Local Agri-food Systems in a Global World: Market, Social and Environmental Challenges

Edited by

Filippo Arfini, Maria Cecilia Mancini
and Michele Donati

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CHAPTER TWO

ENVIRONMENTAL AND TERRITORIAL PROBLEMS OF THE SPANISH OLIVE OIL SECTOR AND PRIORITIES FOR RESEARCH AND INNOVATION: A DELPHI ANALYSIS

JAVIER SANZ-CAÑADA, DANIEL COQ-HUELVA, FLORENCIO SÁNCHEZ-ESCOBAR AND ISABEL HERVÁS-FERNÁNDEZ

Abstract

Spanish olive oil LAFS host a wide environmental diversity and a great variety of olive grove management systems. The types of collective action and territorial governance also differ significantly from one LAFS to another.

The main objectives of this chapter are: i) to analyse and evaluate the main environmental and territorial problems affecting the olive oil LAFS; ii) to assess research and innovation priorities that the Spanish R&D&I system must enhance; iii) to examine the relationship between the problems and the research programmes. The methodology is supported by a cross-interdisciplinary approach, based on Social, Agricultural and Environmental Sciences. A Delphi analysis is applied to a panel of experts in order to evaluate the problems and the programmes. The quantitative scores are supplemented by qualitative information obtained from a round table of experts and from the comments made through the Delphi survey.

As a result, seven R&D&I programmes, grouped under two big categories, are established: i) agro-environmental externalities corrective actions; ii) actions that address the olive oil LAFS and its multifunctionality. These programmes are harmonised with the main problem categories. Soil erosion and degradation appears as the most important problem, whilst changes in the olive grove geography also emerge as a key territorial issue.

1. Introduction and theoretical framework

Spanish olive oil *Local Agro-food Systems (LAFS)* (Économies et Sociétés 2007; Muchnik, Sanz-Cañada and Torres-Salcido 2008; Muchnik and Sainte-Marie 2009; Sanz-Cañada and Muchnik 2011) are characterised by their high levels of environmental and territorial diversity. In Spain, olive groves occupy more than 2.5 million hectares of land. These groves have a wide range of agro-ecological features, landscapes, productivity levels and management systems. Experts have characterised three main groups of olive farms in Spain: intensive (500,000 hectares), average-yield (1.2 million hectares), and low-yield farms (800,000 hectares) (Sanz-Cañada et al. 2008). In the first group, the increase of production, which is concentrated particularly on new areas of irrigated intensive or super-intensive olive grounds, exerts a pressure towards the reduction of bulk olive oil prices in international markets. In the second group, average-yield olive groves, un-irrigated and traditional orchards, must be restructured to remain competitive; this is particularly important in regards to creating strategies that could reduce the cost of harvesting. In the third group, low-yield olive groves in sloping land, also un-irrigated and traditional orchards, are generally considered as economically marginal, although they often retain relatively high environmental, landscape and cultural values in the mountain areas.

Moreover, the territorial organisation of Spanish olive oil LAFS often varies widely. In various areas in which olive oil production is the predominant source of income, it is possible to observe a high spatial concentration of entrepreneurial and institutional networks of olive farms, olive oil milling companies (most of them cooperatives), marketing firms, suppliers of inputs, concentric diversification companies (soaps, woodcrafts...), etc., in addition to a significant number of other institutions, including: associations for employing agricultural engineers for the integrated production, organic producer networks and associations, regulatory and inspection boards that monitor protected designations of origin, local action groups, etc. As a result of the existing high economic, ecological and social diversity, the types of collective action and territorial governance differ significantly from one LAFS to another. So LAFS' effects on local olive chains and territorial development vary widely.

From another point of view, new public policy approaches, as can be seen in the 2013 Common Agricultural Policy reform, will strengthen the monetary incomes associated with the provision of public goods. Not only do olive LAFS produce commercial goods and add value to local chains, but they are also characterised by their high capacities for multifunctionality.

Firstly, agro-environmental policies aim to support olive production systems that reduce negative agro-environmental externalities, such as erosion or diffuse pollution, and also to promote the generation of positive agro-environmental externalities, such as the carbon sink effect or the maintaining of biodiversity. Secondly, although the objective of commercial enhancement strategies is focused on obtaining differentiation-related incomes from high quality oil, these LAFS are also the subject of farming and rural development policies, as they generate positive externalities, such as the conservation of local olive heritage and the creation of a local network for the dissemination of innovation and knowledge. Finally, the economic valorisation of wastes generated in the olive oil chain is not only increasingly considered as a source of additional income, but also a strategy for optimising externalities (renewable energy, restoration of degraded soils, etc.). They are thus also targets of public policies.

