




cambridge.org/rf

Jose-Maria Garcia-Alvarez-Coque<sup>1</sup> , Ola Abdullateef<sup>2</sup>, Loreto Fenollosa<sup>1</sup>,  
Javier Ribal<sup>1</sup> , Neus Sanjuan<sup>3</sup>  and Jose Miguel Soriano<sup>4</sup>

## Research Paper

**Cite this article:** Garcia-Alvarez-Coque J-M, Abdullateef O, Fenollosa L, Ribal J, Sanjuan N, Soriano JM (2021). Integrating sustainability into the multi-criteria assessment of urban dietary patterns. *Renewable Agriculture and Food Systems* **36**, 69–76. <https://doi.org/10.1017/S174217051900053X>

Received: 20 June 2019  
Revised: 14 November 2019  
Accepted: 18 December 2019  
First published online: 30 January 2020

### Key words:

Analytic hierarchy process; dietary pattern; food policy; Mediterranean diet; socio-economic perspective; sustainability

### JEL Classification codes:

Q18; I18; Q58

### Author for correspondence:

Jose-Maria Garcia-Alvarez-Coque, E-mail:  
[jmgarcia@upvnet.upv.es](mailto:jmgarcia@upvnet.upv.es)

<sup>1</sup>Department of Economics and Social Sciences, Universitat Politècnica de València, Valencia, Spain; <sup>2</sup>Fayoum University, Cairo, Egypt; <sup>3</sup>Department of Food Technology, Universitat Politècnica de València, Valencia, Spain and <sup>4</sup>Food & Health Lab, Institute of Materials Science, Universitat de València, Valencia, Spain

### Abstract

This study develops a decision-making procedure to help policymakers compare alternative patterns for sustainable diets by reaching a compromise among three criteria: socio-economic perspective, health and environment (including carbon and water footprints). An Analytical Hierarchy Process (AHP) was performed in several stages. First, a total of 25 stakeholders (members of organizations on the Valencia Food Policy Council) evaluated criteria that are relevant to the sustainability of diets. Secondly, a workshop with 14 experts from different backgrounds evaluated by consensus four dietary alternatives: Mediterranean, flexitarian, pescatarian and vegan. In terms of environment, experts gave priority to the vegan diet. However, the Mediterranean diet pattern (MDP) appeared, according to the process, as the most suitable pattern from the holistic perspective that integrates all relevant criteria. The MDP was ranked first in terms of the health criterion and the socio-economic perspective. These include culture, affordability, social impact and local production as decision elements that food policy advisory bodies take into consideration to define sustainable diets.

### Introduction

The food chain is a multi-functional system that addresses related environmental, economic, social and nutritional issues (Lang *et al.*, 2009). In the past 50 years, food production and dietary patterns have changed substantially in such a way that the global food system needs to be transformed to reduce its impact on human health and environmental stability. This change should recognize the link between human health and the environment, consequently integrating these concerns into a common global agenda to achieve sustainable food systems (Willet *et al.*, 2019). Cities are part of the food system; with more than 60% of the world's population living there, they will play a key role in future food security (Seto and Ramankutty, 2016). In addition, cities are becoming key transition spaces where new forms of governance are being created through the participation of policymakers, academics and civil society actors (Moragues and Morgan, 2015). One dimension of governance is the strategic guidance for local food policies (Guyomard *et al.*, 2012; Debru *et al.*, 2017). Multi-sector groups are needed to advise cities to reach a compromise about what a sustainable diet is and to build consensus on how to raise awareness on suitable dietary patterns. Local dietary patterns have significant links with environment, health and social concerns, which suggests the need to integrate different criteria to define sustainable diets.

The environmental impact of urban food systems has been assessed elsewhere. For instance, a review by Goldstein *et al.* (2017) points out that food demand was typically the third largest source of carbon footprint in cities. Vanham *et al.* (2016) estimated the blue water footprint related to different diets in Mediterranean cities to be a minimum of 20 times larger than direct domestic water use. Furthermore, a growing body of research analyses the environmental impacts in high-income countries of alternative diets (e.g., Pradhan *et al.*, 2013; Castañé and Antón, 2017; Veeramani *et al.*, 2017; Niles *et al.*, 2018). Most of those studies point out that reducing the dependence on animal-based products in diets would lead to lower environmental footprints (Sáez-Almendros *et al.*, 2013; Clark and Tilman, 2017). In addition, an increase in legume consumption could compensate nutritional deficiencies when transitioning to diets with lower meat, bringing additional benefits (Röös *et al.*, 2018). Regarding health, a reduction in red meat consumption has frequently been associated with lower triglyceride and cholesterol levels in the blood, preventing type 2 diabetes, cardiovascular diseases, colorectal and other cancers, and all-cause mortality (WHO, 2015; Aleksandrowicz *et al.*, 2016; Ekmekcioglu *et al.*, 2018).

