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SUSTAINOLIVE

Recommendations to overcome barriers

Deliverable D6.1

WP6. Overcoming barriers and participatory platform

Novel approaches to promote the SUSTAInability of OLIVE cultivation in the Mediterranean

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Executive Summary

This document contains the deliverable 6.1 of the SUSTAINOLIVE project. SUSTAINOLIVE is a project funded by PRIMA H2020 Section 1 under the topic: *Improving the sustainability of Mediterranean agro-ecosystems*. SUSTAINOLIVE aims to enhance the sustainability of the olive oil farming sector throughout the implementation and promotion of a set of innovative sustainable management solutions that are based on agro-ecological concepts, and on the exchange and co-creation of knowledge involving multiple actors and end-users of the olive oil sector.

The document has been prepared as part of SUSTAINOLIVE Work Package WP6 and correspond to the deliverable 6.1 on the recommendations for overcoming barriers. This task summarizes the information obtained using the participatory approach with all the stakeholders to select the recommendations to overcoming the barriers that famers have in implementing Sustainable Technological Solutions (STSs).

In the document gather all the different actions that have been taken during the second part of the project.

The deliverable will be divided into distinct sections: 1) Justification, methodology and process, 2) Results, 3) Recommendations, and 4) References. Additional information is provided in the APPENDIX section.

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1. Justification, methodology and process

1.1. Justification

Currently, the positive effects of some of the specific management practices which promote nature-based processes and the provision of ecosystem services are relatively known by olive farmers. This is the case, for instance, of natural and seeded cover crops versus bare soil, or the application of crushed olive tree pruning residues onto soil versus tree residues burning. Similarly, some of the strategies to convert the main by-product of olive mill into a resource of olive cultivation use (e.g. composted olive mill pomace production) are acknowledged by some olive mill companies. However, the level of implementation of these practices is rather limited in most of the Mediterranean olive producer countries. To boost the future implementation of the STSs and of olive mill by-products valorisation, it is crucial to detect the main barriers which prevent a change in behaviour and to connect the different actors of the olive oil sector in order to share and disseminate information in an efficient way.

The aim of the work package 6 was twofold. On one hand, it was to promote the change of behaviour of olive farmers and olive mill companies towards the implementation of novel sustainable technological solutions which allows farmers to become active agents through the detection and overcoming of barriers for knowledge acquisition, and on the other hand, it was to increase the impact of the project in the Society, by fostering the implementation of sustainable technological solutions (STSs).

During the first part of the project, the main barriers that farmers could encounter in the implementation of the STSs were detected (internal report, task 6.1). The preliminary identification of these barriers was based on a questionnaire which was specifically created by the research team (Parra et al., 2022). Once a preliminary set of barriers were identified, specific actions to foster the STSs implementation in the olive grove sector were designed, taken into account the different dimensions previously stablished through the

mentioned study, such as lack of economic support, lack of training, lack of environmental consciousness.

Participatory approaches provide a mechanism to facilitate feedbacks and social learning (Stringer et al., 2006) and also helps in the knowledge co-creation. This is a 'collaborative process, bringing a plurality of knowledge sources and types together to address a defined problem and build an integrated or systems-oriented understanding of that problem' (Armitage et al., 2011).

Participatory research focuses on a process of sequential actions, in which local people are part of, instead of the subject of, research processes (Cornwall & Jewkes, 1995). Participatory methods are often used in research that concerns values and perceptions related to natural resources, their management and governance, and in projects that seek integration across knowledge systems (de Vos et al., 2021). Stakeholders' participation in the decision-making process guarantees that the decisions taken are more representative, consider those directly involved and expanding knowledge from the base (Sahagún & Plazola, 2017).

Effective participation of olive farmers and olive mill companies was complex. Specific meetings and workshops have been organized by SUSTAINOLIVE project. Through that collaborative and participatory approaches, we designed activities adapted to multiple perspectives. We created the conditions for the implementation of participatory activities and the collection of relevant information.

In the context of SUSTAINOLIVE project, we need the stakeholders' participation to discuss on effective policy recommendations in order to select those with the greatest agreement and support.

Decision analysis is a systematic approach for evaluating information about alternative choices, when multiple options are possible, with many possible outcomes and different trade-offs. In social-ecological systems (SES), multiple types of decisions (policy, management, private, other) – all with different

objectives – influence the social, economic and ecological dimensions, making it hard to compare across alternatives (Crépin & Polasky, 2021).

Multi-criteria decision analysis (MCDA) uses formal approaches that take explicit account of multiple criteria in exploring decisions. Multi-criteria methods support decisions based on a comparative assessment of alternative options to identify a preference order for possible action plans (Esmail and Geneletti, 2018). MCDA applies in particular when the criteria to take into account are sufficiently important for the outcome of the decision and some of them may conflict with one another (Mendoza & Martins, 2006; Karjalainen et al., 2013). MCDA methods were developed to structure, analysis and solve decision problems involving multiple criteria measured in different metrics. However, complex problems in natural resources management, involving multiple objectives, multiple decision makers and uncertainty, have been challenging practitioners, planners and MCDA researchers to find more creative and innovative methodological approaches (Mendoza & Martins, 2006).

Nowadays, different techniques can be used to help end-users in selecting or prioritizing different options and MCDA are mathematical models helping in the field of decision making. The objective of the MCDA is to obtain an order or ranking of the set of alternatives. To obtain this ranking, the set of alternatives must be well defined, and these are evaluated according to criteria that must also be well determined. With these parameters, the MDCA acts on each alternative, and based on this evaluation, the final ranking is established (Ceballos et al., 2016).

In our case, the Technique of Order Preference Similarity to the Ideal Solution (TOPSIS) was used as it is a well-established technique for evaluating different decision challenges in various fields and applications. Developed in 1981 to assist decision makers in selecting the optimal alternative that will maximize profit, TOPSIS is a ranking technique that tries to select the alternative with the minimum distance from the Positive Ideal Solution (PIS) and the maximum distance to the Negative Ideal Solution (NIS) (Aljaghoub, et al., 2022).

1.2. Meetings and workshop: participatory events

Data collection took place in October 2022 in two different events. The first participatory event was in DOP Estepa (Spain), an olive-farmers' cooperative of the consortium of SUSTAINOLIVE and where a capacity building meeting took place during data collection. Most of the 60 attended were olive farmers. During the session, the SUSTAINOLIVE project researchers asked for the farmers to fill in the questionnaire (Appendix 1C, Spanish version).

The second event took place in the University of Évora (Portugal), during the SUSTAINOLIVE annual project meeting. The project stakeholders (CRDOP, ACK, NGC, UANPROL, AIAB, AT, COB, ESP and CEPAAL) attending the meeting were asked for filling the questionnaire.

Participatory event in Évora (Portugal).

With this activity participants were invited to be part of the generation of policy proposals that favor the implementation of the STSs.

The recommendations were proposed by the SUSTAINOLIVE project researchers (Table 1) and following the information obtaining during the first part of the project on farmers' barriers for STSs implementation. Data from the questionnaires were tabulated and coded for the analysis.

Table 1. List of the initial recommendations included in the questionnaires.

