Gomiero *et al.,* 2008) and are being certified according to specific regulations and labels in most countries and continents. The organic system is defined by regulations in more than 80 countries around the world and data from organic production and partly also from consumption are available from more than 160 countries (Willer and Lernoud, 2013/2014). The data are and will be recorded continuously by various institutions (Willer and Lernoud, 2013/2014). Such organic production has markedly increased during the last decade, representing up to 3–20 percent (mean 5.1 percent) of the agricultural area in European Union countries. In some European countries, more than half of the people are used to sometimes consume organic foods while a part of them regularly consumed some organic foods (Pino *et al*., 2012; Torjusen *et al.,* 2004). Two large-scale human surveys in Europe showed a better food consumption pattern for regular organic food consumers (Kesse-Guyot *et al*., 2013; Eisinger-Watzl *et al.,* 2015). Increasing trends are observed for organic food purchases.

These production/consumption conditions were the basis of the traditional Mediterranean food systems (i.e. before the 1950s). Consuming eco-friendly foods is part of the new international recommendations on Mediterranean diet (2011). The organic diet/food system programme is planned to be part of the coming FAO/UNEP-Sustainable Food System Programme.

d. Data sources

In most industrialized countries, data on the organic market volume as well as the market shares are available as well as recorded (Willer and Lernoud, 2013/2014). Detailed data for specific food types can also be available.

During some consumer cohort surveys or in national consumption surveys, individual data are collected on organic food consumption (e.g. Germany, France).

Furthermore, national yearly data are now available and continuously recorded (Willer and Lernoud, 2013/2014) regarding the importance of organic food production (number of farms, acreage, volume of foods produced) and share of total. In some countries, agricultural production data (at local/regional/national) are also available along with organic food import/export data (Willer and Lernoud, 2013/2014).

e. Limitations of the indicator

In some countries organic production can be marginal only or data on organic production or consumption are not available at national or regional level. But the availability of data has been and will be increasing (Willer and Lernoud, 2013/2014).

f. Additional information

Baranski, M., Srednicka-Tober, D., Volakakis, N., Seal, C., Sanderson, R., Stewart, G.B., Benbrook, C., Biavati, B., Markellou, E., Giotis, C., Gromadzka-Ostrowska, J., Rembiałkowska, E., Skwarło-Sonta, K., Tahvonen, R., Janovská, D., Niggli. U., Nicot P. & Leifert, C. 2014. Higher antioxidant and lower cadmium concentrations and lower incidence of pesticide residues in organically grown crops: a systematic literature review and meta-analyses. *Br. J Nutr.,* 112(5): 794–811.

Brandt, K., Leifert, C., Sanderson, R. & Seal, C.J. 2011. Agro-ecosystem management and nutritional quality of plant foods: the case of organic fruits and vegetables. *Crit. Rev. Plant Sci*., 30: 177–197.

Codex Alimentarius. 2010. *Guidelines for the production, processing, labelling and marketing of organically produced foods (GL-32-1999).* Adopted 1999. Revisions 2001, 2003, 2004 and 2007. Amendments 2008, 2009 and 2010. Rome, FAO.

Eisinger-Watzl, M., Wittig, F., Heuer, T. & Hoffmann, I. 2015. Customers purchasing organic food - do they live healthier? Results of the German National Nutrition Survey II. *European Journal of Nutrition & Food Safety*, 5(1): 59–71.

FAO. 2012. Definition of sustainable diets and Platform for action, final document, In *Sustainable diets and biodiversity.* Proceedings of FAO International Scientific Symposium Sustainable Diets and Biodiversity United Against Hunger. Rome, 3–5 November 2010. Rome.

Gomiero, T., Paoletti, M.G. & Pimentel, D. 2008. Energy and environmental issues in organic and conventional agriculture. *Crit. Rev. Plant Sci.,* 27(4).

Kesse-Guyot, E., Péneau, S., Méjean, C., Szabo de Edelenyi, F., Galan, P., Hercberg, S. & Lairon, D. 2013. Profiles of organic food consumers in a large sample of French adults: results from the Nutrinet-Santé cohort study. *PLoSOne*, 8(10): e76998. doi:10.1371/journal.pone. 0076998.

Lairon, D. 2010. Nutritional quality and safety of organic food: a review. *Agron. Sustain. Dev.,* 30: 33–41.

Mondelaers, K, Aertsens, J. & Van Huylenbroeck, G. 2009. A meta-analysis of the differences in environmental impacts between organic and conventional farming. *Brit. Food J., 111(10):* 1098–1119.

Oates, L., Cohen, M., Braun, L., Schembri, A. & Taskova, R. 2014. Reduction in urinary organophosphate pesticide metabolites in adults after a week-long organic diet. *Environ. Res.,* 132: 105–111. doi: 10.1016/j.envres.2014.03.021.

Pino, G., Peluso, A.M. & Guido, G. 2012. Determinants of regular and occasional consumers' intentions to buy organic food. *J. Consumer Aff.,* 46: 157–169.

Smith-Spangler, C., Brandeau, M.L., Hunter, G.E., Bavinger, C., Pearson, M., Eschbach, P.J., Sundaram, V., Liu, H., Schiermer, P., Stave, C., Olkin, I. & Bratava, D.M. 2012. Are organic food safer or healthier than conventional alternatives. *Anal. Intern. Med.,* 157: 348–366.

Torjusen, H., Sangstad, L., O'Doherty-Jensen, K. & Kjaernes, U. 2004. *European consumers' conceptions of organic food: a review of available research*. Project Report 4-2004 for National Institute for Consumer Research, Oslo.

Willer, H. & Lernoud, J. 2013/2014. *The world of organic agriculture* (available at www.organic-world.net).

4. Conclusions

Further discussion on this first draft needs to be developed and additional work is required to assess, as much as possible, the nutrition sustainability of the Mediterranean diet and to reach the global objective to assess sustainable diets.

More joint interdisciplinary effort is necessary to assess not only the nutrition and health dimension of the Mediterranean diet but also indicators related to environment, economic and socio-cultural factors and how to aggregate together all of them.

To consider together the various sustainability dimensions of the Mediterranean diet, by taking into account its differences in the various Mediterranean countries together with their complex interactions, requires more effective intersectoral research across specific disciplines.

There is an indispensable need to develop and strengthen intersectoral studies and research on diets and food consumption patterns, with particular regard to: the need to develop and test methodological approaches addressed to specific contexts; the need to define the scales of priorities for methodological approaches' development; the centrality of the individual, the consumer, for assessing sustainable diets and, in spite of lack of data availability on individuals, of the households.

Some points that need to be further developed and finalized:

- How to weight these indicators? How to calculate a value/score using the data gathered for each indicator?
- How to define the scales of priorities of the further implementation of the methodological approach;
- At which scale (individual, household, country, region) this operational methodological approach should be tested? What are the available data? The centrality of the individual, the consumer, is of paramount importance for assessing sustainable diets, in spite of lack of data availability on individuals.

