REVIEW

Sustainability Dimensions of the Mediterranean Diet: A Systematic Review of the Indicators Used and Its Results

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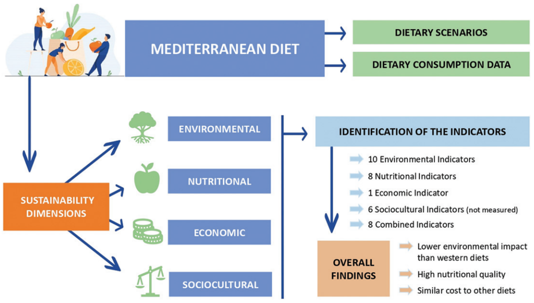
ABSTRACT

The concern about sustainability is growing and the Mediterranean diet has been extensively identified as a promising model, with benefits for human and environmental health. This systematic review aims to identify and describe the indicators that have been used to evaluate the sustainability of the Mediterranean diet and the results from their application. A methodology using PRISMA guidelines was followed, and searches were performed in Web of Science, PubMed, Scopus, and GreenFile. A total of 32 studies assessing the sustainability of the Mediterranean diet were identified. Twenty-five of these studies quantified the environmental impact, 7 studies evaluated the nutritional quality, and 12 studies assessed the daily cost of this dietary pattern. A total of 33 distinct indicators were identified, of which 10 were used to assess the environmental dimension (mainly, carbon, water, and ecological footprint), 8 were used to assess the nutritional dimension (mainly Health score and Nutrient Rich Food Index), 1 was used to assess the economic dimension (dietary cost), and 8 used combined indicators. The remaining 6 indicators for the assessment of sociocultural dimension were only identified in 1 study but were not measured. The Mediterranean diet had a lower environmental impact than Western diets and showed a carbon footprint between 0.9 and 6.88 kg CO_2/d per capita, a water footprint between 600 and 5280 m^3/d per capita, and an ecological footprint between 2.8 and 53.42 m^2/d per capita. With regard to the nutritional dimension, the Mediterranean diet had a high nutritional quality and obtained 122 points on the Health score and ranged between 12.95 and 90.6 points on the Nutrient Rich Food Index. The cost of the Mediterranean diet is similar to other diets and varied between 3.33 and 14.42€/d per capita. These findings show that no uniformity in assessing the MDiet's sustainability exists. *Adv Nutr* 2022;13:2015–2038.

Statement of Significance: Although several articles have presented the Mediterranean diet (MDiet) as a sustainable diet, it is not clear how this sustainability is being assessed by different authors. This systematic literature review aims to fill this gap, by identifying and describing the indicators used to evaluate the sustainability of the MDiet, taking into account the several sustainability dimensions and looking at the results from their application.

GRAPHICAL ABSTRACT



Keywords: Mediterranean diet, sustainability, environmental indicators, nutritional indicators, economic indicators

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Introduction

Food systems around the world are changing rapidly (1), imposing a great pressure on the planet (2), and also affecting human health (3). Global food production occupies more than one-third of the world's land surface, accounting for approximately 30% of total anthropogenic greenhouse gas emissions (GHGE) (4), and it is identified as an important contributor to climate change (5). Simultaneously, the westernization of human diets contributes to the development of noncommunicable diseases (6) due to the high consumption of refined cereals, dairy products, meat, and processed foods (7). Currently, 3 pandemics—obesity, undernutrition, and climate change—are co-occurring in the same time and place, designated as the global syndemic (8). This syndemic affects many people worldwide and is inherently rooted in the way that food is produced, processed, distributed, and consumed (8, 9).

The world population growth leads to a great challenge to adequately feed more than 9 billion people by 2050 (10). This challenge could not be solved without a dietary pattern perspective that embraces the simultaneous preservation of human and planet health (11). For this reason, there is a general concern in adopting sustainable diets focusing, for instance, on reducing GHGE caused by dietary choices (12, 13). According to the FAO, sustainable diets are those "with low environmental impacts which contribute to food and nutrition security and to a healthy life for present and future generations. They 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" (1). Sustainable diets may be assessed using distinct dimensions—namely, the environmental, the health-nutrition, the economic, and the sociocultural dimension (14–16). The environmental dimension is focused on the environmental aspects and aims to promote the balance of the ecosystem and biodiversity and to minimize the negative effects of food production (17). The health-nutrition dimension involves health, nutrition, and food environments and takes into account that diets should provide a sufficient amount of nutritious foods for human consumption (18) and be accessible to everyone, including the most vulnerable populations (14–16). The economic dimension relates to the food value chains (farm-to-fork and waste), including monetary dimensions of the activities and actors (19). For a population or a nation, the income that can be spent on food is also a major factor of the affordability of a diet (18, 20). The sociocultural dimension of sustainable diets involves equity, inclusion, food culture, knowledge, skills, values, and also food system issues such as labor rights and animal health and welfare (14, 16, 21, 22).

The large interest towards more sustainable food systems and diets led to increased attention to the Mediterranean diet (MDiet) as a model of a healthy (23) and sustainable food pattern (24, 25). The MDiet is a way of life that combines a set of skills, knowledge, practices, and traditions related to human nutrition, ranging from land to table, encompassing cultures, crops, and fishing, as well as the conservation, processing, and preparation of food and, in particular, its consumption (26). It is characterized by high consumption of fruits, vegetables, whole grains, pulses, nuts, and olive oil; a moderate-to-high consumption of fish; moderate consumption of dairy products (preferably cheese and yogurt); and low quantities of meat and meat products (23). The traditional MDiet underlines values of hospitality, neighborliness, intercultural dialogue, and creativity, and a way of life guided by respect for diversity (26). Its dietary characteristics are protective against overall mortality and noncommunicable diseases (27, 28) and have also, comparatively, lower environmental impact (29, 30).

Despite the shift to more sound dietary habits, such as the MDiet, the assessment in terms of nutritional quality and the environmental impact of consumer food choices has so far not been systematically covered, although it is of pivotal importance (31). Food systems and dietary patterns are highly complex in terms of the interaction of several factors, such as environmental, human, social, economic, and political. For such complexity, numerous indicators may be needed for an effective measurement that allows defining and characterizing the sustainability dimensions of human dietary patterns (32).

An indicator should allow a relatively universal appreciation of the information, should facilitate comparison in time and space, and should attribute a final value relative to the impact of a given dietary pattern (33–38). In the literature, several sustainability indicators to assess food systems and dietary patterns can be found and are important since they allow to assign a final value to the various aspects of each dimension of the sustainability of the MDiet (15, 31, 39).

During the last few years, several articles have appeared focusing on the sustainability of diets and food systems. Some of them conducted qualitative assessments of food products and diets in general; others present proposals for indicators to assess certain dimensions of sustainability. For example, Nelson et al. (40) performed a systematic review to update the Dietary Guidelines for Americans by assessing the alignment between dietary patterns that are nutritionally sound and healthy and those that are more environmentally sound. Jones et al. (15) performed a systematic literature review on sustainable diets to identify the measured components

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Supplemental Table 1 is available from the "Supplementary data" link in the online posting of the article and from the same link in the online table of contents at https://academic.oup.com/advances/.
Address correspondence to BN (e-mail: belmira.neto@fe.up.pt).
Abbreviations used: CF, carbon footprint; EF, ecological footprint; GHGE, greenhouse gas emissions; GWP, Global Warming Potential; LCA, Life Cycle Assessment; MDiet, Mediterranean diet; NQI, Nutritional Quality Index; NRF, Nutrient Rich Food Index; WF, water footprint.

of sustainability, and the methods applied to do so towards generating the evidence needed to ensure the credibility of new dietary guidelines. Eme et al. (31) compared a range of published methods and indicators used to assess the sustainability of diets and food systems in order to harmonize them. Another recent review from Aldaya et al. (39) conducted a critical review to identify a comprehensive set of indicators for assessing sustainable healthy diets, analyzing the most common weaknesses from a health, environmental, and socioeconomic perspective.

From the above, there are several literature reviews focusing on metrics and approaches to measure the sustainability of diets (15, 31). However, although the MDiet has been considered a sustainable diet, the assessment of its sustainability, by covering all dimensions, is not yet a reality. No clear methods or indicators are being used to assess the sustainability of this type of diet. The present review shows that, among the studies reviewing the different sustainability dimensions, either no indicators or no results are presented for the MDiet. From an MDiet evaluation perspective, it is important to attend to its specificity and, for that purpose, the recognition of the indicators that are being used to evaluate it is necessary. This systematic literature review aimed to fill this gap by identifying and describing the indicators used to evaluate the sustainability of the MDiet in particular, taking into account the several dimensions and looking at the values resulting from their application. This will enable us to compare in the future the set of indicators used in MDiet with those used to assess other dietary patterns. It may then constitute the basis for the proposition of a similar or modified set of adequate indicators and ultimately be used to compare the sustainability dimensions of different types of diets.

Methods

Search strategy

We followed the PRISMA methodology (Preferred Reporting Items for Systematic Reviews and Meta-Analyses), to conduct this systematic review (41, 42). Four databases were searched covering a number of specialty areas in an attempt to ensure an interdisciplinary search strategy: Web of Science, Scopus, PubMed, and GreenFILE. A search strategy was developed and subsequently applied in each database. The 4 main dimensions of a sustainable diet, which include environmental, health-nutrition, economic, and sociocultural aspects, were considered. We included in the search strategy a combination of terms that are related to MDiet: sustainability, indicators, and its dimensions (**Supplemental Table 1**). Database searches were completed by October 2021. Study screening and selection were carried out using EndNote 20 by Clarivate^{TM}. Also, we considered the MDiet classification made by the authors of the articles selected for the review.

Inclusion and exclusion criteria were predefined to ensure study selection relevance. A study met the inclusion criteria if it was an original research study that assessed the sustainability of the MDiet by describing the method adopted and providing a quantitative indicator of the environmental, nutritional, or economical sustainability of Mediterranean meals or diet. Publications with no clearly identifiable indicators and publications that did not evaluate the MDiet or only evaluated individual food products were excluded. We focused on dietary patterns and not on individual assessments of food products. This is because the sustainability evaluation of a dietary pattern already covers the evaluation of single food products. Eligibility assessment of the records was performed independently by 2 authors. A final consensus was achieved between the authors after a discussion.

Arguments to exclude some sustainability dimensions were identified. The review shows that the health-nutrition dimension is widely evaluated in the literature by using mostly nutritional indicators (43). The health dimension integrates a very broad aspect and its evaluation implies a large diversity of possible aspects as, for instance, morbidity and mortality (44). Due to this complexity, the health indicators were excluded from this analysis and only nutritional indicators [e.g., Health score and Nutrient Rich Food Index (NRF)] were looked at in this systematic review. Another reason for the exclusion of health indicators is that the review performed shows that studies that assess the health dimension are generally not intended to assess sustainability of diets.

Study selection

The literature search resulted in 302 records: 92 from PubMed, 180 from Web of Science, 20 from Scopus, and 10 from GreenFILE. After removal of the duplicates, 220 articles remained. Afterwards, the screening by title and abstract resulted in a set of 79 articles assessed for eligibility. Overall, 59 articles were excluded because they did not meet the inclusion criteria described. In particular, those articles were not related to sustainability of an MDiet, did not report primary quantitative results (e.g., review articles or qualitative studies or quantitative studies that present the results in the form of linear or other regression), or focused only on a specific food. Also, the reference lists from eligible studies and existing reviews were considered to identify additional relevant research. Twelve additional articles were identified that met the inclusion criteria by checking the reference lists of studies previously considered. In total, 32 articles were included in the review. A flowchart summarizing the study selection process is depicted in **Figure 1**.

