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Can Healthier Food Demand be Linked to Farming Systems' Sustainability? The Case of the Mediterranean Diet

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ABSTRACT

Promoting healthier diets is strategic to solve the global societal challenge of excessive and unhealthy calorie intake that causes obesity and overweight and is responsible for chronic diseases that burden healthcare systems. The relationship between food and personal health is well established and in recent years it has originated a number of dietary recommendations from the World Health Organisation (WHO) focused on encouraging healthier diets. The environmental impact of food intake and of particular diets is a growing research area. However, neither research nor public policies, in particular, have been able so far to establish a link between promoting healthier diets and their impact on enhancing environmentally healthier farming systems and the sustainability of rural landscapes.

This paper addresses this gap by presenting a multidisciplinary literature review which combines evidence from nutrition and health sciences with that from environmental, agrarian and sustainability studies on the impacts of foods and dietary patterns on the environment, ecosystems and rural landscape. This integrated review, complemented with data analysis, highlights the Mediterranean diet as a healthier dietary pattern whose promotion could be beneficial to recover or maintain the sustainability of Mediterranean rural landscape. Hence, the second part of the paper focus on discussing the role of public policies in enabling the link between enhancing healthier diets and healthier farming systems in order to sustain rural landscapes since these play a key role in the sustainability of Mediterranean rural areas.

Keywords: *Bioeconomy; Food demand; Food systems sustainability; Healthier diets; Mediterranean Diet; Sustainable rural landscapes.*

1 Introduction

Global scale changes in food consumption are currently reshaping both food and farming systems and worldwide transformations in rural landscapes are expected in the coming years (Webb *et al*., 2011). Food demand drivers responsible for these changes relate to well-known socioeconomic dynamics, which comprise the world population growth and its concentration in urban areas along with the rise of middle classes in emerging countries, and population decline and aging in developed countries (FAO, 2009). Food production and productivity are envisaged as major challenges within the next 30 years, due to the expected growth in food demand. FAO estimates that, by 2050, 60% more food will be needed to feed the world population (FAO, 2016).

The rise of purchasing power in emerging countries, such as China and India, powered by the globalised consumption trends, is leading the populations of these countries, in particular the latter's, to replace their traditional rice and vegetable-based diets with higher caloric western-type diets, thus raising the global consumption of red meat and cereals (Zhou, Tian, Wang, Liu, and Cao, 2012). The pressures of this escalating food demand on natural resources, namely on soil and water, will aggravate current sustainability problems related to the loss of biodiversity, declining regulating ecosystem services and the increase in Greenhouse Gas Emissions (GHGE), as well as their concomitant impacts on climate change (Allen and Prosperi, 2016; OECD, 2012; FAO, 2011).

Alongside with this megatrend towards the worldwide westernising dietary patterns, an 'alternative' food consumption megatrend, focused on health and well-being concerns, has emerged in more recent years (Tischner, Kjaernes, 2007; Reisch, Eberle, and Lorek, 2013). In the richest countries, namely in the European Union (EU), ageing has become a major concern of both public policy makers and consumers as far as health and active ageing issues are concerned. A growing attention is being paid to the negative impacts of western-type dietary patterns on human health and some action is being taken to address the matter.

Overweight and obesity are currently major public health issues due to their correlation with chronic diseases with high incidence rates, such as arteriosclerosis, cholesterol and diabetes (Kaur, Scarborough, and Rayner, 2017). The public's concern about these diseases and the costs they represent for healthcare systems have made room for a growing interest and investment on scientific research focused on establishing relationships between food and human health.

The definition of a healthy diet is not straightforward. It can be defined as a food intake pattern whose effects on health are beneficial or, at least, not harmful (Stevenson and Stevenson, 2016). A healthy diet should provide us with the right amount of energy (calories or kilojoules) from foods and drinks to maintain energy balance (energy balance corresponding to a situation in which the calories derived from the diet are equal to the calories used by the body). A balanced and healthy diet will vary, depending on individual needs (e.g. age, gender, lifestyle, and degree of physical activity), the cultural context, locally available foods and dietary habits (Duchin, 2008).

However, growing scientific evidence on the food health impacts has launched the concept of healthy foods and diets. Subsequently, it is acknowledged nowadays that healthy dietary patterns are lower in calories and in the intake of fats, sugar and animal proteins, with a highlight on red meat consumption (UNSCN, 2017). The World Health Organization, for instance, establishes that healthier diets are richer in the intake of fruits, vegetables, legumes, nuts and whole grains and poorer in fats, sugar and red meat (World Health Organization, 2015).

The reshaping of the concept of 'healthy' diets has led to fruits, vegetables, legumes, nuts and whole grains having been included in the list of 'healthy foods'. On the other hand, there is the recommendation that one should eat some foods often labelled as 'unhealthy' foods parsimoniously, and the same goes for diets based on them like which have become to be known as western-type diets.

These recent changes in the World Health Organization's healthy dietary standards have drawn the attention to plant-based diets, such as the vegetarian and the vegan diet. The vegetarian diet is defined as a dietary profile characterized by one's abstaining from consumming meat and meat products, poultry, seafood and meat of any other animal, while the vegan diet bans any substance derived from animals. These dietary patterns were originally motivated by ethical concerns towards non-human animal species but have been increasingly looked upon in more recent years as a way to safeguard the natural resources and the environment (Dinu, Abbate, Gensini, Casini, and Sofi, 2017).

Hence, healthier diets in comparison with the 'western-type' diet are lower in calories, fats and sugar. Therefore, healthy food and diets enhancing beneficial effects on human health go beyond a normal healthy diet required for human nutrition; it is currently established that healthy foods comprise fresh

and low-processed food - fruits, vegetables, nuts, pulses, seeds and whole cereals - that olive oil is a healthy fat and that fish constitutes a healthy source of protein (Food Security Information Network, 2017). The reshaping of the healthy diet concept has brought back ancient dietary patterns like the Mediterranean or the Nordic diets.

The beneficial health effects of the Mediterranean Diet (MedDiet) have been extensively researched and are largely responsible for fruits, vegetables, pulses, seeds and whole cereals olive oil having been included in the list of 'healthy' foods. They are healthy in the sense they are beneficial to human health. However, their degree of healthiness depends on how they are produced and delivered to the final consumer. This explains the passing of increasingly strict legislation on the use of phytopharmaceutical substances in EU agriculture (European Commission, 2017), as well as, at least partially, the worldwide growing demand for organic- grown food (Meemken and Qaim, 2018).