Moreover, there are also many other points in discussing the Mediterranean diet itself, such as:

- The need to develop a more reliable index to assess adherence to the Mediterranean diet model (Sofi *et al*., 2013; Milà-Villarroel *et al*., 2011).
- The need to consider, at least, the adherence to and all items present in the revised MD pyramid (Baich-Faig *et al*., 2011).
- The need to reposition the legumes within the MD pyramid, as a more sustainable dietary pattern, requires also to re-balance the pyramid in terms of kcal.
- The need to revise again the MD pyramid requires updating of food groupings.
- The need to take into consideration the food groupings and components of the different diet scores (monounsaturated/saturated fat ratio – MS ratio), as well as an indicator for water consumption for nutrition, by taking into account the revision of the MD pyramid in which water is placed inside the pyramid.
- Research that studies single nutrient additions or single food has proven positive health outcomes, but does not represent *actual adherence* to the MD.
- The need to define the serving sizes/portions in different Mediterranean countries, and even in different regions within the same country; Mediterranean diet pyramids have been diversely referring to portion sizes and frequency of consumption – daily, weekly and monthly. How to assess them?
- How to combine all scores into a scale and analyse trends over relevant time series? How to assess from this set of indicators/scores the relationship between current dietary patterns, adherence to the MD pattern and the sustainability of food consumption at country level.
- The need to test and revise the methodological approach in one or more Mediterranean countries or specific regions within the country (e.g. Apulia region, Italy).

- How to further develop the methodological approach development for assessing the sustainability of the Mediterranean diet, in which is also taken into consideration cultural appropriateness and transmission of culinary and traditional eating habits?
- The MD is not adhered to sufficiently in the majority of Mediterranean countries – how to improve it? The social economic environment has changed greatly since the 1960s and family structure has downsized – less youngsters and more elderly. Time constraints prevent spending too much on preparation and cooking of meals. The need to further discuss culinary skills, very important to achieve a sustainable MD and the need to raise an indicator for that (number of "traditional dishes" prepared/week? Other?
- The need, by taking into account its differences in the various Mediterranean countries together with their complex interactions, to consider together the various sustainability dimensions of the Mediterranean diet, which requires funds for more effective intersectoral studies and research across specific disciplines.

References

Alexandratos, N. 2006. The Mediterranean diet in a world context. *Public Health Nutrition*, 9(1A): 111–117.

Aranceta, J. & Serra-Majem, L. 2001. Dietary guidelines for the Spanish population. On behalf of the Working Party for the Development of Food-Based Dietary Guidelines for the Spanish Population. *Public Health Nutrition*, 4(6A): 1403–1408.

Babio, N., Bullo, M., Basora, J., Martinez-Gonzalez, M.A., Fernandez-Ballart, J., Marquez-Sandoval, F., Molina, C. & Salas-Salvadó, J. 2009. Adherence to the Mediterranean diet and risk of metabolic syndrome and its components. *Nutr. Metab. Cardiovasc. Dis.*, 19(8): 563–570.

Bach, A., Serra-Majem, L., Carrasco, J.L., Roman, B., Ngo J., Bertomeu, I. & Obrador, B. 2006. The use of index evaluating the adherence to the Mediterranean diet in epidemiological studies: a review. *Public Health Nutrition*, 9(1A): 132–146.

Bach-Faig, A., Berry, E.M., Lairon, D., Reguant, J., Trichopoulou, A., Dernini, S., Medina, F.X., Battino, M., Miranda, G. & Serra-Majem, L. 2011. Mediterranean diet pyramid today. Science and cultural updates. *Public Health Nutrition*, 14(12A): 2274–2284.

Baroni, L., Cenci, L., Tettamanti, M. & Berati, M. 2007. Evaluating the environmental impact of various dietary patterns combined with different food production systems. *Eur. J. Clin. Nutr.*, 61(2): 279–286.

Belahsen, R. & Rguibi, M. 2006. Population health and Mediterranean diet in southern Mediterranean countries. *Public Health Nutrition,* 9(8A): 1130–1305.

Berners-Lee, M., Hoolohan, C., Cammack, H. & Hewitt, C.N. 2012. The relative greenhouse gas impacts of realistic dietary choices. *Energy Policy*, 43: 184–190.

BIP (Biodiversity Indicators Partnership). 2013. Homepage (retrieved 13 December 2013 from http://www.bipindicators.net/).

Bonaccio, M., Di Castelnuovo, A., Bonanni, A., Costanzo, S., De Lucia, F., Persichillo, M., Zito, F., Donati, M.B., de Gaetano, G. & Iacoviello, L. 2014. Decline of the Mediterranean diet at a time of economic crisis. Results from the moli-sani study. *Nutrition, Metabolism & Cardiovascular Diseases*, xx: 1–8.

Bosetti, C., Pelucchi, C. & La Vecchia, C. 2009. Diet and cancer in Mediterranean countries: carbohydrates and fats. *Public Health Nutrition*, 12(9A): 1595–600.

Burke Delaney, J. 2012. Bridging the sustainability gap. *Nutrition Today*, 47(4): 155–159.

Burlingame, B. & Dernini, S. 2011. Sustainable diets: the Mediterranean diet example. *Public Health Nutrition*, 14(12A): 2285–2287.

Buttriss, J. & Riley, H. 2013. Sustainable diets: harnessing the nutrition agenda. *Food Chemistry*, 140: 402–407.

Capone, R., El Bilali, H., Debs, P., Cardone., G. & Driouech, N. 2014a. Mediterranean food consumption patterns sustainability: Setting up a common ground for future research and action. *American Journal of Nutrition and Food Science*, 1(2): 37–52.

Capone, R., El Bilali, H., Debs, P., Cardone, G. & Driouech, N. 2014b. Food system sustainability and food security: connecting the dots. *Journal of Food Security*, 2(1): 13–22.

Carlsson-Kanyama, A. & Gonzalez, A.D. 2009. Potential contributions of food consumption patterns to climate change. *Am. J. Clin. Nutr.*, 89 (suppl): 1704S–1709S.

CBD. 2004. *COP 7 Decision VII/32.* Seventh Meeting of the Conference of the Parties to the Convention on Biological Diversity, Kuala Lumpur, Malaysia, 9–20 February 2004 (available at http://www.cbd.int/decision/cop/default.shtml?id=7769).

CBD. 2006a. *COP 8 Decision VIII/23.* Eighth Meeting of the Conference of the Parties to the Convention on Biological Diversity, Curitiba, Brazil, 20–31 March 2006 (available at http://www.cbd.int/agro/food-nutrition/default.shtml).

CBD. 2006b. *Agricultural biodiversity: a cross-cutting initiative on biodiversity for food and nutrition* (available at https://www.cbd.int/decision/cop/default.shtml?id=11037).

Charrondiere, U.R., Stadlmayr, B., Rittenschober, D., Mouille, B., Nilsson, E., Medhammar, E., Olango, T., Eisenwagen, S., Persijn, D., Ebanks, K., Nowak, V., Du, J. & Burlingame, B. 2012. FAO/INFOODS Food Composition Database for Biodiversity. *Food Chemistry*, 140: 408–412.