1	Economic and financial incentives for farmers who use their own by-products to increase soil fertility (tree pruning and composted olive mill pomace)
2	Penalize those who do not protect the soil from erosion and biodiversity loss
3	Economic and financial incentives to those who integrated livestock in their farms to control the cover crop
4	Economic and financial incentives to those who use just organic fertilization
5	Economic and financial incentives to those for using insect hotel and aromatic plants in farms borders
6	Training courses in cover crop identification, implementation and control
7	Training courses in composting byproducts locally available
8	Training courses focused on the advantages of heterogeneous agroecosystems
9	Communicating updated information on environmental and health impacts of intensive agriculture
10	Communicating potential cost savings using sustainable solutions (less resources and more renewable)
11	Training: Audit my own farm (loss and profit) using farmers with already implemented sustainable technological solutions as trainers
12	Advisor technicians' specific formation on sustainable technological solutions
13	Training courses in local ecological knowledge for olive groves (cultural heritage for future generations)
14	Create Field-labs on sustainable technological solutions' improvement and performance to transfer knowledge to farmers

1.3. Multicriteria decision analyses (MCDA) and TOPSIS

Selecting from several possible decisions requires specific criteria significant to stakeholders and the recommendations implementation. Here we focused in four criteria: a) relevance for the environment; b) prioritization; c) the feasibility of the implementations, and d) the cost of implementation. The grade determined 1, as the minimum, and 4, as the maximum (Table 2; see Appendices 1A, 1B and 1C).

After gathering all the information, the Technique of Order Preference Similarity to the Ideal Solution (TOPSIS) was used to obtain a ranking within the set of recommendations.

Table 2: Specific criteria included in the questionnaires for the recommendations assessment.

a) RELEVANCE	b) PRIORITIZATION	c) EASINESS	d) FEASIBILITY
1 -not relevant	1 -not priority	1 - difficult	1 -highly costly
2-poorly	2 -poorly priority	2 -moderate difficult	2- costly
3 -relevant	3 -priority	3 -moderate easily	3 -moderate costly
4- highly relevant	4 -highly priority	4 -easy	4 -inexpensive

Steps for TOPSIS calculations:

i) Creation of a decision matrix. The decision matrix D is composed of alternatives "m" evaluated by criteria "n".

$$D = \begin{bmatrix} X_{11} & X_{12} & \cdots & X_{1n} \\ X_{21} & X_{22} & \cdots & X_{2n} \\ \vdots & \vdots & \ddots & \\ X_{m1} & X_{m2} & \cdots & X_{mn} \end{bmatrix}$$

ii) Calculation of the normalized matrix. The data in array D can have different sources, so it must be normalized into a dimensional array so that multiple criteria can be compared. To normalize it, the following equation is used:

$$\bar{X}_{ij} = \frac{X_{ij}}{\sqrt{\sum_{i=1}^{n} X_{ij}^2}}$$

$$(i = 1,2, \dots, n; j = 1,2 \dots, m)$$

iii) Calculation of the weighted normalized matrix. The elements of the weighted normalized decision matrix V will be calculated with the following expression, where W_j is the weight associated with each criterion:

$$\boldsymbol{V_{ij}} = \bar{X}_{ij} \times W_j \;\; (i = 1,2, \dots, n; j = 1,2 \dots, m)$$

iv) Calculation of the positive and negative ideal solution. In this step, the calculation of the ideal positive solutions and V^+ the negative ideal solutions V^-, are calculated according to the following expressions:

$$\boldsymbol{V}^+ = \{(max_i Vij \parallel j \in J), (min_i Vij \parallel j \in J')\}$$
$$\boldsymbol{V}^- = \{(min_i Vij \parallel j \in J), (max_i Vij \parallel j \in J')\}$$

v) Calculation of the Euclidean distance of the positive ideal solutions (benefits). Next, the Euclidean distances between any alternative (V_j^+) and the positive ideal solution (S_i^+) are calculated using the following expression:

$$S_i^+ = \left[\sum_{j=1}^{m} \left(V_{ij} - V_j^+\right)^2\right]^{0.5}$$
$$(i = 1,2, \dots, n; j = 1,2 \dots, m)$$

vi) Calculation of the Euclidean distance of the negative ideal solutions. Next, the Euclidean distances between any alternative (V_j^-) and the negative ideal solution (S_i^-) are calculated using the following expression:

$$S_i^- = \left[\sum_{j=1}^{m} \left(V_{ij} - V_j^-\right)^2\right]^{0.5}$$

vii) Calculation of the relative proximity to the ideal solution. To calculate the relative proximity of the feasible solution to the ideal solution, the following expression is used:

$$P_i = \frac{S_i^-}{S_i^+ + S_i^-}$$

Where, P_i is the proximity of the feasible solution to the ideal solution. The best alternatives are those that have the highest relative proximity values considering all the criteria. In this sense, these alternatives should be chosen, since they are closer to the ideal positive solution (Wang, Huang, Yin, Wang, & Zheng, 2022).

Data analyses:

JASP was used for the additional statistical analysis of the information. A free-to-download, R-based statistical software with user-friendly interface, developed by Wagenmakers' team.

2. Results

2.1. Participant sample description

Concerning the demographic information gathered for the analysis: 59% of the surveyed participants come from Spain, 15% from Italy, 10% from Morocco, 7% from Greece, 5% from Portugal, and 4% from Argentina and the Netherlands.

Concerning the gender (Figure 1), 71% were male and 29% female. 51% of the participants were farmers, whereas 43% and 6% were academics and advisory technicians, respectively (Figure 2).

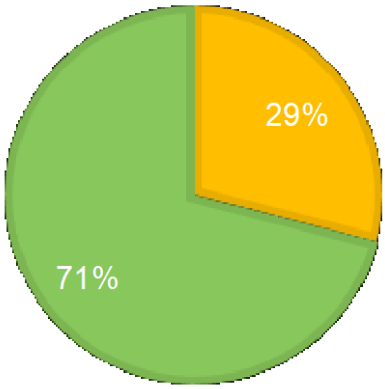


Figure 1. Participants' gender information in percent (females in yellow; males in green).

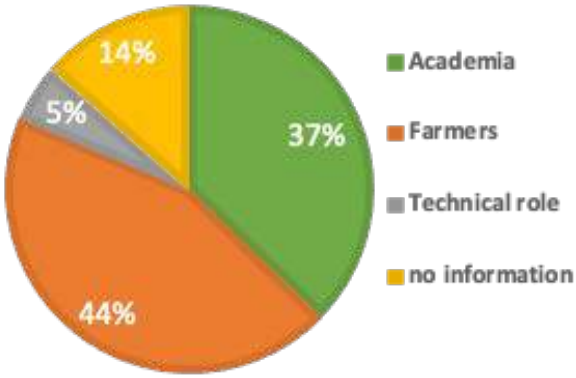


Figure 2. Type of stakeholders in the participatory events.

2.2. TOPSIS solutions

After using TOPSIS, the 14 recommendations were ranked considering the relative proximity to the ideal solution (P_i - Figure 3). Table 3 shows the ranking and recommendations with Pi values higher than 0.6, which were selected to be included in the document SUSTAINOLIVE policy recommendations to foster STSs' implementation in the Mediterranean olive grove sector (Section 3 and Appendix 3).