As a result, the management of spatially different ecological, social and economic features and the implementation of multifunctional policies, require a new territorialised focus on research, innovation and transfer programmes. Consequently, to tackle this issue, it is first necessary to identify the main environmental and territorial problems concerning the Spanish olive oil LAFS. The analysis and assessment of these problems and the R&D&I priorities are the main objectives of this study. This approach is based on Social, Agricultural and Environmental Sciences. This study is part of a wider research project on research and innovation priorities in the Spanish olive oil sector (Sanz-Cañada et al. 2008), that uses a combination of complementary social research techniques applied to panels of experts.

This multidisciplinary study is directed at two main areas of knowledge in regards to sustainability of the olive oil chain and the territory: i) the *environmental externalities of the olive oil chain*, and ii) *multifunctionality, territorial governance and rural development.*

The first topic entails multidisciplinary research and innovation in various interrelated elements that are subject to high levels of territorial variability: fighting against soil erosion and degradation; improvement of water use in olive grove irrigation; reduction of soil and aquifer pollution by means of environmentally friendly farming systems; preservation of biodiversity and olive variety heritage; sustainability of oil milling activities; and waste research, especially in regard to olive pomace and pruning (García-Azcárate, Martin and Orlandi 2010; Gómez-Calero 2009; Guzmán-Álvarez 2004).

The second topic covers a wide range of aspects relating to territory, multifunctionality, sustainability, natural and cultural heritage, governance

and rural development (Arriaza and Nekhay 2010; Sanz-Cañada 2009; Sanz-Cañada and Macías 2005). It was during the final years of the twentieth century that agricultural multifunctionality became progressively more frequent in public policy debates. Normative approaches look at problems of multifunctionality from a multidisciplinary perspective and are aimed at agricultural and rural development policies. They are based on the assertion that efficiency must not be the sole parameter for agricultural policies and that the emphasis should be placed on a range of environmental, economic and social criteria (Cairol et al. 2009; Mann and Wüstemann 2008; Renting et al. 2009; Stobelaar et al. 2009; Zander et al. 2007). Multifunctionality approaches are especially recommended to provide solutions to issues related with marginal olive groves. The wide distribution of marginal olive groves, their risk of abandonment and the imminent changes in the olive grove geography are indicators of the large territorial scale of the phenomenon.

In Section II, the methodology for this study will be presented. In Sections III and IV, the results of the Delphi analysis applied to expert panels will be discussed, including: i) the environmental and territorial problems of Spanish olive oil LAFS (Section III); *ii*) the priorities in research programs and lines, as well as the relationship between research programmes and environmental and territorial problems (Section IV). The conclusions will be presented in Section V.

2. Methodology

The project that frames this study addresses research and innovation priorities in the Spanish olive oil sector and has various objectives: i) identify the main problems of Spain olive oil LAFS; ii) identify and define lines of research and innovation that would help to strengthen the Spanish R&D&I system for olive oil and olive groves; iii) establish priorities for the above; iv) provide a series of strategic recommendations for implementation of R&D&I policies in the Spanish olive oil sector.

The methodology of the whole project is based on a sequence of three consecutive phases (figure 2.1). The first consists of identifying and defining 86 lines of research and innovation based on long semi-structured interviews with experts. The second involved three expert panels that used a workshop strategy (a short Delphi survey, a discussion group and a strategic participation workshop based on the Metaplan methodology) to achieve a consensual vision of the problem, a selection and categorisation of the research lines and a structured series of strategic recommendations for improving the R&D&I system (Oakley 1991). These first phases were

focused on areas of longitudinal-disciplinary knowledge: i) olive farming and olive wastes; ii) milling technologies and new products; iii) olive oil Economic and Social Sciences.

The first two phases confirmed as follows: i) the need to apply more sophisticated discriminating tools to the consensuses reached; ii) the need to supplement the disciplinary approach with a cross-interdisciplinary analysis, based on interrelating technical knowledge (agricultural, agro-industrial, ecological...) and Social Sciences knowledge. In response to the above, the objective of the third phase was to establish a second, more in-depth, consensus among a great number of experts, in order to define priorities in regards to the problems and research lines established in the previous phases. Two cross-interdisciplinary *Delphi analyses* to two thematic areas, involving 70 R&D&I lines, were completed: i) the value chain, quality, food security and consumption, that deals with a vertical food chain focus; ii) sustainability, territory and rural development, that deals with a horizontal and territorial approach. The expert selection, which involved a total of 130 experts, was made seeking to obtain a balanced mix among the different research profiles (scientific, business, public administration, etc.).