CGIAR. 2012. *Achieving food security in the face of climate change*. CCAFS Program Report. Denmark.

Clonan, A. & Holdsworth, M. 2012. The challenge of eating a healthy and sustainable diet. *Am. J. Clin. Nutr*., 96(3): 459–460. doi:10.3945/ajcn.112.044487.

Dangour, A.D., Green, R., Häsler, B., Rushton, J., Shankar, B. & Waage, J. 2012. Linking agriculture and health in low- and middle-income countries: an interdisciplinary research agenda. *Proc. Nutr. Soc.*, 71: 222–228.

Da Silva, R., Bach-Faig, A., Raido Quintana, B., Buckland, G., Vaz de Almeida, M.D. & Serra-Majem, L. 2009. World variation of adherence to the Mediterranean diet, in 1961–1965 and 2000–2003. *Public Health Nutrition*, 12(9A): 1676–1684.

de Boer, J., Hooglan, C.T. & Boersema, J.J. 2007. Towards more sustainable food choices: Value priorities and motivational orientations. *Food Quality and Preference,* 18(7): 985–996.

DEFRA. 2009. *Indicators for a sustainable food system*. Report UK.

del Balzo, V., Diolordi, L., Pinto, A., Giusti, A.M., Vitiello, V., Cannella, C., Dernini, S., Donini, L.M. & Berry E. 2012. Mediterranean diet pyramids: towards the Italian model. *Ann. Ig*., 24: 443–447.

Dernini, S. 2011. The erosion and the renaissance of the Mediterranean diet: a sustainable cultural resource. *Quaderns de la Mediterrania*, *IEMED, Barcelona*, 16: 75–82.

Dernini, S., Berry, E.M., Bach-Faig, A., Belahsen, R., Donini, L.M., Lairon, D., Serra-Majem, L. & Cannella, C. 2012. Scientists reassess a dietary model: the Mediterranean diet. In *Mediterra 2012*. CIHEAM-SciencesPo Les Presses, Paris. pp. 71–88.

Dernini, S., Meybeck, A., Burlingame, B., Gitz, G., Lacirignola, C., Debs, P., Capone, C. & El Bilali, H. 2013. Developing a methodological approach for assessing the sustainability of diets: the Mediterranean diet as a case study. *New Medit.*, 12(3): 28–36.

Dernini, S. & Berry, E.M. 2015. Mediterranean diet: from a healthy diet to a sustainable dietary pattern. *Frontiers in Nutrition*. 2: 15.

Duchin, F. 2005. Sustainable consumption of food: a framework for analyzing scenarios about changes in diets. *Journal of Industrial Ecology*, 9(1–2): 99–114.

EC. 2011. *Sustainable food consumption and production in a resource-constrained world*. A. Freibauer, E. Mathijs, G. Brunori, Z. Damianova, E. Faroult, G.J. Gomis, L. O'Brien & S. Treyer. EU Commission – Standing Committee on Agricultural Research (SCAR), 3rd foresight exercise. Brussels.

EC/JRC. 2009. *Environmental impacts of diet changes in the EU*. Technical Report, European Commission (EC), Joint Research Centre (DG JRC), Institute for Prospective Technological Studies (IPTS). Brussels.

Esnouf, C., Russel, M. & Bricas N., eds. 2013. *Food system sustainability: insights from duALIne*. Cambridge Press.

Estruch, R., Ros, E., Salas-Salvadó, J., Covas, M.I., Corell, D., Arós, F., Gómez-Gracia, E., Ruiz-Gutiérrez, V., Fiol, M., Lapetra, J., Lamuela-Raventos, R.M., Serra-Majem, L., Pintó, X., Basora, J., Muñoz, M.A., Sorlí, J.V., Martínez, J.A. & Martínez-González, M.A. 2013. Primary prevention of cardiovascular disease with a Mediterranean diet. *N. Engl. J. Med.*, 368: 1279–1290.

FAO. 2005. *Nutrition indicators for development.* Rome.

FAO. 2009. *Declaration of the World Food Summit on Food Security*. Rome.

FAO. 2010. *Report of the Technical Workshop on Biodiversity in Sustainable Diets.* Rome.

FAO. 2011. *Looking ahead in world food and agriculture: perspectives to 2050.* P. Conforti, ed. Rome.

FAO. 2012. *Greening the economy with agriculture*. Working Paper 4: utilization. Improving food systems for sustainable diets in a green economy. Rome.

FAO. 2013. *The State of Food and Agriculture. Food systems for better nutrition*. Rome.

FAO/Bioversity. 2012. *Sustainable diets and bioversity. Directions and solutions for policy, research and action*. Rome.

FAO/CIHEAM. 2012. *Towards the development of guidelines for improving the sustainability of diets and food consumption patterns in the Mediterranean area*. Rome.

FAO/INFOODS. 2013a. *FAO/INFOODS Report on the Nutrition Indicators for Biodiversity – Global Progress Report*. Rome, FAO (available at: http://www.fao.org/docrep/019/i3559e/i3559e.pdf).

FAO/INFOODS. 2013b. *FAO/INFOODS Food composition database for biodiversity version 2.1 – BioFoodComp2.1*. Rome, FAO (available at: http://www.fao.org/infoods/infoods/food-biodiversity/en/).

FCRN (Food Climate Research Network). 2014. *Appetite for change. Social, economic and environmental transformations in China's food system*. T. Garnett & A. Wilkes, eds. UK.

Fidanza, F., Alberti, A., Lanti, M. & Menotti, A. 2004. Mediterranean Adequacy Index: correlation with 25-year mortality from coronary heart disease in the Seven Countries Study. *Nut. Metab. Cardiovasc. Dis.*, 14(5): 254–258.

Friel, S., Dangour, A.D., Garnett, T., Lock, K., Chalabi, Z., Roberts, I., Butler, C.D., Waage, J., McMichael, A.J. & Haines, A. 2009. Public health benefits of strategies to reduce greenhouse-gas emissions: food and agriculture. *Lancet*, 374(9706): 2016–25.

Garcia-Closas, R., Berenguer, A. & Gonzalez, C.A. 2006. Changes in food supply in Mediterranean countries from 1961 to 2001. *Public Health Nutrition*, 9(1): 53–60.

Garnett, T. 2013. Food sustainability: problems, perspectives and solutions. *Proceedings of the Nutrition Society,* 72: 29–39.

Gerber, M. 2006. Qualitative methods to evaluate Mediterranean diet in adults. *Public Health Nutrition*, 9 (1A): 147–151.

Godfray, H.C.J., Beddington, J.R., Crute, I.R, Haddad, L., Lawrence, D., Muir, J.F., Pretty, J., Robinson, S., Thomas, S.M. & Toulmin, C. 2010. Food security: the challenge of feeding 9 billion people. *Science*, 327: 812–818.

