

The future of the Mediterranean agri-food systems: Trends and perspectives from a Delphi survey

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ABSTRACT

The Mediterranean region is widely acknowledged as one of the most exposed in the world to the effects of climate change, water scarcity, biodiversity loss and land degradation, coupled with a nutrition transition of its populations. In such a context, to explore the evolution of the region is of both political and theoretical interest. This study presents the result of a scenario-building exercise, based on a Delphi method – an interactive forecasting technique – relying upon about 60 practitioners, experts and academics representing 19 Mediterranean countries and a wide range of disciplines and expertise. The present article has three main purposes. First, to identify the main challenges, trends and driving forces that influence the agri-food systems in the Mediterranean over a short (2020) and medium (2030) term. Second, to discuss the alternative policy responses to the challenges that the region will face in terms of water resource management, farming systems and agri-food value chains in terms of desirability and feasibility. Thirdly, to provide informed, evidence-based recommendations that might help different stakeholders to take action in the region's agri-food sector. Based on this Delphi's results, the study suggests that the gap between the countries in the South and the North of the Mediterranean in terms of challenges posed in water management, farming systems and the agri-food value chain is expected to grow. Experts agree that climate change is going to play a key role in the future of both sides of the Mediterranean, but with a differential impact in the sub-two regions. Nutrition-related challenges will exert a growing pressure especially in the Southern Mediterranean countries. A set of desirable and feasible policy option for addressing the Mediterranean food-related challenges are discussed.

1. Introduction

Global agri-food systems face the challenge of nourishing a growing and increasingly urbanised population, while preserving the Earth's ecosystems and natural resources. The distortions of current food systems span from hunger to overweight and obesity and, through climate change and natural resources impairment, food loss and waste. The Mediterranean countries are not immune from these challenges. The region features a variety of ecosystems and species, as well as significant differences in the socio-economic development in the Southern, Eastern and Northern areas (FAO and Plan Bleu, 2018), which make the area vulnerable to endogenous and exogenous threats. For instance, the Mediterranean region is a climate change hotspot, with substantial impacts on vegetation and hydrologic cycle (Giorgi, 2006; Lindner et al., 2010). The Mediterranean is also one of the more water-scarce regions in

the world (Mekonnen and Hoekstra, 2016). A decrease in mean precipitations and groundwater availability, as well as an increase in frequency and duration of drought, is expected due to climatic drivers (Cisneros J. et al., 2014), exacerbating water scarcity (Schewe et al., 2014). Urbanisation, demographic and socio-economic trends, as well as the need to meet food requirements, are expected to worsen water scarcity (Malek and Verburg, 2017; Fader et al., 2016) and call for effective response measures to manage sustainably land and water in the region (Harmanny and Malek, 2019). Other challenges include the sustainability of the Mediterranean diet as a mainly plant-based dietary pattern to reduce greenhouse gas emissions and water footprints (Derini et al., 2017; Barilla Foundation and Research Unit on Nutrition, Diabetes and Metabolism, University of Naples Federico II, 2021; Tilman and Clark, 2014). At the same time, however, deviations from the Mediterranean dietary pattern, arise issues concerning overweight,

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obesity, and food-related chronic diseases (Belahsen, 2014; Dernini and Berry, 2015; Naja et al., 2021). Food consumption patterns have been shown to act as important drivers of environmental pressures in the region (Lacirignola et al., 2014a), due to both population trends and consumption patterns towards higher intakes of energy-dense food (Naja et al., 2021).

As the above examples show, agri-food system challenges are complex, far-reaching and closely interconnected. Nonetheless, current research typically addresses each of them in isolation. As Capone et al. (2021) notes, whilst there is an increasing number of studies on climate change, land use, water-related challenges (Tuel and Eltahir, 2020; Cramer et al., 2018), or on the Mediterranean diet (Barros and Delgado, 2022; Martínez-González et al., 2015; Willett, 2006), comprehensive studies on the region's food systems are still very limited.

The present work aims to contribute to overcome some of these limitations, by looking comprehensively at some of the most pressing food-related social, economic, and environmental challenges in the Mediterranean area – i.e., from farm to fork, from the impacts of agriculture on natural resources, to nutritional challenges and household food waste. The empirical findings presented in the article are based on the results of a Delphi survey, which is an iterative social science technique for gathering opinions, conducted between 2017 and 2018 drawing upon the expertise of about 60 practitioners, experts, and academics, from 19 Mediterranean countries. The study focuses on two areas in the region: the Northern area which include France, Greece, Italy, Portugal, Spain, and the Southern area, comprising Algeria, Egypt, Israel, Jordan, Lebanon, Morocco, Tunisia, Turkey.

Addressing the multifaceted dimensions of food systems in such a heterogeneous area – from an economic, industrial and social point of view – is also a unique opportunity to accelerate the transition towards sustainable development, as the economic, environmental and social challenges the region is facing affect and are affected by food systems (Capone et al., 2021).

By adopting such an integrated, comprehensive purview of the agri-food system, the study has a twofold objective. First, to identify the main challenges, trends and driving forces of agri-food systems in the Mediterranean over the short (2020) and medium (2030) term. Second, to assess the desirability and feasibility of alternative policy responses to the challenges the region has to face in terms of water resource management, farming systems and the agri-food value chains.

The main implication of this study is to provide informed, evidence-based recommendations that might help different stakeholders to take action in the region's agri-food sector.