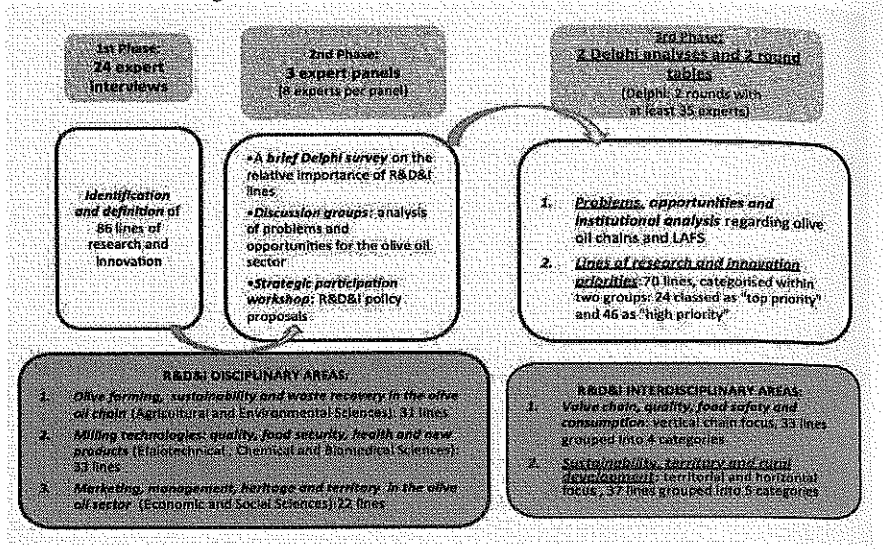
This chapter discusses some of the results obtained from the second *Delphi analysis on sustainability, territory and rural development* (outlined in Figure 2-1). A Classical Delphi model design was used. Its objective was to establish a consensus and also to predict future tendencies and events. The study was based on the assumption that the selected experts had an extensive professional experience and great information in order to establish a series of shared priorities. For this reason, it was not deemed necessary to introduce weighting coefficients in the measures of central tendency.

Answers to the Delphi survey questions were based on the Likert scale: 5 was the highest possible mark ("very high importance" or "very high certainty") whilst 1 was the lowest possible mark ("very little importance" or "very little certainty"). Additionally qualitative information was obtained, in part, from comments made by the experts in the Delphi survey stage and, also, during a round table, which took the format of an expert discussion group.

To define the level of consensus, the inter-quartile range (IQR) was used. That is to say, for a given question a "high consensus" was achieved when the IRQ ≤ 1. For many questions (69.33% of the total) a high consensus was achieved in the first round of the survey. The fact that lines of research and innovation would have been endorsed by a progressive selection process in the first and second phases of the project facilitated

the consensus process, which was obtained in the second round for all items. The experts' response rate during the two rounds was 58.3% and the aim of attaining 35 valid surveys was fulfilled following the two rounds.

Figure 2-1 R&D&I priorities, opportunities and problems in the Spanish olive oil sector: methodological framework



3. Environmental and territorial problems of Spanish olive oil LAFS

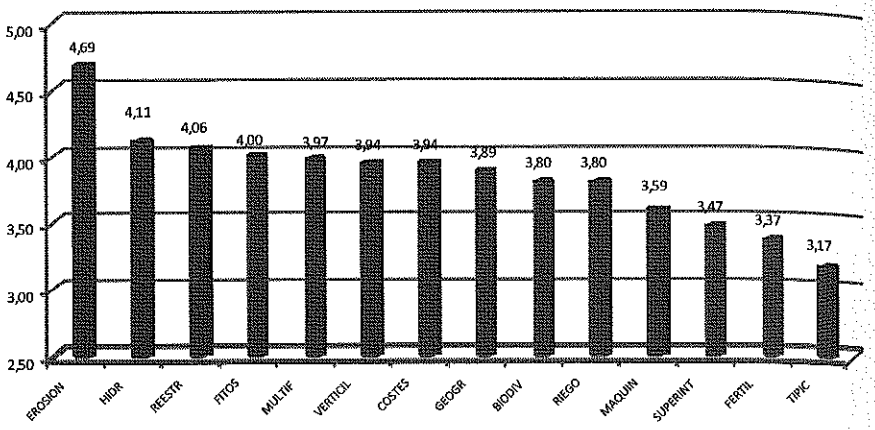
The experts were provided with a list of fourteen main problems. Their definition and median are shown in Table 2-1. The arithmetic mean of the problems is presented, in decreasing order, in Figure 2-2. Depending on the scores and qualitative information supplied by the experts, these problems were divided into four sub-groups that are examined in the next pages.