Gotsis, E., Anagnotis, P., Mariolis, A., Vlachou, A., Katsiki, N. & Karagiannis, A. 2014. Health benefits of the Mediterranean diet: An update of research over the last 5 years. *Angiology*. DOI:10.1177/0003319714532169.

Gussow, J.D. 1995. Mediterranean diets: are they environmentally responsible? *Am. J. Clin. Nutr.*, 61(suppl): 1383S–1389S.

Gussow, J.D. & Clancy, K. 1986. Dietary guidelines for sustainability. *Journal Nutrition Education*, 18(1): 1–5.

Guyomard, H., Darcy-Vrillon, B., Esnouf, C., Marin, M., Momot, A., Russel, M. & Guillou, M. 2011. *Eating patterns and food systems: critical knowledge requirements for policy design and implementation*. INRA. Document prepared for the Commission on Sustainable Agriculture and Climate Change.

Haines, A., McMichael, A., Smith, K., Roberts, J., Woodcock, J., Markandya, A., Armstrong, B.G., Campbell-Lendrum, D., Dangour, A.D., Davies, M., Bruce, N., Tonne, C., Barrett, M. & Wilkinson, P. 2009. Public health benefits of strategies to reduce greenhouse-gas emissions: overview and implications for policy makers. *The Lancet*, 374(9707): 2104–2114.

Hawkesworth, S., Dangour, A.D., Johnston, D., Lock, K., Poole, N., Rushton, J., Uauy, R. & Waage, J. 2010. Feeding the world healthily: the challenge of measuring the effects of agriculture on health. *Philosophical Transactions of the Royal Society, B – Biological Sciences*, 365: 3083–3097.

Health Council of the Netherlands. 2011. *Guidelines for a healthy diet: the ecological perspective*. The Hague.

Heller, M.C., Keoleian, G.A. & Willet, W.C. 2013. Toward a life cycle-based, diet-level framework for food environmental impact and nutritional quality assessment: A critical review. *Environmental Science & Technology*, 47: 12632–12647.

HLPE. 2014a. *Food losses and waste in the context of sustainable food systems*. Rome.

HLPE. 2014b. *Note on critical and emerging issues for food security and nutrition.* Rome.

Holdsworth, M. 2010. Sustainability should be integral to nutrition and dietetics. *J. Hum. Nutr. Diet*, 23: 467–468.

Ingram, J., Ericksen, P. & Liverman, D., eds. 2010. *Food security and global environmental change*. Earthscan, Washington, DC.

IOM. 2014. *Sustainable diets: food for healthy people and a healthy planet. Workshop summary*. Washington, DC, The National Academies Press.

IOTF. 2005. *EU platform on diet, physical activity and health*. Briefing paper. London, International Association for the Study of Obesity.

Issa, C., Darmon, N., Salameh, P., Maillot, M., Batal, M. & Lairon, D. 2011. A Mediterranean diet pattern with low consumption of liquid sweets and refined cereals is negatively associated with adiposity in adults from rural Lebanon. *Int. J. Obes. (Lond.),* 35(2): 251–258.

Johnston, J.J., Fanzo, J.C. & Cogill, B. 2014. Understanding sustainable diets: A descriptive analysis of the determinants and processes that influence diets and their impact on health, food security, and environmental sustainability. *Adv. Nutr.*, 5(4): 418–429.

Kastner, T., Rivas, M.J.I., Koch, W. & Nonhebel, S. 2012. Global changes in diets and the conseguences for land requirements for food. *Proceedings of the National Academy of Sciences*, 109(18): 6868–6872.

Kastorini, C.M., Milionis, H.J., Esposito, K., Giugliano, D., Goudevenos, J.A. & Panagiotakos, D.B. 2011. The effect of Mediterranean diet on metabolic syndrome and its components a meta-analysis of 50 studies and 534,906 individuals. *J. Am .Coll. Cardiol.*, 57(11): 1299–1313.

Kearney, J. 2010. Food consumption trends and drivers. *Phil. Trans. R. Soc.*, 365: 2793–2807.

Kesse-Guyot, E., Peneau, S., Mejean, C., Szabo de Edelenyi ,F., Galan, P., Hercberg, S. & Lairon, D. 2013a. Profiles of organic food consumers in a large sample of French adults: results from the Nutrinet–Sante cohort study. *PLOS/One*, 8(10): 1–13.

Kesse-Guyot, E., Fezeu, L., Hercberg, S., Ahluwalia, N. & Lairon, D. 2013b. Adherence to Mediterranean diet reduces the risk of metabolic syndrome: a 6-year prospective study. *Nutr. Metab. Cardiovasc. Dis.*, 23(7): 677–683. doi: 10.1016/j.numecd.2012.02.005. Epub 2012 25 May.

Keys, A.B., ed. 1970. Coronary heart disease in seven countries. *Circulation*; 51–52 (1 Suppl.).

Koularba, G. & Panagiotakos, D.B. 2009. Dietary quality indices and human health: a review. *Maturitas*, 62(1): 1–8.

Lang, T. & Barling, D. 2013. Nutrition and sustainability: an emerging food policy discourse. *Proceedings of the Nutrition Society*, 72: 1–12.

Lawrence, G., Lyons, K. & Wallington, T., eds. 2010. Food security, nutrition and sustainability. Earthscan, Washington, DC.

Lee, P.H., Macfarlane, D.J., Lam, T.H. & Stewaart, S.M. 2011. Validity of the international physical activity questionnaire short form (IPAQ-SF): A systematic review, *The International Society of Behavioral Nutrition and Physical Activity*, 8:115 doi:10.1186/1479-5868-8-115.

León-Muñoz, L.M., Guallar-Castillón, P., Graciani, A., López-García, E., Mesas, A.E., Aguilera, M.T., Banegas, J.R. & Rodríguez-Artalejo, F. 2012. Adherence to the Mediterranean diet pattern has declined in Spanish adults. *Journal of Nutrition*, 142(10): 1843–1850. doi: 10.3945/jn.112.164616.

Lock, K., Smith, D.R., Dangour, A.D., Keogh-Brown, M., Pigatto, G., Hawkes, C., Fisberg, R.M. & Chalabi, Z. 2010. Health, agricultural, and economic effects of adoption of healthy diet recommendations. *The Lancet,* 376: 1699–1709.

Lundqvist, J., de Fraiture, C. & Molden, D. 2008. *Saving water: from field to fork – curbing losses and wastage in the food chain*. SIWI Policy Brief, Stockholm International Water Institute (SIWI), Stockholm.

Macdiarmid, J.I. 2013. Is a healthy diet an environmental sustainable diet? *Proceedings of the Nutrition Society,* 72: 13–20.

Macdiarmid, .JI., Kyle, J., Horgan, G.W., Loe, J., Fyfe, C., Johnstone, A. & McNeil, G. 2012. Sustainable diets for the future: can we contribute to reducing greenhouse gas emissions by eating a healthy diet? *Am. J. Clin. Nutr.,* 96(3): 632–639.