There is an emerging research field on the environmental impacts of these healthier diets, such as plant-based vegetarian and vegan, and Nordic and Mediterranean diets, compared with the 'standard' western-type diet. In some cases, this research also addresses the human health effects.

However, there is not an integrated review of these 'healthy' dietary patterns in terms of their impacts on human health, on the environment and on the sustainability of farming systems and respective rural landscapes. This is an important matter in the context of the current discussions on what bioeconomy is and how it should be promoted, searching for a common ground between: (a) the industrial-oriented perspective, focused on lab-biotech innovation and capital-intensive industries located at the upper levels of the value chains; and, (b) the agro-ecological-oriented bioeconomy standing for sustainable farming, forestry and related activities, ensuring the supply of public goods (*e.g.*, water quality, landscape attractiveness, typical foodstuffs) and rural development (*e.g.* European Comission, 2012; Levidow, Birch, and Papaioannou, 2012).

Hence, this paper aims at contributing to reinforce the importance of bioeconomy being viewed as a system that manages to integrate health and environmental concerns into food systems; this can be achieved by ensuring that public policies and consumer food demand are oriented towards the integrity of rural landscapes built on environmentally healthy farming systems. Its contribution draws on systematic literature review with an interdisciplinary approach and on large statistical datasets analysis, and it has two goals.

The first goal is to provide an integrated synthesis of the literature, making it possible to establish a link between food, health and environment, reinforced by the analysis of statistical data on food and health provided by FAOSTAT's and WHO's databases. The second goal is to discuss how the food demand component of food systems can be linked to the sustainability of farming systems and rural landscape in the case of MedDiet.

This is a proven diet with strong synergies between food intake and human health, but whose promotion may or may not enhance the sustainability of Mediterranean rural landscapes. Raising consumers' awareness of the link between food, human health and sustainability of Mediterranean rural landscape entails changes as far as their mindset is concerned. These can be supported by integrated public policies able to acknowledge that healthier diets depend on farming systems' and rural landscapes' sustainability.

By compiling scattered strands of literature, the present paper highlights the existing research gaps which hinder society and politicians from being able to grasp the notion that healthy food is associated with its ecologically sustainable growth. A growing awareness of this association could make a difference regarding the argument in favour of an agro-ecological-oriented bioeconomy standing for sustainable farming, forestry and related activities, ensuring both the supply of public goods and rural development. The MedDiet is an exemplary case to analyse the strengths as well as the contradictions raised by coupling healthy food and ecologically-sustainable farming, by bridging consumer issues and farming systems both at the research and policy levels.

Following the introduction, the present paper is organised into five sections. Section two reviews and summarises evidence on the relationship between food, diets and health, presenting data on MedDiet dietary patterns and the prevalence of obesity and overweight in the European region. Section three presents a literature review linking food and dietary patterns to environmental sustainability. Section four discusses how sustainability weaknesses of the Mediterranean farming landscape can be reinforced or, on the contrary, overcome by a growing demand of 'healthy' foodstuffs related to this region. Finally, section five presents the concluding remarks.

2 Evidence linking food and health and the rediscovery of the Mediterranean diet

The effect of diets on human health has been largely reported in many studies, providing evidence that a rich dietary pattern in some beneficial food groups, such as fruits, vegetables, whole grains and fish, reduces the incidence of cardiovascular and neoplastic diseases (Sofi, Macchi, Abbate, Gensini, and Casini, 2013; Miller, Cassady, and Nielsen, 2015; Birt *et a*l., 2017; Miller, Cassady, and Nielsen, 2015). However, so far, most of the studies have followed an approach of assessing nutrients or food groups in relation to the occurrence of the disease, rather than analysing the individual role of nutrients in the dietary pattern (Sofi *et al*., 2013). As a result, lately there has been a rise in the number of studies that consider the sum of the food through a general measure of the quality of the diet.

The Mediterranean diet has been highlighted in several studies for its benefits to human health, because of the consumption of a balanced quantity of different nutrients, distributed in the form of a pyramid structure (Dernini and Berry, 2015). Plant-based foods are situated at the base of the pyramid, contributing to maintaining a balanced diet. They should be consumed in larger quantities and more frequently, as opposed to those situated in the upper levels, that are rich in sugars and fats and of animal origin, that should be eaten moderately (Bach-Faig *et al*., 2011).

In the early 1970s, many researchers referred to the beneficial role of the MedDiet, as originally reported by Ancel Keys, a physiologist and nutritionist who did intensive research on the relationship between coronary heart disease, blood cholesterol levels and diet and lifestyle in seven countries: Greece, Italy, former Yugoslavia, the Netherlands, Finland, the United States and Japan. His research showed that the MedDiet was rich in fruits, vegetables, and cereals, with olive oil as the sole source of fat. This diet contemplated a moderate intake of red wine, especially during meals, and little red meat.

These studies proved the MedDiet to be more balanced and less responsible for the occurrence of the above-mentioned diseases than other dietary patterns. The justification for its healthier features lies in that fact that it is lower in fats, animal proteins and calories in comparison with the more conventional eating patterns of developed industrialized societies.

In the footsteps of Ancel Keys' pioneer studies, research on the health benefits of MedDiet has expanded. Nowadays, there is significant evidence confirming that higher adherence to the MedDiet may decrease the rate of some diseases. Kastorini *et al*. (2011) have conducted a systematic review and a meta-analysis of the findings of published original research articles in which the researchers have assessed the effect of a Mediterranean type of diet on the development of the metabolic syndrome (MS) as well as on its components. The results of these authors' meta-analysis indicate that adherence to the MedDiet has a positive effect on abdominal obesity, lipid levels, glucose metabolism and blood pressure levels. These are all all components of MS, and also risk factors in the development of cardiovascular diseases, insulin resistance and diabetes. The antioxidant and anti-inflammatory effects of the MedDiet as a whole, as well as the effects of its individual components, more specifically olive oil, fruits and vegetables, whole grains and fish, could be the basis of the above-mentioned results.

Other available meta-analyses (Dinu, Pagliai, Casini, and Sofi, 2018; Sofi *et al*., 2013) present similar findings, confirming that adherence to the MedDiet can significantly reduce the risk of global mortality, cardiovascular disease (CVD) mortality, cancer incidence or mortality, as well as the incidence of Parkinson's and Alzheimer's diseases.