Table 2-1 Main environmental and territorial problems of olive oil LAFS
Median score of "importance of the problem": Me IP

	Me IP	Abbreviation
High level of soil erosion and degradation, especially in the case of olive groves on sloping land	5	EROSION
Excessive use of synthetic phytosanitary products (herbicides, pesticides, fungicides, etc.)	4	FITOS
Widespread verticillium wilt amongst irrigated olive orchards	4	VERTICIL
Organic weakening of soil and scarce availability of organic fertilisers	3	FERTIL
Appearance of new environmental problems as a result of super-intensive olive production (pests and diseases, use of agrochemicals, plant strength, loss of biodiversity...)	3.5	SUPERINT
Optimisation of water use in irrigated farms	4	RIEGO
Limitations on water resource availability for olive production due to the increased irrigation	4	HIDR
Loss of biodiversity in olive grove agro-systems	4	BIODIV
Regression of autochthonous olive varieties	3	TIPIC
Geographical olive grove changes as a result of increased intensive and super-intensive cultivation	4	GEOGR
Cost reduction requirements for extensive olive production	4	COSTES
Need to restructure medium and low-yield olive groves	4	REESTR
Lack of innovation in regards to machinery adapted to traditional olive groves on sloping land	4	MAQUIN
Scarce efforts to add value to the environmental, social and cultural roles of the olive oil LAFS	4	MULTIF

1= very little importance; 2 = little importance; 3 = average importance; 4 = high importance; 5= very high importance.

Figure 2-2 Main environmental and territorial problems of olive oil LAFS
Arithmetic mean score of "importance of the problem"



1= very little importance; 2 = little importance; 3 = average importance; 4 = high importance; 5= very high importance.

3.1 Environmental problems regarding soil erosion and degradation, diffuse pollution and biodiversity

The *high level of soil erosion and degradation, especially in the case of olive groves on sloping land* (EROSION) represents an environmental and territorial problem to which the experts awarded the highest average score of all the fourteen problems (μ=4.69). It is also the only problem attaining a median of 5, which means that it is a "very important problem". The experts highlighted that inadequate soil management is a significant factor in olive grove soil degradation. This is in part attributable to the general systematic use of herbicides to maintain bare soil, which contributes to the destruction of adventitious plant coverage, but also due to the failure to consider natural organic fertilisation processes (Calatrava et al. 2007; Francia et al. 2006; Graaff et al. 2010).

The *excessive use of synthetic phyto-sanitary products (herbicides, pesticides, fungicides, etc.)* is a closely related issue, identified by the experts as of "high importance" (FITOS; μ=4 & Me=4). Amongst the main environmental externalities that are caused by these practices, nitrate contamination of ground and surface water and soil fertility reduction are of particular concern; these effects are evident in regards to water retention

and increased erosion. Furthermore, the use of herbicides can cause negative externalities not just in the surrounding land, but also in oil milling, as this entails additional olive washing and water treatment costs.

The *loss of biodiversity in olive grove agro-systems* (BIODIV, μ=3.80) is another important issue according to the experts (Me=4). It is also recognised as an aspect that is closely related to olive grove management systems. Therefore, certain common practices, such as the use of herbicides or copper salts, and the maintenance of bare soils without any supplying of organic matter, have a serious impact on biodiversity of agro-systems. Improving biodiversity is especially important when addressing management of olive groves that are likely to be abandoned.

Finally, two problems were designated to be of "average importance" (Me=3). The first of these was the *organic weakening of soil and scarce availability of organic fertilisers* (FERTIL, μ=3.37). Although the experts recognised that organic fertilisers external to the farm are scarce, they considered that the low availability of these resources does not represent a major problem because a more holistic solution is needed for preventing soil degradation, including fertility problems; this focus seemed to contribute to assigning a median of 3. The experts proposed enriching the soil with pomace and pruning waste and the use of vegetable covers in the crop. Finally, although we believe that the *regression of autochthonous olive varieties* (TIPIC, μ=3.17) restricts current and future possibilities for local differentiation of olive oils, the experts have only attributed a median of 3 to this problem.

3.2 Environmental problems regarding water resources for olive groves

The *limitations on water resource availability for olive production due to the increased irrigation* (HIDR, μ=4.11) and the *optimisation of water use in irrigated farms* (RIEGO, μ=3.8) were both considered as being of "high importance" by the experts (Me=4). The expansion of intensive and super-intensive olive farming has resulted in a significant increase in water used, despite generalised improvements in irrigation efficiency. The panel was of the opinion that in many areas in which the development of irrigated intensive farming system is particularly strong, demand will soon exceed the water supply availability. In 2008, irrigated olive groves occupied 418,170 hectares in Spain; this represented 17% of the olive groves surface (MARM 2009).