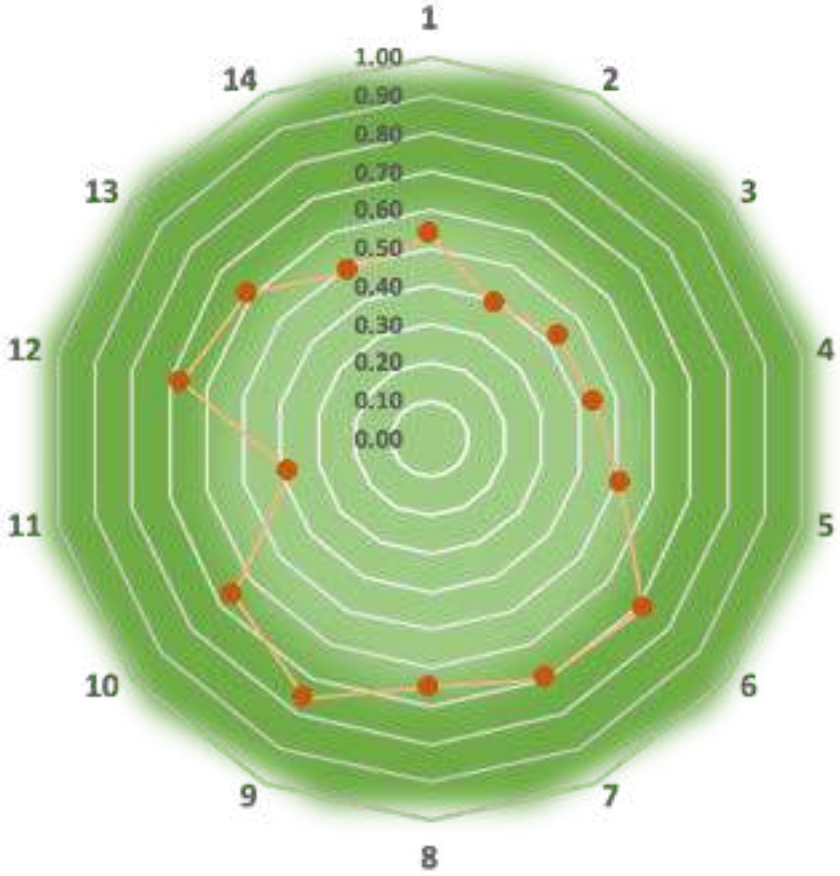


Figure 3. Web graph with the identification of the proximity coefficient (P_i) for each alternative. The selected ones were those with P_i higher than 0.6.

3. Recommendations for overcoming barriers and foster STSs implementations

Agriculture provides many benefits to people, such as producing food and creating jobs in rural areas, but it can also have negative impacts on the environment and, therefore, in human health (Becker, 2017; Scown & Nicholas, 2020). The Common Agricultural Policy (CAP) designed to guide the agricultural policy throughout the European Union, should also be the tool for transforming the agricultural sector and its contribution to the Sustainable Development Goals (SDGs). This is of urgent importance as the EU because aims to being a world leader in achieving the SDGs (EESC 2017). Most of the SUSTAINOLIVE policy recommendations proposed fall into the Pilar II, focusing on rural development programmes. These recommendations can help in solving several reproaches to

the CAP, as the limited internal and external coherence of the policy objectives, and the real contribution of the policy instruments to the overall SDGs (Pe' er et al., 2017). The current CAP instruments only support SDGs 1 and 2 (Pe' er et al., 2017). Important changes in agriculture policy are needed mainly those relate to the good health and well-being of farmers (SDG 3) and a better the alignment of existing CAP funding instruments with the SDGs (Scown & Nicholas, 2020).

Table 3. Recommendations ranking according to their relative proximity value. Those with P_i value higher than 0.6 have been highlighted in light green.

Ranking	Recommendation	Pi
1st	9. Communicating updated information on environmental and health impacts of intensive agriculture	0.75
2nd	6. Training courses in cover crop identification, implementation and control	0.72
3rd	7. Training courses in composting by-products locally available	0.70
4th	12. Advisor technicians' specific formation on sustainable technological solutions	0.67
5th	10. Communicating potential cost savings using sustainable solutions (less resources and more renewable)	0.66
6th	8. Training courses focused on the advantages of heterogeneous agroecosystems	0.65
7th	13. Training courses in local ecological knowledge for olive groves (cultural heritage for future generations)	0.61
8th	1. Incentives for those who use their own by-products to increase soil fertility (pruning, composted olive mill pomaces)	0.53
9th	5. Incentives to those for using insect hotel and aromatic plants in farms borders	0.51
10th	14. Create Field-abs on sustainable technological solutions' improvement and performance to transfer knowledge to farmers	0.49
11th	4. Incentives to those who use just organic fertilization	0.44
12th	3. Incentives to those who use livestock for managing the cover crop	0.43
13th	2. Penalize those who do not protect the soil from erosion and biodiversity loss	0.39
14th	11. Training: Audit my own farm (loss and profit) using farmers with already implemented sustainable technological solutions as trainers	0.38

Some studies have highlighted the need for specialized training and formation in the agricultural sector, considering the social and ecological obsolescence of the conventional agricultural model (García-Llorente et al., 2019). In the context of SUSTAINOLIVE project and to improve the implementation of STSs, we propose the following recommendations to the European policy-makers and policy-takers:

3.1. Carry out effective processes to communicate updated information on environmental and health impacts of intensive agriculture

It is important to raise awareness on how our own actions and activities produce impacts on the environment and how those can besides impact our health. The Paris agreement recognizes the "right to health", and also the "social, economic and environmental value of voluntary mitigation actions and their co-benefits for adaptation, health and sustainable development".

Considering this recommendation, we would like to highlight the role that SUSTAINOLIVE project has taken in offering the farmers simple and understandable information on how their agricultural practices might affect their own health and also other people health.

As part of the communication and dissemination program of SUSTAINOLIVE scientific results, two practice abstracts have been produced concerning the impacts that non-responsible management of plant protection products might have on human health.

The first one is warning on the effects of the overuse of pesticides on farmers, pickers and consumers, but also on the environment (Figure 4).

The second one is informing about how easily estimate the level of risk that farmers are exposed to when using agrochemicals (Figure 5).