Along the same lines, Gotsis *et al.* (2015) provide a literature review focusing on the last 5 years up to 2014 that evaluated the effectiveness of the MedDiet in reducing the prevalence of chronic and degenerative diseases. Their findings support the protective role of the MedDiet against atherosclerosis, cancer, CVD, obesity, MS, and DM (diabetes mellitus), while helping prevent respiratory, neurodegenerative, and kidney diseases.

The health benefits of MedDiet foods, such as olive oil, fish, fruits and vegetables, have been associated with a reduction in blood pressure (BP) levels. The nutrients and substances in these foods, such as oleic acid and omega 3, in addition to phytochemicals and antioxidants, the low sodium content and the high content of potassium, magnesium and calcium, are also relevant to the characteristics of the MedDiet. The systematic review and meta-analysis of Nissensohn, Román-Viñas, Sánchez-Villegas, Piscopo, and Serra-Majem (2016) have looked into the effects of the MedDiet on systolic BP (SBP) and diastolic BP (DBP). In summary, the authors have found evidence that the MedDiet pattern matches the nutrient levels that are most relevant to the prevention of hypertension.

There are also studies that have examined the role of healthy eating patterns like the MedDiet on obesity. Obesity is one of major causes of death worldwide and according to the definition of the WHO (2017) is as

an abnormal or excessive accumulation of fat that represents a risk to one's health. It is measured in terms of the body mass index (BMI) and it is calculated by dividing the weight in kilograms by the square of a person's height in metres. Among children or adolescents, if BMI≥30 Kg/m^2, then they are considered obese; and if BMI≥10 Kg/m^2, they are considered overweight. According to World Health Organization's estimates (2017), among the world population almost two billion adults are overweight (40% of the population), of whom over 600 million are obese, and 41 million children under the age of five are overweight or obese.

Still according to the World Health Organization (2017), in Europe the number of overweight and obese people has been growing in recent years. In 2014, the last European health survey reported that 39% of the men and 40% of the women aged 18 or over were overweight (Eurostat, 2018). The prevalence of obesity and overweight is increasing in MedDiet countries, which appears to be linked to these countries' gradual shift from the healthy MedDiet towards a more Western type-diet and unhealthy lifestyles (Hakanen *et al*., 2006; Kontogianni *et al*., 2008; Manios and Costarelli, 2011).

Fig. 1 presents a graphic based on FAOSTAT data and includes the European countries with a MedDiet - Cyprus, Greece, Italy, Spain and Portugal - with the exception of Croatia (formerly part of Yugoslavia) since there were no data for part of the 52-year period (between 1961 and 2013) under analysis.

Calories in the MedDiet were accounted for, including the main foods of this diet, such as cereals, fruits, vegetables, nuts and olive oil.

Fig. 1 also shows evidence of the increase in calorie intake in this region over the last 50 years, an estimated 22% on average, and has reached a value well above the recommended average (around 2000 calories for an adult) (WHO, 2018). In parallel, the figure illustrates the decrease in calorie intake of the dietary basis of the MedDiet over time.

The decrease in the intake of foods belonging to the MedDiet pyramid was 16% on average; it was particularly noticeable in two of the core countries of the MedDiet, Greece and Spain, experiencing a decrease of 20%, but not so much in Italy (where it reached only 7%). As for Cyprus, it was somewhat expressive (although this country experienced a moderate increase in the total calorie intake during the period under analysis). Portugal, however, showed an opposite trend, with an increase of 20%, although it is the country with the highest increase in total calorie intake: 40% for the period under analysis. Hence, data not only confirm this regional divergence from the MedDiet but it over time also highlight its relation to the rise in the countries' average purchasing power.

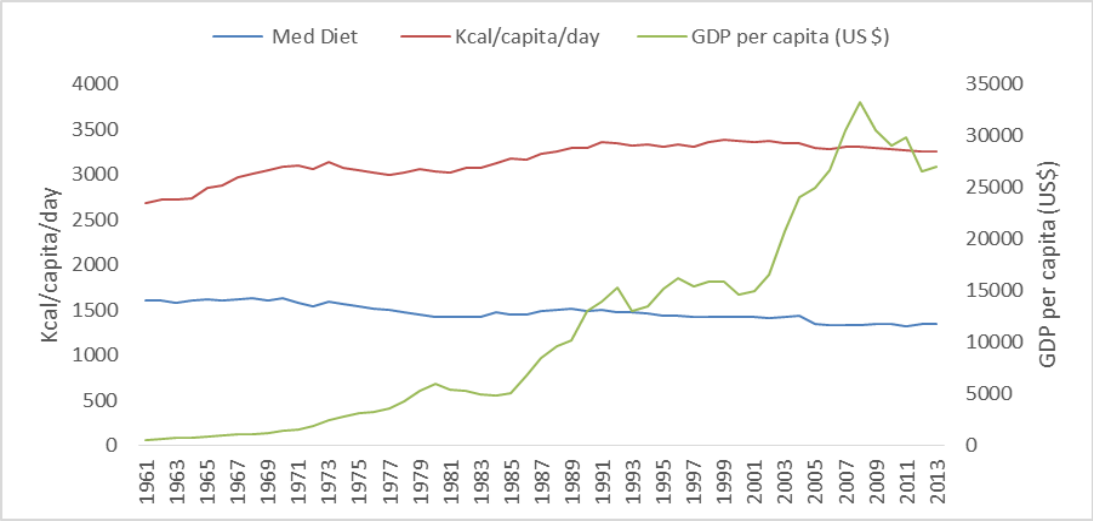

Figure 1. Average total and MedDiet food kilocalories per capita per day in the MedDiet region, 1961-2013 (Source: Data retrieved from FAOSTAT, 2018).

The time dynamics regarding prevailing levels of obesity among the youngest age group in the MedDiet countries (which is similar to the adults') is illustrated in Fig. 2. The rise of obesity and overweight among young people gives one particular reasons for concern, since chronic diet-related diseases are expected to increase in coming years. Overweight among youths in this region shows a similar trend; in 2016, it more than doubled, sometimes it even tripled, in some countries compared to figures from 1975.