A sustainable dietary pattern implies not only environmental and nutritional aspects, but also a broad range of socio-economic and cultural factors including food access, availability, cultural acceptability and religion (Dernini *et al.*, 2013; Gustafson *et al.*, 2016), these concerns

© Cambridge University Press 2020

**CAMBRIDGE**  
UNIVERSITY PRESS

being crucial for the transition toward sustainable dietary patterns. Along these lines, when food policies are formulated, local stakeholders are key actors to promote a holistic approach that considers also socio-economic concerns. In the last few years, cities are becoming increasingly involved in food-related initiatives, as evidenced by the emergence of EU-funded projects, which involve local authorities and focus on urban food strategies (de Cunto *et al.*, 2017). The creation of the ‘Milan Urban Food Policy Pact’ (MUFPP), led by the city of Milan, has been key in the recognition of cities as food policy actors. Those cities that wish to join the MUFPP agreement must implement local policies to promote sustainable food systems. Likewise, local administrations in many countries have shown an increasing support to local food initiatives such as Food Policy Councils (FPC) in the USA (Patel, 2009), UK (Moragues-Faus, 2017) and African cities (Morgan, 2009). FPC provides governance platforms to provide guidance to support the transition toward sustainable local food systems (Prové *et al.*, 2019).

Valencia (Spain) was one of the first cities that signed the MUFPP in October 2015 and it was selected by the FAO as the world’s food capital in 2017. Later on, in October 2018, Valencia created its FPC (called *Consell Alimentari*) and approved a food strategy to support the transition toward more sustainable, healthy, affordable, safe and diversified local food systems and encourage the adoption of sustainable diets. The Valencia FPC is governed by participatory approaches and consists of a multi-actor group from 50 organizations that attempt to reach consensus on sustainable dietary guidelines in a context of growing concerns on food-related diseases in the Mediterranean region (Belahsen and Rguibi, 2006; Vareiro *et al.*, 2009; Padilla *et al.*, 2012; Dernini and Berry, 2015).

The literature shows different approaches to design and assess sustainable diets. Linear and goal programming techniques have been used to determine optimum solutions (Macdiarmid *et al.*, 2012; Van Dooren *et al.*, 2015; Horgan *et al.*, 2016; Ribal *et al.*, 2016). Those studies incorporate nutritional, environmental (mainly carbon footprint) and price-related criteria, although they fail to take account of social aspects of eating and the reasons behind consumers’ food choices, such as habits, culture and social norms (Horgan *et al.*, 2016; Hoek *et al.*, 2017), nor do they involve other relevant stakeholders. The multi-criteria decision-making (MCDM) field can provide numeric techniques to help decision makers, in a multi-person decision context with multi-criteria situations (Triantaphyllou, 2013; Tarne *et al.*, 2019).

This study aims at developing an MCDM method based on the Analytical Hierarchy Process (AHP) to assess the sustainability of diets by using an alternative participatory process involving policymakers and other stakeholders to obtain consensus applied to the Valencia metropolitan area. The approach integrates environmental, health and socio-economic concerns. Consequently, this study addresses the complex challenge of integrating several criteria that are not always aligned. Four dietary patterns were evaluated in such a context, through a participatory methodology in which different local stakeholders have been involved; in this way, they can shape political interventions aiming at promoting healthier and more sustainable dietary patterns. The AHP has not been directly applied to diet evaluation, although there are some precedents to measure the importance of factors for obesity prevention (Bizjak *et al.*, 2016) or to calculate the weight of factors affecting adolescents’ choice to eat out (Lan *et al.*, 2017). Sylvie *et al.* (2013) turned to AHP to identify the environmental settings and factors that promote healthy eating

in older adults. All the primary sources in those studies were expert panels.

## Methods

### Evaluation procedure

The evaluation procedure is based on the AHP (Saaty, 2005), which is capable of translating experienced decision makers’ qualitative and quantitative assessments into a multi-criteria classification. The AHP produces weights for each evaluated criterion after decision makers perform pairwise comparisons of criteria and alternatives (Scholl *et al.*, 2005; Alfares and Duffuaa, 2008). Weights of criteria and alternatives are combined for ranking alternatives. AHP is easy to use and scalable, and its hierarchy structure can be easily adjusted to fit many sized problems (Velasquez and Hester, 2013). Other MCDM methods (e.g., TOPSIS or Promethee) need to rely on a second tool to compute criteria weights.

Figure 1 shows a flow diagram that represents the entire process of reaching a compromise between the consistent judgments required by the AHP and the knowledge provided by those involved. In the first stage, criteria and sub-criteria to assess the dietary patterns were compared through responses to individual questionnaires answered by a group of stakeholders who represent institutions of the Valencia FPC. Their judgments were then aggregated to find the corresponding weights. In the second stage, a workshop was held in Valencia with a smaller group of experts from the same institutions. These experts were classified into three sub-groups according to the main criteria. For the main goal of identifying a sustainable diet, each sub-group proposed (by consensus) the weights and ranking of the alternatives (or diets) for each criterion or sub-criterion.

The hierarchy of the process is based on three criteria (environmental, health and socio-economic factors) and two pairs of sub-criteria (carbon/water footprint and consumer/producer perspective). This hierarchy divides the main goal into a set of elements (Fig. 2). The three main levels of the hierarchy are the goal, the criteria (factors relating to each alternative that affect the main goal) and the alternatives for which trade-offs are made to reach the goal. As indicated, the main goal is to choose the best dietary pattern from the alternatives that could be recommended or considered as dietary guidelines. The alternatives were:

- Mediterranean dietary pattern (MDP)
- Pescatarian pattern (PES)
- Vegan pattern (VEG)
- Flexitarian pattern (FLEX).