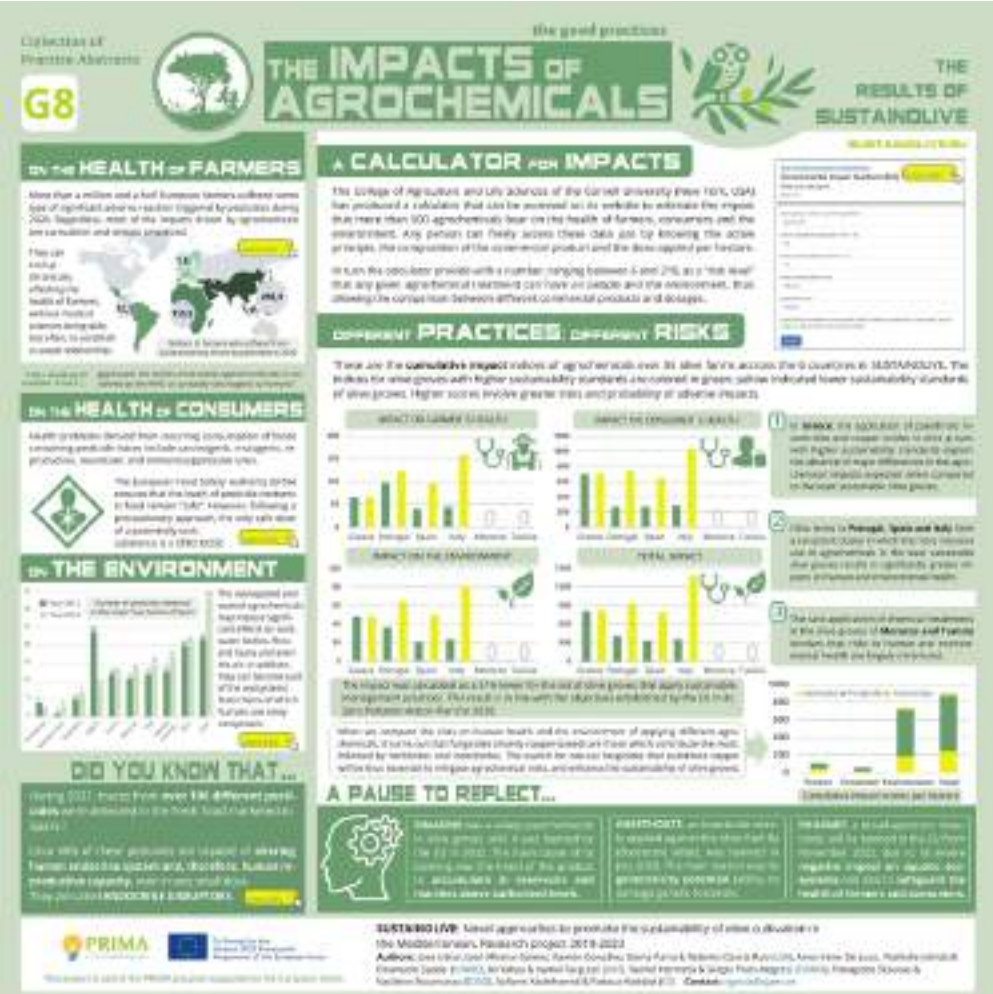


Figure 4. Practice Abstract on the impacts of agrochemicals.
You can download the file in high resolution by clicking HERE.

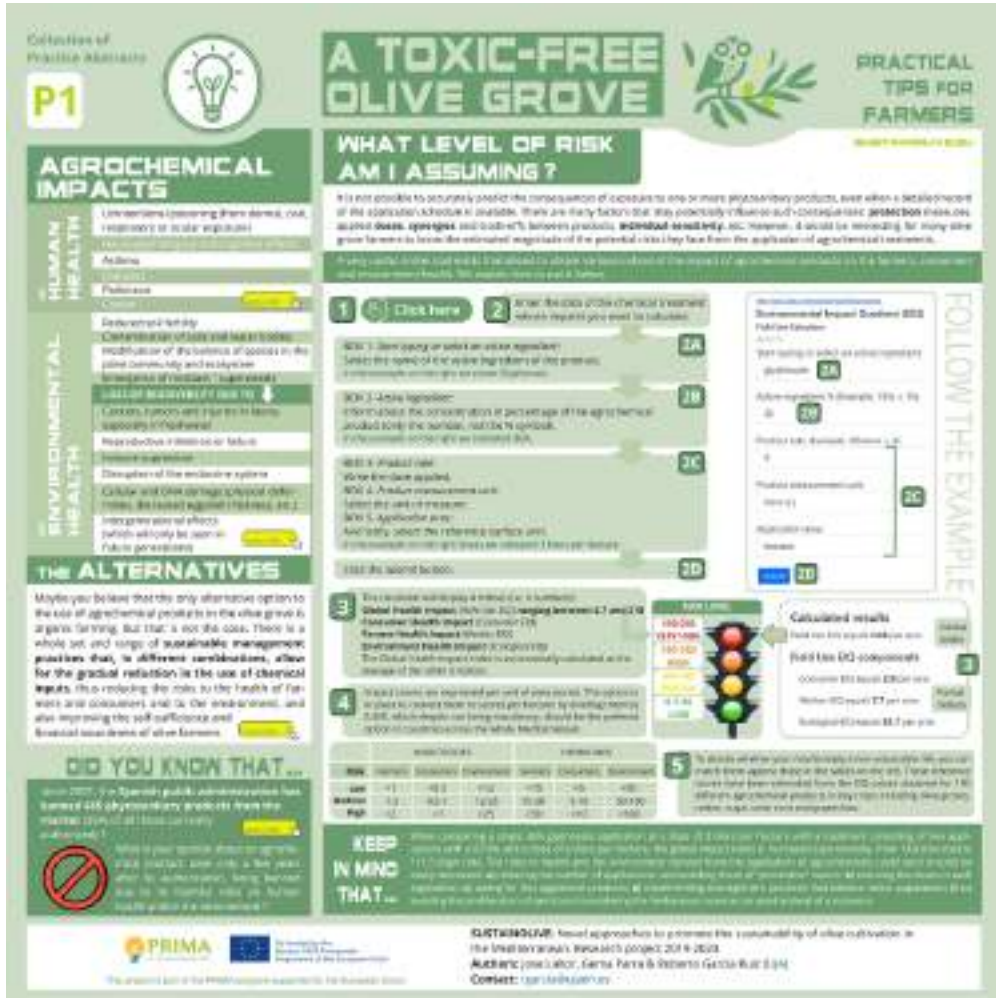


Figure 5. Practice Abstract on how to reach a toxic-free olive grove.
You can download the file in high resolution by clicking HERE.

Cross-sector actions should be taken in association with health care systems in each country. Doctors and nurses in rural areas should be trained also in promoting, through communitarian health, efficient self-protection practices and warning of agrochemical health effects. The health education opportunities are basic for improving prevention (Dulin et al., 206). Similar actions have been promoted in other productive activities, such as coal mining, in rural areas (see among others, Stephens et al., 2001).

3.2. Accelerate the training and formation of farmers with courses on cover crop identification and implementation

Implementation of cover crops is one of the most effective STS to be executed, as it improves organic matter content in soil, protects soil from erosion, reduces agrochemical leaching, etc. Management techniques of herbaceous cover crops should be a basic knowledge accessible to olive farmers.

Cover crops have been extensively recommended for increasing soil fertility, reducing soil erosion, maintain soil functionality, recycling nutrients, preventing desertification, reducing biodiversity loss and increasing resistance to climate change (Lietor & García Ruiz, 2022; see Appendix 2A). Detailed information on how to use cover crops in olive agriculture is also available for farmers in the SUSTAINOLIVE Manual of good practices in the olive grove (Figure 6).

Figure 6. Manual of good practices in the olive grove, available HERE.

Herbaceous cover crops were the protagonists of a relevant part of the events and dissemination materials produced at SUSTAINOLIVE. For instance, we organized a webinar on cover crops in olive groves (Figure 7).

Figure 7. Webinar on cover crops of olive groves. Top: Poster and Power Point presentation. Bottom: Webinar recording (check HERE).

Additionally, some of the practice abstracts developed in the framework of the SUSTAINOLIVE dissemination program focused on importance and benefits (Figure 8) and management of cover crops by using livestock (Figure 9).

Moreover, our training manual for farmers (a comprehensive set of easy procedures and management recommendations to evolve towards sustainable olive groves) included a specific section on cover crops (Figure 10).

Figure 8. Practice Abstract on the importance and beneficits of maintaining cover crops in olive groves. You can download the file in high resolution by clicking HERE.