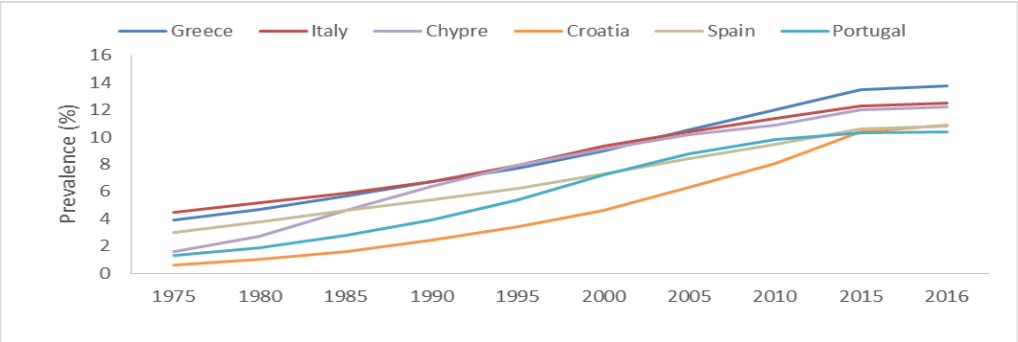

Figure 2. Prevalence of obesity among children and adolescents, age 5-19, by country, in the MedDiet region, 1975-2016 (Source: Data retrieved from World Health Organization, Global Health Observatory, 2018).

Negative trends that have been observed regarding overweight prevalence and obesity in the MedDiet countries are related to an increase in the consumption of western-type food products, such as red meat and sugar, as shown in Fig. 3, where it is possible to see the evolution of the consumption of two basic western-type foods - red-meat and sugar- in the Southern European region, as well as calorie intake derived from essentially healthy MedDiet products, fruits and olive oil.

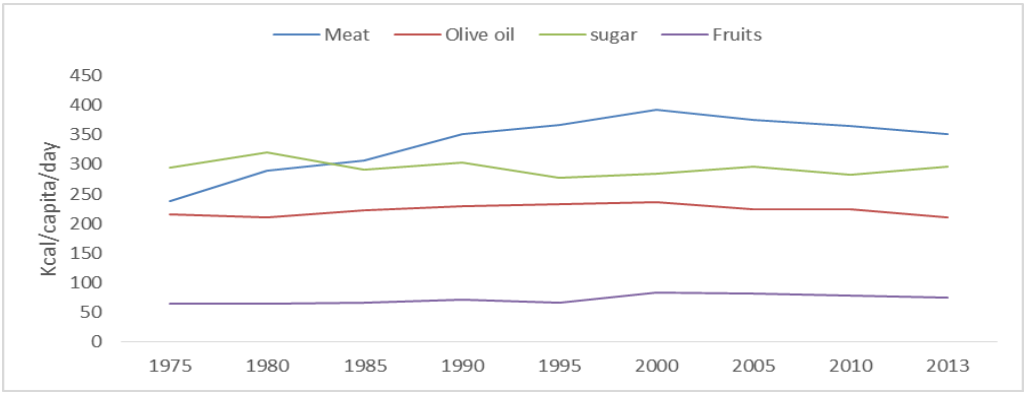

Figure 3. Average consumption of red meat, sugar, fruits and olive oil in the Southern European region in kilocalories per capita, 1975-2013 (Source: Data retrieved from FAOSTAT, 2018).

The consumption of these four products in Northern Europe in the same period provides a different picture (Fig. 4). Although these countries show evidence of a western-type diet, they also portray a decrease in the intake of ('unhealthier') calories from sugar and red meat and an increase in the intake of ('healthier) calories from fruits and olive oil.

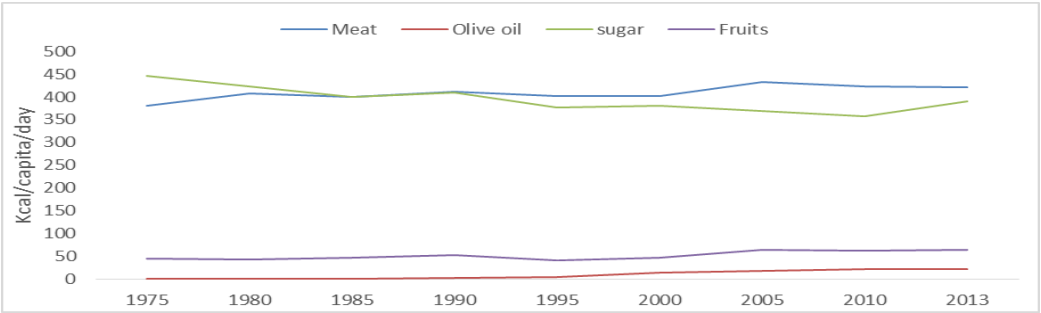

Figure 4. Average consumption of meat, sugar, fruits and olive oil in the Northern European region in kilocalories per capita, 1975-2013 (Source: Data retrieved from FAOSTAT, 2018).

The-westernisation of the diet in Northern Europe is led by Sweden and Denmark; in recent years, these two countries have been implementing a set of public policies designed to promote healthier food in schools. These policies appear to positively impact on obesity and overweight prevalence among the young.

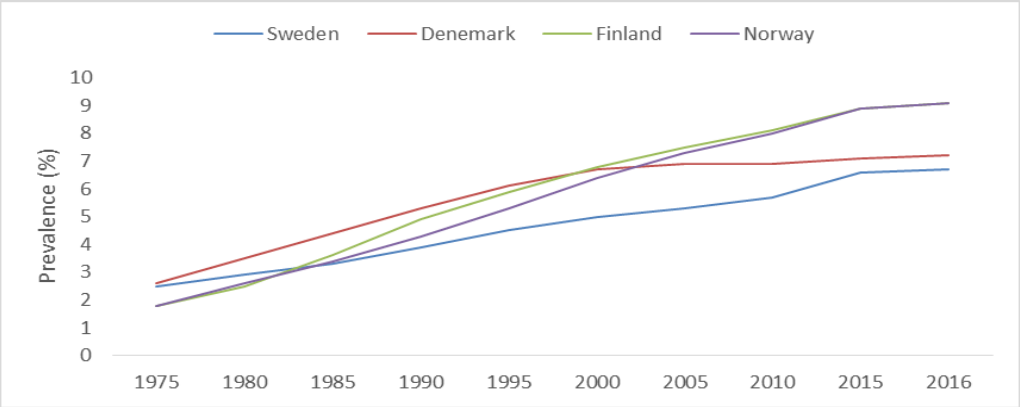

Figure 5. Prevalence of obesity among children and adolescents, age 5-19, by country, in the Northern European countries, 1975-2016 (Source: Data retrieved from World Health Organization, Global Health Observatory, 2018).

The link between dietary patterns, obesity and overweight prevalence, and concomitantly the prevalence of diet-related chronic diseases that represent a heavy burden on public budgets, are driving European countries to adopt policies to promote healthier food consumption. These policies include decentralised measures, such as implementing healthy food procurement policies in schools, taxing 'unhealthy' foods like sugar and fats, and adopting command-control type policies which set limits to the use of salt, sugar or fats in processed foods.