### First stage: criteria’s pairwise comparisons

The first stage of the evaluation procedure, after arranging the hierarchy structure for the main goal, was to identify the priorities of the experts (or decision makers) together with the weights to attach to the core criteria. The interviewer explained the methodology to the experts who were compelled to determine the relative importance of each criterion with respect to others.

The criteria were compared as follows: ‘What is the relative importance of each criterion compared to the other one from the decision makers’ point of view?’ This relative importance was in relation to the main goal. In the AHP, a verbal scale is used to enter different judgments for each level but the software

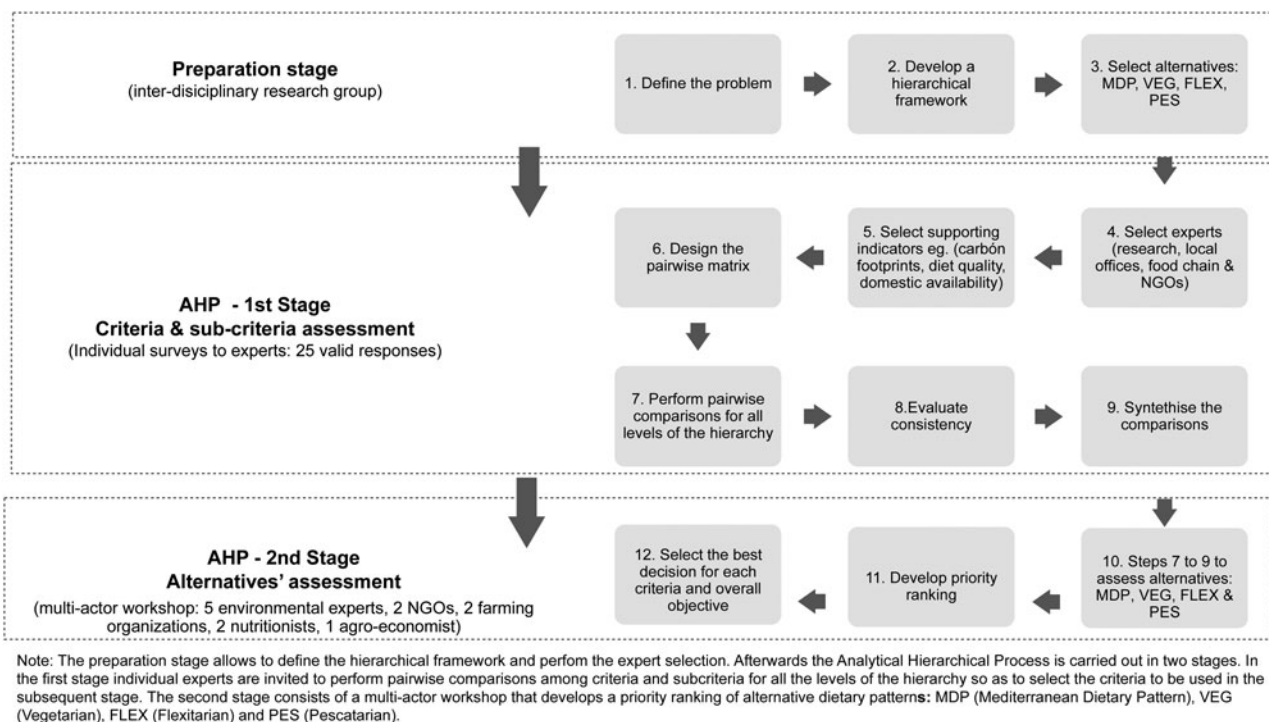


Fig. 1. Flow diagram for acquiring a compromise solution using the Analytical Hierarchy Process (AHP).

requires numbers; therefore, and according to Saaty (2005), the verbal scale is converted to an ordinal scale. For a given pair of alternatives or criteria A and B, the scale measures the intensity of preference by attaching values between 1/9 (B is extremely more important than A) and 9 (A is extremely more important than B), 1 meaning 'equal importance'.

If each pair of elements in this row is compared, the number of comparisons is given by Equation (1):

$$N = \frac{n(n-1)}{2} \quad (1)$$

where  $N$  is the number of comparisons and  $n$  is the number of elements. There were three pairs: environmental impact vs health, environmental impact vs socio-economic factors and health vs socio-economic factors. The same operation was performed for the two sub-criteria within the environmental and socio-economic criteria. This process yields a matrix of priorities or relative weights of criteria, sub-criteria and alternatives. Priorities in the AHP are expressed as numbers between 0 and 1. These numbers reflect relative preference. AHP ratings are assumed to be consistent, in other words, they assumed that decision makers are rational. Saaty (2013) proposed the use of a Consistency Ratio (CR). If CR is greater than 0.1, the judgments should be modified until they reach a CR lower than 0.1. Otherwise, the set of answers must be excluded from the analysis.