The panel also recognised the need to optimise irrigation use, although the experts were initially divided in this topic, as was pointed out in the

qualitative information provided. Some experts believed that water use in olive groves irrigation is already sufficiently developed and that current localised irrigation systems are efficient. On the other hand, other experts stated that, as irrigation water is provided as part of a government concession which is not proportional to the volume consumed, farmers externalise a significant part of the cost attributable to its use. It appears that knowledge of deficit irrigation techniques and rational use of water amongst farmers is not sufficiently developed.

3.3 Problems regarding the need for restructuring and changes in olive grove geography

Many of the experts commented that most of the main environmental and territorial issues of olive oil LAFS have been catalysed by common agricultural policies that historically favoured, until the CMO reforms in 2003-04, the intensification of production, with no regard to the environmental consequences. On the other hand, although EU agro-environmental programmes were established in 1992, financial funds directed to support traditional olive grove systems that could foster positive externalities have been much lower when compared to market support policies. The panel also identified the lack of an integrated and public system of agricultural advisory services that could connect farmers with the R&D&I system and counteract the strong influence that agricultural input companies have traditionally had on farmers.

Five problems have been considered as part of this section, all of which have a median of 4 (high importance). The difference registered between each of the four problems is relatively low, with all attaining a score between 3.89 and 4.

The first two address the restructuring process of extensive olive groves: *need to restructure medium and low-yield olive groves* (REESTR, μ=4.06) and *cost reduction requirements for extensive olive production* (COSTES, μ=3.94). The panel stated that the reconversion of average-yield olive groves can be achieved by one of two means. The first option is to convert existing orchards to intensive olive groves, but this would be difficult to implement on a wide scale due to the lack of new water resources in many areas. The second option, which is well suited to groves on a relatively flat surface, is to select strategies of reduced harvesting costs, which represent the main cost incurred by olive farms. According to AEMO (2010), harvesting costs represent between 35% and 41% of the total costs of the farms, depending on the type of olive grove.

Problems associated with *geographical olive grove changes as a result of increased intensive and super-intensive cultivation* (GEOGR, μ=3.89), are closely related to the two problems mentioned above. This fact is causing a downward trend in the international price of bulk olive oil. When adding the effects of the strengthening of the commercial margins in the olive oil chain promoted by the big retailing companies, the opportunities for traditional mountain low-yield olive groves to make a profit are limited. The experts stated that unless public policies are implemented, a significant part of marginal Spanish olive groves may be abandoned. In areas of traditional olive orchards on sloping land, there are often no agricultural alternatives to olive farming. Therefore, if these groves fell into disuse, the consequences could be irreparable, from both an environmental perspective (biodiversity, increased risk of forest fires, etc.) and a socio-economic and territorial viewpoint (depopulation of rural areas, disappearance of economic activities, etc.) (Fleskens and Graaff 2008; Guzmán-Alvarez and Navarro 2008; Nekhay, Arriaza and Guzmán-Alvarez 2009). As a result, the panel recognised the need to promote the multifunctionality in olive oil LAFS, especially in areas of traditional olive orchards located on sloping land, through local development strategies that respect the environment and that valorise both the landscape and the cultural heritage. This tallies with the relatively high score attributed by the panel to *scarce efforts to add value to the environmental, social and cultural roles of the olive oil chain* (MULTIF, μ=3.97).

The last problem, although registering a median of 4, was the lowest ranked of the five issues: *lack of innovation in regards to machinery adapted to traditional olive groves on sloping land* (MAQUIN, μ=3.59). The panel made special mention of the fact that it is not currently possible to automate harvesting using tree-trunk shakers for olive groves located on steep slopes, given the structural weakness of these soils and the accessibility problems posed by this type of orchards. Likewise, current machinery is not suitably adapted to vegetal cover control tasks for olive groves in mountainous areas.

3.4 Environmental issues linked to the development of super-intensive olive production

The *widespread verticillium wilt amongst irrigated olive orchards* (VERTICIL; μ=3.94 & Me=4) is a high priority issue that has been particularly affected by the growing intensification of irrigation used in olive farming, particularly in super-intensive olive groves. The panel agreed to cataloguing verticillium as an important issue, but also on the

need to apply safeguard measures aimed at repressing, or at least reducing, the spreading of the infectious agent to olive farms.

However, two relatively opposing opinions emerged in regards to how to overcome this disease, as qualitative information showed. One group of experts suggested that this primarily represents a research and investigation issue. They justify the need to prioritise interdisciplinary research programmes that aim to improve specific knowledge concerning mechanisms that spread the disease in each area: polluted water used in irrigation, crops sewn prior to the planting, absence of sanitary certification of the nurseries, etc. On the other hand, the second group stated that the investment in investigating verticillium, which is closely linked to inappropriate farming practices and to intensive production processes, is detrimental to research into other pests and diseases. They believe that research should be directed at biological control, with a view to isolating new natural insecticide molecules, at evaluating potentially infected soil risks or at using resistance rootstocks.