Since these policies are relatively new, research must be done on how to make them more efficacious and cost-effective. The case of Sweden suggests that decentralised policies might be more effective than sugar taxes (which are not implemented in this country).

With the exception of the MedDiet, evidence relating health and dietary patterns (Aleksandrowicz *et al.*, 2016, Kaur, Scarborough, and Rayner, 2017), is few and far between. For the WHO (2015), a healthy diet is one that contains fruits, vegetables, legumes, nuts and whole grains, which proves the important role of plants in the MedDiet, and suggests that stricter plant-based diets, such as the vegetarian or the vegan diets, might also be healthier. However, few studies have evaluated the impact of these diets on human health. Dinu, Gensini, Casini, and Sofi (2017) have done a systematic review of the literature with a meta-analysis of observational studies and have concluded that the vegan diet seems to be associated with a lower level of cancer incidence. This result, however, should be interpreted with caution, in view of the small size of the sample that has been observed and the scarcity of studies available which evaluate this aspect.

On the other hand, the authors have found there is significant protection against ischemic heart disease and cancer in vegetarians, albeit not significant in terms of general mortality, cardio- and cerebrovascular diseases. In spite of there being pioneering research linking strict plant-based diets with health, evidence is still too scarce to allow for a comparison with the health benefits of the MedDiet, which remain to be proven outside the contextual lifestyle factors defining this dietary pattern, such as eating-related socialising habits. The classification of the MedDiet as World Heritage by UNESCO in 2001, for instance, called the attention to the relationship between the diet and lifestyle of Mediterranean communities (Castro-Quezada, Román-Viñas, and Serra-Majem, 2014), which suggests that a MedDiet type might lose its efficacy if constrained by factors such as time availability, work obligations and financial stress (Gorski and Roberto, 2015).

Clearly further research is needed to link human health with dietary patterns, namely because there is little knowledge relating healthy foods and healthy dietary patterns to the environmental aspects of food production and processing.

3 Evidence of the relationship between food systems and the environment

Studies examining environmental impacts of individual foods and dietary patterns are now beginning to emerge, whilst varying considerably in design and research methodologies. The study of the environmental impacts of individual foods relies mostly on such indicators as water extraction and land use (Godfray *et al.*, 2010). Life cycle assessment (LCA) is the most popular method used to assess the GHGE of dietary patterns (Heller, Keoleian, and Willett, 2013). Through the LCA, it is possible to extend the analysis from individual products to entire value chains (Duchin, 2008).

Most studies support the notion that there are environmental benefits associated with increasing the consumption of fruits and vegetables and reducing the consumption of animal-based foods (Pretty *et al*., 2010), since it significantly helps reduce GHGE (Hallström, Carlsson-Kanyama, and Börjesson, 2015; Scarborough et al., 2014; Springmann, Mason-D'Croz, *et al.*, 2016; Tilman and Clark, 2014; Westhoek *et al*., 2014). The literature review on this topic, while recent, provides studies evaluating the environmental impact of dietary changes at both global and regional scales. For instance, Hallström *et al.* (2015) provide a systematic review evaluating the environmental impact of dietary change. Amongst the various scenarios examined by the authors, the vegan diet followed by the vegetarian diet stand out as the ones with the largest potential to reduce GHGE. Compared to them, diets replacing ruminant meat with pork and poultry have a lower but still significant potential to reduce GHGE. Similarly, according to the present author's analysis, the vegan and vegetarian diets are the best placed to reduce land demand for agricultural use.

Aleksandrowicz, Green, Joy, Smith, and Haines (2016) have studied the impacts of dietary change on GHGE, land use and water abstraction. These authors have done a systematic review and have come to the conclusion that by adopting sustainable dietary patterns it is possible to reduce GHGE and land use up to 70-80%, and water abstraction up to 50%. These authors' conclusions are in keeping with the findings of Hallström *et al*. (2015), according to which vegan and vegetarian diets have the lowest environmental impact. Nonetheless, the authors provide evidence of the substantially lower environmental impact of the MedDiet in comparison with the typical western meat-based diets.

Fresán, Martínez-Gonzalez, Sabaté, and Bes-Rastrollo (2018) have analysed the impact of enhancing adherence to the MedDiet on land, water, and energy consumption and on GHGE in Spain. In order to achieve this purpose, they have gathered specific environmental footprints of the production and processing of food items from various available studies conducted, resorting to the LCA technique. They have concluded that higher adherence to the MedDiet is associated with lower land use, water consumption, energy consumption and GHGE, in comparison with western-type diets, and that the MedDiet can be envisaged as an eco-friendly diet.

In the last decade, the MedDiet has become the object of an increasing number of studies addressing its environmental sustainability, because of its mainly plant-based dietary pattern and its lower GHGE and lower water footprints, when compared to current Western dietary patterns (Gerbens-Leenes, Nonhebel, and Krol, 2010; Tilman and Clark, 2014). Meals including products of plant origin are associated with the reduction of carbon, hydro and ecological footprints (Birt *et al*., 2017; Scarborough *et al*., 2014).

However, it is important to evaluate plant-based diets accounting for farming systems and practices, and logistical food chains, as they strongly affect the environmental impact of food products. Moreover, the available evidence doesn't allow to compare diets in terms of other important environmental impacts, such as the biodiversity loss and the use of phytopharmaceutical products.

In addition, in more recent years, discordant authors have been arguing that plant-based diets may not actually have the substantially lower environmental impact they are credited with (Kamp and Temme, 2018; Lacour *et al*., 2018; Perignon, Vieux, Soler, Masset, and Darmon, 2017; Rosi *et al*., 2017). The arguments underpinning this view focus on the high amount of vegetables that need to be consumed to replace animal proteins and calories; furthermore, if meat is replaced with fruits and vegetables, keeping total food energy constant, there will be an increase in GHGE (Vieux, Darmon, Touazi, and Soler, 2012).