2. Method

2.1. The Delphi method

Delphi is a technique based on group communication to examine, discuss, and build informed knowledge on specific domains, by eliciting, refining, and analysing the collective opinion of selected experts in an anonymous way (Turoff and Linstone, 1975; Gupta and Clarke, 1996). The technique, initially developed at RAND corporation in the 1950s to gather experts' estimates on military and security issues (Dalkey and Helmer, 1963), has gained relevance over time, and it has been applied to a wide range of research domains, such as health care, education, and business (Gupta and Clarke, 1996; Flostrand et al., 2020). Recently, the method's potentiality has been increasingly explored also in the agri-food system domain (Frewer et al., 2011). Previous food-related studies conducted with the Delphi technique include topics such as food system metrics (Allen et al., 2019), food policy (Frewer et al., 2011), food security (Wolfe and Frongillo, 2001), food risk and food safety systems (Wentholt et al., 2009), food governance (Moragues-Faus et al., 2017), diet-related issues (Vinnari and Tapio, 2009), infectious animal diseases (Wentholt et al., 2012), at European, international (Frewer et al., 2011), or national level (Huan-Niemi et al., 2017;

Makkonen et al., 2016). Recently, a Delphi methodology has been applied to the Mediterranean region to develop a multidimensional framework to evaluate sustainability in the agri-food system (Prosperi et al., 2013).

The increased use has led also to adaptations and modifications in the approach, concerning both the goals and the concrete applications of the method. First, there is not a single purpose for the use of the Delphi; indeed, although it has been mainly employed as a forecasting technique, with experts asked to express their informed opinion or estimates (Turoff and Linstone, 1975) relating to future events and trends, the Delphi has also been applied to support decision making (Hasson et al., 2000) and to develop scenarios (Melander et al., 2019; von der Gracht, 2012). More important, the goal of the Delphi is not necessarily about achieving consensus among experts but also to gain informed knowledge (Gupta and Clarke, 1996) or controversial views, as in the Policy Delphi (Turoff, 2002). Second, the method has shown flexibility in its evolution, being able to adapt itself to technological developments, and especially the use of web-based platforms (von der Gracht, 2012). Irrespective of this variety of applications, some core elements of a Delphi remain unaltered (Turoff and Linstone, 1975; von der Gracht, 2012). In particular, the Delphi follows an *iterative approach*, in which experts are asked to respond to *at least* two waves of questionnaires, called “rounds”. In the second and later rounds, respondents are *fed back with the summary results* of the group's answers, and they are then invited to revise or to confirm their previous estimates, in light of the overall group's evaluation. In this way, experts have an opportunity to share their views and change or revise their estimate in a moderated way. Another key feature is that participants' *anonymity* is preserved, to make sure the exchange of opinions takes place without any undue influence from prevailing or charismatic personalities as well as to minimise group dynamics and social desirability issues.

2.2. The Delphi analysis

The Delphi analysis, building upon the core elements of the method, invited a group of experts, practitioners, and policymakers in the agri-food system to take part in a three rounds exercise, that lasted over eight months (from September 2017 to October 2018), using an Internet-based approach.¹ As Cole et al. (2013) argue, Internet-based Delphi overcomes geographical barriers, especially when the community of experts is large and geographically dispersed (Frewer et al., 2011). Moreover, internet is a cost and time saving alternative to traditional paper-based Delphi surveys. Questionnaires were all sent in English, in line with previous studies confirming its acceptability as lingua franca (Cole et al., 2013).

Experts were selected from a list of potential candidates, drawn from personal contacts and publicly available lists (Frewer et al., 2011) in academic institutions, think tanks, policy making, and business contexts. From this broader group, the final list of experts was based on several criteria: scope of expertise (national/comparative or focus on the Mediterranean area/single country), with preference given to experts covering broader issue area; seniority, with preference given to senior experts, where ‘senior’ was defined as professional experience exceeding 10 years and beginning with their first postgraduate or post-doctoral job; qualitative assessment of the expert's publication record and the institution of affiliation. Out of the 130 shortlisted experts invited to join the present exercise, 79 agreed to answer the questionnaire (response rate: 61 %), with 63 experts who eventually filled the first round. The

¹ Questionnaires were administered in Computer Assisted Web Interview (CAWI) mode, centrally managed by the [anonymize for review process], hosted at the university of [anonymized for review process]. Each expert received a unique, personal link to the survey, and, for each round, experts could answer, interrupt and re-open the survey at any time, within the allotted time frame.

final panel was mainly composed by academics (65 %). Although an effort was made to recruit experts from all countries involved, the final composition sees a prevalence of experts from North Mediterranean countries (76 %). However, regardless of their nationality, recruited experts have an expertise on both geographical areas, with 51 % reporting knowledge on South Mediterranean and 71 % on the North Mediterranean. Finally, in terms of socio-demographic characteristics, the panel featured a higher presence of men (71 %), with an average age of 51 years old, ranging from 28 to 77 years old. This latter feature reflects the overall high seniority of expertise of the selected participants, with an average of 14 years of experience, ranging from 3 to 42 years. A detailed description of experts' characteristics is reported in [Appendix A](#).

The response rate for this Delphi study was 80 % in Round 1 and above 90 % in the other two rounds, which is well beyond the 70 % threshold response rate recommended to ensure the rigour of the study ([Sumsion, 1998](#)) ([Table 1](#)).

The questionnaires for the three rounds of the Delphi study were designed by the research team at the University of [anonymized for review process], with the support of a board of advisors, which was also consulted in-between each round to discuss the results, as recommended in [Frewer et al. \(2011\)](#).

The Delphi study was organised in three thematic areas: Water Management, Farming System, and Agri-food Value Chain, based on the priority areas of the [anonymized for review process] initiative. Throughout the three rounds, the questionnaires focused on the trends and policy interventions in the agri-food system.²

In the first round, for each thematic area, experts were first asked to assess the intensity and direction of change of a set of trends³ affecting the South and North Mediterranean, both in the near (2020) and long-term (2030) future, on a scale from - 2 (decrease) to + 2 (increase), through 0 (no change). For each indicator, experts were provided with tables showing current values of indicators in each country, which they could use for reference⁴ Respondents were also given the opportunity to offer reasons and arguments supporting their answers in open-ended questions.

Moreover, they were invited to evaluate the adequateness of the proposed measures; respectively, 59 % (on Water Management), 63 % (on Farming System) and 70 % (on Agri-food Value Chain) of respondents considered the proposed indicators as well capturing the main trends related to the three areas. They could also suggest further indicators in open-ended questions. However, since there was no significant convergence among respondents on any of the newly added indicators, no new indicator was included in the following round.