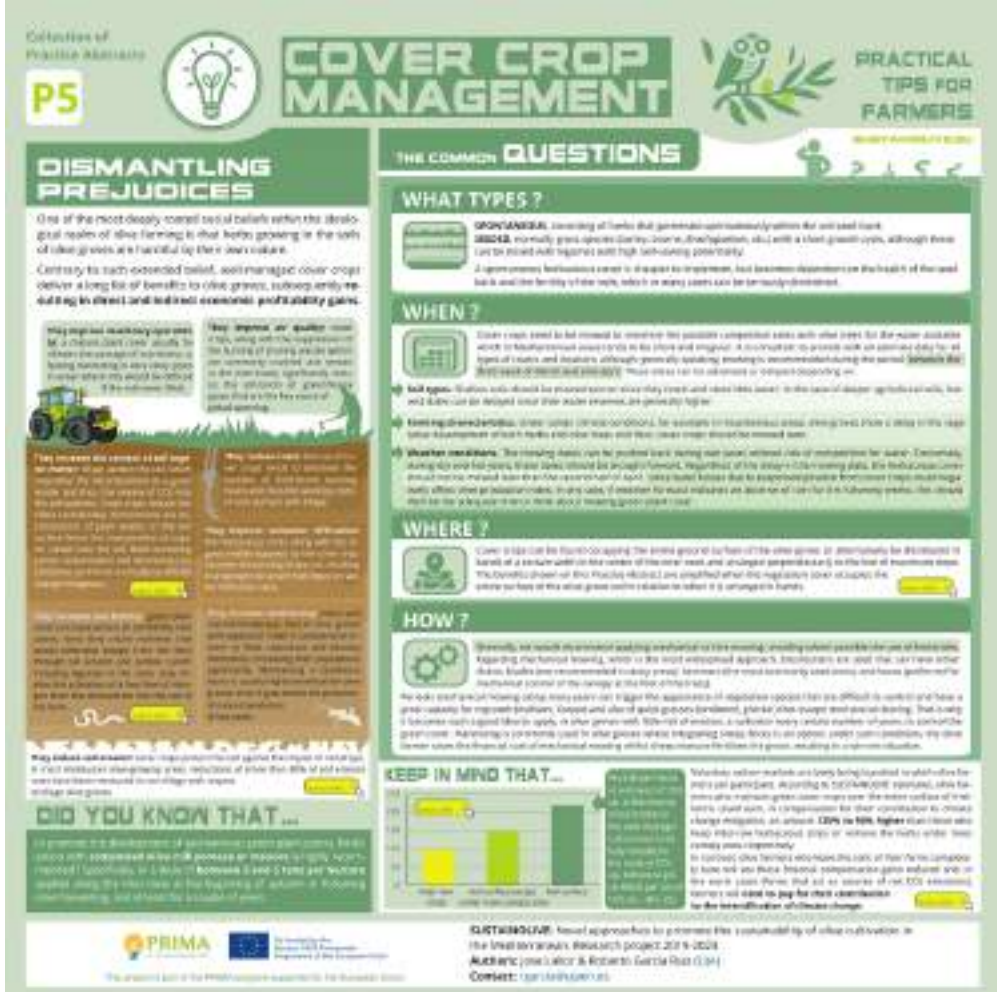


Figure 9. Practice Abstract on how to manage cover crops in olive groves. You can download the file in high resolution by clicking HERE.

Figure 10. Section on cover crops within the SUSTAINOLIVE training manual for ecological transition of olive farming. The home page of the manual and some representative pages of the cover crop section are shown. The file can be downloaded by clicking HERE.

3.3. Investing in training courses for farmers on composting the by-products generated in their olive grove

Prescribed training program for composting would reduce the lack of specific skills in olive farmers. Regional and local governments are called to design specific courses to improve rural development under the European agriculture policy (CAP Pilar II).

During the SUSTAINOLIVE project, the communication team has carried out several training and capacity building activities to promote composting, including webinars. Indeed, one of the most successful webinars organized by SUSTAINOLIVE in its 2022 dissemination program was the one dedicated exclusively to olive mill pomace composting (Figure 11).

Figure 11. Webinar on olive mill pomace composting. Top: Poster and Power Point presentation. Bottom: Webinar recording (check HERE).

Olive mill pomace composting also had a place in our training manual on ecological transition for olive farming (Figure 11) and our collection of practice abstracts (Figure 12).

Also, a booklet of policy recommendations on promoting composting olive mill pomace and biochar was prepared during the writing of this report (Figure 13).

3.4. Promote specialized training for advisor technicians on sustainable technological solutions

Investing in training agricultural technicians is an effective approach to promote sustainable agriculture, and would lead to boost the use of STSs. The know-how in STSs would be carried out by universities and colleges specialized in olive

grove agriculture. In the report *Mapping the development of agroecology in Europe*, the authors highlighted that despite the existence of studies and research dedicated to agronomy, agroecology is weakly presented (Wetzel et al., 2023).

Group of technicians from the olive sector during a transfer session guided by the SUSTAINOLIVE coordinator.

Figure 11. Section on olive mill pomace valorization within the SUSTAINOLIVE training manual for ecological transition of olive farming. The home page of the manual and some representative pages of the cover crop section are shown. The file can be downloaded by clicking HERE.

Figure 12. Practice Abstract on the recommendations for farmers to take advantage of olive mill pomace compost. You can download the file in high resolution by clicking HERE.

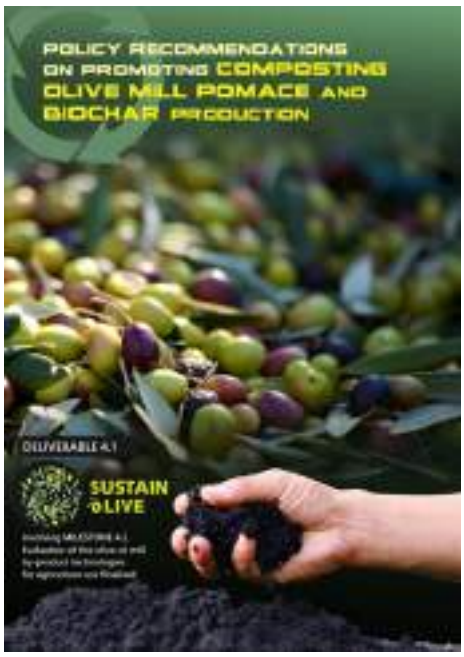


Figure 13. Cover and inside page of the booklet on composting of olive mill pomace (in progress).

3.5. Investing in communicating potential cost savings using STSs (less resources and more renewable energy sources)

It is important to aware farmers in how sustainable agriculture can lead to increased productivity and profitability by, for example, reducing costly inputs, like fertilizer and herbicides. Additionally, sustainable agriculture practices lead to mitigate climate change by sequestering carbon in the soil and reducing greenhouse gas emissions.

In this sense, during the capacity building actions carried out by SUSTAINOLIVE team special interest has been devoted to inform on cost savings, using analogies and quantitative data for a better understanding (Figure 14).

Figure 14. Clear examples used during participatory events with information on cost savings.

3.6. Arise awareness on farmers on the advantages of diverse and heterogeneous agroecosystems with target courses

Under the climate change future scenarios, diversity, complexity and heterogeneity in agroecosystems will be beneficial to farmers as a bet-hedging

strategy. However, the policies for the adaptation to climate change need to include and promote the heterogeneous agroecosystems approaches and initiatives (see Appendices 2A and 2B, which can be downloaded by clicking in the following links: 1 and 2.

3.7. Promote and protect cultural heritage of local ecological knowledge relate to olive groves (future generations)

Local ecological knowledge of the olive groves communities, which has been acquired over generations, leads to the maintenance of nature contributions and the provision of their ecosystem services, which can assure sustainability and the socioecological systems resilience to disturbances. Previous studies in rural areas have concluded that ecological knowledge can facilitate collective responses to crises and contribute to the maintenance of long-term resilience of socioecological systems (Gómez-Baggethun et al., 2012). The European institutions should have a central role providing socioecological systems with the capacity to respond to disturbance (Berkes and Folke, 1994). It is also crucial to develop strategies to ensure the transmission of knowledge across generations.