4 Healthier diets: an opportunity or a threat to Mediterranean rural landscapes?

As shown by the previous literature review, the MedDiet is evaluated as being more beneficial both to human health and to the environment (Tilman and Clark, 2014; Dooren, Marinussen, Blonk, Aiking, and Vellinga, 2014; Hallström *et al*., 2015; Springmann, Mason-D'Croz, *et al.* 2016; Springmann, Godfray, *et al.* 2016). Some authors argue that the MedDiet is more than just a dietary pattern: it is also a representation of different food cultures and lifestyles (Dernini and Berry, 2015); they highlight other dimensions of this diet, such as its being a cultural heritage, the local food production, and the nutritional value (e.g. Piscopo, 2009; Diet and Regional, 2012; Bach-Faig *et al.*, 2011; Burlingame and Dernini, 2011, 2016; Allen, Prosperi, Cogill, and Flichman, 2014; CIHEAM, 2015). Unlike what happens with vegan and vegetarian diets, which are not anchored in cultural traditions with territorial expression.

The arguments in favour of the MedDiet's are also linked to the fact that a plant-based diet requires less biocapacity, that is, less demand for agricultural land (Zurayk, 2012; Lacirignola, Capone, Debs, El Bilali, and Bottalico, 2014; CIHEAM, 2015). Although this argument is also valid for strict plant-based diets, the MedDiet is associated with diversified farming systems, enhancing agrobiodiversity through land use patterns that not only promote mosaic landscape and farming practices like crop rotation, but also

enhance agrobiodiversity, and supply ecosystem services, namely pollination, nitrogen fixation, pest control, soil quality, fire resilience and nutritional value (FAO, 2016; Declerck, Gentle, Gordon, and Kennedy, 2014; Myers et al., 2014; Gamfeldt et al., 2013; Cadotte, Dinnage, and Tilman, 2012; Kremen and Miles, 2012; Kremen and Miles, 2012; Shennan, 2008).

It is widely acknowledged though, that the Mediterranean agroecosystem is fragile, registering an ecological deficit in degraded landscape areas mainly located in the Balkans and the Northern Mediterranean, and consuming around 40% more renewable natural resources and ecosystem services than they provide (Galli *et al.,* 2015). In these regions, traditionally diversified and plant-based diets have contributed to the preservation of landscape and genetic biodiversity. Hence, farming systems need to be ecologically sustainable and not strictly eco-efficient, if the sustainability of the Mediterranean landscape is to be preserved.

The sustainability of the Mediterranean rural landscape requires the adoption of sustainable production systems and innovative practices built on biodiversity enhancement and agro-ecological knowledge (Allen *et al.*, 2017), along with high value-added food chains that enable local farmers to capture value (Galanopoulos, Surry, and Mattas, 2011). Thus, growing demand for MedDiet foodstuffs driven by human health concerns might enhance the sustainability of Mediterranean farming systems if based on preferences for food associated with rural landscape sustainability.

There is some evidence that this demand, and especially the demand for organic production, is currently becoming more than just a niche demand (WBCSD, 2010), in spite of organic products reaching higher prices than food products produced by conventional modes. The index of producer prices of agricultural products (output index) made available from the Eurostat by product for the period between 2008 and 2017 (this index is based on the sales of the agricultural products at farm gate prices) highlights farmers' trend in the MedDiet region to increase the price of olive oil and nuts. That trend is not so obvious in the case of fresh vegetables and fresh fruits, although these are not exclusively produced in this European region.

Fig. 6 shows these price trends, suggesting a growing demand for these products.

The demand-pull and price increase of such products as olive oil and nuts create an opportunity for producers to capture value-added in the cases in which they act across value chains, producing, processing and distributing the products for higher price segments. It includes the external markets, namely Central and Northern Europe, along with the traditional exporting markets for olive oil.

However, the sustainability threats of this demand-pull accompanied by higher prices are already visible in those countries with area expansion, intensification and more recently hyper-intensification of farming systems responsible for these crops in the Mediterranean hinterlands when water for irrigation is available. On the other hand, in the Mediterranean uplands, the sustainability of farming systems is becoming mandatory due to landscape fragility and accentuation of climate change impacts. However, to achieve farming sustainability in these areas farmers need to adopt agro-ecological knowledge and labour-intensive farming practices, which are costly and pose competitiveness difficulties (economic sustainability limitations) to these ecologically-sustainable farming systems (Colantuoni, Pascucci, and Fritz, 2011).

Sustainability challenges could be overcome in both cases if consumers and public policies acknowledged that healthy food has to be produced by ecologically-sustainable farming systems. The need for public policies derives from the fact that diverting the production of these products only for external markets and consumer niches with high purchasing power jeopardises lower-income consumers' affordability of MedDiet products and hinders the recovery of this dietary pattern in this region where it originated (Birt *et al*., 2017).

If sustainability is to be enhanced, healthier diets need to meet the three fundamental requirements of sustainability: be economically viable, environmentally responsible and capable of promoting social balance and well-being (Wilson *et al*., 2013). Only recently have some authors focused on the economic perspective of healthier and ecologically sustainable diets (Lee *et al*., 2013; Lee, Kane, Ramsey, Good, and Dick, 2016; Vandevijvere, Young, Mackay, Swinburn, and Gahegan, 2018).

The price and affordability of 'healthier' and 'less healthier' foods and diets vary across countries and might accentuate local and regional inequalities in each country, by denying populations with less purchasing power access to better diets (Lee, Kane, Ramsey, Good, and Dick, 2016). Lower-income families would have to spend a significant amount of their monthly income to fill the necessary dietary recommendations, and that would aggravate poverty (Lee *et al.*, 2013).

There is a trade-off between price and affordability because the individual prices of some healthier foods, particularly meats, fruits and vegetables, are relatively expensive compared to energy-dense foods, and also more expensive than basic (healthier) cereals (see Figure 7).