Maillot, M., Issa, C., Vieux, F., Lairon, D. & Darmon, N. 2011. The shortest way to reach nutritional goals is to adopt Mediterranean food choices. Evidence from computer-generated personalized diets. *Am. J. Clin. Nutr.,* 94(4): 1127–1137.

Marlow, J.H., Hayes, W.K., Soret, S., Carter, R.L., Schwab, R.E. & Sabate', J. 2009. Diet and the environment: does what you eat matter? *Am. J. Clin. Nutr.*, 89(suppl): 1699s–1703.

Martínez-González, M.A., Fernandez-Jarne, E., Serrano-Martinez, M., Marti,A., Martinez, J.A. & Martín-Moreno, J.M. 2002. Mediterranean diet and reduction in the risk of a first acute myocardial infarcton. An operational healthy dietary score. *Eur. J. Nutr.,* 41: 153–160.

Martínez-González, M.A., Bes-Rastrollo, M., Serra-Majem, L., Lairon, D., Estruch, R. & Trichopoulou, A. 2009. Mediterranean food pattern and the primary prevention of chronic disease: recent developments. *Nutr. Rev.*, 67 Suppl 1: S111–116.

Masset, G., Vieux, F., Verger, E.O., Soler, L.G., Touazi, D. & Darmon, N. 2014. Reducing energy intake and energy density for a sustainable diet: A study based on self-selected diets in French adults. *Am. J. Clin. Nutr.,* 99(6): 1460-1469. doi:10.3945/ajcn.113.077958.

Medina, F.X. 2011. Food consumption and civil society: Mediterranean diet as a sustainable resource for the Mediterranean area. *Public Health Nutrition*, 14(12A): 2346–2349.

Milà-Villarroel, R., Bach-Faig, A., Puig, J., Puchal, A., Farran, A., Serra-Majem L. & Carrasco, J.L. 2011. Comparison and evaluation of the reliability of indexes of adherence to the Mediterranean diet. *Public Health Nutrition*, 14(2A): 2338–2345.

Ministero della Salute. 2004. *To orient the citizen towards healthier behaviors.* G. Calabrese, C. Cannella, M. Carruba, G.S. Morino & G. Spera. On behalf of the Working Expert Group of the Italian Health Ministry, Rome.

Nestle, M. 1995. Mediterranean diets: historical and research overview. *American Journal Clinical Nutrition*, 61(suppl.): 1313S–1320S.

ODI. 2014. *Future diets. Implications for agriculture and food prices*. S. Keats & S. Wiggins, eds. Overseas Development Institute, UK.

O'Kane, G. 2012. What is the real cost of our food? Implications for the environment, society and public health nutrition. *Public Health Nutrition*, 15(02): 268–276.

Padilla, M. 2008. Dietary patterns and trends in consumption. In *Mediterra 2008: The future of agriculture and food in Mediterranean countries*. CIHEAM–Presses de Sciences Po. Paris, pp. 149–170.

Pairotti, M.B., Cerutti, A.K., Martini, F., Vesce, E., Padovan, D. & Beltramo, R. 2015. Energy consumption and GHG emission of the Mediterranean diet: a systemic assessment using a hybrid LCA–IO method. *Journal of Cleaner Production,* 103: 507–516.

Pérez-Escamilla, R., Obbagy, J.E., Altman, J.M., Essery, E.V., McGrane, M.M., Wong, Y.P., Spahn, J.M. & Williams, C.L. 2012. Dietary energy density and body weight in adults and children: a systematic review. *J. Acad. Nutr. Diet,* 112(5): 671–684. doi: 10.1016/j.jand.2012.01.020.

Pinstrup-Andersen, P. & Herforth, A. 2008. Food security: achieving the potential. *Environment*, 50: 48–60.

Pluimers, J. & Blonk, H. 2011. *Methods for quantifying the environmental and health impacts of food consumption patterns*. Blonk Milieuadvies, PJ Gouda, The Netherlands.

Popkin, B.M. 1993. Nutritional patterns and transitions. *Population and Development Review*, 19(1): 138–157.

Popp, A., Lotze-Campen, H. & Bodirsky, B. 2010. Food consumption, diet shifts and associated non CO_2 grenhouse gases from agricultural production. *Global Environmental Change*, 20: 451–462.

Sáez-Almendros, S., Obrador, B., Bach-Faig, A. & Serra-Majem, L. 2013. Environmental footprints of Mediterranean versus Western dietary patterns: beyond the health benefits of the Mediterranean diet. *Environ. Health*, 12(1):118.

Sanchez-Villegas, A., J. Martinez, de Irala, J. & Martınez-Gonzalez, M. 2002. Determinants of the adherence to an a priori defined Mediterranean dietary pattern. *European Journal of Nutrition*, 41: 249–257.

Saxe, H., Larsen, M.T. & Mogensen, L. 2013. The global warming potential of two healtht Nordic diets compared with the average Danish diet. *Climatic Change*, 116:249–262.

Scarborough, P., Allender, S., Clarke, D., Wickeamasinghe, K. & Rayner, M. 2012. Modelling the health impact of environmentally sustainable dietary scenario in the UK. *European Journal of Clinical Nutrition*, 66: 710–715.

Schweiger, C., Weiss, R., Berry, E.M. & Keidar, A. 2010. Nutritional deficiencies in bariatric surgery candidates. *Obesity Surgery*, 20: 193–197.

Serra-Majem, L., Roman, B. & Estruch, R. 2006. Scientific evidence of interventions using the Mediterranean diet: a systematic review. *Nutrition Review*, 64: S27–S47.

Serra-Majem, L., Riba,s L., Ngo, J., Mortega, R., Garcıa, A., Perez-Rodrigo, C. & and Aranceta, J. 2004. Food, youth and the Mediterranean diet in Spain. Development of KIDMED, Mediterranean Diet Quality Index in children and adolescents. *Public Health Nutrition*, 7(7): 931–935.

Serra-Majem, L,. Bes-Rastrollo, M., Roman-Vinas, B., Pfrimer, K., Sanchez-Villegas, A. & Martinez-Gonzalez, M.A. 2009. Dietary patterns and nutritional adequacy in a Mediterranean country. *Br..J. Nutr.*, 101 Suppl 2: S21–S28.

SDC. 2009. *Setting the table – advice to Government on priority elements of sustainable diets*. Sustainable Development Commission. UK.

SDC. 2011. *Looking back, looking forward. Sustainability and UK food policy 2000–2011*. Sustainable Development Commission. UK.

Smith, P. & Gregory, P.J. 2012. Climate change and sustainable food production. *Proc. Nutr. Soc.*, 72: 21–28.

Sofi, F., Cesari, R., Abbate, R., Gensini, G.F. & Casini, A. 2008. Adherence to Mediterranean diet and health status: meta-analysis. *BMJ.* 337: a1344.

Sofi, F., Abbate, R., Gensini, G.F. & Casini, A. 2010. Accruing evidence on benefits of adherence to the Mediterranean diet on health: an updated systematic review and meta-analysis. *Am. J. Clin. Nutr*., 92: 1189–1196.