Data collection and analysis

Information from eligible studies was extracted and synthesized in tables with the information on *1*) author, *2*) country and sample, *3*) indicators used, and *4*) the key findings. The studies presented in the tables are organized in alphabetical order of the author's last name. For the articles that assessed the environmental sustainability of an MDiet, information about the system boundaries was also collected. For indicators within this specific dimension, represented in **Figure 2**, the values from the several studies

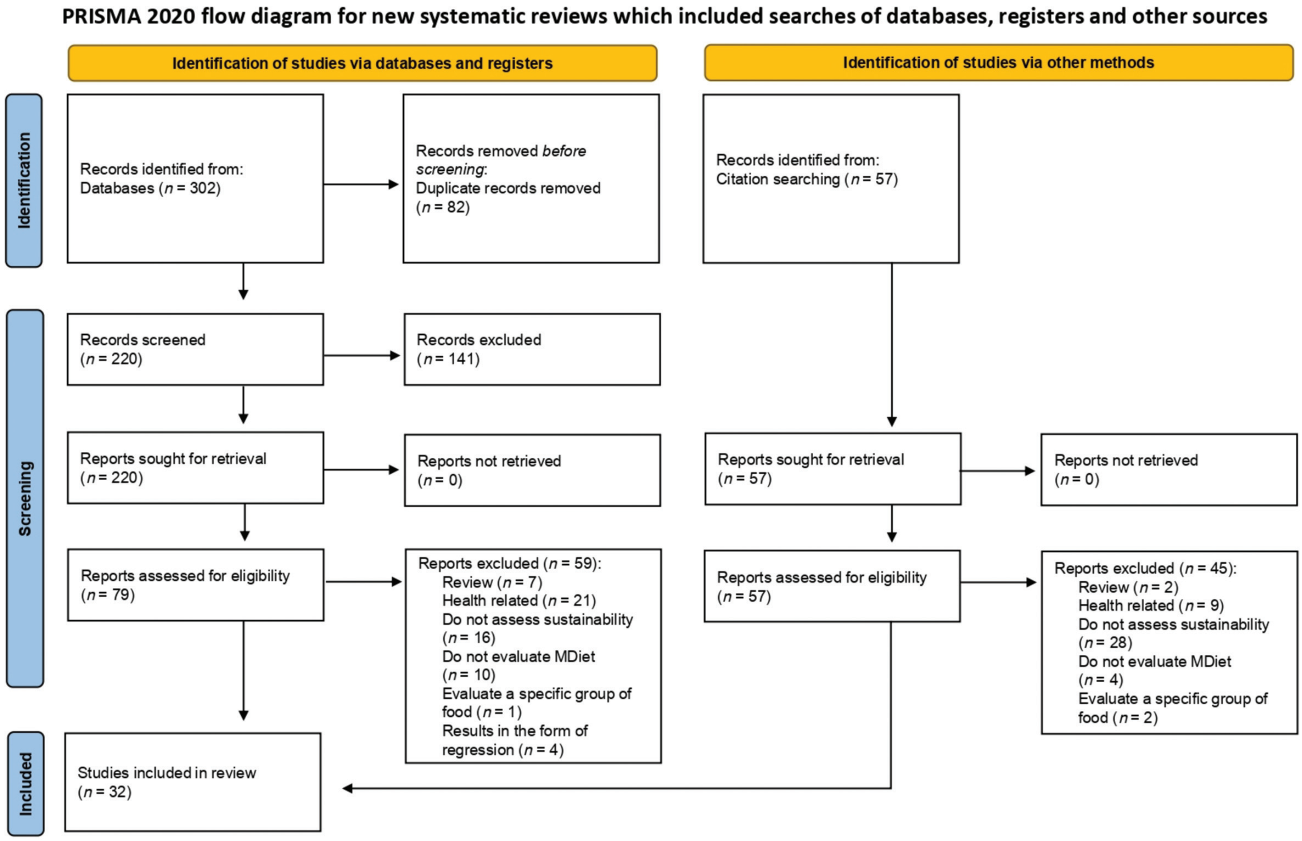

FIGURE 1 PRISMA flow diagram showing study selection. MDiet, Mediterranean diet; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

were harmonized to a common unit [e.g., carbon footprint (CF) in kilograms of carbon dioxide equivalents per day per capita, water footprint (WF) in liters per day per capita, and ecological footprint (EF) in meters squared per day per capita]. To build **Figure 3**, economic diet cost was expressed in Euros per day per capita. These units were chosen for being the most used by the authors. Conversion from years and weeks to days was done by dividing the original values by 365 or by 30, respectively. The purpose of Figures 2 and 3 is to present the variability of results and not compare them, since the methodological aspects from the studies (e.g., boundaries) may vary greatly.

Results

Study characteristics

All of the studies were published after 2006, with 23 studies (71.9%) published in 2016 or later. Of the 32 papers reviewed, all were set in high-income countries, except for 2 studies that were conducted in Lebanon and Albania (upper-middle-income countries) according to the World Bank classification system (45). Most of the studies used food data from or were carried out in Europe (29, 30, 46–66) and other Mediterranean countries (67–71), followed by the United States (51, 72, 73), the United Kingdom (74), and New Zealand (75).

In this systematic review, 3 of the reviewed studies evaluated the sustainability of Mediterranean menus focusing only on the lunch meal. Two of them used the CF and the other used the WF as an environmental indicator. The remaining studies evaluated the sustainability of an MDiet considering a whole food day, and used a variety of indicators.

In order to assess the sustainability of an MDiet, most of the studies compared the MDiet with other dietary patterns: current French diet (60), current Spanish diet (30, 50), current Italian diet (29, 57, 58, 61), current Dutch diet (64, 65), recommended Dutch diet (65), American diet (51, 73), Healthy American diet (72, 73), Western diet (30, 69), Nordic diet (63, 64), Atlantic diet (54), EAT-LANCET Diet (71), Low Land diet (64), European diet (48), high-protein diet (69), healthy diet (57), semi-vegetarian diet (65), vegetarian diet (57, 65, 72, 73), and vegan diet (52, 65).

With regard to the methodological approach of the studies, 11 assessed the sustainability of the MDiet using dietary consumption data obtained using FFQs or national food baskets (46, 53, 55, 58–60, 66–69, 74), 16 investigated the sustainability of an MDiet using dietary scenarios based on recommendations/guidelines (48, 49, 51, 52, 54, 56, 57, 61–64, 70–73, 75), and 5 studies used a combined approach based on dietary consumption data and dietary scenarios (29, 30, 47, 50, 65).

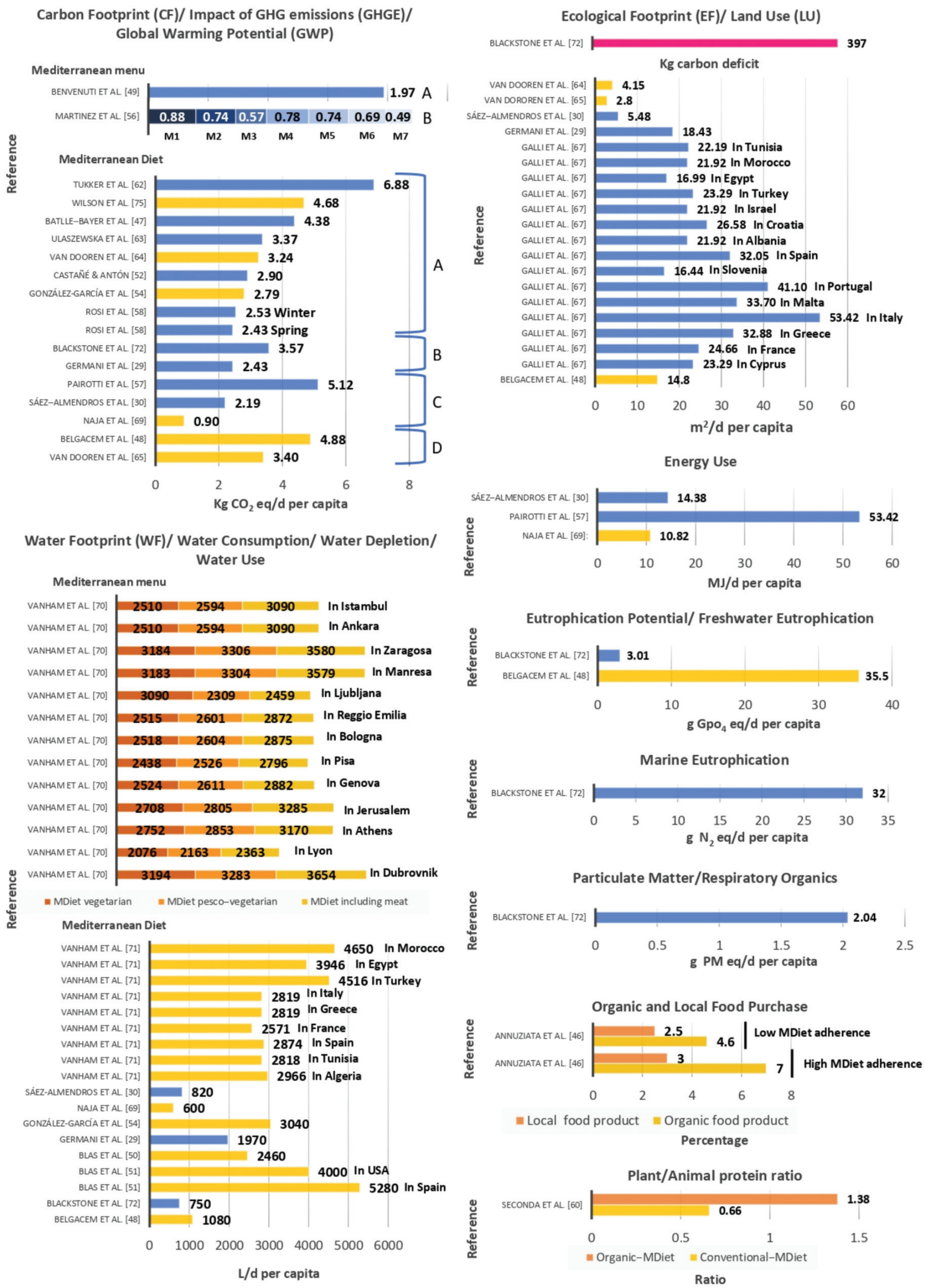

FIGURE 2 Systematization of the results by indicator for the environmental sustainability of the MDiet. In orange are the results presented in the original paper. The converted results are in blue. In the carbon footprint graph, the letters A, B, C, and D correspond to the different system boundaries considered by the authors to calculate this footprint. Letter A corresponds to "Cradle to consumer"; letter B corresponds to "Cradle to farm gate"; letter C corresponds to "Cradle to market"; and letter D corresponds to "Not mentioned." Rosi et al. (58) defined 2 MDiet scenarios, one for the spring and the other for the winter. Vanham et al. (70) defined 3 MDiet scenarios for 13 Mediterranean countries, one including meat, another seafood-vegetarian, and the last vegetarian. Vanham et al. (71) assessed the water footprint for the MDiet in 9 Mediterranean countries. Blas et al. (51) assessed the water footprint for the MDiet in 2 countries. Galli et al. (67) assessed the ecological footprint of food production and food consumption for 15 selected Mediterranean countries, and the data in this figure correspond to the ecological footprint of food consumption. Legend for carbon footprint/Mediterranean menu: Martinez et al. (56) defined 7 different MDiet-based menus for lunch, with M1 corresponding to the baseline menu with all of the typical food groups included, M2 to the menu without dairy and without legumes, M3 to the menu without meat, M4 to the menu without fish, M5 to the menu without eggs, M6 to the hypocaloric menu, and M7 to the astringent menu (designed to address intestinal illnesses). GHG, greenhouse gas; MDiet, Mediterranean diet.