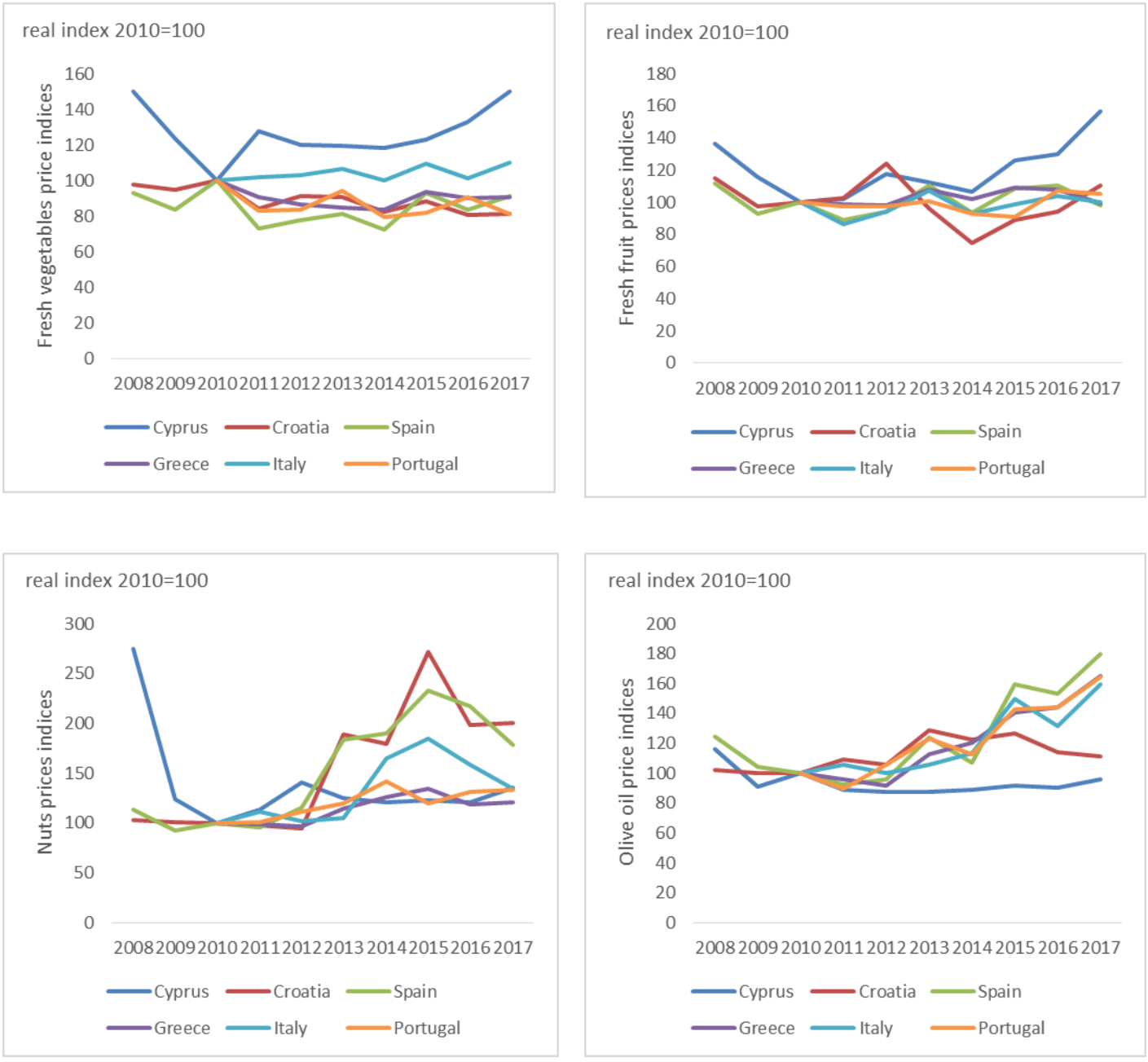

Figure 6. Index of producer prices of agricultural products for MedDiet central products in the European countries of the MedDiet, 2008-2017 (Source: Source: Eurostat (online code apri_pi10_outa)).

Fig. 8 illustrates the relation between world level food consumption and the food price index in the last 40 years, confirming these two variables to be negatively correlated.

The world food prices declined from the early 1970s up to the early 2000s, when they reached a historic low, coinciding with the higher level of world food consumption. During the first decade of 2000, this declining trend was inverted and prices started to rise again, reaching its peak in 2008, coinciding with the world food and oil price crisis. As a response, food consumption declined along this decade and decreased to the levels of the early nineties.

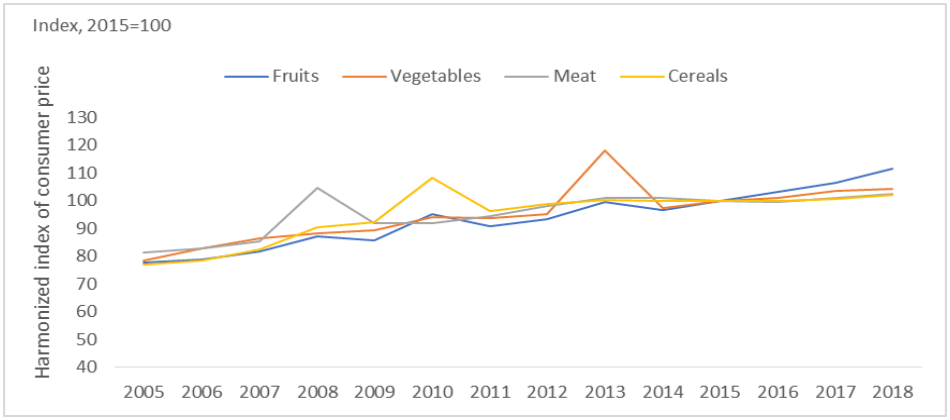

Figure 7. Harmonized Index Price (fruits, vegetables, meat and cereals) for the EU 28 countries 2005-2018. (Source: Data retrieved from Eurostat, 2018).

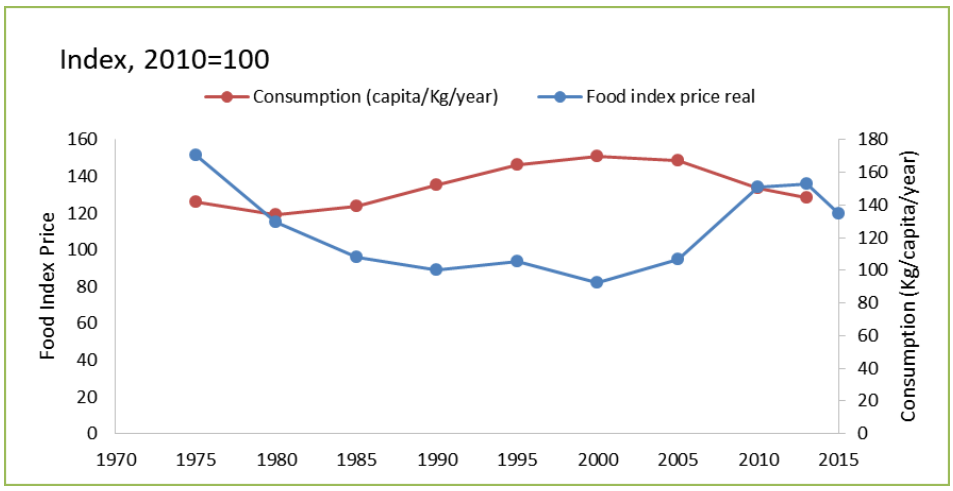

Figure 8. Trends and relationships between world food consumption and real food index prices, 1970-2015 (Source: Data retrieved from FAOSTAT, 2018).