Then, experts were asked to rate, on a 1 (low) to 10 (high) scale, the

desirability and feasibility of some policy solutions to address the main challenges in each of the three thematic areas.⁵ The list of policy solutions was initially developed by the research team based on relevant literature, and then further refined and validated by the project's scientific board of advisors. Finally, at the end of Round 1, respondents were invited to provide feedback and suggestions to improve the following rounds.

In the second round, the questionnaire reiterated the questions on trends⁶ and feasibility⁷ of policy solutions only for those items where consensus had not been reached in the first round.⁸ The threshold of consensus for trends' policy actions' estimates was set looking at the Coefficient of Variation (CV); convergency is reached for values lower than 190 in trends, and lower than 28 for policy actions.⁹

For such iterated questions, experts were presented with the group's averages and standard deviations from the first round and given the opportunity to revise or confirm their views, in light of the answers provided by their colleagues. Furthermore, they were asked to explain the rationale of their answers in open-ended questions. A few, novel policy solutions were nonetheless added to the list of policy initiatives, based on respondents' suggestions and insights emerged from the analyses of the previous round.

The third round focused on those trends and solutions where disagreement persisted after two rounds; however, this last questionnaire mainly aimed at exploring to the reasons and arguments that are likely to explain the changes in trends and the feasibility of the policy solutions. Accordingly, experts were first asked to select the most convincing arguments, from a list of options drawn on the comments provided by the panellists themselves in the previous rounds; then, they were asked to either confirm or revise their estimates and evaluations, as in the previous round.

3. Findings and discussion

The study focused experts' attention on two main areas: the expected trends concerning water management, farming systems and agri-food value chains that constitute challenges to the Northern and Southern Mediterranean countries, and the main policy answers to address these challenges. We discuss them in turn.

3.1. Expected trends in water management, farming systems and agri-food value chains

The first part of the analysis aims at examining what trends will shape the future of the Mediterranean agri-food systems in the short (2020) and medium (2030) term in water management, farming systems

Table 1
Response rate.

Round	No. of respondents who completed the survey	No. of experts who received the survey link	Response rate (%)
1	63	79	80
2	57	63	90
3	56	57	98

² The questionnaires also included questions about respondents' background, and general opinions on the agri-food systems. The codebook of the three rounds of the Delphi is available as [Supplementary material](#).

³ The list of trends was drawn on the indicators chosen by the [anonymized for review process] initiative to monitor the impact of the anonymized for review process] research and innovation projects in the Mediterranean countries, as described in [Saladini et al. \(2018\)](#).

⁴ All values of indicators shown to experts come from official sources, such as, mainly, FAO, AQUASTAT, World Bank, WHO, Unicef.

⁵ Unlike trends, the evaluations on policy solutions were not assessed on different time periods, since the main interest of this section is to identify a ranking of necessary policy actions, regardless of the time required for their implementation.

⁶ As flagged by some comments from the first round, disagreements on trends could be explained by the differences among countries within each of the two geographical areas (North and South Mediterranean). Accordingly, in the second round, for each trend, respondents were also asked whether they expected a pattern of homogeneity or heterogeneity in trends among these countries.

⁷ Since there was large convergence on answers concerning the desirability of policy solutions, the second round reiterated only questions about their feasibility.

⁸ To reduce complexity and the likelihood of misunderstandings in questionnaires, items on trends were not reiterated in the following round when convergence was achieved on at least one area (North or South) and/or one time period (2020 or 2030).

⁹ All thresholds are shown in the bottom of all tables. These thresholds are set looking at the distribution of all CVs, in particular considering their median value. Values close to the median are considered doubtful in term of convergency, below it convergent and above divergent.

and agri-food value chains. Tables 3.1–3.3 report the results by showing in which round convergence was reached, if at all, with emoticons visually representing the CV level finally achieved on each item. Tables report the frequency distribution for each item (in percentage). The results presented here outline a Mediterranean region that is marked by high heterogeneity between Northern and Southern countries, and with a gap that is expected to increase towards the year 2030 in a business-as-usual scenario.

Overall, results for water management show (Table 3.1) that convergence on estimates was easier to reach for trends over the medium (2030) than the short-term (2020). This is interesting as it unveils margins of unpredictability of current, ongoing dynamics. In the attempt to summarise what is an inevitably complex and sometime confused picture emerging from several trends, three main results stand out across the three areas. First, the gap between the Northern and Southern aisle of the Mediterranean is expected to grow in several sectors, with differential trends magnifying these differences. Pressures on water resources, vulnerability to climate change and nutritional challenges are expected to increase among the Southern Mediterranean countries, while Northern Mediterranean countries are expected to contrast and, sometime to stymie, these challenges. What is interesting, but somehow to be expected, is that some of these gaps will be increased because of the improvements in economic and technological conditions in the South. One example is the expected increase in production due to larger use of fertilisers that will stress even more the quality of environment in the South. A second result emerging from these estimates is that while not much was expected to change between the time of the study and 2020, things are expected to change more over a longer-term perspective. As an example, the agriculture value added in the South is expected to improve over the short term but then to decline over the 2030-time horizon. This is of course a possible consequence of path dependency, that emphasises the constraint operating over the short term while expecting a much larger room for changes – mostly negative – over the longer term. Last, our results show several areas on which experts do not agree, although no clear pattern can be detected on why some areas show greater consensus than others.