This partial dissent between groups of different environmental stances was also visible in the importance given, only "above average" (Me=3.5), to the *appearance of new environmental problems as a result of super-intensive olive production* (SUPERINT; μ=3.47). The dilemma is based on whether high density groves foster environmental problems, other than the increase of water consumption: very high use of inputs as agrochemicals, drastic reduction in olives varieties or increase of pests and diseases. As little more than ten years have passed since the initial implementation of super-intensive orchards in Spain, environmental effects are still not entirely measurable.

4. Environmental and territorial research and innovation programmes for the olive oil sector

The panel was provided with a list of seven research and innovation programmes to be incorporated, from an environmental, territorial and rural development perspective, into the National R&D&I System.[1] In Table 2-2 and Figure 2-3 the arithmetic means and the medians attributed by the experts for each of the programmes can be seen. The nature of this valuation process was threefold: i) importance of the research and/or innovation programmes; ii) level of certainty in regards to the research results; iii) importance of the result and knowledge transfer actions.

Firstly, many of the experts stated that national research programmes must address urgently cross-interdisciplinary focus, rather than solely individual aspects. They also remarked that these programmes should promote working together various research groups as, to date, cooperation levels among them have been too low, which in turn has resulted in reduced efficiency in overcoming important environmental and territorial issues such as soil erosion, use of irrigation, verticillium management, multifunctionality, etc.

Table 2-2 Environmental and territorial R&D&I programmes for the olive oil sector

Median score of "importance of research and innovation lines": Me I R&I
Median score of "certainty in research results": Me CERT
Median score of "importance of transfer activities": Me I TR

	Me I R&I	Me CERT	Me I TR	Abbreviation
Fighting soil erosion and degradation	5	4	5	SUELO
Sustainability of water use and irrigation efficiency	4	4	5	RIEGO
Fighting pests and diseases	4	3	5	ENF-PLAGAS
Certification systems linked to the territory (designations of origin, organic agriculture, integrated production, etc.): differentiation-related incomes, local governance and rural development	4	3	4	DO-AECOL
Multifunctionality and environmental externalities in olive groves and olive millsl	4	3.50	5	MULTIF
Value-added strategies for the olive oil natural and cultural heritage. Oleotourism	4	4	4	PATRIM
Treatment of biomass and waste water from the olive oil chain	4	4	5	BIOMASA

Me I R&I and Me I TR:
1= very little importance; 2 = little importance; 3 = average importance; 4 = high importance; 5= very high importance.

Me CERT:
1= very little certainty; 2 = little certainty; 3 = average certainty; 4 = high certainty; 5= very high certainty

All seven *R&I lines* have been attributed a median of 4, apart from *fighting soil erosion and degradation*, which was scored as a 5. Likewise, the arithmetic means awarded to the research and innovation lines fall within a high, limited range of between 3.91 and 4.43. The methodology sequence used to select and prioritise the corresponding lines and programmes in the two previous phases of the project has meant that all lines and programmes are considered as at least high importance.

The score attributed to *transfer activities*, varying between 3.97 and 4.83, is significantly higher than the scores attributed to R&I lines (figure 2-3) for programmes addressing the *correction of agro-environmental externalities* (SUELO, RIEGO, ENF-PLAGAS and BIOMASA). Furthermore, five of the seven programmes have been scored as of "very high importance" (the four mentioned above and MULTIF). This evaluation can be explained, in part, by the lack of public training and knowledge transfer systems offered to farmers over the last decades.