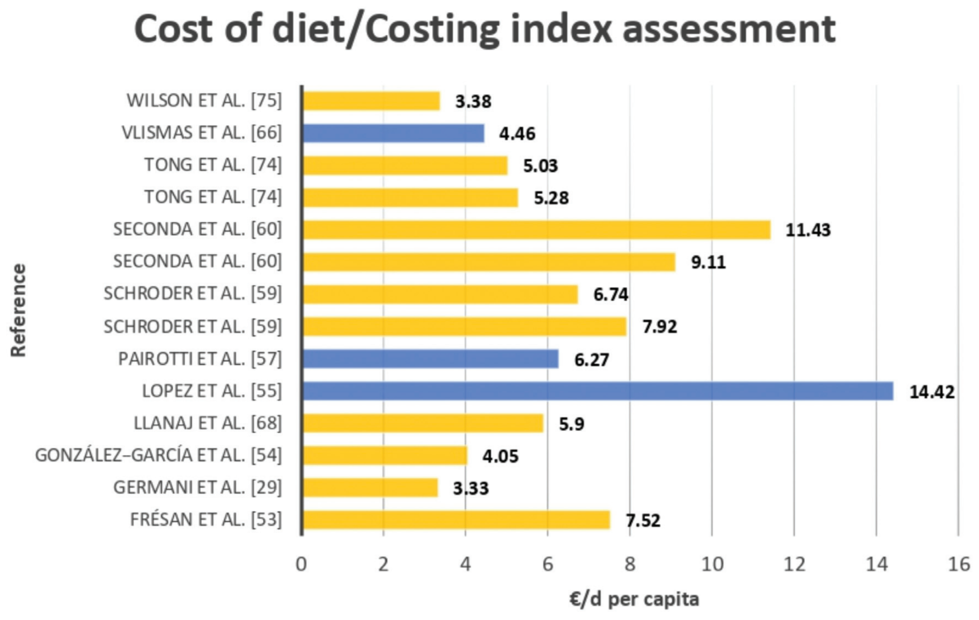

FIGURE 3 Systematization of the results for the economical sustainability of the MDiet. In orange are the results presented in the original paper. The converted results are in blue. Lopez et al. (55) presents the MDiet cost in €/1000 kcal per adherence to MDiet quintile. To convert this result in €/d per capita, the average diet energy quintile values and the average of the respective cost were calculated. Pairotti et al. (57) presents the cost of an MDiet for an average Italian family. For the conversion in €/d per capita, we searched the average number of people per household in Italy for 2015 ($n = 2.35$ people) (110). Conversion from weeks to days was calculated considering 30 d/mo. MDiet, Mediterranean diet.

Twenty studies assessed only a single sustainability dimension, of which 15 assessed the environmental dimension (30, 46–51, 56, 58, 63, 67, 69–72), 5 assessed the economic dimension (55, 59, 66, 68, 74), and 1 assessed the nutritional dimension (61). Articles that assessed more than 1 dimension always assessed the environmental dimension together with the economic and/or nutritional dimension.

The indicators found were grouped into different sustainability dimensions according to the classification given by the authors of the eligible studies, including *1*) environment, *2*) nutrition, *3*) economic, and *4*) sociocultural (**Figure 4**). A description of the identified indicators and related studies can be found in **Table 1** and the information on the sustainability dimensions assessed in each of the eligible studies is compiled in **Table 2**.

Environmental indicators

Twenty-five studies analyzed the environmental impacts of the MDiet (29, 30, 46–54, 56–58, 60, 62–65, 67, 69–72, 75) (**Table 3**). Generally, articles that assessed the environmental dimension used more than 1 indicator. There were 10 identified different environmental indicators. The CF/impact of GHGE/Global Warming Potential (GWP) were largely the most commonly measured components (18 studies), but other aspects, such as WF/water consumption/water depletion/water use (12 studies), EF/land use (9 studies), energy use (4 studies), freshwater and marine eutrophication (2 studies), plant:animal ratio (1 study), particulate matter or respiratory organics (1 study), organic food (1 study), and local food (1 study), were also assessed. Although the CF, impact of GHGE, and GWP indicators look at the emission of the greenhouse gases, the articles included in the review use different methodologies to calculate an indicator that is nevertheless expressed as a mass of carbon dioxide equivalents. The same applies to WF/water consumption/water depletion/water use, with different methodologies being used by the authors to calculate an indicator that is nevertheless expressed as a volume of water. Almost all the studies used the Life Cycle Assessment (LCA) for the calculation of environmental impact. Only 2 studies assessed the environmental impact with distinct methodologies. One of these 3 studies assessed GHGE and energy consumption at the product level through a method the authors called hybrid Input-Output Analysis (IOA)–LCA and the other used a European Environmentally Extended Input-Output (E3IOT) model that allows the calculation of environmental interventions (emissions and resource extraction) due to the production, consumption, and waste disposal of food products (62).

Different system boundaries were identified in the studies assessing the environmental sustainability of the MDiet and varied from the stage of food production to consumption and waste disposal. Moreover, a range of distinct functional units was used to present the results of the same environmental indicator. For the CF, the results were presented in tons, kilograms, or gigagrams of CO_2 equivalents per capita by day, week, month, or year. For the WF, the results were presented in liters or cubic meters (m^3) and cubic kilometers

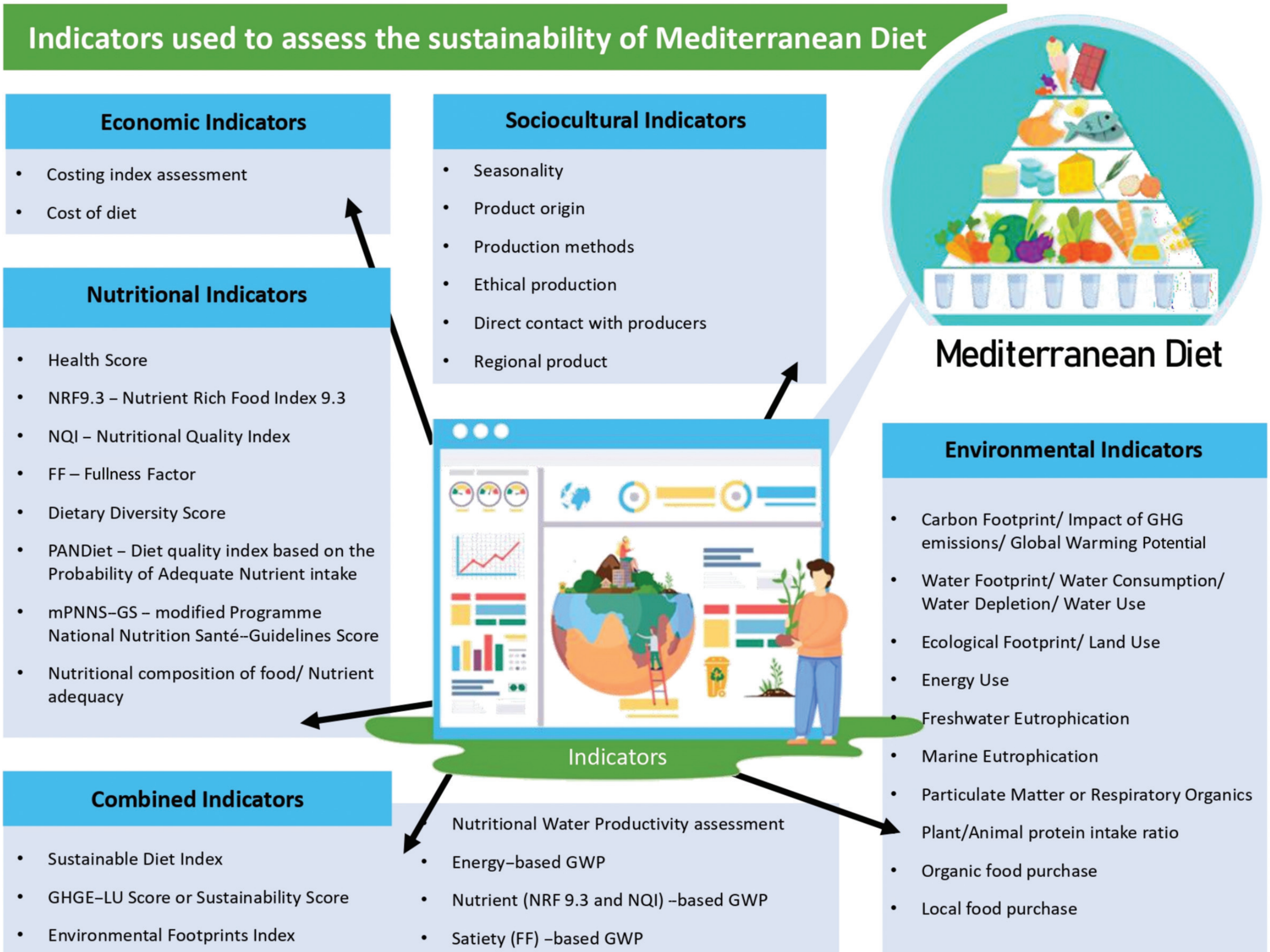

FIGURE 4 Results from the review showing the indicators used to assess the sustainability of the Mediterranean diet grouped according to the sustainability dimension considered. GHG, greenhouse gas; GHGE, greenhouse gas emissions; GWP, Global Warming Potential; LU, land use.

(km^3) per capita by day, week, month, or year. For the EF, the results were presented in hectares (ha) or square meters (m^2)/kilogram of food product per capita by day, week, month, or year.

The resulting indicator values related to the MDiet's environmental sustainability are presented in Figure 2. Also, the presentation of the results took into account the different system boundaries considered in the studies regarding the CF. Overall, for the most used environmental indicators found, it was possible to observe that the outcomes varied largely. For example, the MDiet showed a CF varying from 0.9 and 6.88 kg CO_2/d per capita. The WF of the MDiet varied between 600 and 5280 m^3/d per capita, and the EF of the MDiet changed between 2.8 and 53.42 m^2/d per capita. For the Mediterranean menus, the values ranged between 0.49 and 1.97 kg CO_2/d per capita for the CF and between 2076 and 3654 m^3/d per capita for the WF. Note that these results should be carefully interpreted considering the specific reality of the population where they were measured. Furthermore, due to the different measurement contexts, these values cannot be compared among each other.