Figure 8 also highlights the importance of prices as regards food intake. Thus, high food prices tend to worsen poverty, food insecurity and malnutrition. However, high prices represent an opportunity to stimulate long-term investment in agriculture, in the long run contributing to sustainable food security (FAO, 2016).

Price is considered by some consumers as a determining factor at the time of the purchase decision (Lee, Kane, Ramsey, Good, and Dick, 2016). A systematic review by Rao, Afshin, Singh, and Mozaffarian (2013) has shown that healthier diets cost more than less healthier ones, depending on whether the cost of the total diet or the cost per 2000 kcal was compared. However, given the implications of an 'unhealthier diet' for an increased incidence of chronic diseases, besides the ageing of the population in many parts of the world, and consequent burdens on public expenditure with health care (especially true of the European case), governments are starting to create public policies regarding food consumption that target healthy food consumption, following the good practices pioneered by Nordic countries (Nordic Council of Ministers, 2018, 2008)

5 Concluding remarks

Available data shows a worldwide trend towards overconsumption of calories. The calorie intake per person is rising across the developing world, particularly in emerging economies. This trend contributes to people becoming overweight and obese, harming human health and rising healthcare costs in the process. On the other hand, food overconsumption creates unsustainable pressure on farming systems, natural resources, ecosystems services and biodiversity.

Healthier diets appear, then, to be the solution to overcome overweight and obesity problems worldwide problems and to be able to simultaneously respond to the environmental challenges posed by food overconsumption. However, moving towards plant-based diets, including proven healthier diets like the

MedDiet, can only improve environmental sustainability of food systems if based on sustainable farming systems. In other words, measures must be taken to raise the general public's awareness, and in particular consumers', of the fact there is a positive link between their health and the food they choose to buy and eat, when that food is produced by sustainable farming systems. That means a major change in food consumers' mind-set is necessary, enabling them to link healthier food with its environmentally sustainable production.

The literature review that has been conducted in this paper confirms that from a nutritional and public health perspective, the promotion of fruit, vegetable, whole grain and fish intake is a proven strategy to improve diets around the world. Moreover, available evidence allows the establishment of the MedDiet as a healthier dietary pattern due to its protective effect on diseases related with ageing and overweight prevalence, such as arteriosclerosis, cholesterol and diabetes.

Yet, there is a lack of evidence regarding other dietary patterns or the adoption of a MedDiet type in different sociocultural contexts other than its place of origin. In addition, empirical research establishing a link between beneficial health effects of 'healthier' foods and its environmentally-sustainable production is few and far between.

Studies on the environmental impact of different foods and diets have been developed a considerable strand of literature on food production and consumption impacts on GHGE, land use and water abstraction is available. On the production side, the available data shows that increasing the share of plant-based protein in diets, while reducing consumption of animal-based protein and specifically red meat, could be a most significant contribution to a sustainable food future, reducing agriculture's use of resources and environmental impacts.

However, there are still considerable gaps in the available evidence regarding food consumption impacts on environmental aspects like the food pesticide footprint or the effects on biodiversity and ecosystem services provision of using pest control, food nutrients, or pollination, which can be aggravated by a subsequent increase of plant-based diets.

In fact, the attempts to relate food, environment and diet simultaneously are very scarce in the literature, and the evidence available is still insufficient to create a case in favour of making healthier food dependent on environmental sustainability, and, to an even lesser degree, on ecologically-sustainable production. The present research provides evidence of the gaps that make it difficult for ecologically-sustainable farming systems to take advantage of the trend towards an increasing healthy food demand across developed countries, in particular in the EU, and especially in Sweden and Denmark.

The establishment of a scientifically-sound relationship between the MedDiet foodstuffs' healthiness and its ecologically-sustainable production is crucial to the sustainability of Mediterranean rural landscapes. In the near future, the current trend of the growing market demand for foods like fruits, nuts and olive oil, and drinks like wine is likely to become more pronounced, which poses major challenges to the Mediterranean farming systems.

Land use changes and intensification and hyper-intensification of farming practices are spreading across the Mediterranean hinterlands, creating pressure on soil and water resources, changing traditional landscape and threatening biodiversity and diverse ecosystems services relevant to the safeguarding of natural and cultural heritage in the region. Smart agriculture and other innovations enhancing eco-efficiency are helpful but are not the answer to the ecological balances of the Mediterranean ecosystem's requirements.

In the Mediterranean uplands, demand for MedDiet foods could be beneficial to prevent land abandonment and the decline in landscape fire resilience; however, ecologically-sustainable farming systems are imperative in these areas, not only because of the ecosystem's fragility but also because of the pressures imposed by climate change and the spread of plant pests and diseases.

The systematic review that has been conducted in this paper confirms that while there is evidence that the diet is indeed a pillar of sustainable development, public policies have not been able to establish the link between food systems, health and environment policies, or agriculture and rural development policies, despite some steps having been taken in that direction The case of the Nordic countries reveals that integration between policies accounting for public expenditure must include healthy and eco-friendly public procurement for food, focussing on educating children about food habits.

An integrated EU level policy, combining agricultural, environmental, food marketing and health policies is absolutely necessary. Otherwise there is the risk of aggravating hyper-intensification of some areas besides the decline of mountainous and dry areas within Mediterranean Europe.

Recovering MedDiet patterns in its supply region is also fundamental to reinforce the link between this healthier diet and the sustainability of the respective farming systems. The detachment of Southern European consumers from their diet, which has been anchored in their territory, culture and heritage, will endanger the sustainability of the MedDiet and might accentuate the dissemination of unsustainable farming systems in this region.

Hence, the MedDiet cannot continue to be envisaged by the countries in this region solely as a cultural heritage asset. They have to promote it as a 'modern' healthy and eco-friendly diet, affordable to consumers in general, by launching integrated public policies and using this healthy diet as a tool to reduce chronic diet-enhanced diseases. Savings in the health care system would allow investment in the affordability of the MedDiet and would facilitate the sustainability of the respective farming systems.

Moreover, interdisciplinary research is needed to support the promotion of affordable healthier diets both for human health and rural landscapes, along with disciplinary research and the creation of statistical datasets linking food with health, and food consumption with environment. The relationship between dietary changes and savings in health care systems also needs further looking into, given its importance in supporting public policies to promote healthier diets.

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