Coming to a more detailed reconstruction of trends and challenges, experts mostly agree on the increase, in the mid-term, of crop water productivity, at least in the North, as well as of the use of improved drinking water sources by the rural population across the entire Mediterranean region. Moreover, while in the northern Mediterranean countries the share of rural population using improved sanitation facilities should remain stable, this proportion is expected to increase in southern countries in the next future. Convergence was also achieved on predicting an increase in the annual freshwater withdrawal for agriculture, as well as in the pressure of annual freshwater use in agriculture on total renewable water resources in the South Mediterranean area, both in 2020 and 2030. Meeting water and food challenges is arguably one of the most pressing issues in the Mediterranean, as many of the most vulnerable countries in the world are found in this region, especially the South (see among others, Mekonnen and Hoekstra, 2016). Our results are also consistent with other studies estimating that, in southern and eastern Mediterranean countries, agricultural land management is likely to intensify and to drive an increase in water resource use to enhance irrigation systems and stabilise food production (Cramer et al., 2018). The increase in irrigation requirements is projected to reach up to 74% by the end of the century due to the combination of climate change, population growth, without improvements in irrigation systems and conveyance (Fader et al., 2016).

As regards the Farming Systems trends, large consensus was achieved about the prediction of greater vulnerability to climate change across the whole Mediterranean region, although more intense in the South, with such a trend already emerging in the short-term and lasting in 2030. This is in line with other studies (MedECC, 2020; Cisneros J. et al., 2014), which also expect to reduce yields for both winter and spring crops, and increase crop diseases (Deryng et al., 2016;

Giannakopoulos et al., 2009). Experts mostly agree also on the expected larger consumption of fertilisers and use of energy in agriculture in southern countries, and especially in the medium-term. On the other hand, the access to electricity in rural south is expected to improve, at least in the medium-term, while it should remain stable in northern countries. Furthermore, majorities among panellists (52 %) foresee some, although slight, increase in the agriculture value added in the South in the short-term, but the trend would be likely to be reversed heading to 2030. The other indicators (cereal yield, agricultural land, GHG emissions), did not achieved sufficient consensus.

Estimates on trends in the Agri-food Value Chains revealed that nutritional challenges are expected to intensify overall, with an increase in child and adolescent overweight in the year 2020 in both the North and South Mediterranean. Experts agree that this trend will continue unabated through the 2030s in the South, while it will come to a standstill in the North. Encouraging, positive trends, on the other hand, seem to emerge about the healthy life expectancy in the South, which are expected become higher in the short (predicted by 60 % of experts) and in the medium (predicted by 90 % of experts) term. Indicators on the prevalence of wasting did not achieve a significant consensus among panellists.

Finally, the ecological footprint of food consumption in the south is expected to increase in 2020 and 2030, while no clear pattern emerges in the North, especially in the medium-term, with panellists evenly divided between those predicting a slight increase (33 %) or decrease (33 %), or no change at all (29 %).

Besides the estimates, the study offered relevant insights concerning the main drivers of the trends under scrutiny, which can here be only briefly summarised, stressing some of the more interesting and less consensual drivers discussed by experts.

- The indicator on **crop water productivity in the South (2020 and 2030)** revealed that, despite the lack of consensus among experts about the expected trends, as earlier argued, there is agreement on the likely causes of its decrease. In particular, climate change is more often mentioned by experts both with reference to the short (indicated 52 % of times) and medium-term (64 % of mentions). This is followed by conflicts and political crisis and poor institutional capacity, which are mentioned in nearly one-third of cases. On the other hand, technological development and innovation is considered as the main potential source of the increase in crop water productivity.
- The decrease in **cereal yield in the North (2020) and South (2020 and 2030)**, is expected to be mainly a consequence of climate change in the North by 2020 (mentioned by 55 % of cases), as well as in the South, both in the short (64 % of mentions) and medium-term (73 % of mentions). As secondary causes, experts considered land degradation and water scarcity, with the latter being relevant specially to explain decrease in the South. Likely drivers of increase, on the other hand, include new technology and innovation and integrated land and water management, although its impact in Southern countries would be more relevant only in the medium-term.
- Decrease in **agricultural land use**, according to the experts, would be mainly an effect of urbanisation, climate change and soil fertility degradation both in the southern and the northern countries, with urbanisation being more relevant in the short than the medium term. In southern countries, rural migration is also believed to have an impact on decreasing patterns. Increase in agriculture land use, on the contrary, is expected consequently mainly of increasing food demands in the entire Mediterranean region, both in 2020 and 2030.
- A decrease in **GHG emissions in agriculture in northern countries**, according to experts, could mainly occur as a consequence of technology and innovation and stringent policy measures, both in the short and medium term. Likewise, the lack of stringent policy measures, followed by the lack of incentives and of technological

Table 3.1
Expected trends: water management.

	Round of convergence	2020					Round of convergence	2030				
		Strong decrease	Slight decrease	No change	Slight Increase	Strong Increase		Strong decrease	Slight decrease	No change	Slight Increase	Strong Increase
Crop water productivity North	2 ☹️		7.4	55.6	37.0		2 ☺️	5.6	5.6	20.4	64.8	3.7
Crop water productivity South	3 ☹️	1.8	20.0	50.9	27.3		3 ☹️	10.9	14.6	14.6	47.3	12.7
Rural population using improved drinking water sources North	3 ☹️		5.5	63.6	30.9		2 ☺️	3.7	1.9	48.2	44.4	1.9
Rural population using improved drinking water sources South	3 ☹️	5.5	12.7	30.9	49.1	1.8	2 ☺️	7.4	9.3	11.1	48.2	24.1
Population using improved sanitation facilities (rural) North	1 ☹️	0.0	6.7	58.3	31.7	3.3	1 ☹️	3.3	10.0	45.0	26.7	15.0
Population using improved sanitation facilities (rural) South	1 ☹️	4.8	9.7	33.9	51.6	0.0	1 ☺️	10.0	5.0	6.7	45.0	33.3
Annual freshwater withdrawal for agriculture North	2 ☹️		7.4	59.3	31.5	1.9	3 ☹️	1.8	18.2	40.0	38.2	1.8
Annual freshwater withdrawal for agriculture South	2 ☺️	1.9	11.1	29.6	55.6	1.9	2 ☺️	5.6	14.8	16.7	38.9	24.1
Freshwater withdrawal as % of total renewable water resources North	1 ☹️	0.0	18.3	25.0	50.0	6.7	1 ☹️	10.0	11.7	13.3	40.0	25.0
Freshwater withdrawal as % of total renewable water resources South	1 ☺️	6.6	8.2	21.3	52.5	11.5	1 ☺️	13.1	4.9	6.6	32.8	42.6

Legend: ☺️ CV<190 convergence; ☹️ 190<CV<250 doubt convergence; ☹️ CV>250 not convergence.

strong decrease = -2; slight decrease = -1; no change = 0; slight increase +1; strong increase = +2

Table 3.2
Expected trends: farming systems.