Specific actions should be taken to improve the identity, the sense of belonging to a community and culture. The social appreciation of specific food products, such as extra virgin olive oil, enhances the way local communities identify themselves, fostering a wider interpretation of sustainability. Institutional promotion of the sustainable food production in the area, along with the complementary activities, such as the agro-tourism, would be key strategies to re-boost local cultural heritage and add value to sustainable food production.

3.8. To sum up

At a first glance, many recommendations fall into the strategies to overcome the lack of information and training that have been detected as one of the main barriers for implementing STSs (Parra et al., 2022). Innovative formative programs should be designed and funded to reactivate the olive sector in Mediterranean rural areas. Agricultural technicians and farmers need specialize

guidance, as have been identify for different studies (i.e., to be able to understand and apply new technologies related to primary production, soil science, crop and livestock genetics, use of technologies such as remote sensors, satellites and robotics (Lourenço et al., 2021)). It is important to highlight that other recommendations that have been well positioned are those related to incentives to specific practices (see Table 3, position 8 and 9). However, the implementation of any recommendation will be limited by the amount and type of required resources, so they will be the governments and institutions who will select and prioritize them according to the availability of resources.

Five of the nine planetary boundaries (PBs) are in the high-risk zones, being agriculture the major driver of four of them. Besides, agriculture is also a significant driver of many of the rest of PBs that still are in the safe zone (Campbell et al. 2017). At the same time, no one questions the need for food production, and how food and ecological knowledge benefit local people from traditional farming (Vidal-Abarca et al., 2022). However, a better agriculture is possible and the information gathered by the SUSTAINOLIVE project can help in the way this transformative change might be carried out in the olive grove sector. Not only with scientific evidence on the benefits of the proposed STSs, but also with policy recommendations to foster their implementation (Appendix 3). Hopefully, the project has contributed gather significant information to foster the adaptation of agroecological practices to sustain the ecosystem services that the olive sector provides to the Mediterranean area.

4. References

Aljaghoub, H., Abumadi, F., AlMallahi, M. N., Obaideen, K., & Alami, A. H. (2022). Solar PV cleaning techniques contribute to Sustainable Development Goals (SDGs) using Multi-criteria decision-making (MCDM): Assessment and review. International Journal of Thermofluids, 16, 100233.

Armitage, D., F. Berkes, A. Dale, E. Kocho-Schellenberg, and E. Patton. 2011. 'Co-management and the Co-Production of Knowledge: Learning to Adapt in Canada's Arctic.' Global Environmental Change 21(3): 995–1004.

Becker (2017) External costs of food production: environmental and human health costs of pest management. Environmental pest management: challenges for agronomists, ecologists, economists and policymakers. John Wiley & Sons, Hoboken, pp 369–384.

Campbell, B. M., D. J. Beare, E. M. Bennett, J. M. Hall-Spencer, J. S. I. Ingram, F. Jaramillo, R. Ortiz, N. Ramankutty, J. A. Sayer, and D. Shindell. 2017. Agriculture production as a major driver of the Earth system exceeding planetary boundaries. Ecology and Society 22 (4):8. https://doi.org/10.5751/ES-09595-220408

Ceballos, B., Lamata, M. T., & Pelta, D. A. (2016). A comparative analysis of multi-criteria decision-making methods. Progress in Artificial Intelligence, 5, 315-322.

Cornwall, A., and R. Jewkes. 1995. 'What is Participatory Research?' Social Science and Medicine 41(12): 1667–1676.

Crépin, A. S., and Polasky, S. (2021). Decision analysis based on optimisation. In The Routledge Handbook of Research Methods for Social-Ecological Systems (pp. 400-411). Routledge.

de Vos, A., Preiser, R., and Masterson, V. A. (2021). Participatory data collection. The Routledge handbook of research methods for social-ecological systems, 119.

Dulin, M. K., Olive, K. E., Florence, J. A., & Sliger, C. (2006). The financial value of services provided by a rural community health fair. Journal of Health Care for the Poor and Underserved, 17(4), 821-829.

EESC (2017). The EU must become the world leader in meeting SDGs [press release]. European Economic and Social Committee.
Retrieved from https://www.eesc.europa.eu/en/news-media/press-releases/eu-must-become-worldleader-meeting-sdgs

Esmail, B. A., and D. Geneletti. 2018. Multi-criteria decision analysis for nature conservation: a review of 20 years of applications. Methods in Ecology and Evolution 9(1):42-53. https://doi.org/10.1111/2041-210X.12899

Berkes, F., & Folke, C. (1994). Linking social and ecological systems for resilience and sustainability. F. Berkes, C. Folke (Eds.), Linking Social and Ecological Systems, Cambridge University Press, Cambridge, UK, pp. 1-25

García-Llorente, M., Pérez-Ramírez, I., Sabán de la Portilla, C., Haro, C., & Benito, A. (2019). Agroecological strategies for reactivating the agrarian sector: the case of Agrolab in Madrid. Sustainability, 11(4), 1181.

García-Martín, M., Huntsinger, L., Ibarrola-Rivas, M. J., Penker, M., D'Ambrosio, U., Dimopoulos, T., ... & Plieninger, T. (2022). Landscape products for sustainable agricultural landscapes. Nature Food, 1-8.

Gómez-Baggethun, E., Reyes-García, V., Olsson, P., & Montes, C. (2012). Traditional ecological knowledge and community resilience to environmental extremes: A case study in Doñana, SW Spain. Global Environmental Change, 22(3), 640-650.

Karjalainen, T.P., P.M. Rossi, P. Ala-Aho, R. Eskelinen, K. Reinikainen, B. Kløve, M. Pulido-Velasquez, and H. Yang. 2013. 'A Decision Analysis Framework for Stakeholder Involvement and Learning in Groundwater Management.' Hydrology and Earth System Sciences 17: 1–13.

Lamichhane, P., Hadjikakou, M., Miller, K. K., & Bryan, B. A. (2022). Climate change adaptation in smallholder agriculture: adoption, barriers, determinants, and policy implications. Mitigation and Adaptation Strategies for Global Change, 27(5), 32.

Lietor Gallego J and García Ruis R. (2022). Recomendations for the organic transition of olive cultivation. A synthetic guide for olive farmers and politicians. SUSTAINOLIVE project (PRIMA funded 2019-23). University of Jaén (Spain).

Lourenço, P., Baptista, F., Picuno, P., Cruz, V. F., Silva, L. L., Silva, J. R., ... & Papadakis, G. (2021). Training and Learning Needs for MSc Programs in Sustainable Agriculture. Proceedings of the European Conference on Agricultural Engineering AgEng2021, p. 212-215. ISBN: 978-972-778-214-7

Mendoza, G.A., and H. Martins. 2006. 'Multi-criteria Decision Analysis in Natural Resource Man-agement: A Critical Review of Methods and New Modelling Paradigms.' Forest Ecology and Man-agement 230(1): 1–22.

Parra, G., Garcia-Lopez, L. J., Piqueras, J. A., and García, R. (2022). Identification of farmers' barriers to implement sustainable management practices in olive groves. Sustainability, 14(11), 6451.

Pe'er, G., Lakner, S., Müller, R., Passoni, G., Bontzorlos, V., Clough, D. Zinngrebe, Y. (2017). Is the CAP Fit for Purpose? An Evidence-Based Fitness-Check Assessment. German Centre for Integrative Biodiversity Research (iDiv).

Sahagún F.J. and Plazola L. 2017. Participación ciudadana y métodos de toma de decisiones para la gobernanza y la gestión ambiental. En: Hemisferios: Alianzas de la táctica a la práctica Antología de textos científicos y literarios en favor del medio ambiente. Universidad Austral de Chile, pp 220-227.