Nutritional indicators

Seven studies evaluated the nutritional quality of the MDiet (52, 60, 61, 64, 65, 73, 75) (Table 3). There were 8 identified different nutritional indicators: the Health score (1 study), the Dietary Diversity score (1 study), the NRF 9.3 (2 studies), the Nutritional Quality Index (NQI; 1 study), the Fullness Factor (1 study), the PANDiet (diet quality index based on the Probability of Adequate Nutrient intake; 1 study), the mPNN-GS (modified Programme National Nutrition Santé-Guidelines Score; 1 study), and the nutritional composition of food/nutrient adequacy (2 studies) were the indicators used. For this evaluation, the nutrients and foods were generally classified as "to encourage" or "to discourage" based on dietary recommendations. The nutritional indicators identified were based on either qualifying or disqualifying nutrients/foods or a combination of both. Nutritional quality

TABLE 1 Indicators used to assess the sustainability of the Mediterranean diet

Indicators of sustainability by dimensions	Brief description	Study
Environmental indicators		
Carbon footprint (CF)/ Impact of greenhouse gas emissions (GHGE)/ Global warming potential (GWP)	CF is an indicator currently used to describe the amount of GHGE that a particular product or service releases into the environment during its lifetime [expressed in CO_2 equivalents (CO_2e)] (76). GWP allows the comparisons of the global warming impacts of different gases. It is a measure of how much energy the emissions of 1 ton of a gas will absorb over a given period of time (normally 100 y), relative to the emissions of 1 ton of CO_2 (77)	(29, 30, 47–49, 52–54, 56–58, 62–65, 69, 72, 75)
Ecological footprint (EF)/ Land use (LU)	EF, expressed in global hectares, is a measurement of the ecological assets, referring to the productive land needed, that a given population requires to produce the natural resources it consumes (including plant-based food, livestock and fish products, timber and other forest products, space for urban infrastructure) and to absorb its waste, especially carbon emissions (78, 79)	(29, 30, 48, 53, 58, 64, 65, 67, 72)
Water footprint (WF)/ Water consumption/ Water depletion/ Water use	WF is an indicator of freshwater consumption (from rainfall, surface, and groundwater) that looks at direct and indirect water use of a producer or consumer and water resources appropriation through pollution (80). The blue WF refers to the volume of surface and groundwater consumed (evaporated or used directly) as a result of the production of a good. The green WF refers to the amount of rainwater required to make an item. The gray WF refers to the volume of freshwater that is required to assimilate a load of pollutants based on existing ambient water quality standards (81, 82)	(29, 30, 48–51, 53, 54, 69, 70–72)
Energy use	The International Federation of Institutes for Advanced Study (83) has defined energy analysis as "the determination of the energy sequestered in the process of making a good or service within the framework of an agreed set of conventions or applying the information so obtained" (84)	(30, 53, 57, 69)
Plant:animal protein intake ratio	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 the environmental impact of diets (16). The methodology is a calculation of the ratio of the 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 MDiet, can be judged by simple comparison, and the trend can be monitored over the time series of available data, regardless of the data source (85)	(60)
Freshwater and marine eutrophication	Eutrophication is defined by "the enrichment of water by nutrients causing an accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to the balance of organisms present in the water and the quality of the water concerned, and therefore refers to the undesirable effects resulting from anthropogenic enrichment by nutrients" (86)	(48, 72)
Particulate matter or Respiratory organics	Particulate matter is a term for a mixture of solid particles and liquid droplets found in the air. Most particles form in the atmosphere as a result of complex reactions of chemicals such as sulfur dioxide and nitrogen oxides, which are pollutants emitted from power plants, industries, and automobiles (87)	(72)
Organic food purchase	The EU Regulation (2018/848) recognizes that "Organic production is an overall system of farm management and food production that combines best environmental and climate action practices, a high level of biodiversity, the preservation of natural resources and the application of high animal welfare standards and high production standards in line with the demand of a growing number of consumers for products produced using natural substances and processes. Organic production thus plays a dual societal role, where, on one hand, it provides for a specific market responding to consumer demand for organic products and, on the other, it delivers publicly available goods that contribute to the protection of the environment and animal welfare, as well as to rural development" (88)	(46)

(*Continued*)

TABLE 1 (*Continued*)

Indicators of sustainability by dimensions	Brief description	Study
Local food purchase	Local food is defined as the direct or intermediated marketing of food to consumers that is produced and distributed in a limited geographic area. No predetermined distance is defined for what consumers consider "local," but a set number of miles from a center point or state/local boundaries is often used. More importantly, local food systems connect farms and consumers at the point of sale (89)	(46)
Nutritional indicators		
Health score	Van Dooren et al. (65) developed a score, relevant to the European context, for the health and sustainability of diets. The Health score is based on 10 nutritional indicators (65). The WHO suggested 9 reference indicators quantified as 200 g fruits, 200 g vegetables, 30% of energy from total fatty acids, <10% of energy from SFAs, <1% of energy from *trans* fats, ≤10% of energy from free sugars, 30 g fiber, 6 g salt (sodium chloride), and 37 g fatty fish (90). The World Cancer Research Fund emphasized another important indicator: good energy balance (2000 kcal/d reference) (91)	(64, 65)
Nutrient-Rich Food Index 9.3 (NRF9.3)	The NRF9.3 was developed by Fulgoni et al. (92). This index is based on the difference between 9 nutrients whose consumption is to be encouraged (protein, fiber, iron, calcium, potassium, magnesium, vitamin E, vitamin A, and vitamin C) and 3 nutrients to be limited (saturated fats, free sugars, and sodium) (92). The NRF9.3 score reflects the composite nutritional quality of a food product per 100 kcal (93). The Recommended and Maximum Daily Value (RDV and MDV) are usually obtained from health organizations. When the nutrients to encourage exceed the RDV, they are capped to this former value, in order to avoid overestimation caused by overconsumption (94). NRF9.3 is calculated for each food item (NRF9.3 food score) and it is converted to the individual NRF9.3 by multiplying the amount of kilocalories consumed of each food item, in 100-kcal units, by the NRF9.3 food scores and then summing these scores for each individual (95)	(52, 73)
Nutritional Quality Index (NQI)	The NQI is quantified using an approach like NRF9.3, including the same 9 qualifying nutrients and the 3 disqualifying nutrients. However, the qualifying nutrients are not capped, since the baseline is the actual and not the recommended dietary intake. A product with a high content of a single nutrient whose dietary intake is low and simultaneously high levels of several disqualifying nutrients might still have a high NQI (96)	(73)
Fullness Factor (FF)	The FF is a mathematical formula to predict satiety from the nutrient content of a given food or recipe using values from those nutrients that have been shown experimentally to have the greatest impact on satiety. FF values fall within the range of 0 to 5. Foods with high FFs are more likely to satisfy your hunger with fewer calories. Foods with low FFs are less likely to satisfy your hunger (97)	(73)
Dietary Diversity Score	The Dietary Diversity Score evaluates the number of food groups consumed per day and includes the following components: cereals, grains, pulses, tubers, dark-green leafy vegetables, vitamin A–rich vegetables, vitamin C–rich vegetables, other vegetables, vitamin C–rich fruits, vitamin A–rich fruits, other fruits, soybeans and soy products, seafood, fish, meat, eggs, dairy products, cheeses, fat, and insects. A minimum portion size is required for each food group to be included in the score: 40 g for vegetables or fruits; 15 g for grains, pulses, and cheese; and 30 g for other foods. The score is the sum of individual food groups consumed, on average, per day, among 21 food groups. The score range is between 0 and 21 points (98)	(60)
PANDiet	The PANDiet aims to measure the overall diet quality of an individual through the probability of having an adequate nutrient intake based on French nutritional recommendations. The calculation of the probability considers the number of days of dietary data, the mean intake and the day-to-day variability of intake, the nutrient reference value, and the interindividual variability. For each nutrient, adequate intake was assumed to be the level likely to satisfy the nutrient requirements and unlikely to be excessive and elicit adverse health effects. The score range is between 0 and 100 points (99)	(60)

(*Continued*)

TABLE 1 (*Continued*)

Indicators of sustainability by dimensions	Brief description	Study
mPNNS-GS	The mPNNS-GS is based on the Programme National Nutrition Santé Guideline (PNNS-GS). For each component, a score is attributed according to the adequacy of the daily intake in relation to the French food-based recommendations defined by the PNNS. Fruit and vegetables (0–2), starchy foods (0–1), whole grains (0–1), dairy products (0–1), meat (0–1), seafood (0–1), added fat (0–1), sweets (–0.5 to 1), water and soda (0–1), alcohol (0–1), salt (–0.5 to 1.5), penalty if energy intake is >105%. The scale range of the score is between 0 and 13.5 points (60)	(60)
Nutritional composition of food/nutrient adequacy	These indicators are used to assess the meeting of requirements for key macronutrients and micronutrients. The levels of reference intakes of nutrients and energy are usually obtained from national or health organizations	(61, 75)
Economic indicators		
Cost of diet/costing index assessment	Cost of diet is an indicator, expressed in euros per person per day or per week, that is calculated considering the average prices of foodstuff paid by consumers. Generally, the total daily cost of diet is obtained by multiplying the price by food quantity consumed (g/d or g/wk). Prices are expressed in €/g or kg in the case of solid foods and €/L in the case of liquid foods. The prices are collected through multiple sources, such as supermarket data, Ministry of Agriculture, and others. An adjustment considering food waste at the consumption stage can be done (29, 61)	(29, 53–55, 57, 59, 60, 62, 66, 68, 74, 75)
Sociocultural and ethical indicators		
Seasonality	Department for the Environment, Food, and Rural Affairs (DEFRA) proposed 2 definitions of seasonal food. One is based on where the food is produced (global seasonality), and the other on where it is produced and consumed (local seasonality) (100). The common aspect of both definitions is that the food is grown or produced outdoors at a natural season without the use of additional energy, which is important to avoid the need to create additional GHGE (101)	(60)
Product origin	Product origin is associated with "country of origin" defined as "the country from which the product was wholly obtained or if production involved more than one country, the country where the product last underwent substantial, economically justified processing" (102)	(60)
Production methods	Method used to produce food products, which may include agricultural methods and animal production methods. A clear example is the organic vs. conventional food production	(60)
Ethical production	Ethical production is included in a major concept called "ethical trade," which encompasses a breadth of international labor rights such as working hours, health and safety, freedom of association, and wages (103). However, other components can be included, such as animal welfare, fair prices for all the actors in the supply chain, sustainable production methods, and workers' rights (104)	(60)
Direct contact with producers	Short food supply chains in the EU are understood as chains in which foods involved are identified by, and traceable to, a farmer and for which the number of intermediaries between farmer and consumer should be minimal or ideally null (105)	(60)
Regional product	Regional products, defined as having characteristics related to the area of origin, in most cases refer to the place of manufacture, providing additional details to its name (106)	(60)
Combined indicators		
Nutritional Water Productivity (NWP) assessment	The NWP is a concept developed by Renault and Wallender (107) and it is defined as "the nutritional content of a crop per volume of water consumed, connecting crop productivity, food production, and nutrition by applying the water productivity concept to nutritional values."	(50)
Combined GHGE-Land Use (-LU) score or Sustainability score	The sustainability score was developed by Van Dooren et al. (65) and is defined as the average of the GHGE and LU score per diet. The score is calculated with the following formula (65): $\text{Sustainability score} = \frac{(\frac{kg\ CO_2\ eq\ GHG}{3.27kg}) + (\frac{m^2 * year\ LU}{2.97LU})}{2}$	(64, 65)

(*Continued*)

TABLE 1 (*Continued*)