	Round of convergencies	2020					Round of convergencies	2030				
		Strong decrease	Slight decrease	No change	Slight Increase1	Strong Increase		Strong decrease	Slight decrease	No change	Slight Increase1	Strong Increase
Fertilizer consumption North	1 ☹️	0.0	19.0	62.1	19.0	0.0	1 ☹️	3.6	41.1	16.1	33.9	5.4
Fertilizer consumption South	1 ☺️	0.0	6.9	36.2	48.3	8.6	1 ☺️	5.3	8.8	8.8	47.4	29.8
Cereal yield North	3 ☹️		11.1	59.3	29.6		2 ☹️		13.0	29.6	55.6	1.9
Cereal yield South	3 ☹️	1.8	18.2	65.5	14.6		3 ☹️	5.5	18.2	29.1	41.8	5.5
Agriculture value added North	3 ☹️		11.3	49.1	39.6		2 ☺️	5.6	25.9	22.2	40.7	5.6
Agriculture value added South	3 ☺️	3.7	3.7	40.7	51.9		2 ☺️	14.8	51.9	9.3	24.1	
Energy in agriculture North	1 ☹️	1.7	15.5	41.4	37.9	3.5	1 ☹️	6.9	27.6	10.3	43.1	12.1
Energy in agriculture South	1 ☺️	0.0	3.4	33.9	55.9	6.8	1 ☺️	0.0	6.9	10.3	44.8	37.9
Climate change vulnerability index North	1 ☺️	0.0	8.5	25.4	61.0	5.1	1 ☺️	3.5	6.9	5.2	41.4	43.1
Climate change vulnerability index South	1 ☺️	0.0	6.8	15.3	52.5	25.4	1 ☺️	0.0	7.0	1.8	28.1	63.2
Agricultural land use North	3 ☹️		36.4	56.4	7.3		3 ☹️	5.5	40.0	38.2	14.6	1.8
Agricultural land use South	3 ☹️	3.6	25.5	52.7	18.2		3 ☹️	12.7	18.2	32.7	32.7	3.6
GhG emissions in agriculture North	3 ☹️		29.6	53.7	14.8	1.9	3 ☹️	3.6	52.7	27.3	10.9	5.5
GhG emissions in agriculture South	2 ☹️		7.4	37.0	53.7	1.9	2 ☹️		13.0	14.8	55.6	16.7
Access to electricity, rural North	1 ☺️	0.0	0.0	80.0	18.3	1.7	1 ☺️	0.0	1.7	63.3	25.0	10.0
Access to electricity, rural South	1 ☹️	1.7	5.0	41.7	48.3	3.3	1 ☺️	1.7	1.7	38.3	30.0	28.3

Legend: ☺️ CV<190 convergence; ☹️ 190<CV<250 doubt convergence; ☹️ CV>250 not convergence.

strong decrease = -2; slight decrease = -1; no change = 0; slight increase +1; strong increase = +2

Table 3.3
Expected trends: agri-food value chains.

	Round of convergencies	2020					Round of convergencies	2030				
		Strong decrease	Slight decrease	No chang e	Slight Increase	Strong Increase		Strong decrease	Slight decrease	No chang e	Slight Increase	Strong Increase
Prevalence of overweight among male children and adolescents North	2 ☺	3.7	3.7	40.7	50.0	1.9	2 ☺	1.9	14.8	24.1	53.7	5.6
Prevalence of overweight among male children and adolescents South	2 ☹	1.9	3.7	22.2	68.5	3.7	2 ☹	5.6	3.7	5.6	59.3	25.9
Prevalence of overweight among female children and adolescents North	2 ☺	1.9	11.1	50.0	35.2	1.9	2 ☺	1.9	20.4	31.5	44.4	1.9
Prevalence of overweight among female children and adolescents South	2 ☺	1.9	3.7	33.3	53.7	7.4	2 ☺	5.6	5.6	5.6	68.5	14.8
Ecological footprint of food consumption North	3 ☹		11.1	57.4	29.6	1.9	3 ☹		32.7	29.1	32.7	5.5
Ecological footprint of food consumption South	2 ☺	1.9	3.7	29.6	55.6	9.3	2 ☺	3.7	5.6	7.4	50.0	33.3
Prevalence of wasting, under -5s North	3 ☹	5.6	22.2	59.3	13.0		2 ☺	1.9	31.5	53.7	11.1	1.9
Prevalence of wasting, under -5s South	3 ☹	5.5	21.8	50.9	20.0	1.8	2 ☹	1.9	27.8	42.6	24.1	3.7
Healthy life expectancy at birth North	1 ☺	0.0	1.7	69.5	25.4	3.4	1 ☺	0.0	6.8	45.8	33.9	13.6
Healthy life expectancy at birth South	1 ☺	1.7	5.0	33.3	60.0	0.0	1 ☺	3.4	5.1	1.7	69.5	20.3

Legend: ☺ CV<190 convergence; ☹ 190<CV<250 doubt convergence; ☹ CV>250 not convergence.

strong decrease = -2; slight decrease = -1; no change = 0; slight increase +1; strong increase = +2

convergence within and between countries would likely lead to an increase in such emissions.