Sofi, F., Macchi, C., Abbate, R., Gensini, G.F. & Casini A. 2013. Mediterranean diet and health status: an updated meta-analysis and a proposal for a literature-based adherence score. *Public Health Nutrition*, 29: 1–14.

Stehfest, E., Bouwman, L., van Vuuren, D.P., den Elzen, M.G.J., Eickhout, B. & Kabat, P. 2009. Climate benefits of changing diet. *Climatic Change*, 95: 83–102.

Supreme Scientific Health Council, Ministry of Health and Welfare of Greece. 1999. Dietary guidelines for Adults in Greece. *Archives of Hellenic Medicine*,16: 516–524.

Swedish National Food Agency. 2013. *Towards environmental sound dietary guidelines – scientific basis for environmental assessment of the Swedish national food agency's dietary guidelines.* C. Lagerberg Fogelberg, ed. Uppsala.

Trichopoulou, A. & Lagiou, P. 1997. Healthy traditional Mediterranean diet: an expression of culture, history, and lifestyle. *Nutrition Reviews*, (55): 383–389.

Trichopoulou, A., Bamia, C. & Trichopoulos, D. 2009. Anatomy of health effects of Mediterranean diet: Greek EPIC prospective cohort study. *BMJ*, 338: b2337.

Trichopoulou, A., Kouris=Blazos, A., Wahlqvist, M.L., Gnardellis, C., Lagiou, P., Polychronopoulos, E., Vassilakou, T., Lipworth, L. & Trichopoulos, D. 1995. Diet and overall survival in elderly people. *BMJ*, 311: 1457–1460.

Trichopoulou, A., Martínez-González, M.A., Tong, T., Forouhi ,N.G., Khandelwa, S., Prabhakaran, D., Mozaffarian, D. & de Lorgeril, M. 2014. Definitions and potential health benefits of the Mediterranean diet: views from experts around the world. *BMC Medicine*, 12: 112.

Tukker, A., Goldbohm, RA., de Koning, A., Verheijden, M., Kleijn, R., Wolf, O., Perez-Dominguez, I. & Rueda-Cantuche, J.M. 2011. Environmental impact of changes to healthier diets in Europe. *Ecological Economics*, 70: 1776–1788.

UN. 2014. *Report of the Special Rapporteur on the Right to Food, Olivier De Schutter*. Final report: the transformative potential of the right to food. New York.

UNCSD. 2012. *Rio+20 United Nations Conference on Sustainable Development. The future we want. Outcome of the Conference*. New York.

UNEP. 2012. *The critical role of global food consumption patterns in achieving sustainable food systems and food for all*. Discussion paper. Nairobi.

UNESCO. 2010. *Inscription of the Mediterranean diet on the Representative List of the Intangible Cultural Heritage of Humanity*. Paris.

Van Dooren, C., Marinussen, M., Blonk, H., Aiking, H. & Vellinga, P. 2014. Exploring dietary guidelines based on ecological and nutritional values: A comparison of six dietary patterns. *Food Policy*, 44: 36–46.

Vanham, D., Mekonnen, M.M. & Hoeskstra, A.Y. 2013. The water footprint of the EU for different diets. *Ecological Indicators*, 32: 1–8.

Vareiro, D., Bach-Faig A., Raidó Quintana, B., Bertomeu, I., Buckland, G., Vaz de Almeida, M.D. & Serra-Majem, L. 2009. Availability of Mediterranean and non-Mediterranean foods during the last four decades: comparison of several geographical areas. *Public Health Nutrition*, 12(9A): 1667–1675.

Vernele, L., Bach-Faig, A., Buckland, G. & Serra-Majem, L. 2010. Association between the Mediterranean diet and cancer risk: a review of observational studies. *Nutrition and Cancer,* 62(7): 860–870.

Vieux, F., Darmon, N., Touazi, D. & Soler, L.G. 2012. Greenhouse gas emissions of self-selected individual diets in France: changing the diet structure or consuming less? *Ecological Economics*, 75: 91–101.

Vieux, F., Soler, LG., Touazi, D. & Darmon, N. 2013. High nutritional quality is not associated with low greenhouse gas emissions in self-selected diets of french adults. *Am. J. Clin. Nutr.*, 97(3): 569–583.

Watson, D., Lorenz, U. St. Hansen, M., Szlezak, J., Zoboli, R., Kuhndt, M., Wilson, C., Mont, O. & Wittmer, D. 2010. *European Environment Agency (EEA); towards a set of indicators on sustainable consumption and production (scp) for EEA reporting*. European Topic Centre on Sustainable Consumption and Production (ETC/SCP) working paper 1/2010, Copenhagen.

Willett, W.C., Sacks, F., Trichopoulou, A., Drescher, G., Ferro-Luzzi, A., Helsing, E. & Trichopoulou, D. 1995. Mediterranean diet pyramid: a cultural model for healthy eating. *Am. J. Clin. Nutr.*, 61 (suppl): 1402S–1406S.

Wilson, N., Nghiem, N., Mhurchu, C.N., Eyles, H., Baker M.G. & Blakely, T. 2013. Food and dietary patterns that are healthy, low-cost, and environmentally sustainable: a case study of optimization modelling for New Zealand. *PLOS/one*, 8(3): e59648.

WHO. 2003. *Diet, nutrition and the prevention of chronic diseases.* Report of a Joint WHO/FAO Expert Consultation. Geneva, Switzerland.

WHO. 2004. *The global strategy on diet, physical activity and health*. Geneva, Switzerland.

WHO. 2011. *Non communicable diseases country profiles 2011*. Global report. Geneva, Switzerland.

WRI. 2013. *Creating a sustainable food future. Interim findings*. Washington, DC, World Resource Institute.

WWF. 2013. *LiveWell report: adopting sustainable diets: opportunities and barriers*. UK.

ANNEX 1

Table 1. Potential indicators for assessing the sustainability of the Mediterranean diet