A total of 52 experts from different backgrounds were surveyed in the first stage, from which 33 responses could be collected. However, eight were discarded because  $CR > 0.1$ , retaining 25 questionnaires (see first stage survey's questions as Supplementary Material). As for the composition of the group with consistent answers, 12 of them were female and 13 were male. Specifically, ten participants were members of research institutions (food

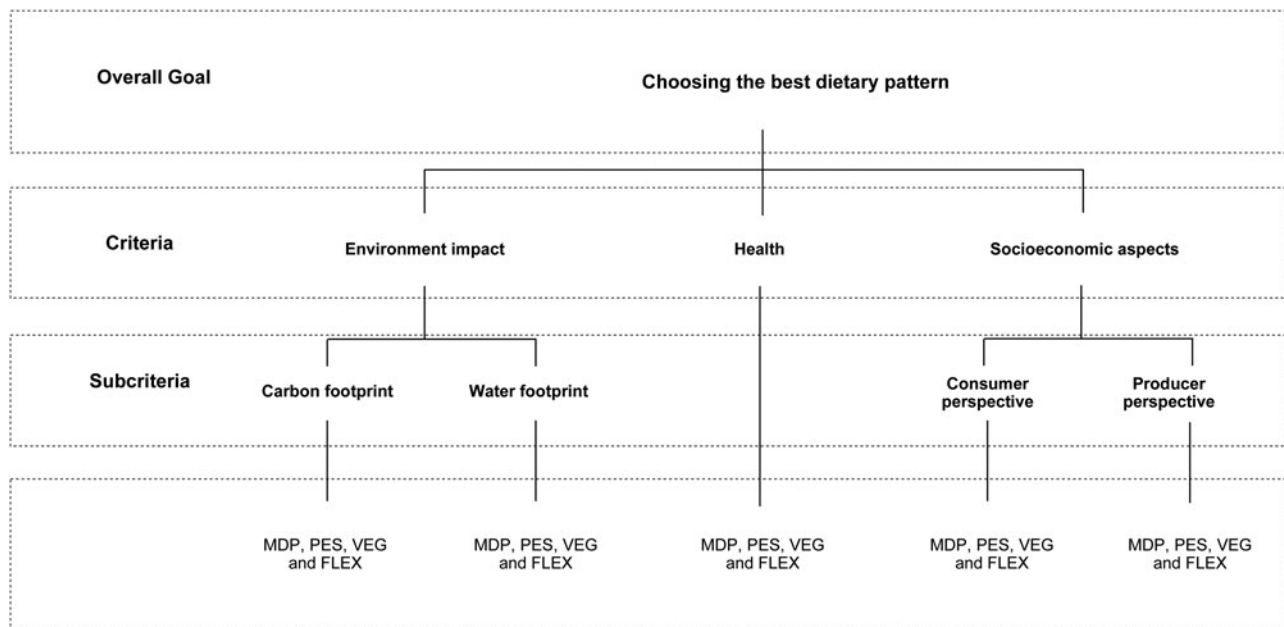
technology, nutrition, agricultural sciences and policies), three participants from local public institutions, five participants from the food chain including farmers, co-ops, local catering, food manufacturing and consumers, and seven from NGOs connected to the environment, nutrition and poverty. Super Decision software (v.3.2) was used to create the AHP model.

Grouping the pairwise comparisons is an important step when a group of experts offer judgments and want to reach a consensus, in this case regarding certain dietary patterns. The chosen aggregation method for the first stage (Fig. 1) was based on aggregating individual priorities using the geometric mean method.

### Description of dietary alternatives

To define the dietary alternatives considered in the multi-criteria assessment (second stage), adult dietary patterns in the Valencia metropolitan area were taken into consideration. The EAT-Lancet Commission on healthy dietary guidelines for sustainable food systems was used as a benchmark to define a healthy diet (Willett *et al.*, 2019). Using the ranges indicated in this benchmark, the four alternative patterns were further adjusted and provided to the experts. Actual dietary patterns (Generalitat Valenciana, 2013) were also provided as a complementary information (Table 1).

The Mediterranean dietary pattern (MDP) is a traditional diet in Mediterranean countries. It is characterized by a high consumption of vegetables, fruits, nuts, seeds, legumes, whole grains, bread, fish, seafood and olive oil. The MDP covers moderate consumption of protein from poultry, eggs, cheese and yogurt. It is rare however to consume red meat and highly processed foods. The vegan pattern excludes the consumption of all animal-based foods, also fish and dairy products. Popular foods amongst vegans include grains, nuts, legumes and beans. The flexitarian diet is an eating pattern that promotes crop-based foods whilst permitting



Note: The hierarchy structure of the AHP process for selecting sustainable dietary patterns is composed of 3 criteria, 4 subcriteria (2 for each criteria) and 4 alternative dietary patterns: MDP (Mediterranean Dietary Pattern), VEG (Vegetarian), FLEX (Flexitarian) and PES (Pescatarian).

Fig. 2. The hierarchy structure for this study.

the consumption of meat and other animal-based products in small quantities, thus being more flexible than vegan diets. Furthermore, the pescatarian pattern refers to a vegetarian one that also allows the consumption of fish and other seafood. It relies heavily on crop-based foods such as whole grains, nuts, pulses and healthy fats and seafood is the principal source of proteins. All dietary alternatives must ensure that people's nutritional needs are met. This means eating a set of foods that comply with the daily nutritional guidelines while taking advantage of all available food choices.