3.2. Policy interventions

The second part of the study aims at unveiling what policies and initiatives are considered as desirable and feasible to address the challenges related to water management, farming systems and agri-food value chains in the Mediterranean region. Average and median values, and the rounds when the convergence was achieved for both the desirability and the feasibility of policy interventions are reported in [Appendix](#). Additional results can be found in the Report of the project.¹⁰

To better organise and to interpret data, we use the Boston Consulting Group (BCG) Matrix, also known as the Growth Share Matrix ([Madsen, 2017](#)). This is a bidimensional graph, in which we combine two dimensions relevant for policy assessment – feasibility and desirability – organised on two axes. Feasibility is set on the horizontal axis and desirability on the vertical axis. Average mean value of desirability and feasibility for each policy intervention are report on the graph. Each axis is then dichotomised, namely divided in two parts, based on the overall average mean value of respectively, feasibility and desirability. In this manner four quadrants are formed (see [Fig. 1](#)): (i) a bottom left corner quadrant, where the value of each policy is below average on both the feasibility and desirability dimension; (ii) a bottom right corner quadrant, where the value of the policy is below the average along the desirability (vertical) axis and above the average along the feasibility (horizontal) axis; (iii) a top left corner quadrant, where the value of the observation is above the average along the desirability (vertical) axis and below the average along the feasibility (horizontal) axis; (iv) the top right corner quadrant, where the value of the observation is above average both in the horizontal axis and in the vertical axis. Policy areas were thus coded into a four-fold typology:

a) *Should do policies* (top left quadrant): this set includes policies that are deemed highly desirable by experts but that also are afflicted by

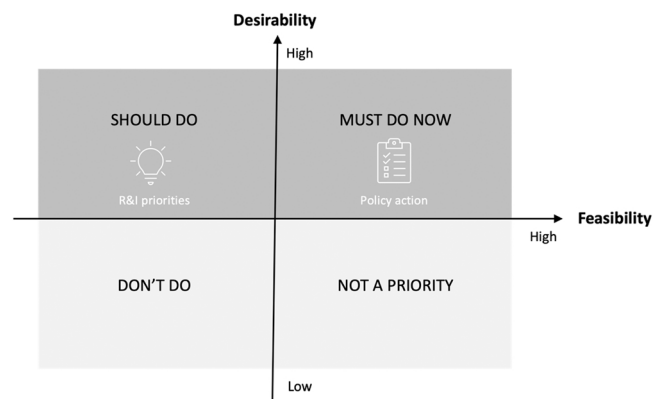


Fig. 1. Policy interventions: desirability and feasibility.

constraints in their actual feasibility. These should be considered as the priority areas of intervention.

- Must do now policies* (top right quadrant): these are policies that are both highly desirable and feasible. They are the areas that could be considered as a priority for policy makers.
- Don't do policies* (bottom left quadrant): policies in this set are the ones to be avoided, since they are considered both not desirable and highly unfeasible.
- Not a priority policy* (bottom right quadrant): These policies although highly feasible, are deemed by experts as low in desirability. making them not a high priority for policy making.

The level of desirability of policy actions has been asked only in the first round of the Delphi, since there was large convergence among experts across all items. A few new policy actions were added in the second round, and the level of desirability for those is not available. Accordingly, for the sake of analysis, a medium high level of desirability was assumed for these items.

[Tables 3.4–3.6](#) report the results of this type of analysis on the assessment of experts for each of the policy interventions both in terms of feasibility and desirability. Clearly, policies have different importance

¹⁰ <http://www.primaitaly.it/wp-content/uploads/2019/06/AGRIFOODMED-Delphi-Final-Report.pdf>.

Table 3.4

Water management: feasible and desirable policy options.

SHOULD DO	MUST DO NOW
Manage water resources in Mediterranean countries in an integrated way, that is going beyond the sectorial approach, in recognition of the water-food-energy nexus	Involve farmers in the use of new technology, e.g. for soil moisture monitoring in Mediterranean countries
Develop binding policies such as the EU Water Framework Directive, at the Mediterranean level	Pursue water use efficiency through improvements in distribution networks at the local level
Considering the evaluation of virtual water trade as a tool for water policy making	Implement adaptive water management against climate change through effective measures and economic means in National planning in Mediterranean countries
	Create integrated water resources and demand management a priority in all Mediterranean countries
	Adopt common criteria for the assessment of water resources at the Mediterranean level
	Use non-conventional water supplies to meet agricultural water demands
NOT TO DO	NOT A PRIORITY
Use Public-private partnerships (PPPs) as a tool to manage water resources and finance services in an effective, sustainable and affordable manner in Mediterranean countries	
Use irrigation water charging in Mediterranean countries as a tool for demand management	
Use irrigation water charging in Mediterranean countries as a tool for cost recovery	

and relevance for each of the three areas, being some policies of a narrower scope than others and not always equally effective in addressing the challenges discussed in the previous section. As to Water Management policies (Table 3.4) experts agree on the desirability of promoting integrated water management with a water-food-nexus approach; employing virtual water trade as a concept to inform policy making; and the implementation of binding policies at the regional level, such as the EU Water Framework Directive (considered as feasible however by only by 38 % of respondents). The desirable and feasible policy interventions include: increasing efficiency in water use through better access to technology (e.g. for monitoring soil moisture), a feasible measure according to over 81 % of experts; improving distribution networks at the local level (89 %); prioritising adaptive water management for climate mitigation in national planning (74 %); converging on common criteria to assess and monitor the status of water resources in the region (70 %); complement with non-conventional water supplies the agricultural demand for irrigation (61 %). The establishment of irrigation water charging considered feasible by 24 % and 44 % of experts, respectively. This is interesting as irrigation water demand has been considered to be quite inelastic, and therefore less effective than other measures e.g., electricity connection fees, finance models (Uhlenbrook et al., 2022).

As to farming, Table 3.5 reports among the policy interventions deemed desirable but not currently feasible related to farming systems, we find the elaboration of dual-purpose crops for achieving high yields and maintaining soil fertility; developing a regional agricultural policy; as well as establishing a Mediterranean Intergovernmental Panel on Food Safety, Nutrition and Food Security. Interestingly, achieving carbon neutrality for food production through binding agreements established at the Mediterranean level is deemed to be feasible only by 40 % of respondents. Among the interventions deemed both desirable and feasible by our experts there are the ban of routine use of antibiotics in healthy animals to prevent infectious diseases, as recommended by the WHO (94 %); fostering employment opportunities to increase youth in

Table 3.5

Farming systems: feasible and desirable policy options.