Scown MW, Nicholas KA (2020). European agricultural policy requires a stronger performance framework to achieve the Sustainable Development Goals. Global Sustainability 3, e11, 1–11. https://doi.org/10.1017/sus.2020.5

Stephens, C., & Ahern, M. (2001). Worker and community health impacts related to mining operations internationally: A rapid review of the literature. London: London School of Hygiene & Tropical Medicine.

Stringer, L.C., A.J. Dougill, E. Fraser, K. Hubacek, C. Prell, and M.S. Reed. 2006. 'Unpacking "Par-ticipation" in the Adaptive Management of Social-Ecological Systems: A Critical Review.' Ecology and Society 11(2): 39.

Vidal-Abarca Gutiérrez, M. R., Nicolás-Ruiz, N., Sánchez-Montoya, M. D. M., & Suárez Alonso, M. L. (2022). Ecosystem services provided by dry river socio-ecological systems and their drivers of change. Hydrobiologia, 1-23.

Wezel, A., Grard, B. and Gkisakis. V. (eds) 2023. Agroecology in Europe. Country Reports Series,Vol. 1, ISARA, Lyon, France; Agroecology Europe, Corbais, Belgium.

APPENDIX 1 (ENGLISH)

RECOMMENDATIONS TO IMPROVE THE IMPLEMENTATION OF SUSTAINABLE TECHNOLOGICAL SOLUTIONS IN THE OLIVE GROVE

SUSTAINOLIVE project aims to promote the sustainability of the olive oil sector through innovative and sustainable solutions in management practices, based on agro-ecological concepts and the effective and active exchange of knowledge among the main actors in the sector. For this, in the generation of policy proposals that favor the implementation of these solutions it is necessary **the participation of all the stakeholders** involved.

We need your help to classify the following proposals according to 4 criteria: a) relevant to the environment; b) prioritization; c) easiness of implementation; and d) Economically feasible. Please, score them from 1 (minimum) to 4 (maximum).

SECTOR:	Country:	Province:	Age:	Gender:

	Recommendations	a) RELEVANCE	b) PRIORITIZATION	c) EASINESS	d) FEASIBILITY
		1 -not relevant 2-poorly 3 -relevant 4- highly relevant	1 -not priority 2 -poorly priority 3 -priority 4 -highly priority	1 - difficult 2 -moderate difficult 3 -moderate easily 4 -easy	1 -highly costly 2- costly 3 -moderate costly 4 -inexpensive
1	Incentives for those who use their own by-products to increase soil fertility (pruning, composted olive mill pomaces)				
2	Penalize those who do not protect the soil from erosion and biodiversity loss				
3	Incentives to those who use livestock for managing the cover crop				
4	Incentives to those who use just organic fertilization				
5	Incentives to those for using insect hotel and aromatic plants in farms borders				
6	Training courses in cover crop identification and implementation				

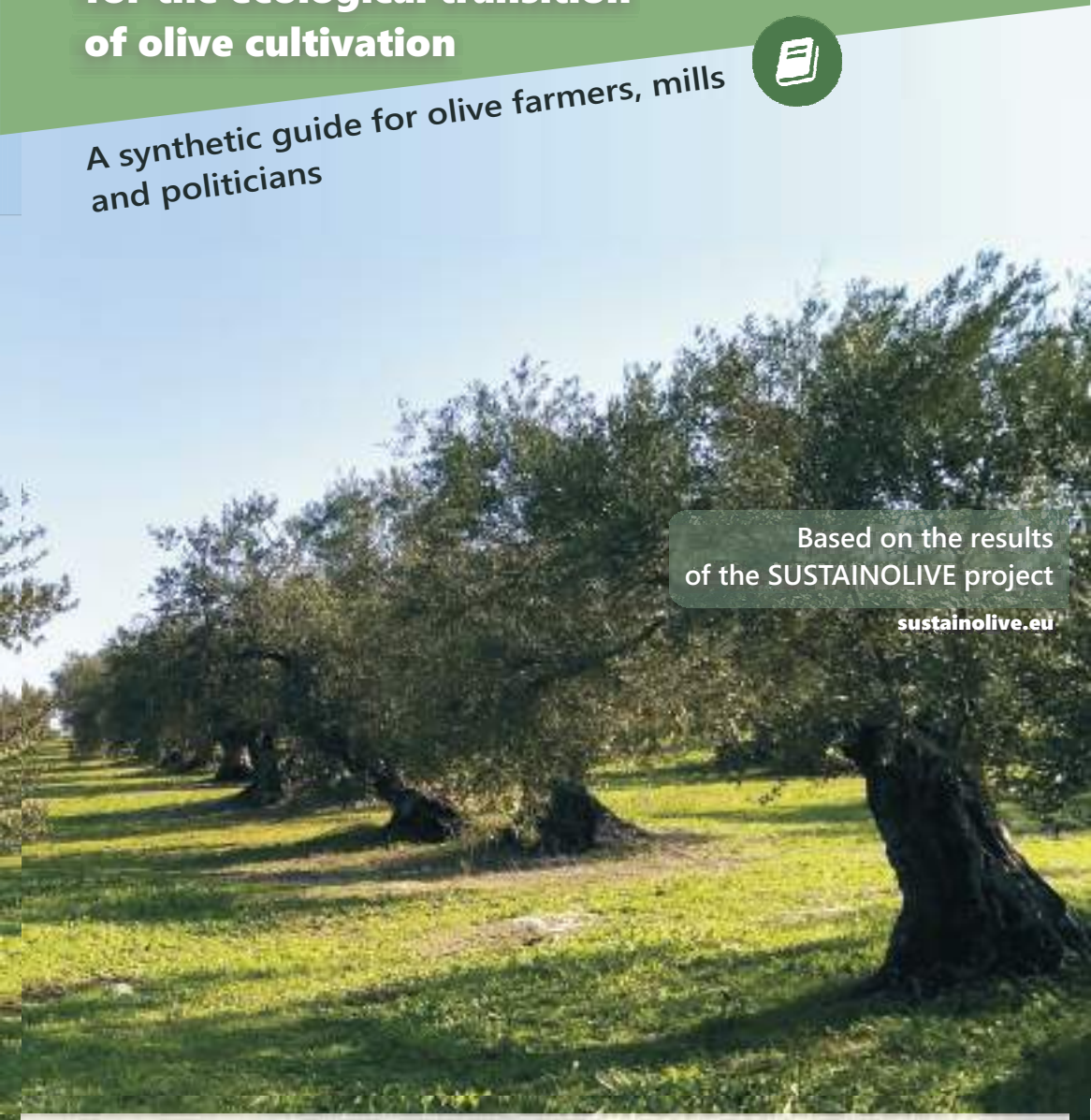
7	Training courses in composting near olive grove by-products				
8	Training courses focused on the advantages of heterogeneous agroecosystems				
9	Communicating updated information on environmental and health impacts of intensive agriculture				
10	Communicating potential cost savings using sustainable solutions (less resources and more renewable)				
11	Training: Audit my own farm (loss and profit) using farmers with already implemented sustainable technological solutions as trainers				
12	Advisor technicians' specific formation on sustainable technological solutions				
13	Training course in local ecological knowledge for olive groves (cultural heritage for future generations)				
14	Create Field-abs on sustainable technological solutions' improvement and performance to transfer knowledge to farmers				
15	Your own proposal:				

APPENDIX 2 (ENGLISH)