### Second stage: workshop

The second stage of the fieldwork was carried out with participants from the first stage who attended a workshop to rank the alternative diets according to the criteria and sub-criteria (see second stage questions as Supplementary Material). The reciprocal pairwise comparison matrix among dietary patterns for each criterion, sub-criteria and the main goal was built by consensus. The workshop brought together 14 stakeholders (six female, eight male) who confirmed participation. They previously received some information, alongside the workshop schedule, including, first, a small presentation about the main objectives of the study and the methodology. Secondly, a presentation with the results of the first stage showed the weights of the defined criteria and sub-criteria with its initial rank. The stakeholders were classified into three sub-groups in terms of the three main criteria. The nutrition and health group had four members: two nutritionists from the Red Cross, one food technologist and the manager of a catering company. The environmental group had five members, all of whom were academics: a specialist in LCA applied to food, two specialists in animal science with an environmental focus and another two specialists (one in water management and one in agricultural economics). The socio-economic group had five members: two NGO representatives (Right to

Food Observatory and CARITAS), a consultant to farming organizations, a farming organization leader and an agricultural economics PhD student. In this way, the sample reflected the possible interests and backgrounds of different institutions working in Valencia and its metropolitan area. Therefore, the workshop reflected the complexity of the food governance process. After a 40-min discussion in each sub-group, AHP priorities were generated for each criterion and sub-criterion. This was achieved by constructing the reciprocal pairwise comparison matrix, although this time by comparing pairs of alternative dietary patterns for each criterion or sub-criterion. Afterwards, each sub-group had 10 min to express its judgments to the other sub-groups. Additionally, there was a general discussion between the groups to reach consensus.

### Findings and discussion

After the first stage, judgments were recorded to obtain the priority (or weight) for each criterion and sub-criterion. The global priorities (i.e., each sub-criterion's contribution to the main goal) were then calculated. Across the hierarchy, the global priorities sum to 1. The results in Table 2 present health, with 44%, as the main priority, but the other priorities are also relevant: environmental concerns represent 33%, while socio-economic factors represent 23%.

Results showed that, although socio-economic factors were part of this holistic analysis, the valuation of the producer perspective was perhaps not too high. A reason for this outcome is that many stakeholders live in the urban area and are not growers, despite Valencia's rich peri-urban agricultural area. However, some participants work with food producers or in related agricultural research fields. The importance of the producer's perspective would have definitively been different if the process had taken place in a rural area. Therefore, this AHP analysis reflects a decision-making process in the metropolitan area.



**Table 1.** Composition and macronutrient intakes (g day<sup>-1</sup>) for the Mediterranean, vegan, flexitarian and pescatarian dietary patterns

Dietary pattern composition	Macronutrient intake g day <sup>-1</sup>			
	Mediterranean	Vegan	Flexitarian	Pescatarian
Whole grains:				
Rice, wheat, etc.	232	232	232	232
Starchy vegetables:				
Potatoes	50	70	70	70
Vegetables:				
All vegetables	500	600	600	600
Dark green vegetables	100	200	200	200
Red orange vegetables	200	200	200	200
Other vegetables	200	200	200	200
Fruits:				
All fruits	200	300	300	300
Dairy foods:				
Whole milk or derivatives (e.g., cheese)	350	0	200	200
Protein sources:				
Beef	2	0	1	0
Lamb and goat meat	5		1	
Pork	7	0	2	0
Chicken and other poultry	45	0	30	0
Eggs	15	0	13	13
Fish	50	0	30	90
Legumes:				
Dry beans	50	100	80	80
Tree nuts	25	25	25	25
Added fats:				
Unsaturated oils	70	70	70	70
Dairy fats	0	0	0	0
Added sugars:				
All sweeteners	15	15	15	15

Source: Authors' elaboration based on proposed guidelines for dietary patterns (Willett *et al.*, 2019).

The process of comparing pairs of criteria or sub-criteria requires decisions regarding which one is most relevant from the experts' point of view with respect to selecting the most appropriate dietary pattern. This decision can be difficult, but the role of experts is to determine the most important criterion from their point of view, and they must assess the relative importance of one criterion with respect to others.

The final ranking of the dietary alternatives after the workshop (second stage of the study) is shown in Table 2.

The workshop illustrates the trade-offs that policymakers face when designing food strategies in urbanized societies where both cultural aspects and the interests of local production also play prominent roles. MDP appears, according to the process, as the most suitable pattern with respect to the criteria and sub-criteria. The MDP was ranked first in terms of the health criterion and socio-economic criterion. This result is consistent with the studies

that focus on the MDP and its health value (Sofi *et al.*, 2010; Curtis and O'Keefe, 2002). Cultural considerations could explain the high weight of the MDP. From the water consumption perspective, the MDP was ranked lowest because of the relative importance of animal production. The experts highlighted other environmental advantages due to lower greenhouse gas emissions related to close proximity of food production to the city and the prominence of fruit and vegetables.