Indicators of sustainability by dimensions	Brief description	Study
Environmental Footprints Index	The Environmental Footprints Index is created by summing the quartile values of the 4 footprints: land use, water use, energy use, and GHGE. Total use of land, water, and energy and GHGE were calculated as the sum of all item values, obtaining the impact on these 4 footprints according to the daily food consumption of each participant. The participants are classified into quartiles of these values, each of them ranking from 1 to 4 (less to high resource consumption or GHGE). Thus, the Environmental Footprints Index is ranked from 4 to 16 points (from low to high environmental repercussions).	(53)
Sustainable Diet Index	Index that gathers the impact of the daily diet on 3 aspects: health, environmental footprints, and monetary costs. For these aspects to contribute equally to the overall index, a score from 0 to 3 points is given for each of them. The health aspect is obtained through the Rate Advancement Period. The environmental Footprints index is created by summing the quartile values of the 4 footprints: land use, water use, energy use, and GHGE. The daily monetary cost is calculated as the monthly reported national average costs by each item. The less suitable value for each aspect scores 0 points and the more suitable value scores 3 points. Summing these 3 values, the overall Sustainable Diet Index ranked from 0 to 9 points, with 0 being the less suitable diet and 9 being the most appropriate diet (53)	(53)
Energy-based GWP	The Energy-based GWP was defined as the mass of food in a diet that provides 2000 kcal. The mass of component foods in a 2000 kcal/d diet depended on the daily intake of each food specified in the dietary patterns (73)	(73)
Nutrition-based GWP	The Nutrition-based GWP (NRF9.3-based GWP and NQI-based GWP) of a diet was calculated by dividing the GWP of a 2000-kcal/d diet by the total NRF9.3, NQI values of its component foods, respectively, giving the dietary GWP per unit of NRF9.3 and NQI (73)	(73)
Satiety-based GWP	The Satiety-based GWP of a diet was calculated by dividing the GWP of a 2000-kcal diet by the total FF values of its component foods, respectively, giving the dietary GWP per unit of FF (73)	(73)

[1] EU, European Union; MDiet, Mediterranean diet.

considerations of the MDiet as a component of sustainability have focused on the consumption of adequate dietary energy or essential micronutrients to moderation in the consumption of processed foods, SFAs, sugars, or sodium (94).

For studies that assessed the sustainability of the MDiet using dietary intake data, different tools were applied to assess the level of adherence to the MDiet—namely, the Mediterranean Diet Score (58, 59, 68, 74), the Mediterranean Diet Index (46), the Mediterranean Diet Scale (53), the Literature-based Score of MDiet (60), and the Mediterranean Diet Score Modified (66). These tools allow to classify individuals between low and high adherence to the MDiet and then apply different sustainability indicators to their food consumption. Studies that assess the MDiet's sustainability using dietary scenarios generally define a reference daily energy value based on dietary guidelines for a healthy adult. Most studies established a daily energy value for the MDiet at 2000 kcal (29, 48, 52, 65, 72, 73); however, some studies defined other values, such as 2665 kcal (47), 1860 kcal (50), 2500 kcal (61, 67), 2100 kcal (62), and 2815 kcal (75). Only 1 study defined a different daily energy value for men (2500 kcal) and women (2000 kcal) (71). Regardless of methodological differences, the MDiet was associated with better performance in the nutritional dimension. For the 2 most used nutritional indicators in the eligible studies, the MDiet obtained 122 points on the Health score (64, 65) and ranged between 12.95 and 90.6 points on the NRF (52, 73).

Economic indicators

Twelve studies evaluated the economic dimension of the MDiet (29, 53–55, 57, 59, 60, 62, 66, 68, 74, 75) (Table 3). To assess the economic dimension of the MDiet the only indicator used was the cost of diet/cost index assessment. Almost all of the studies analyzed the food prices of the food consumed in a day and calculated the daily cost of the diet. The most used methodology to select the price of food products considered the average national prices of a food product obtained from different sources such as supermarkets or the national Ministries of either Agriculture or Economy. The other methodology used to assess the economic dimension was supported by the Common Agricultural Policy Regional Impact Analysis (CAPRI) model conducted by Tukker et al. (62). The CAPRI model is a partial equilibrium model for the agricultural sector developed for policy impact assessment of the Common Agricultural Policy and trade policies from global to regional scale with a focus on Europe (108). It makes use of nonlinear mathematical programming tools to maximize regional agricultural income in the EU27 (109).

The resulting indicators from the several studies, harmonized to a common unit, are presented in Figure 3. The cost

TABLE 2 Dimensions of sustainability assessed in each of the eligible studies for the review conducted[1]

Study (reference)	Environmental	Nutritional	Economic	Sociocultural
Annunziata et al. (46)	✔	×	×	×
Batlle-Bayer et al. (47)	✔	×	×	×
Belgacem et al. (48)	✔	×	×	×
Benvenuti et al. (49)	✔	×	×	×
Blackstone et al. (72)	✔	×	×	×
Blas et al. (51)	✔	×	×	×
Blas et al. (50)	✔	✔	×	×
Castañé and Antón (52)	✔	✔	×	×
Chapa et al. (73)	✔	✔	×	×
Fresan et al. (53)	✔	✔	✔	×
Galli et al. (67)	✔	×	×	×
Germani et al. (29)	✔	×	✔	×
Gonzalez-Garcia et al. (54)	✔	×	✔	×
Llanaj et al. (68)	×	×	✔	×
Lopez et al. (55)	×	×	✔	×
Martinez et al. (56)	✔	×	×	×
Naja et al. (69)	✔	×	×	×
Pairotti et al. (57)	✔	×	✔	×
Rosi et al. (58)	✔	×	×	×
Sáez-Almendros et al. (30)	✔	×	×	×
Schröder et al. (59)	✔	×	×	×
Seconda et al. (60)	✔	✔	✔	✔✗
Tong et al. (74)	×	×	✔	×
Tucci et al. (61)	×	✔	×	×
Tukker et al. (62)	✔	×	✔	×
Ulaszewska et al. (63)	✔	×	×	×
Van Dooren et al. (65)	✔	✔	×	×
Van Dooren et al. (64)	✔	✔	×	×
Vanham et al. (70)	✔	×	×	×
Vanham et al. (71)	✔	×	×	×
Vlismas et al. (66)	×	×	✔	×
Wilson et al. (75)	✔	✔	✔	×

[1] ×, not evaluated dimension; ✔, evaluated dimension; ✔✗, identified but not evaluated dimension.

of an MDiet varied between 3.33 and 14.42€/d per capita. The exception is for the study by Tukker et al. (62), which presents the cost of MDiets for a total of 27 countries in the European Union and is not included in Figure 3.

Sociocultural indicators

Only 1 study analyzed the sociocultural aspects of an MDiet (60). This study by Seconda et al. (60) considered seasonality, geographic origin of foods, farming production methods, ethics, contact with producers, and regional and traditional foods of the product as sociocultural indicators, although they were not quantified.

Combined indicators

Five studies used combined indicators to assess the sustainability of the MDiet (50, 53, 64, 65, 73) (Table 3). There were 8 different combined indicators identified. Five indicators combined the nutritional and environmental aspects—namely, the Nutritional Water Productivity assessment, the Energy-based GWP, the NRF9.3-based GWP, the NQI-based GWP, and the Satiety-based GWP.

The Sustainability score combined 2 environmental aspects, specifically GHGE and land use. The Environmental Footprints Index combined 4 environmental aspects, specifically GHGE, land use, water use, and energy use. The Sustainable Diet Index was the most complete indicator by combining the impact of the daily diet by considering 3 aspects: health, environmental footprints, and monetary costs.

Discussion

This review adds to the current knowledge by providing the identification and description of the indicators that have been used to assess the sustainability of the MDiet. This was done by looking at the various sustainability dimensions. The literature on this topic has mostly been conducted in the last decade. We have identified 32 studies reporting 33 indicators within 4 dimensions of sustainability—namely, environmental, nutritional, economic, and sociocultural.

Several international organizations and governments have developed sets of indicators for the assessment of the sustainability of food production and consumption (111). However, the large number of indicators that can be used to assess the sustainability of dietary patterns does not provide evidence on which are the best indicators. This gap led to the recent proposals for indicators to be used to assess the

TABLE 3 Summary of environmental, nutritional, economic, and combined dimensions used for the sustainability assessment of the Mediterranean diet in different countries[1]

Study (reference)	Country and sample	Indicators used	System boundaries	Key findings
Environmental sustainability dimension				
Annunziata et al. (46)	Italy, participants ($n = 44{,}984$) in the survey "Aspects of Daily Life" from the Italian National Institute of Statistics, and dietary pattern derived (MDiet)	- Organic food - Local food	NA	Respondents with high adherence to the MDiet are more likely to buy organic products (7%) and local products (3%) compared with respondents with low adherence (4.6% and 2.5%, respectively)
Batlle-Bayer et al. (47)	Spain, 3 dietary patterns (current Spanish food consumption, NAOS and MDiet)	- Carbon footprint (CF)	- Cradle-to consumer - Food losses along the whole food supply chain	The diet-related GHGE of current eating patterns would be reduced by 11%, when shifting to the MDiet. The MDiet food baskets pattern of an average Spanish adult citizen emits about 1.3 tCO_2 eq/y
Belgacem et al. (48)	Greece, 3 dietary patterns (European diet, Western diet, and MDiet)	- GHGE - Land use - Water use - Eutrophication potential	Not mentioned	The MDiet pattern exerts less pressure on biodiversity (including lower land use, water use, GHGE, and eutrophication emissions) in comparison to European and Western dietary patterns. MDiet had an agricultural land use of 14.80 m^2/d per capita, a water use of 1079.965 L/d per capita, GHGE of 4.88 kg CO_2 eq/d per capita, and a eutrophication potential of 35.50 gPO_4 eq/d per capita
Benvenuti et al. (49)	Italy, MDiet-based menu lunches from infant primary and secondary school (average menu, low GHGE menu, low water consumption menu)	- CF - Water footprint (WF)	- Cradle to farm gate	The average emission of GHGs of the monthly MDiet schedules defined by the municipality nutritionists were 13.81 kg CO_2 eq and the average water consumed was equal to 21.61 m^3. The monthly schedule that minimizes the GHGE obtained a GHGE of 7.77 kg CO_2 eq and a WF of 16.64 m^3. The monthly schedule that minimizes the water consumption obtained a GHGE of 10.85 kg CO_2 eq, and a WF of 13.72 m^3
Blackstone et al. (72)	USA, Dietary Guidelines for Americans (healthy US-style, healthy MDiet, and healthy vegetarian)	- GWP - Land use - Water depletion - Freshwater and marine eutrophication - Particulate matter or respiratory organics	- Cradle to farm gate or cradle to processor gate (excluding packaging)	The healthy US diet and MDiet had similar impacts, except for freshwater eutrophication (greater in MDiet). The vegetarian diet had the lowest environmental impacts MDiet had a global warming potential of 24.7 kg CO_2 eq/wk per capita, a land use in terms of kg carbon deficit of 397/wk per capita, a water depletion of 0.75 m^3/wk per capita, a freshwater eutrophication of 21.1 g PO_4eq/wk per capita, a marine eutrophication of 224 g N_2 eq/wk per capita, and a particulate matter or respiratory inorganics of 14.3 g PM eq/wk per capita
Blas et al. (51)	Spain and USA, 2 diets (MDiet and American diet)	- WF	NA	MDiet has a lower WF than the American diet in the 2 countries. In Spain, the WF of an MDiet is 5276 L/d per capita (3941 for green water, 861 for blue water and 473 for gray water). In the USA, the WF of an MDiet is 4003 L/d per capita (2481 for green water, 731 for blue water, 790 for gray water)
Blas et al. (50)	Spain, Household Consumption Database Program ($n = 8000$ households) and dietary pattern derived (MDiet)	- WF	NA	WF (green, blue, and gray) of the MDiet were lower than the Current diet. MDiet showed (approximately) a total WF of 2455 L/d per capita, a green WF of 1835 L/d per capita, a blue WF of 380 L/d per capita, and a gray WF of 240 L/d per capita
Castañé and Antón (52)	Spain, 2 diets (MDiet and vegan diet)	- GWP	- Cradle to gate - Transport to retailer - Home cooking	The MDiet had a higher GWP than the vegan diet The absolute values of the final GWP were 20 kg CO_2 eq/wk per capita for the MDiet