SHOULD DO	MUST DO NOW
Elaborate dual-purpose crops for achieving high yields while maintaining or possibly increasing soil fertility in the long term	Stop routine use of antibiotics in healthy animals to promote growth and prevent infectious diseases
Develop legally binding documents and agreements at the Mediterranean level to make food production carbon neutral by 2050	Create employment opportunities for rural youth in Mediterranean countries
Generate value in the agricultural sector in the Mediterranean by means of greater integration and cooperation between Arab/South Mediterranean and the European Union	Provide incentives for shifting to conservation agriculture to improve soil organic matter and soil quality
Build a unique strategy at the Mediterranean level across plant-animal-human health	Prioritise investments for sustainable intensification in national agricultural planning and policies
Apply more stringent reporting requirements for food companies	Increase the proportion of organic farming in Mediterranean countries
Developing an agricultural policy at the Mediterranean level, such as the EU Common Agricultural Policy	Fostering education on food safety at the household and farmer level (NEW)
Investing in rural development and more efficient agrifood value chains to mitigate migration pressures	Improving coordination on food safety standards across the Mediterranean countries
Put the safeguard of agrobiodiversity on the top of the national policy agenda in Mediterranean countries	Fostering investments on capacity building and training for smallholder farmers to improve food safety
Creating a Mediterranean Intergovernmental Panel on Food Safety, Nutrition and Food Security	Improve rural livelihoods by introducing policies that strengthen the role of women in agricultural development (e.g., facilitating lending procedures)
NOT TO DO	NOT A PRIORITY
Develop a common legal and institutional framework targeting the agricultural sector with a systemic approach at the Mediterranean level	Use social media as a new tool for monitoring plant pests and disease
Include agriculture in carbon markets	
Further restrict the import and movement of plants and plant products to control plant pests and disease	
Control crop pests and diseases through genetic improvement technologies	
Increase the use of biotechnology and GMOs in Mediterranean countries	

farming (91 %); incentives to agroecological practices to improve soil organic matter and soil quality (78 %); giving priority to investments in sustainable intensification in national planning and policies (70 %); increase organic farming across the Mediterranean countries (76 %); fostering training and education on food safety at the household and farmer level (74 %); leverage on the role of women in agriculture to improve rural livelihoods (89 %); applying more stringent reporting requirements for food companies (56 %); strengthening cooperation between Southern and Northern countries in the Mediterranean (59 %). The inclusion of agriculture in carbon markets, as well as the use of biotechnologies and GMOs, are among the policy interventions considered nor feasible or desirable; pest and disease monitoring through social media is considered as a feasible but not desirable intervention.

The responses in the area of agri-food value chain (Tables 3.6) highlight the desirability of the establishment of compulsory targets to reduce food loss and waste across the supply chain; the development of legal frameworks for food safety and risk assessment at the Mediterranean level; the prioritisation of policy coherence across different sectors to achieve the Sustainable Development Goals as well as establishing a region-wide monitoring systems; adopting urban food policies to mitigate climate change and improve nutrition. These measures are, however, not considered as feasible (Table 3.6). From the experts in this Delphi exercise, a comprehensive list of policy measures considered to be of utmost desirability as well as feasibility emerged. Among these,

Table 3.6

Agri-food value chains: feasible and desirable policy options.

SHOULD DO	MUST DO NOW
Address the technological and managerial innovation gap through increased public spending in research & development	Improve public health by providing routine health education at school
Establish compulsory targets at the Mediterranean level to reduce food loss and waste	Address the technological and managerial innovation gap through increased collaboration with academia and research
Develop a legal framework for food safety and risk assessment at the Mediterranean level	Strengthen innovation in the agrifood sector through vocational training and engagement of young farmers
Adopt a common standard at the Mediterranean level to enable cities to quantify and report on food loss and waste	Develop a Mediterranean Protocol to assess the nutritional value of diets in the different Mediterranean countries
Increase adoption of primary production technologies (e.g. aquaculture) to increase productivity	Prevent food waste by banning food retailers from throwing away unsold products by signing donation contracts with non-for-profit organisations
Prioritising policy coherence across sectors (e.g. nutrition, agriculture, poverty reduction) to achieve the Sustainable Development Goals	Prevent food waste by making it compulsory for the private sector to recycle organic waste
Increasing domestic spending on education for nutrition-related diseases prevention	Tackle food waste by means of national legislation
Adopting urban food policies to improve nutrition in cities	Strengthen innovation in the agrifood sector through investments in information and communication technologies (ICTs)
Adopting urban food policies to mitigate climate change	Adopt a common standard at the Mediterranean level to enable companies to quantify and report on food loss and waste
Establishing a Mediterranean monitoring system on agrifood value chains and the Sustainable Development Goals	Strengthen innovation in the agrifood sector through public incentives for the modernisation of equipment in agricultural holdings
	Address the technological and managerial innovation gap through increased public spending in research & development
NOT TO DO	NOT A PRIORITY
Adopt a common standard at the Mediterranean level to enable countries to quantify and report on food loss and waste	
Introduce progressive taxes initially on sugary drinks and then on all foods and drinks with added sugar	
Address food supply chain fragmentation in the Mediterranean countries to reduce food safety concerns	
Address food safety concerns by creating a Mediterranean Food and Drug Authority	
Adopt the same standards to control the safety of locally produced and imported food in Mediterranean countries	

increasing public investment to provide health and food-related education at school (feasible according to 59 % of experts); strengthening vocational training of young farmers (76 %); increasing public spending in research and development to address the technological and managerial innovation gap in the region (92 %). A number of desirable and feasible policy options pertain to food loss and waste reduction. In the Near East and North Africa, high levels of food loss and waste affect food availability and contribute to water scarcity, natural resource impairment, and increased food imports. Fruit and vegetables represent 45 % of food loss and waste, the largest majority of which occurs in the post-harvest phase. Food waste at consumer level is higher in Northern