<table>
<tr><th rowspan="2">Impact indicators</th><th colspan="2">Pressure indicators</th></tr>
<tr><th>Production[1]</th><th>Consumption</th></tr>
<tr><td rowspan="2">Environment and natural resources (including agro–biodiversity)</td><td colspan="2">– Water footprint
– Carbon footprint
– Ecological footprint
– Energy efficiency</td></tr>
<tr><td>– Food biodiversity inventory
– Share of land under organic agriculture
– Share of land under sustainable management[2]
– Use of agro–chemicals (pesticides, fertilizers)
– Number of CDO, PDO, PGI (food quality labels)
– Resilience capacity of production systems
– Change in arable land area
– Change in aquatic resources
– Share of area dedicated to urban and peri–urban agriculture.
– Organic matter content (soil fertility)
– Level of food processing
– Carrying capacity
– Number and area (ha) of GMO varieties</td><td>– Share of organic and eco–friendly food consumption
– Food biodiversity consumption</td></tr>
<tr><td rowspan="2">Economy</td><td colspan="2">– Degree of self–sufficiency (trade balance)
– Regional (subnational) income
– Employment
– Availability of total supply (products from Mediterranean crops)
– Volatility of prices and yields
– Fair price /trade</td></tr>
<tr><td>– Land price
– Economic impact of organic agriculture
– Diversification of food production
– Number/capacity of farm structures
– Number of SME in agro–food</td><td>– Food expenditure/weekly income[3]
– Share of home food consumption on total consumption
– Cost of obesity and non–communicable diseases (NCDs[4])</td></tr>
<tr><td rowspan="2">Society and culture</td><td colspan="2">– Number of traditional products still in use
– Number of direct sale outlets and farmer markets
– Social Life Cycle Analysis (LCA) index
– Gender empowerment
– Number of socio–cultural events on Mediterranean food cultures
– Number of training sessions related to Mediterranean food cultures
– Number of gastronomic tourism itineraries
– Level of transmission of traditional knowledge to new generations</td></tr>
<tr><td>– Degree of multifunctionality of agriculture
– Level of salary of farm workers[5]</td><td>– Consumer perception and attitude towards MD
– Number of consumer organizations
– Level of active involvement of the young in MD promotion</td></tr>
</table>

Impact indicators	Pressure indicators	
	Production[1]	Consumption
Nutrition, health and lifestyle	– Share of diets that is locally produced – Household food security – Prevalence of obesity and non–communicable diseases[6] – Level of physical activity[7] – Burden of nutrition–related diseases	
	– Biodiversity and food composition. – Nutrient profile of foods – Food energy density – Level of food processing in the diet	– Biodiversity in food consumption – Level of consumption of traditional foods and dishes – Dietary diversity score (food choice) – Number of young people adhering to the Mediterranean diet/ food consumption pattern[8] – Ratio fresh/ processed foods – Mediterranean diet adherence scores and new Mediterranean diet pyramid – Nutrient adequacy scores – Diet energy density – Share of eco–friendly and organic food consumption – Nutritional anthropometry[9] – Biochemical measurements of nutritional status[10] – Adequate diet affordability[11] – Frugality – Time spent on food preparation – Time for rest/ sleep – Number of meals consumed with family (conviviality)

1 Includes processing and distribution.
2 Biodiversity Indicators Partnership 2010, UNEP; http://www.bipindicators.net
3 Household income and expenditure surveys.
4 Cardiovascular disease, cancer, chronic lung diseases and diabetes.
5 Cf. emigrant workers.
6 WHO. 2011. Noncommunicable diseases country profiles 2011. Geneva. ISBN: 978924502283.
7 WHO.
8 Disaggregated data: gender, age, etc.
9 Body measurements (height, weight, etc.).
10 Anti–oxidants, fatty acids, blood measurements, etc.
11 Minimum cost for meeting nutrient recommendations in a socially acceptable way.

FAO/CIHEAM International Workshop, 28–29 November 2011 at the CIHEAM–Bari, participants: Anna BACH–FAIG, Fundación Dieta Mediterránea, Barcelona, Spain; Rekia BELAHSEN, Chouaib Doukkali University, Morocco; Gianluca BRUNORI, Professor, Laboratory of Agricultural and environmental economics, Pisa University, Italy; Barbara BURLINGAME, FAO, Rome; Fabian CAPITANIO, University of Naples "Federico II", Italy; Roberto CAPONE, CIHEAM– Bari, Italy; Gianluigi CARDONE, CIHEAM–Bari, Italy; Nicole DARMON, University Aix–Marseille, France ; Philipp DEBS, University of Bologna, Italy; Sandro DERNINI, Forum on Mediterranean Food Cultures, Rome, Italy; Hamid EL BILALI, CIHEAM–Bari, Italy; Abderaouf EL FERCHICHI, CIHEAM–Bari, Italy; Maroun ELMOUJABBER, CIHEAM–Bari, Italy; Vincenzo FERSINO, CIHEAM, France; Mauro GAMBONI, CNR, Italy; Francesco GIARDINA, Italian information system on organic farming, Italy; Habiba HASSAN–WASSEF, Medical Research Council of the National Research Centre, Giza, Egypt; Massimo IANNETTA, ENEA, Rome, Italy; Denis LAIRON, University Aix–Marseille, France; Giulio MALORGIO, University of Bologna, Italy; F. Xavier MEDINA, Universitat Oberta de Catalunya, Spain /ICAF–Europe; Martine PADILLA, CIHEAM – Montpellier, France; Stefano PADULOSI, Bioversity International, Rome.

ANNEX 2

SELECTED INDICATORS

A. Nutrition and health

By Angela POLITTO, Aida TURRINI, Federica INTORRE, Giuseppe MAIANI, CREA - Research Centre for Food and Nutrition; Valeria DEL BALZO, Lorenzo M DONINI, Alessandro PINTO, Annamaria GIUSTI, CIISCAM/Sapienza University of Rome.

1. Energy density – solid food only (proxy for frugality)
This indicator measures the amount of energy (Kcal) in 100g of diet (based on solid food only).

2. Insufficient physical activity: Physical inactivity prevalence
Individuals not meeting any of the following criteria: at least 30 minutes of moderate–intensity activity per day on at least 5 days per week, or at least 20 minutes of vigorous–intensity activity per day on at least 3 days per week, or an equivalent combination.

3. Fruit and vegetables consumption
It measures the intake (g/day) of fruit and vegetables.

4. Vegetable/animal proteins
It is the ratio between vegetable (cereals, vegetables, pulses, fruit, oil) and animal (meet, fish, eggs, dairy products) proteins intake.

5. Nutritional anthropometry (over and undernutrition)

- **Overweight or obesity:** Prevalence of individuals having a body mass index (BMI) >=25.0 kg/m^2 calculated from self–reported weight and height.
- **Undernutrition:** Prevalence of individuals having a body mass index (BMI) <18.5 kg/m^2 calculated from self–reported weight and height.

6. Obesity and related morbidities
The prevalence of individuals having obesity, physician–diagnosed cardiovascular diseases, type II diabetes, osteoporosis, some types of cancer.

b. Environment

By Massimo IANNETTA, ENEA, Italy; Eva ALESSI, WWF, Italy

1. Water footprint (ENEA)
The water footprint is an indicator of freshwater use that looks at both direct and indirect water use to produce specific groups of products and is measured in terms of water volumes consumed (evaporated or incorporated into a product along its supply chain). The water footprint is a geographically explicit indicator.

2. Carbon footprint (ENEA)
The carbon footprint is an indicator of the total amount of greenhouse gases produced to directly and indirectly support human activities, usually expressed in equivalent tonnes of carbon dioxide (CO_2). It is associated to a specific groups of products and is calculated following some steps defined by the GHG protocol corporate standard.