(Continued)

TABLE 3 (*Continued*)

Study (reference)	Country and sample	Indicators used	System boundaries	Key findings
Galli et al. (67)	15 Mediterranean countries and correspondent food consumption (Cyprus, France, Greece, Italy, Malta, Portugal, Slovenia, Spain, Albania, Croatia, Israel, Turkey, Egypt, Morocco, Tunisia)	- Ecological footprint (EF)	- Food production - Food consumption	Results of food EF production ($_{f}EF_{P}$) and food EF consumption ($_{f}EF_{C}$) are expressed in global hectares (gha)/year per capita for 15 selected Mediterranean countries Approximate $_{f}EF_{P}$: Cyprus, 0.2; France, 1.72; Greece, 1.2; Italy, 0.72; Malta, 0.18; Portugal, 0.6; Slovenia, 0.4; Spain, 1.43; Albania, 0.6; Croatia, 0.8; Israel, 0.2; Turkey, 0.92; Egypt, 0.47; Morocco, 0.57; Tunisia 0.62 Approximate $_{f}EF_{C}$: Cyprus, 0.85; France, 0.9; Greece, 1.2; Italy, 1.95; Malta, 1.23; Portugal, 1.5; Slovenia, 0.6; Spain, 1.17; Albania, 0.8; Croatia, 0.97; Israel, 0.8; Turkey, 0.85; Egypt, 0.62; Morocco, 0.8; Tunisia, 0.81. The average $_{f}EF_{P}$ for the 15 Mediterranean countries was 0.87, and the average $_{f}EF_{C}$ was ∼0.86
Germani et al. (29)	Italy, 2 diets (current dietary pattern and MDiet)	- CF - WF - EF	- Production cycle	MDiet had a lower CF, WF, and EF than the current Italian dietary pattern MDiet had a CF of 17.04 kg CO_2 eq/wk per capita, a WF of 13,781 L/wk per capita, and an EF of 129 m^2/wk per capita
Gonzalez-Garcia et al. (54)	Spain, dietary guidelines (MDiet, SEAD, NAOS)	- CF - WF	- Food production stage - Distribution to wholesale and retail - Household consumption	MDiet showed the lowest CF and WF. The CF of MDiet was 2.79 kg CO_2 eq/d per capita, the total WF was 3044 L/d per capita, the gray WF was 325 L/d per capita, the green WF was 2194 L/d per capita, the blue WF was 525 L/d per capita, and the combined WF (green + blue) was 2719 L/d per capita
Martinez et al. (56)	Spain, school MDiet menus following Spanish school dietary guidelines (baseline menu, no milk and no legumes menu, no fish menu, hypocaloric menu, no meat menu, no eggs menu, and astringent menu)	- CF	- Food production - Transportation - Cooking	The CF of the baseline MDiet menu was 26.26 kg CO_2 eq/mo per capita. The CF of menus was 22.26 kg CO_2 eq/mo per capita for the lunch meal for the menu without dairy and without legumes, 17.11 kg CO_2 eq/mo per capita for the lunch meal for the menu without meat, 23.41 kg CO_2 eq/mo per capita for the lunch meal for the menu without fish, 22.33 kg CO_2 eq/mo per capita for the lunch meal for the menu without eggs, 20.72 kg CO_2 eq/mo per capita for the lunch meal for the hypocaloric menu, and 14.77 kg CO_2 eq/mo per capita for the lunch meal for the astringent menu
Naja et al. (69)	Lebanon, data from previous national survey ($n = 337$, >18 y) and dietary patterns derived (Western, Lebanese-Mediterranean, and high-protein)	- GHGE - Water use - Energy use	- Cradle to market (or distribution point)	The Lebanese-MDiet had the lowest impact values, except for energy use (higher than high-protein diet). The Lebanese-MDiet had a water use of 602.06 L/d per capita, energy use of 10.82 MJ/d per capita, and GHGE of 0.90 kg CO_2 eq/d per capita
Pairotti et al. (57)	Italy, 4 diets (national average diet, MDiet, healthy diet, and vegetarian diet)	- CF - Energy consumption	- Food production - Transport - Trade - Waste	Environmental performance of the MDiet was better than the national average diet but higher than vegetarian diet. MDiet consumes 19.5 GJ/y per capita and had GHGE of 1.87 tCO_2 eq/y per capita
Rosi et al. (58)	Italy, schoolchildren ($n = 172$, 8–10 y) and dietary pattern derived (MDiet)	- CF - EF	- Food production to consumption	Total diet CF in g CO_2 eq/d among groups with high adherence to MDiet: 2528 ± 610 (winter), 2427 ± 646 (spring); total diet EF in m^2/d among groups with high adherence to MDiet: 17.2 ± 3.3 (winter), 15.9 ± 3.6 (spring)
Sáez-Almendros et al. (30)	Spain, 3 diets (MDiet, current Spanish diet, and Western diet)	- GHGE - Land use - Energy consumption - Water consumption	- Agricultural production - Processing and packaging - Transportation - Retail	MDiet showed the lowest footprints in all environmental pressures MDiet had an agricultural land use of ∼2000 ha/y per capita, an energy consumption of 5250 MJ/y per capita, a water consumption of 300 m^3/y per capita, and GHGE of 800 kg CO_2 eq/y per capita

(*Continued*)

TABLE 3 (*Continued*)

Study (reference)	Country and sample	Indicators used	System boundaries	Key findings
Seconda et al. (60)	France, NutriNet-Santé Study ($n = 22,866$, >18 y) and dietary pattern derived (MDiet)	- Plant:animal protein intake ratio	NA	MDiet combined with organic food had the best plant:animal protein intake ratio. For the Conv-Med diet followers, the ratio was 0.66, and for the Org-Med diet followers, the ratio was 1.38
Tukker et al. (62)	Europe, 4 diet scenarios (scenario 0: European status quo; scenario 1: pattern according to universal dietary recommendations; scenario 2: the same pattern in scenario 1 with reduced meat consumption; and scenario 3: Mediterranean pattern)	- GWP	- Production - Consumption - Waste disposal	The results for global warming are similar. Global warming impacts from the Mediterranean pattern scenario (only food) were 2.44E +03 kg CO_2 eq/y per capita for the total of 27 countries of the European Union in 2008
Ulaszewska et al. (63)	Europe, dietary guidelines [MDiet and New Nordic diet (NND)]	- GHGE	- Production at farm level - Transformation - Distribution - Cooking - Consumption	Correct food choices, approaching official MDiet and NND recommendations, show a similar GHGE impact for all food categories. The MDiet shows GHGE of 23.6 kg CO_2 eq/wk per capita and the NND shows 25.8 kg CO_2 eq/wk per capita
Vanham et al. (70)	Mediterranean region (Dubrovnik, Lyon, Athens, Jerusalem, Genova, Pisa, Bologna, Reggio Emilia, Zaragosa, Manresa, Ljubljana, Istanbul), 4 dietary scenarios [reference situation (REF); MDiet-meat or S1, MDiet-seafood-vegetarian or S2, MDiet-vegetarian or S3]	- WF	NA	All 3 MDiet scenarios lead to a lower WF for each city. The WF (L/d per capita) for the cities varied. Dubrovnik: REF = 4537, S1 = 3654, S2 = 3283, S3 = 3194; Lyon: REF = 3845, S1 = 2363, S2 = 2163, S3 = 2076; Athens: REF = 5017, S1 = 3170, S2 = 2853, S3 = 2752; Jerusalem: REF = 5789, S1 = 3285, S2 = 2805, S3 = 2708; Genova: REF = 4935, S1 = 2882, S2 = 2611, S3 = 2524; Pisa: REF = 5157, S1 = 2796, S2 = 2526, S3 = 2438; Bologna: REF = 4933, S1 = 2875, S2 = 2604, S3 = 2518; Reggio Emilia: REF = 4933, S1 = 2872, S2 = 2601, S3 = 2515; Ljubljana: REF = 3277, S1 = 2459, S2 = 2309, S3=2211; Manresa: REF = 5441, S1 = 3579, S2 = 3304, S3 = 3183; Zaragosa: REF = 5441, S1 = 3580, S2 = 3306, S3 = 3184; Ankara: REF = 4323, S1 = 3090, S2 = 2594, S3 = 2510; Istanbul: REF = 4316, S1 = 3090, S2 = 2594, S3 = 2510. The average WF for the S1 was 2591, for the S2 was 2735, and for the S3 was 2640 L/d per capita
Vanham et al. (71)	Mediterranean region (Spain, France, Italy, Greece, Turkey, Egypt, Tunisia, Algeria, and Morocco), 3 diets (current food intake, MDiet, and EAT-Lancet diet)	- WF	NA	The MDiet requires more water resources than the EAT Lancet diet. The total MDiet (green and blue together) WF of consumption (in L/d per capita) ranges across countries: 2966 in Spain, 2818 in France, 2874 in Greece, 2571 in Italy, 2819 in Turkey, 2819 in Egypt, 4516 in Morocco, 3946 in Algeria, and 4650 in Tunisia. The blue WF for the MDiet was 296 for Spain, 353 for France, 455 for Greece, 373 for Turkey, 1421 for Egypt, 692 for Morocco, 664 for Algeria, and 503 for Tunisia. The average MDiet WF for the 9 Mediterranean countries was 3.33 L/d per capita
Van Dooren et al. (65)	Netherlands, 6 diets (current average Dutch, official "recommended" Dutch, semi-vegetarian, vegetarian, vegan, and MDiet)	- GHGE - Land use	Not mentioned	MDiet had a lower GHG and land use (only higher than vegetarian and vegan diet) MDiet showed GHGE of ~3.40 kg CO_2 eq/d per capita, and a land use of ~2.80 m^2/d per capita

(*Continued*)

TABLE 3 (*Continued*)