Mediterranean countries (CIHEAM, 2016; Lacirignola et al., 2014b). The interventions include the implementation of national legislation to tackle food waste (70 %), and a legal framework that required food retailers to sign donation contracts with non-profit organisations to prevent food waste of edible products (76 %), as well as to recycle organic waste (76 %). Adopting a common standard to enable companies to quantify and report on food loss and waste is also among the desirable and feasible measures (76 %). Finally, the development of a Mediterranean-wide protocol to assess the nutritional value of diets in the region's countries is highly desirable and feasible, according to 81 % of experts. Interestingly, the measures that are not deemed to be desirable or feasible include the establishment of progressive taxes on sugary drinks and products; the establishment of a Mediterranean Food and Drug Authority to address food safety concerns (only 18 % indicated feasibility); as well as the adoption of common food safety standards to be applied to locally produced and imported food products in the Mediterranean countries.

To sum up, three considerations stand out across the three policy areas analysed. Firstly, the establishment of binding documents and agreements across the Mediterranean is seen as desirable although not feasible, across water resources preservation, agricultural policy or to achieve common purposes, such as carbon neutrality, as well as food loss and waste targets. Limited feasibility is also recognised to the creation of common bodies. These results seem to suggest that despite the Mediterranean countries share common challenges and opportunities, the possibility to deploy common policy frameworks is not seen as a possible option and can be connected to the poorly feasible greater cooperation between South and Northern Mediterranean countries. Thirdly, the need to leverage on innovation and technology emerges among both the desirable and feasible options across water resource management (from improvements in water networks to the use of non-conventional water resources) and agri-food value chains, coupled with increased spending on R&D, investments and public investments. Thirdly, experts attribute to the adoption of a more systemic approach to water resource management as well as to the one (human-plant-animal) health approach high desirability but low feasibility.¹¹ The importance of such an approach has been highlighted by the COVID19 pandemic.

4. Conclusions

The main contribution of this study is the attempt to address, thanks to a Delphi survey, the Mediterranean food systems from farm to fork, also distinguishing between Northern and Southern countries which present quite different challenges and possible pathways. This study has sought to address two main questions: 1) What trends will shape the future of the Mediterranean agri-food systems in the short (2020) and medium term (2030)? 2) What policies and initiatives are considered as the most desirable and the most feasible. Based on the assessments of about 60 experts involved in a Delphi exercise, the present study suggests that water-related challenges will persist in the South Mediterranean, especially in terms of an increase in the pressure over renewable freshwater resources due to agricultural use, both in the short and medium term. This is linked to an expected higher annual agricultural freshwater withdrawal. Experts suggested that vulnerability to climate change will significantly affect both the North and the South of the region, particularly in the longer term. In the Mediterranean, climate change exacerbates environmental pressures exerted by land-use change (such as, urbanisation, agricultural intensification), pollution and declining biodiversity, which are likely to impact the livelihoods of people in the entire basin, in terms of environmental security but also in

¹¹ We have cross-tabulated these results with several characteristics of experts, such as area of expertise, years of experience, country, gender. None of these analyses show significative differences among experts. This supports the strength of the findings.

socio-economic terms, by possibly triggering famines, migrations and conflicts (Cramer et al., 2018). The study has also shown that the region is not exempted from nutritional challenges as, in the opinion of the experts, prevalence of overweight will increase. This expected trend should be seen in the context of the region's nutrition transition. Dietary trends show the abandonment of the Mediterranean diet due to multi-factorial influences including lifestyles changes, food globalisation, as well as socio-cultural factors. This dietary model is based on the consumption of high amounts of olive oil and olives, fruits, vegetables, cereals (mostly unrefined), legumes, and nuts, moderate amounts of fish and dairy products, and low quantities of meat and meat products, and has been recognised to bring benefits for both human and planetary health (Tilman and Clark, 2014; Dernini and Berry, 2015).

The experts have different expectations about the South and the North of the Mediterranean region. Perspectives are gloomier for the South than for the North and while the North is deemed capable of addressing, although not reversing, present negative trends and to strengthen the positive ones, still the multiple challenges the South is exposed to makes the overall balance negative or mixed at the best.

By seeking to provide an outlook of the expected trends that will affect the Mediterranean agri-food systems, the present paper contributes to a better understanding of future challenges for all stakeholders in the sector, especially to inform decision-making and to align business strategies and practices. The Delphi survey also enabled us to provide a few insights on the types of policy interventions that are desirable and feasible to address the aforementioned challenges in terms of water management, farming systems and agri-food value chains. The top priorities include improving public health by providing routine health education at school; stopping routine use of antibiotics in healthy animals to promote growth and prevent infectious diseases, as prescribed by the WHO; fostering employment opportunities for rural youth; involving farmers in the use of new technology in agriculture to raise efficiency; addressing technological and managerial innovation gap through increased collaboration with the research community. In a more general way, the study intended to contribute to a better understanding of the Mediterranean's agri-food dynamics in order to assess its progress towards the 2030 Agenda for Sustainable Development in the region.

The present study has its own limits, of course. These limitations include, for instance, the limited geographic representation of the experts involved in the study, due to the high number of experts from Northern Mediterranean countries, and Italy in particular. The limited gender diversity of the panel of experts is also acknowledged. Moreover, our results are aggregated, and the impact of the experts' field of expertise or geographic origin have not been explored. However, the study offers a comprehensive overview of the main issue at stake concerning the future developments of the agri-food sector in the region, with a multi-dimensional approach, potentially opening-up new directions of research, as well as research and innovation collaboration. Among the former, we stress the relevance of replicating the same research in a different context, such as the European Union which has approved a new Farm to Fork Strategy, at the core of the European Green Deal; and at a different time, to understand the challenges and opportunities arisen in the context of the COVID-19 pandemic which have exacerbated food system challenges to a large extent.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.landusepol.2022.106263.

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