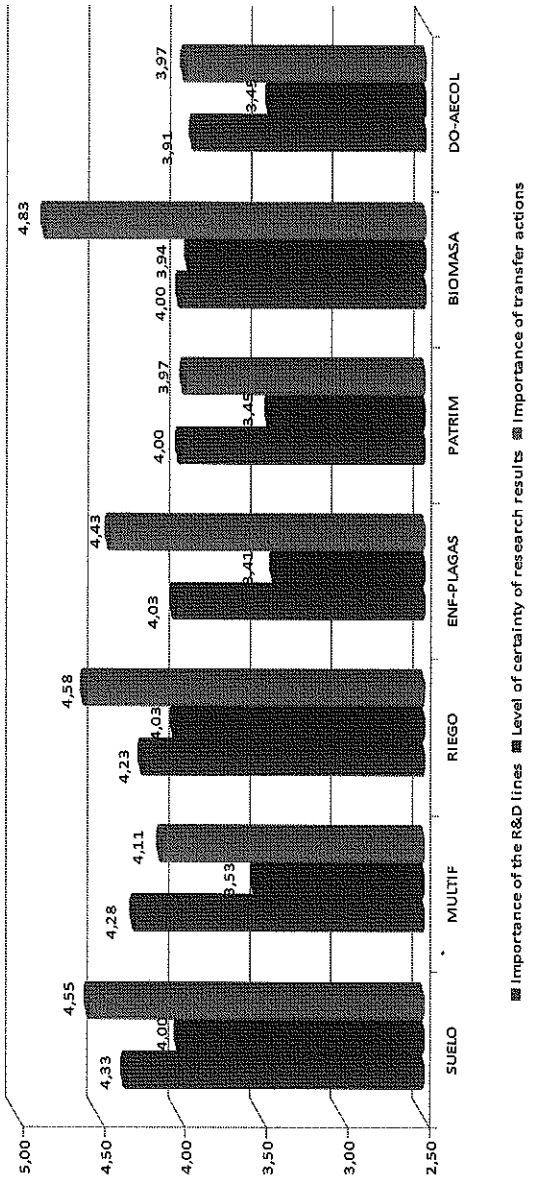
In regards to the *multifunctionality and olive oil LAFS programmes*, similar scores have been attributed both to transfer activities and to R&I lines (MULTIF, DO-AECOL and PATRIM). Significant work is still required in order to promote interdisciplinary investigation in these areas, due to the fact that this is still a relatively new research area, in addition to the high levels of environmental and territorial variability inherent to the Spanish olive oil LAFS.

The scores awarded to the *level of certainty* by the panel are significantly lower than those attributed to transfer activity and to the importance of R&I lines. Four of the seven programmes were awarded a median of 4 ("high certainty"), whilst three were considered as of "average certainty" (ENF-PLAGAS and DO-AECOL, Me=3) or "above average certainty" (MULTIF, Me=3.5).

Next, the *importance of research and innovation lines* will be analysed and compared to the scores awarded to the *environmental and territorial problems* discussed in Section III.

The first category includes programmes that aim to *correct agro-environmental externalities.* Although the general objectives are based on the reduction of negative externalities, in certain cases, such as olive oil waste, promotion of positive externalities policies can also be important. The average R&I line scores fall between 4 and 4.43, whilst transfer actions scoring even higher, between 4.44 and 4.83:

Fig. 2-3 Environmental and territorial R&D&I programmes for the Spanish olive oil sector



I+D and I TR
1= very little importance; 2 = little importance; 3 = average importance;4 = above average importance; 5= high importance.
L CERT
1= very little certainty; 2 = little certainty; 3 = average certainty;4 = above average certainty; 5= very high certainty

- The highest R&I mark awarded was in the program of *fighting soil erosion and degradation* (SUELO, μ=4.43). Additionally, this is the only programme that was awarded a score of 5 in both R&I and transfer actions. This score is mirrored by the high score awarded to "high level of soil erosion and degradation" problems (EROSION; μ=4.69, Me=5), which is higher than scores of all other thirteen problems.
- The *sustainability of water use and irrigation efficiency* was attributed the second/third highest score of all seven programmes in regards to R&I lines (RIEGO, μ=4.29 & Me=4). Its order of magnitude is similar to that of the following "highly important" problems: "limitations on water resource availability" (HIDR, μ=4.11) and "optimisation of water use in irrigated farms" (RIEGO, μ=3.8).
- The *fighting pests and diseases* programme shares a mean of 4 (ENF-PLAGAS) with problems related to the "excessive use of synthetic phyto-sanitary products" (FITOS) and was scored only slightly higher than "widespread verticillium wilt amongst irrigated olive orchards" (VERTICIL, μ=3.94).
- Finally, one programme aims not just to correct negative externalities, but to also enhance olive oil chain wastes: *treatment of biomass and waste water from the olive oil chain* (BIOMASA, μ=4). Many experts stated that olive biomass should primarily be directed towards restoring soil fertility and overcoming soil degradation rather than the use in energy or bio fuels production.

The second category, *olive oil LAFS and multifunctionality,* encompasses three programmes that all attained relatively high scores: those for R&I lines varied between 3.91 and 4.29, whilst those for transfer actions between 3.97 and 4.21. Together they aim to address problems related to geographical changes and territoriality in olive oil LAFS:

- The score awarded to *multifunctionality and environmental externalities in olive groves and oil mills* (MULTIF, μ=4.29 in R&I), is of particular interest, occupying the second/third place amongst the seven selected programmes. It is generally considered that new methodological frameworks that assess jointly different environmental externalities must be developed urgently in order to design a list of policy priorities. The objective of policies aimed at promoting multifunctionality is to reward economic and social agents in their role of producers of public goods. According to the experts, these policies should consider as a group not only environmental externalities, but socio-economic and cultural ones as well.
- The second and third programmes are linked to environmental and socio-cultural value-added strategies for specific olive oil territorial assets. They integrate private strategies for the commercial goods (oil, cosmetics, touristic goods, etc.) with public policies. *Adding-value strategies for the olive oil natural and cultural heritage; oleo-tourism* (PATRIM, μ=4), address the enhancement of the local olive landscapes and olive oil cultural assets, whether through oleo-tourism strategies, or creating marketing synergies together with the local oil firms and institutions. The *certification systems linked to the territory* (DO-AECOL; μ=3.91) programme looks to foster inter-professional quality organisation strategies for LAFS, aiming to obtain differentiation-related incomes associated with the collective labels and to contribute to the territorial governance processes; this is particularly the case for designations of origin boards and organic agriculture associations,

The assessment of olive oil LAFS and multifunctionality programmes is consistent with the evaluation of main environmental and territorial problems linked to them. These problems registered scores between 3.89 and 4.06: "need to restructure medium and low-yield olive groves" (REESTR), "cost reduction requirements for extensive olive production" (COSTES) and "geographical olive grove changes as a result of increased intensive and super-intensive cultivation" (GEOGR).

5. Conclusions

The research project, aiming to establish research and innovation priorities in the Spanish olive oil sector, verified the adequate application of a combination of social research techniques to expert panels, in order to resolve complex problems in the area of environment, territory and local olive oil development. Delphi methodologies facilitated, on one hand, the analysis and valuation of R&D&I programs and lines and, on the other hand, olive oil LAFS environmental and territorial problems. In this study, the panel used a cross-interdisciplinary perspective, integrating environmental, agricultural and socio-economic approaches. Additionally, it is also necessary to develop programmes on a national scale that

overcome excessive research group fragmentation, as is common place in the case of multifunctionality and verticillium, among other topics.

Another conclusion of the study is the urgency with which the Spanish R&D&I system must foster transfer programmes. In many of these knowledge areas, transfer activities require more immediate attention than the promotion of strictly research lines; this is particularly apparent in regards to soil degradation and sustainable use of water. The adoption of applied research and transfer programmes must consider agro-environmental heterogeneity, as well as the diverse farming, agro-industrial and management practices that are present in the Spanish olive oil LAFS. A truly territorialised focus must be adopted.

Additionally, the study has facilitated the establishment of seven R&D&I programmes, grouped under two different categories: firstly, agro-environmental externalities corrective actions and, secondly, actions that address olive oil LAFS and multifunctionality. These programmes are relatively harmonised, in terms of their relative importance, with the main environmental and territorial problem categories that Spanish olive oil LAFS must overcome.

With regards to the first category, the high level of agro-environmental externalities produced by the Spanish olive oil LAFS is principally visible in high soil erosion and degradation. The panel identified this as the most important territorial problem facing the Spanish olive oil sector; the respective research and transfer actions have also been clearly attributed the highest priority. Correcting soil degradation forms the basis of the recommendations that interacts with other agro-environmental externalities that have a significant impact on the Spanish olive oil sector, such as diffuse pollution, loss of biodiversity, lack of organic fertilisation, water shortage and the need to treat olive oil waste.

Secondly, olive oil LAFS and multifunctionality R&DI programmes and lines aim to respond to the enhancement of public and commercial goods. The key issue is to reduce/promote the negative/positive territorial externalities linked to olive oil local development strategies. These proposals address olive oil LAFS problems relating to olive grove geography, such as the survival of marginal olive groves, restructuring of low and medium-yield olive groves and the environmental impacts of olive farming intensification. In addition, it is necessary to solve the problem of lack of methodologies aimed at assessing how to distribute the reward of public goods to economic and social agents. Multifunctionality policies must adopt a clearly territorialised focus.

In this sense, the panel agreed that urgent actions are required in order to promote multifunctional public policies directed at avoiding the

abandonment of mountain olive groves. It must be noted that, to date, financial support provided to traditional olive grove systems likely to generate positive environmental externalities and local olive sector development has been lower than the support received by the Spanish olive sector from direct payment policies and market support. It is hoped that, in light of the 2013 reforms, significant changes will be made that favour the rewarding of environmental, socio-economic and cultural goods. Organic olive production, designations of origin, locally-driven joint marketing, natural and cultural heritage enhancement strategies, in addition to a series of networks and institutions resulting from collective action, all have the potential to play a lead role in olive oil territorial development in the near future.

Notes

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1. Each of these seven programmes groups different research and innovation lines, 37 in total, which were both evaluated and prioritised by the panel. A detailed analysis will be the subject of a future study.

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