In terms of environment, the vegan diet was ranked first by the workshop experts. Animal products in big cities are typically from intensive farms, which require high quantities of animal feed and drinking water throughout the life cycle of the animals. Even though animals produce manure that can contribute to soil fertility, intensive animal production is a major source of harmful emissions, as indicated by Gerber *et al.* (2013). Although organic livestock is less harmful to the environment, experts were asked

**Table 2.** Final ranking of the alternatives according to the experts' judgments on sustainability criteria and sub-criteria

Pattern	Environment		Health	Socio-economic aspects		Total
	Carbon footprint	Water footprint		Consumer concerns	Producer concerns	
FLEX	0.03	0.02	0.12	0.03	0.03	0.23
MDP	0.03	0.01	0.24	0.07	0.06	0.42
PESC	0.03	0.04	0.05	0.01	0.00	0.13
VEG	0.09	0.07	0.02	0.02	0.01	0.22
Total	0.19	0.14	0.44	0.12	0.11	1.00
	0.33			0.23		1.00

FLEX, flexitarian; MDP, Mediterranean dietary pattern; PESC, pescatarian; VEG, vegan.  
Source: AHP analysis.

for their judgments based on the actual production systems and technologies used for mass consumption in the city. The pescatarian dietary pattern was ranked second by the environmental experts, who considered two kinds of fish sources. The first refers to wild-caught fish. In this case, although the pescatarian diet has almost no impact on the consumptive use of water, it has a negative impact on carbon footprint because of the emissions from the fishing vessels and the transport to retail outlets. The second source is fish farming, which could also be intensive in freshwater consumption (because of fish feed). However, the experts considered that wild fish is the most consumed in Valencia.

Regarding the health sub-group's judgments, experts considered MDP the most balanced alternative with respect to health recommendations. However, they stressed the similarities between the MDP and both flexitarian and pescatarian diets, which could be considered to some extent modified forms of the MDP. In experts' minds, a balanced vegan diet needs dietary complements to meet the nutritional guidelines. However, the four proposed patterns meet the EAT–Lancet nutritional guidelines and also support the transition toward the environmental thresholds established by Springmann *et al.* (2018). Therefore, the AHP exercise suggests an 'ideal' model that could be obtained as a weighted combination of the four alternatives with the weights shown in Table 2.

The socio-economic sub-group considered culture, affordability and local production as the main decision elements. Their choice was in favor of products that are heavily produced in the surrounding area. Although the region of Valencia produces some fish from the Mediterranean Sea, most of the fish consumed in Valencia comes from the Atlantic Ocean. The cost of breeding some species of fish consumed heavily in Valencia is still high and the pescatarian diet was the least preferred from the producer perspective. Although fish consumption is significant in Valencia, the sub-group admitted that if consumers relied solely on fish protein, there would not be an economic benefit for the household. Furthermore, a pescatarian diet is not fully consistent with the food culture in Valencia, where people habitually combine meat and fish.

## Conclusions

Most Mediterranean regions, including Valencia, are turning away from the traditional Mediterranean consumption pattern. However, experts from institutions that participate in the

Valencia FPC still attach high value to this diet. Accordingly, food-system decision makers and strategic planners should promote this diet. Although there is already a wide body of research enhancing the MDP, in this case, it was chosen from a systematic participatory approach. As previously mentioned, the method used to rank the dietary patterns was supported by existing knowledge, while taking into consideration different interests and dimensions of sustainability.

Experts' judgments were tested regarding three criteria (environmental, health and socio-economic). This participatory approach gives not only a general picture of what specialists think about dietary alternatives but also illustrates a method to support future research in identifying dietary orientations in a certain context. This governance process itself could be considered an improvement in the guidelines of food and sustainability advisory committees or commissions.

This procedure allows compromise alternatives for sustainable diets to be reached, respecting local contexts where culture and socio-economic perspectives must be considered. Of course, a balanced selection of experts supported by complementary information is needed. In any case, the local expert selection is facilitated in governance bodies such as food councils, advisory food committees, etc.

The participatory approach gives strengths to the decision process. The effective use of an MCDM method (i.e., AHP) can provide guidelines for policymakers, particularly regarding the types of diets to be promoted in urban areas to achieve sustainable food consumption habits. Trade-offs are relevant, and the proposed method has the potential of providing a holistic view that integrates conflicting criteria, as by means of the AHP questions the experts are faced with the need of stating the comparative importance of the criteria. The AHP approach can be applied when food policy advisory groups wish to integrate socio-economic consideration in their assessment of sustainable diets.

Although the method can be used to integrate several criteria, the results only express the beliefs of a confined group of experts with respect to a specific geographical context. In addition, the conditions affecting experts' judgments and, consequently, food governance vary from one period to another. Ultimately, future studies should compare the chosen patterns with the current patterns to differentiate between both models, considering an indicator for food strategic planning at the local or national level.

**Supplementary material.** The supplementary material for this article can be found at <https://doi.org/10.1017/S174217051900053X>.