3. Nitrogen footprint (WWF–Italy)
The vitrogen footprint (NF) is a measure of the amount of reactive nitrogen (all N species except N_2) released into the environment as a result of human activities. The excess N in the ecosystems causes eutrophication, enhanced greenhouse effect, biodiversity loss, acidification, etc.

c. Economy

By Roberto CAPONE, Hamid EL BILALI, Philipp DEBS, Virginia BELSANTI, CIHEAM–Bari; Giulio MALORGIO, University of Bologna.

C1. Food consumer price index (FCPI): cereals, fruit, vegetables and meat
The food price index is a measure of the monthly change in international prices of a basket of food commodities. It is a current social and economic indicator that is constructed to measure changes over time in the general level of prices of consumer goods and services that households acquire, use or pay for consumption.
C2. Cost of living index (COLI) related to food expenditures: cereals, fruit, vegetables, fish and meat
This indicator aims to measure the effects of price changes on the cost of achieving a constant standard of living. The cost of living index measures relative evolution in retail prices over time and space.
C3. Distribution of household expenditure groups: food
The distribution of household expenditure groups refers to the average monthly or annually totals household expenditure and its percentage distribution by household consumption and household non–consumption expenditures. It is the value of consumer goods and services acquired, used or paid for by a household. This indicator assesses the percentage of household annual income that is spent for buying food and non–alcoholic beverages.
C4. Food self–sufficiency: cereals, fruit and vegetables
Food self–sufficiency is defined as the ability of a country to meet food consumption needs (particularly for staple food crops) from own production rather than by buying or importing. This indicator measures the degree of national food self–sufficiency considered as the share of national production in total national consumption of determined groups of products (e.g. cereals, fruit and vegetables).
C5. Intermediate consumption in the agricultural sector: nitrogen fertilizers
This indicator gives an idea about the level of intensification of the agricultural production process. It accounts flow of nitrogen fertilizers used up as input in agricultural production. It is calculated as the average quantity of nitrogen (in kg) used per hectare of national utilised agricultural area.

d. Socio–cultural indicators

By Mauro GAMBONI and Silvana MOSCATELLI, CNR, Italy

D1. Collective participation, cohesion, conviviality and commensality (Proportion of meals alone consumed outside home).
Consuming and sharing the same food at the same table is to be considered a social experience and represents a peculiar characteristic of Mediterranean lifestyle. The distance from the social sustainability is measured by food consumption in places other than a "table" around which people consume the same meal together. The indicator proposed is the "proportion of meals consumed individually not collectively outside home in a week" which is useful to indicate the level of conviviality and sharing the same food at the same table. Social sustainability of diet is inversely proportional to the frequency of such episodes.
D2. The involvement of consumer in the preparation of food (Proportion of already prepared meals).
Preparing and cooking food is expression of the importance devoted to food by people in their daily life. For this reason, the time dedicated to the preparation of food and the selections of fresh products in the daily diet have specific and significant social implications. The objective is to assess the direct consumer intervention in the preparation of food. The distance from the social sustainability is measured, in this case, by the frequency of consuming pre–cooked food directly ready to use. The indicator proposed is the "proportion of already prepared meals consumed in a week" which is useful to understand the effective involvement of the consumer in preparing food. Social sustainability of diet is inversely proportional to the occurrence of these kind of food consumption.

D3. Traditional diets relevance: Consumption of traditional products (e.g. Proportion of product under PDO – Protected Designation of Origin – or similar recognized traditional food).
The presence of traditional food in population current diet is a clear manifestation of recognizing their cultural identity. The culinary culture represents not only the sum of diverse food referred to it but also food habits which regulates the relationship between the individual and the food. The distance from the cultural sustainability is measured by the absence/low consumption of traditional food, resorting to the use of food without identity.

The indicator proposed is the "proportion of product under PDO (Protected Designation of Origin) or similar recognized traditional food consumed in a week", which is useful to verify if and how much traditional products are currently consumed, as expression of the cultural aspects and traditions connected to food.

D4. Transmission of knowledge: Mass media activities and products dedicated to traditional food (Proportion of mass media initiatives dedicated to the knowledge of food background cultural value).
Affirmation of a cultural sustainable diet depends on its pervasiveness, in turn connected to generational transmission ability (from father/mother to children). It is therefore significant to analyse the efficiency of traditional food transmission and culinary culture knowledge among generations. The knowledge of food and preparation methods is a treasure for protecting an important component of cultural expression of individuals and within families and communities. Given that it is not possible to calculate by an indicator the extent of oral transmission of food traditions, it seems appropriate to test the transfer of knowledge from a generation to another taking into account the use of all the available information tools, including information and communication technologies, to which people have daily access, especially the youngest. The distance from the cultural sustainability is measured, in this case, by the absence/low occurrence of any transmission tools, especially devoted to young, connected to traditional food. The indicator proposed is "proportion of mass media initiatives (TV programmes, newspapers, magazines, websites, educative activities, publishing companies, etc.) dedicated to the knowledge of food background cultural value" which is useful to understand the diffusion level of traditions linked to food selection, preparation and cooking. This is important to verify the dimension of information dedicated to traditional foods by mass media and their interest in disseminating traditional food and culinary knowledge.

(Source: FAO/CIHEAM, 2012)

Interest in sustainable diets is markedly increasing within the broader and complex context of the sustainability of food systems. However, defining a theoretical methodological framework for the assessment of the sustainability of diets presents many challenges.

This publication presents the proceedings of the international workshop "Assessing sustainable diets within the sustainability of food systems. Mediterranean diet, organic food: new challenges", held on 15–16 September 2014, at the Centro di ricerca per gli alimenti e la nutrizione (National Institute of Research on Food and Nutrition – CRA-NUT), Rome organized by the International Research Network for Food Quality and Health (FQH) and the Research Centre for Food and Nutrition of the Council for Agricultural Research and Economics (CREA), in collaboration with the FAO-UNEP Sustainable Food Systems Programme, CIHEAM-Bari, CIISCAM, ENEA, CNR and PTBio Italia.

The international workshop aimed to address two pressing needs: to foster a scientific debate on how to address the question of sustainable diets within organic production/consumption concepts and achievements and what contribution the sector can provide to the ongoing discussions; and to finalize ongoing collaboration on identification of indicators and methods for assessing sustainable diets within the improvement of the sustainability of food systems, using the Mediterranean diet and the Mediterranean area as a case study.

Its overall objective was to contribute to a better understanding of the relationship between diets and food systems. It focused on the impacts of diets on food systems) in order to be able to concretely assess the sustainability of diets, intended as their contribution to the sustainability of food systems.

The publication addresses several interdisciplinary and interdependent issues related to: food systems; sustainable diets; the Mediterranean diet; health implications of current food consumption patterns; food environmental footprints; organic food; and food production systems.

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Economic Affairs, Education and Research EAER
Federal Office for Agriculture FOAG

With the Patronage of
EXPO MILANO 2015
FEEDING THE PLANET
ENERGY FOR LIFE

MED DIET EXPO 2015

ISBN 978-92-5-108825-8

9 789251 088258

I4806E/1/07.15