Study (reference)	Country and sample	Indicators used	System boundaries	Key findings
Van Dooren et al. (64)	Netherlands, 6 diets (Dietary guidelines, Present Dutch, MDiet, New Nordic Historical, Low Lands Optimized, Low Lands)	- GHGE - Land use	- Raw materials acquisition and natural resources to final disposal (including food waste)	MDiet has a higher environmental impact and a lower sustainable score than an optimized Low Lands diet. MDiet showed GHGE of 3.24 kg CO_2 eq/d per capita, a land use 4.15 m^2/d per capita, and a sustainable score of 90
Wilson et al. (75)	New Zealand, modeling and data analysis of 16 dietary patterns scenarios grouping in 4 scenarios: *1*) low-cost; *2*) low in GHGs and low-cost; *3*) "relatively healthy diets" with high vegetable intakes—an MDiet-style and an Asian-style diet (within cost and GHG constraints); and *4*) "more familiar meals"	- GHGE	- Farm to fork	The MDiet scenario had higher GHGE than the other scenarios, except for the "more familiar meals." The MDiet scenario showed GHGE of 4.68 kg CO_2 eq/d per capita
Nutritional sustainability dimension				
Castané and Antón (52)	Spain, 2 diets (MDiet and vegan diet)	- Nutrient Rich Food Index (NRF9.3)		The MDiet had a lower NRF9.3 score than the vegan diet The final NRF9.3 score for the MDiet was 90.6
Chapa et al. (73)	USA, 4 diets [healthy American diet (HUS), lacto-ovo-vegetarian (VEG), and "typical" American (TYP) diet, MDiet]	- NRF9.3 - Nutritional Quality Index (NQI) - Fullness Factor (FF)		The MDiet had the highest NRF9.3 score and FF score in comparison to the other diets. MDiet's NQI was just above the vegetarian diet's NQI The final NRF9.3 score was 12.95, the NQI was 98.81, and the FF was 61.55 for the MDiet
Seconda et al. (60)	France, NutriNet-Santé Study ($n = 22{,}866$, >18 y) and dietary pattern derived (MDiet-conventional food and MDiet-organic food)	- PANDiet - mPNNS-GS - Dietary Diversity score		Higher adherence to MDiet with conventional or organic food was associated with a higher diet quality For the Conv-MDiet followers, the PANDiet was 69.02, the mPNNS-GS was 9.30, and the Dietary Diversity score was 10.39 For the Org-MDiet followers, the PANDiet was 71.40, the mPNNS-GS was 9.29, and the Dietary Diversity score was 10.67
Tucci et al. (61)	Italy, 2 dietary pattens (MDiet adapted to the Italian food habits and Italian Dietary Guidelines based)	- Nutrient adequacy		Dietary plans were compared and a higher amount of fiber and lower levels of calcium were evidenced for the MDiet compared with the Italian Dietary Guidelines–based diet The MDiet provides 2500 kcal, 97.7 g protein (47.6 g animal protein and 50.2 g vegetal protein), 84.3 g of lipids (23.2 g SFAs, 41.3 g MUFAs, 10.3 g PUFAs, 3.1 g omega-6, 0.6 g omega-3, 248.7 mg cholesterol), 317.3 g carbohydrates (111.5 g sugars, 39.1 g fiber), 2000 μg vit. A, 2.3 μg vit. D, 17.1 mg vit. E, 1.4 mg vit. B-1, 2.4 mg vit. B-2, 23.0 mg vit. B-3, 2.8 mg vit. B-6, 617.5 μg vit. B-9, 4.3 μg vit. B-12, 250.9 mg vit. C, 1079.1 mg calcium, 2070.3 mg sodium, 1217.0 mg chlorine, 17.9 mg iron, 356.2 mg magnesium, 1851.4 mg phosphorus, 4939.2 mg potassium, and 14.8 mg zinc
Van Dooren et al. (65)	Netherlands, 6 diets (current average Dutch, official "recommended" Dutch, semi-vegetarian, vegetarian, vegan, and MDiet)	- Health score		MDiet had higher overall health score with 122 points
Van Dooren et al. (64)	Netherlands, 6 diets (Dietary guidelines, Present Dutch, MDiet, New Nordic Historical, Low Lands Optimized, Low Lands)	- Health score		MDiet has equivalent nutritional characteristics to the optimized Low Lands diet and the Nordic diets. MDiet showed a Health score of 122

(*Continued*)

TABLE 3 (*Continued*)

Study (reference)	Country and sample	Indicators used	System boundaries	Key findings
Wilson et al. (75)	New Zealand, modeling and data analysis of 16 dietary patterns scenarios grouping in 4 scenarios: *1*) low-cost; *2*) low in GHGs and low-cost; *3*) "relatively healthy diets" with high vegetable intakes—an MDiet-style and an Asian-style diet (within cost and GHG constraints); and *4*) "more familiar meals"	- Nutritional composition of food		The MDiet scenario provided 2815.52 kcal, 100 g protein, 125 g total sugars, 13 g SFAs, 14 g PUFAs, 57 g fiber, 625 μg vit. A, 3 μg vit. D, 14 mg vit. E, 2.1 mg vit. B-1, 94 mg vit. C, 840 mg calcium, 1670 mg sodium, 24 mg iron, 3800 mg potassium, 60 μg selenium, and 15 mg zinc
Economic sustainability dimension				
Fresan et al. (53)	Spain, participants ($n =$ 18,429) in the SUN cohort follow-up, and dietary pattern derived (Western, MDiet, and pro-vegetarian)	- Cost of diet		Participants with the highest adherence to the MDiet spent a mean of 7.52€/d, 1.42€/d more in their daily diet than those with the poorest adherence to the MDiet
Germani et al. (29)	Italy, 2 diets (current dietary pattern and MDiet)	- Cost of diet		MDiet had a similar cost to the current Italian dietary pattern MDiet had a cost of 37.3 €/wk per capita
Gonzalez-Garcia et al. (54)	Spain, dietary guidelines (MDiet, SEAD, NAOS)	- Costing index assessment		The costing index was similar between the MDiet and NAOS; both were lower than SEAD. Costing index of MDiet was 4.05 €/d per capita
Llanaj et al. (68)	Albania, 289 students (18–24 y) from 3 universities in Tirana, Albania [Dietary Approaches to Stop Hypertension (DASH), EAT-Lancet reference diet, and MDiet]	- Cost of diet		A transition to more human and environmental health-promoting diets is not constrained by cost, but rather by the level of out-of-home eating. Higher adherence to this Mediterranean dietary pattern was not associated with increased food and drink expenditures Mean cost of MDiet was ∼730 ALL/d per capita (∼5.9€/d per capita)
Lopez et al. (55)	Spain, SUN study participants ($n = 17{,}197$, 38.6 y average)—Spanish university graduates, and dietary pattern derived (MDiet and Western)	- Cost of diet		A higher score on the MDiet pattern was positively associated with increased costs of daily food consumption after adjusting for age and sex. Daily food costs (€/1000 kcal, mean) for each MDiet pattern quintile of scores of adherence was 2.75€ for the first quintile, 2.93€ for the second quintile, 3.04€ for the third quintile, 3.22€ for the fourth quintile, and 3.52€ for the fifth quintile
Pairotti et al. (57)	Italy, 4 diets (national average diet, MDiet, healthy diet, and vegetarian diet)	- Cost of diet		MDiet had a similar cost compared with the national average diet, a lower cost than healthy diet, and a higher cost than vegetarian diet. An MDiet for an average Italian family would require expenditure of 441.77€ per month
Schröder et al. (59)	Spain, Spanish men ($n = 1547$) and women ($n = 1615$) aged 25–74 y, and dietary pattern derived (MDiet and Healthy Eating)	- Cost of diet		MDiet has the lowest cost compared with the Healthy Eating dietary pattern. Participants with a high adherence to the MDiet spend 7.92€/d per capita ($9.90/d per capita) and the participants with low adherence spend 6.74€/d per capita ($8.43/d per capita) with diet
Seconda et al. (60)	France, NutriNet-Santé Study ($n = 22{,}866$, >18 y), and dietary pattern derived (MDiet)	- Cost of diet		MDiet combined with organic food was the highest cost. For the Conv-Med diet followers, the diet cost was 9.11€/d per capita. For the Org-Med diet followers, the diet cost was 11.43€/d per capita
Tong et al. (74)	United Kingdom (UK), 12,417 adults in the UK Fenland Study (30–65 y), and dietary pattern derived (MDiet)	- Cost of diet		High adherence to the MDiet was associated with higher dietary cost. On average, the participants with high adherence to the MDiet spend £4.47/d per capita (∼5.28€/d per capita) and the participants with low adherence to the MDiet spend £4.26/d per capita (∼5.03€/d per capita) with diet

(*Continued*)

TABLE 3 (*Continued*)

Study (reference)	Country and sample	Indicators used	System boundaries	Key findings
Tukker et al. (62)	Europe, 4 diet scenarios (scenario 0: European status quo; scenario 1: pattern according to universal dietary recommendations; scenario 2: the same pattern in scenario 1 with reduced meat consumption; and scenario 3: Mediterranean pattern)	- Cost of diet		The MDiet was only more expensive than scenario 3. MDiet expenditure on food was, on average, 444 billion euros for the total of 27 countries part of the European Union in 2008
Vlismas et al. (66)	Greece, ATTICA study participants ($n = 1514$ men and 1528 women (>18 y), and dietary pattern derived (MDiet)	- Cost of diet		Current cost of Mediterranean diet was 31.2€/wk per capita. The total cost (€/wk per capita) for food type: red meat, 0.51€; sweets, 0.45€; eggs, 0.78€; potatoes, 0.23€; pulses, 1.10€; poultry, 0.98€; fish, 2.86€; dairy products, 4.50€; olive oils, 1.32€; olives, 0.64€; fruits, 2.54€; vegetables, 4.03€; non-refined cereals, 9.03€; red wine 2.23€
Wilson et al. (75)	New Zealand, modeling and data analysis of 16 dietary patterns scenarios grouping in 4 scenarios: *1*) low-cost; *2*) low in GHGs and low-cost; *3*) "relatively healthy diets" with high vegetable intakes—an MDiet-style and an Asian-style diet (within cost and GHG constraints); and *4*) "more familiar meals"	- Cost of diet		The MDiet scenario had a higher cost than the other scenarios, except for the "more familiar meals." The MDiet showed a cost of \$5.64/d per capita (3.38€/d per capita)
Combined sustainability dimensions				
Blas et al. (50)	Spain, Household Consumption Database Program ($n = 8000$ households) and dietary pattern derived (MDiet)	- Nutritional Water Productivity (NWP) assessment		MDiet exhibited greater efficiencies of NWP values for blue water and with respect to all nutritional components for the food groups
Chapa et al. (73)	USA, 4 diets [healthy American diet (HUS), lacto-ovo-vegetarian (VEG), and "typical" American (TYP) diet, MDiet]	- Energy-based GWP - NRF9.3-based GWP - NQI-based GWP - FF-based GWP		MDiet generated a higher GWP regardless of nutritional quality and satiety than a VEG diet. The total energy-based GWP for the MDiet was 6.26, the NRF9.3-based GWP was 0.385, the NQI-based GWP was 0.058, and the FF-based GWP was 0.100
Fresan et al. (53)	Spain, participants ($n =$ 18,429) in the SUN cohort follow-up (Western dietary pattern, MDiet, and pro-vegetarian dietary pattern)	- Sustainable Diet Index - Environmental footprints		A better overall Sustainability Diet Index was found for the MDiet, with 5.57 points for the lowest quartile and 6.64 points for the highest. The Environmental Footprints Index for the MDiet was lower than the Western dietary pattern and higher than the pro-vegetarian dietary pattern, with 10.35 points for the lowest quartile and 9.5 points for the highest
Van Dooren et al. (65)	Netherlands, 6 diets (current average Dutch, official "recommended" Dutch, semi-vegetarian, vegetarian, vegan, and MDiet)	- Sustainability score		MDiet had a higher overall sustainability score with 102 points
Van Dooren et al. (64)	Netherlands, 6 diets (Dietary guidelines, Present Dutch, MDiet, New Nordic Historical, Low Lands Optimized, Low Lands)	- Sustainability score		MDiet has a lower sustainable score than an optimized Low Lands diet, with 90 points

[1] ALL, Albanian Lek; Conv-MDiet, conventional consumers and Mediterranean diet followers; GHG, greenhouse gas; GHGE, greenhouse gas emissions; g PO_4 eq, grams of phosphorus equivalent; kg CO_2 eq, kilograms of carbon dioxide equivalent; MDiet, Mediterranean diet; N_2 eq, nitrogen equivalent; NA, not applicable; NAOS, Spanish dietary guidelines; Org-MDiet, organic consumers and Mediterranean diet followers; SEAD, Southern European Atlantic diet; SUN, Study of the University of Navarra; tCO_2 eq, tons of carbon dioxide equivalent; vit., vitamin.

sustainability of dietary patterns (31, 39). The present review is the basis to provide insights on the indicators being used to assess diets in general and the MDiet in particular. It reveals the need for a harmonized set of indicators that may be applicable to the MDiet and that allow a complete assessment of the several sustainability dimensions. This work may also allow future comparisons of the sustainability dimensions among human dietary patterns.