## References

- Aleksandrowicz L, Green R, Joy EJ, Smith P and Haines A (2016) The impacts of dietary change on greenhouse gas emissions, land use, water use, and health: a systematic review. *PLoS ONE* **11**, e0165797.
- Alfares HK and Duffuaa SO (2008) Assigning cardinal weights in multicriteria decision making based on ordinal ranking. *Journal of Multi-Criteria Decision Analysis* **15**, 125–133.
- Belahsen R and Rguibi M (2006) Population health and Mediterranean diet in southern Mediterranean countries. *Public Health Nutrition* **9**, 1130–1135.
- Bizjak M, Peršolja M and Stirn LZ (2016) Expert opinions about the use of comprehensive nutrition protocol in practice for obesity prevention. *Obzornik zdravstvene nege* **50**, 224–231.
- Castañé S and Antón A (2017) Assessment of the nutritional quality and environmental impact of two food diets: a Mediterranean and a vegan diet. *Journal of Cleaner Production* **167**, 929–937.
- Clark M and Tilman D (2017) Comparative analysis of environmental impacts of agricultural production systems, agricultural input efficiency, and food choice. *Environmental Research Letters* **12**, 064016.
- Curtis BM and O’Keefe Jr JH (2002) Understanding the Mediterranean diet: could this be the new ‘gold standard’ for heart disease prevention? *Postgraduate Medicine* **112**, 35–45.
- De Cunto A, Tegoni C, Sonnino R, Michel C and Lajili-Djalāi F (2017) Food in cities: study on innovation for a sustainable and healthy production, delivery, and consumption of food in cities. European Commission. Directorate-General for Research and Innovation. Directorate A - Policy Development and Coordination. Brussels.
- Debru J, Albert S, Bricas N and Conaré D (2017) Urban food policies: Proceedings of the International Meeting on Experience in Africa, Latin America and Asia. 16–18 November, Unesco Chair in WorldFood Systems, Montpellier, France.
- Dernini S and Berry EM (2015) Mediterranean diet: from a healthy diet to a sustainable dietary pattern. *Frontiers in Nutrition* **2**, 15.
- Dernini S, Meybeck A, Burlingame B, Gitz V, Lacirignola C, Debs P, Capone R and El Bilali H (2013) Developing a methodological approach for assessing the sustainability of diets: the Mediterranean diet as a case study. *New Medit* **12**, 28–36.
- Ekmekcioglu C, Wallner P, Kundi M, Weisz U, Haas W and Hutter HP (2018) Red meat, diseases, and healthy alternatives: a critical review. *Critical Reviews in Food Science and Nutrition* **58**, 247–261.
- Generalitat Valenciana (2013) *Encuesta de Nutrición de la Comunidad Valenciana 2010–2011*. Valencia: Conselleria de Sanitat.
- Gerber PJ, Steinfeld H, Henderson B, Mottet A, Opio C, Dijkman J, Falucci A and Tempio G (2013) *Tackling Climate Change Through Livestock: A Global Assessment of Emissions and Mitigation Opportunities*. Rome: Food and Agriculture Organization of the United Nations.
- Goldstein B, Birkved M, Fernández J and Hauschild M (2017) Surveying the environmental footprint of urban food consumption. *Journal of Industrial Ecology* **21**, 151–165.
- Gustafson D, Gutman A, Leet W, Drewnowski A, Fanzo J and Ingram J (2016) Seven food system metrics of sustainable nutrition security. *Sustainability* **8**, 196.
- Guyomard H, Darcy-Vrillon B, Esnouf C, Marin M, Russel M and Guillou M (2012) Eating patterns and food systems: critical knowledge requirements for policy design and implementation. *Agriculture & Food Security* **1**, 13.
- Hoek AC, Pearson D, James SW, Lawrence MA and Friel S (2017) Shrinking the food-print: a qualitative study into consumer perceptions, experiences and attitudes towards healthy and environmentally friendly food behaviours. *Appetite* **108**, 117–131.
- Horgan GW, Perrin A, Whybrow S and Macdiarmid JI (2016) Achieving dietary recommendations and reducing greenhouse gas emissions: modelling diets to minimise the change from current intakes. *International Journal of Behavioral Nutrition and Physical Activity* **13**, 46.
- Lan TS, Lan YH, Chen PC and Lo WC (2017) A study of investigating adolescents’ eating out behavior by using analytic hierarchy process. *Eurasia Journal of Mathematics Science and Technology Education* **13**, 3227–3234.
- Lang T, Barling D and Caraher M (2009) *Food Policy: Integrating Health, Environment and Society*. Oxford: OUP.
- Macdiarmid JI, Kyle J, Horgan GW, Loe J, Fyfe C, Johnstone A and McNeill G (2012) Sustainable diets for the future: can we contribute to reducing greenhouse gas emissions by eating a healthy diet? *The American Journal of Clinical Nutrition* **96**, 632–639.
- Moragues-Faus A (2017) Urban food policy alliances as paths to food sovereignty insights from sustainable food cities in the UK. In Desmarais AA, Claeys P and Trauger A (eds), *Routledge Studies in Food, Society and the Environment*. London and New York: Routledge, pp. 147–163.
- Moragues-Faus A and Morgan K (2015) Reframing the foodscape: the emergent world of urban food policy. *Environment and Planning A: Economy and Space* **47**, 1558–1573.
- Morgan K (2009) Feeding the city: the challenge of urban food planning. *International Planning Studies* **14**, 341–348.
- Niles MT, et al. (2018) Climate change mitigation beyond agriculture: a review of food system opportunities and implications. *Renewable Agriculture and Food Systems* **33**, 297–308.
- Padilla M, Capone R and Palma G (2012) Sustainability of the food chain from field to plate: the case of the Mediterranean diet. In *Sustainable Diets and Biodiversity-Directions, Solutions for Policy, Research and Action*. Rome: FAO, pp. 230–240.
- Patel R (2009) Food sovereignty. *The Journal of Peasant Studies* **36**, 663–706.
- Pradhan P, Reusser DE and Kropp JP (2013) Embodied greenhouse gas emissions in diets. *PLoS ONE* **8**, e62228.
- Prové C, de Krom MP and Dessein J (2019) Politics of scale in urban agriculture governance: a transatlantic comparison of food policy councils. *Journal of Rural Studies* **68**, 171–181.
- Ribal J, Fenollosa ML, García-Segovia P, Clemente G, Escobar N and Sanjuán N (2016) Designing healthy, climate friendly and affordable school lunches. *The International Journal of Life Cycle Assessment* **21**, 631–645.
- Röös E, Carlsson G, Ferawati F, Hefni M, Stephan A, Tidåker P and Withöft C (2018) Less meat, more legumes: prospects and challenges in the transition toward sustainable diets in Sweden. *Renewable Agriculture and Food Systems*, 1–14.
- Saaty TL (2005) *Theory and Applications of the Analytic Network Process: Decision Making with Benefits, Opportunities, Costs, and Risks*. Pittsburgh, PA: RWS publications.
- Saaty TL (2013) Analytic hierarchy process. In Gass SI and Harris CM (eds.). *Encyclopaedia of Operations Research and Management Science*. Boston, MA: Springer, pp. 52–64.
- Sáez-Almendros S, Obrador B, Bach-Faig A and Serra-Majem L (2013) Environmental footprints of Mediterranean versus Western dietary patterns: beyond the health benefits of the Mediterranean diet. *Environmental Health* **12**, 118.
- Scholl A, Manthey L, Helm R and Steiner M (2005) Solving multiattribute design problems with analytic hierarchy process and conjoint analysis: an empirical comparison. *European Journal of Operational Research* **164**, 760–777.
- Seto KC and Ramankutty N (2016) Hidden linkages between urbanization and food systems. *Science* **352**, 943–945.
- Sofi F, Abbate R, Gensini GF and Casini A (2010) Accruing evidence on benefits of adherence to the Mediterranean diet on health: an updated systematic review and meta-analysis. *The American Journal of Clinical Nutrition* **92**, 1189–1196.
- Springmann M, Clark M, Mason-D’Croz D, Wiebe K, Bodirsky BL, Lassaletta L and Jonell M (2018) Options for keeping the food system within environmental limits. *Nature* **562**, 519.
- Sylvie AK, Jiang Q and Cohen N (2013) Identification of environmental supports for healthy eating in older adults. *Journal of Nutrition in Gerontology and Geriatrics* **32**, 161–174.
- Tarne P, Lehmann A and Finkbeiner M (2019) Introducing weights to life cycle sustainability assessment—how do decision-makers weight sustainability dimensions? *The International Journal of Life Cycle Assessment* **24**, 530–542.
- Triantaphyllou E (2013) *Multi-Criteria Decision Making Methods: A Comparative Study*, vol. 44. Boston, MA: Springer Science & Business Media.
- Van Dooren C, Tyszle M, Kramer G and Aiking H (2015) Combining low price, low climate impact and high nutritional value in one shopping basket through diet optimization by linear programming. *Sustainability* **7**, 12837–12855.

- Vanham D, Del Pozo S, Pekcan AG, Keinan-Boker L, Trichopoulou A and Gawlik BM** (2016) Water consumption related to different diets in Mediterranean cities. *Science of the Total Environment* **573**, 96–105.
- Vareiro D, Bach-Faig A, Quintana BR, Bertomeu I, Buckland G, de Almeida MDV and Serra-Majem L** (2009) Availability of Mediterranean and non-Mediterranean foods during the last four decades: comparison of several geographical areas. *Public Health Nutrition* **12**, 1667–1675.
- Veeramani A, Dias GM and Kirkpatrick SI** (2017) Carbon footprint of dietary patterns in Ontario, Canada: a case study based on actual food consumption. *Journal of Cleaner Production* **162**, 1398–1406.
- Velasquez M and Hester P** (2013) An analysis of multi-criteria decision making methods. *International Journal of Operations Research* **10**, 56–66.
- WHO** (2015) *Q&A on the Carcinogenicity of the Consumption of Red Meat and Processed Meat*. Geneva: World Health Organization. Available at <http://www.who.int/features/qa/cancer-red-meat/en/> (Accessed 4 April 2017).
- Willett W, Rockström J, Loken B, Springmann M, Lang T, Vermeulen S and Jonell M** (2019) Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. *The Lancet* **393**, 447–492.