The use of sustainability indicators is essential for an integrated evaluation of dietary patterns (36). For each dimension, there is a set of complementary indicators, as they focus on different aspects of these dimensions (15). For example, within the environmental dimension, the CF is widely used, but by itself it does not reflect the overall environmental impact of a diet (112). Other environmental footprints (e.g., water and ecological) are also relevantly used, such as local/regional food consumption and seasonality and biodiversity. Another aspect is that, although indicators are intended to assign a final value regarding the impact of a certain dietary pattern, the interpretation of their results was made by comparison (e.g., MDiet vs. vegan diet), which may have some subjectivity given the characteristics of each dietary pattern and the methodology chosen to assess them.

Methodologies for quantifying sustainable diets show significant variation among each other. These methodological variations concern the different dimensions of sustainability evaluated, the indicators chosen for each dimension, the method chosen to apply the indicators, as well as the unit in which the results are presented. Additionally, some indicators are associated with specific domains, but no clear consensus regarding domain classification exists. For example, one of the eligible studies, conducted by Seconda et al. (60), classified as sociocultural some indicators—namely, product origin and production methods—that other authors classified as environmental (46). The same study considered the plant:animal protein ratio as an environmental indicator, which is also described in the literature as a nutritional indicator (83).

Most studies focused only on the environmental dimension of the MDiet or combined it with nutritional diet quality or diet monetary cost. Sociocultural impacts of MDiet are generally not considered. This shows the existing gaps on a complete sustainability assessment of the MDiet by considering its several sustainability dimensions. Other gaps are observed—namely, within a specific dimension. For this case, only a few indicators are used, which can contribute to an incomplete assessment. For example, environmental impacts are often reduced to a few indicators, such as the CF, EF, and WF. These environmental footprints look at the burden along the whole food supply chain (114) by making use of life cycle–focused principles that are essential for the sustainability assessment.

LCA is a standardized methodological framework that is widely used. This methodology assesses the environmental impact attributable to the life cycle of a food product, from the extraction of materials from the environment through the production of the product and the use phase until the product is no longer used (115). Although the LCA method follows international guidelines (116), the absence of standardized LCA databases for representative foods in the marketplace can affect the results obtained and impair comparisons (63, 117). Another aspect that may influence the comparison of results is the boundaries of the LCA considered to determine the environmental impact associated with each dietary pattern. In the studies reviewed, different boundaries of a food product life cycle were considered. Some studies considered a "cradle to grave" perspective focusing on 3 stages: food production, distribution to wholesale and retail, and household consumption. Others only accounted for 1 or 2 of these stages. Moreover, there were observed differences in the functional unit selected in the reviewed studies—namely, of the estimation of the footprints, with differences in the unit of mass, volume, energy, and temporal measurements used, which makes it difficult to compare the results.

The studies reviewed analyzed a variety of attributes of diets affecting use of land, water, and energy across the food chain. In these studies, the MDiet was identified as an environmentally friendly dietary pattern, due to its low environmental impact when compared with Western dietary patterns, and only showing a higher environmental impact than the vegetarian and vegan diets for all of the environmental indicators. The MDiet was considered a plant-based–oriented diet with low consumption of meat, moderate consumption of dairy products and fish, and the sporadic consumption of processed foods (118). Pulses are an important protein source in the MDiet and have a very low CF compared with beef, the most common protein source in Western diets (119). These characteristics contribute to lower GHGE, lower WF, and improved use of arable land (118). Even though vegan diets are usually the most environmentally sustainable (4, 120–122), the MDiet may lead to even better average environmental outcomes in comparison to a high-fat vegan diet, which includes a high consumption of oil and nuts with a larger WF (123). In addition, the MDiet also includes locally produced foods, with a lower transportation-related CF (124).

In the studies reviewed, MDiet food pattern data were obtained from 2 different methodologies: one based on real dietary consumption and the other using dietary scenarios. Possibly, these different methodologies can be complementary if the objective is to compare an ideal scenario of MDiet consumption (based on recommendations) with the real consumption of individuals who have a high rate of adherence to this diet (assessed by MDiet adherence scores). Also, the variety of MDiet adherence scores used by different studies has an impact on the indicators' results, since the number of components (nutrients, foods, or food groups), classification categories, measurement scale, statistical parameters (mean, median), and the contribution of each component (positive or negative) to the score total are distinct (125, 126). This shows that the relation between MDiet food composition, the adherence score, and the environmental aspects of the MDiet still needs to be further investigated.

Looking at the nutrition dimension, the NRF9.3 and the Health score were the most used indicators to assess the nutritional quality of the MDiet. Food intake impacts and determines an individual's nutritional status. Assessing the nutrition impacts poses many challenges—for example, how to evaluate a set of individual diets and how to assess the overall consumption of the population and the health status of a population, at the country level, given, for example, the heterogeneity of consumption (127). Several factors contribute to the variation in the results regarding nutritional indicators: *1*) daily energy intake defined for the different MDiet scenarios, *2*) food groups considered in these scenarios and their proportion, *3*) different sources of food and nutrition data, *4*) different functional units, and *5*) number and selection of encouraging and dis-encouraging nutrients/foods in the indicators. Macronutrients, like protein and fiber, and micronutrients are considered, in general, nutrients to encourage and total or added sugar, fat, and sodium are often dis-encouraged foods (128, 129). The choice of nutrients and foods to include in indicators is often guided by national or regional reports of the nutritional status of the population in contrast with dietary recommendations (129). Also, the reference amount for the calculation of the indicators varies and can be expressed per mass unit (e.g., 100 g), per energy content (e.g., 100 kcal), per daily intake, or standardized portion (130).

Of the studies reviewed, the MDiet was the dietary pattern with the highest overall health and nutritional scores (only lower than vegetarian and vegan diets). The MDiet has long been reported to be protective against the occurrence of noncommunicable diseases due to its nutritional richness (131). Positive health effects may be a result of a synergetic combination between high amounts of dietary fiber, antioxidants, polyphenols, high oleic acid content, and a balanced ratio of omega-6 and omega-3 fatty acids (132).

To assess the economic dimension of the MDiet, the most used indicator was the cost of diet. In fact, one of the main factors driving and conditioning economic impacts of a specific diet is the price of food (127), which determines food choices. From a consumer perspective, lower food prices may facilitate the access to diversified and nutritious diets (127). The estimation of food costs brings significant challenges, such as the price of similar food items that can vary considerably depending on various factors (volume/weight, quality, brand, different regions of the country, seasons, and types of stores, among others) (55, 119). Nevertheless, a similar methodology was used to calculate the daily cost of a diet, which can vary greatly due to the different price database utilized.

The FAO defined that a sustainable diet must be "economically fair and affordable," and although the term "affordability" was included in the search strategy, the studies retrieved only assessed the cost of the diet or the cost index assessment. The MDiet has been debated regarding its affordability, and so far there is not a final consensus (133). According to data found, the MDiet tended to be considered the most expensive compared with the other diets. Another systematic review by Saulle et al. (134) also reported that adopting the Mediterranean dietary patterns was associated with increased costs of daily food consumption. MDiet products tend to be consumed by groups of higher socioeconomic status, while consumption of processed meats, refined grains, and added fats has been associated with lower socioeconomic status consumers (135). These consumers tend to adopt dietary patterns that are rich in energy-dense foods, which have the advantage of being affordable, convenient, and good-tasting (130). However, a study conducted by Goulet et al. (136) concluded that predefined MDiet-oriented choices are not necessarily associated with increased overall daily dietary cost or energy costs since the cost associated with a higher intake of vegetables, fruits, vegetables, nuts and seeds, olive oil, whole grains, poultry, and fish can be offset by reducing the expense with lower intakes of red meat, refined grains, desserts, sweets, and fast food.

With regard to the sociocultural dimension, no MDiet assessment is available in this dimension. This dimension tends to be overlooked in assessing the sustainability of dietary patterns in general (22), and the MDiet is no exception. The focus on social describes the roles of society and how the individual members of society interact. There are many meanings of social sustainability, focusing on diverse and context-specific social priorities, which could be a reason for this gap. In addition to social equity of access to food and social well-being, examples of topics that can link to the social perspective in food systems research could include food choice behaviors, food systems ethics, and socioecological systems (22).

Limitations

Our systematic review has some limitations. Although the search strategy was effective in allowing the capture of articles of interest and excluding those that would not meet the inclusion criteria, it is possible that studies that used sustainability indicators and that do not mention the word "sustainability" (or similar terms) were not captured. Moreover, this review did not consider the gray literature, which can be a source of evidence due to its large extent.

Additionally, this review does not allow to directly compare the indicators used by the different studies. This cannot be done because the MDiet food pattern was either defined a priori (theoretical scenario) or was measured through adherence levels assessed by different instruments (based on real food consumption data) in different populations. Also, comparisons among environmental indicators are not possible because they are calculated based on distinct system boundaries (production, distribution, or consumption).

Conclusions

This systematic review identified and described the indicators used to evaluate the sustainability dimensions of the MDiet, and also presented the results of their application. This review identified 33 indicators that can be grouped into 4 domains of sustainability: environmental, nutritional, economic, and sociocultural. The analysis of the number and type of dimensions evaluated in the eligible studies for the review, as well as the number of indicators used to evaluate each of the dimensions of sustainability, demonstrates that there is no uniformity in the way in which the sustainability of a diet is evaluated. Results show that, within a dimension, the indicators chosen to assess it only focus on 1 aspect of that dimension, which does not allow for a comprehensive view of the overall aspects of sustainability.

Clearly, the environmental dimension was the most frequently assessed. In particular, GHGE were the most measured element, with water and land use also frequently assessed. Regarding the nutritional dimension, the nutritional indicators varied from study to study and the only 2 that were adopted more than once were the Health score and the NRF9.3. The costs associated with diet were assessed as the primary aim of only 5 studies. The sociocultural dimension was also disproportionately underrepresented. Regarding the combined indicators, the only one that considered more than 2 dimensions was the Sustainable Diet Index. Despite the different methodologies and variable results found in the articles, the MDiet was considered in all articles as a sustainable dietary pattern.

In sum, this review can serve as a basis for the development of a composite assessment indicator allowing for a complete assessment of all dimensions of sustainability, as it describes how the MDiet has been evaluated and points out what could be the main limitations of these assessments.

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Data availability statement

Data described in the manuscript will be made available upon request.

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