RECOMMENDATIONS

for the ecological transition of olive cultivation

A synthetic guide for olive farmers, mills and politicians



Based on the results of the SUSTAINOLIVE project

sustainolive.eu

SUSTAIN OLIVE

PRIMA

Co-funded by the Horizon 2020 Framework Programme of the European Union

This project is part of the PRIMA programme supported by the European Union

THE PROJECT

The main goal of SUSTAINOLIVE is to improve the sustainability of the olive oil sector, through the implementation and promotion of a set of innovative sustainable management solutions based on agroecological concepts, as well as through the exchange of knowledge and experiences among its multiple associates and end users.

the numbers

- **6** countries
- **22** partners
- **88** experimental farms
- **Hundreds** of field experiments
- **31** deliverables

an easy effective approach

Conventional olive farms

Olive farms applying sustainable management practices

Comparison of multiple ecological and socio-economic variables and processes

RESULTS

RECOMMENDATIONS

TABLE OF CONTENTS

INCREASING FERTILITY AND FUNCTIONAL QUALITY OF THE SOIL

The SUSTAINOLIVE project has verified that soils of olive groves with little disturbance (e.g., minimum or no tillage) and with an inflow of a wide diversity of organic carbon sources (cover crops, shredded tree pruning remains, manure and/or composted olive mill pomace) develop highly diverse and active microbial communities, in some cases comparable with that of nearby forests.

This has an enormous value for the farmer, both in environmental and productive/economic terms.

Recommendations for OLIVE FARMERS

- Identify the **type of soil** and its physicochemical properties
- Minimize **soil tillage**
- Maintain a spontaneous or planted **cover crop**. Once cleared, apply the remains on top of the soil
- Allocate a percentage of the farm area to sowing **legumes**, especially in soils poor in nitrogen
- Apply **organic fertilizers**, locally available, such as composted olive mill pomace and manure
- Integrate **livestock** (e.g., sheeps) into the olive grove. They provide processed organic matter through droppings and help the control of the cover crops
- Intercropping by integrating **other crops** in the inter-rows area. Aromatic plants for honey production are a good option
- Avoid or minimize **chemical fertilization**, especially when it is not based on a nutrient balance or the real needs of the crop
- Avoid or minimize the use of **pesticides**, especially broad-spectrum ones

According to the results of SUSTAINOLIVE

The annual application of 430 kg of manure and 3400 kg of composted olive mill pomace per hectare would improve the organic carbon level of the soil by **18%** over a period of 30 years. Furthermore, the regular application of shredded remains of pruning for 30 years would improve the stock of soil organic carbon by **22%**.

INCREASING FERTILITY AND FUNCTIONAL QUALITY OF THE SOIL

According to the results of SUSTAINOLIVE

The application of sustainable management practices in olive groves can potentially increase the amount of nitrogen available to plants **by up to 30%**.

If the percentage of organic matter in an olive grove soil is raised **from 1 to 2.5%**, both total nitrogen and plant assimilable nitrogen (i.e., in the form of nitrates) contents can be doubled.

Recommended POLICY ACTIONS

- Establish an incentive system to reward olive farmers who demonstrate a **notable improvement** in soil properties linked to fertility (e.g. the percentage of organic matter)
- Promote the use of bio-based fertilizers, by boosting their production and distribution, so that their use becomes **more profitable**
- Encourage **active communication** between the academic sector and olive farmers to show how organic fertilization of olive groves is an economically viable alternative to chemical fertilizers
- Promote **participatory events** that popularize the use of cover crops in olive groves (e.g. photographic or painting contests)
- Produce easy-to-use **informative materials** that provide knowledge to olive farmers on the properties that define soil fertility
- Set up a **minimumn soil fertility and soil functional quality standards** that should be incorporated into any call for aid involving olive groves
- Improve the organization and coordination of the **R+D+I system** and the effectiveness of **transfer and advisory services**

REUSING NUTRIENTS AND PROMOTING A CIRCULAR OLIVE CULTIVATION

Increasing the levels of organic matter in the soil of olive groves implies that nutrients are retained, instead of being lost through surface runoff, leaching or erosion. Undoubtedly, maintaining a seeded or spontaneous herbaceous **cover crop** becomes crucial to achieve it.

The olive sector generates a **colossal amount of by-products** with high energy power that is **not being sufficiently valued**. For example, the `orujillo´ has a calorific value of 4200 kilocalories per dry kilogram.

According to our calculations

If the calorific value of the `orujillo´ produced in Andalusia during 2015 (around 913000 tons) were converted to equivalent liters of diesel, the 300 million European cars could travel 25 kilometers at a time. In other words, thanks to the energy stored in the Andalusian `orujillo´ for a year, **600000 cars could go around the world.**

Recommendations for OLIVE FARMERS

- Consider olive grove residues and by-products as **usable and profitable** raw materials
- Develop agronomic practices that improve the **levels of organic matter** in the surface soil
- Assess yield response to the application of fertilizers, avoiding routines or **non-specific fertilization calendars**
- Know the **real nutritional status** of the crop, identifying nutritional excesses and deficiencies through foliar and soil analysis, and nutrient balance
- Avoid the application of nitrogenous fertilizers in periods of **inactivity of the root system** (from November to January)
- If there is no other option but to use chemical fertilizers, know their fertilizing capacity and their **release and assimilability** features
- **Avoid burning** pruning remains (unless there are symptoms of infestation by pests, fungi or other pathogens), hedgerows and boundaries of riparian vegetation

REUSING NUTRIENTS AND PROMOTING A CIRCULAR OLIVE CULTIVATION

Recommended POLICY ACTIONS

- Accelerate the **administrative procedures** for the opening of facilities and equipments related to the recovery of waste and by-products from the olive oil sector
- Incentivize facilities and equipments related to recovery and **valorization of olive grove residues and by-products**, especially when they are used in nearby olive farms or imply `kilometer zero´
- Encourage and reward oil mills that install **olive mill pomace composting plants**
- Encourage olive farmers to use composted olive mill pomace and manure as **sources of organic fertilization**
- Encourage olive farmers to maintain a **minimum herbaceous cover** area (between 35 and 50% of the total farm area is suggested)
- Establish a structure that allows the **integral exploitation of olive pruning residues** (use of the olive branches remains for electricity generation and thermal uses, and the branches-leaves combination for composting)

According to results of SUSTAINOLIVE

The implementation of sustainable agronomic techniques not only reduces the application of external sources of nitrogen, but also halves the losses of this essential nutrient, since **the potential to recyle it efficientlly by appropiate management practices is huge: up to 3.5 times more** in comparison with conventional olive groves model.

Usually, the nutritional diagnosis is carried out **once a year during the month of July**, although it is recommended to run a second analysis once the harvest is finished; so farmers can know the possible deficits that harvesting might have caused in olive trees.

REDUCING SOIL EROSION

The greatest **wealth** of olive farmers is the **soil** of their farms.

The best strategy to guarantee that olive trees have an adequate stock of nutrients and water, and prevent the land from being severely affected by erosion, is to invest in soil conservation.

Recommendations for OLIVE FARMERS

- Maintain a spontaneous or seeded **cover crop**
- Plan auxiliary constructions to reduce **the traffic of vehicles** through the olive grove
- Adjust the design of the plantation to the **slope** of the land. Thus, agricultural tasks can be carried out following level curves
- Avoid any preparatory work when the soil is **waterlogged or snowy** (or when the weather forecast indicates a high probability of precipitation)
- Avoid the use of heavy machinery that can excessively **compact** the soil
- Avoid carrying out tillage with **soil turning** in the direction of the maximum slope
- Minimize **tillage**, making shallow tillage and limiting the number of tillage passes that, whenever possible, will follow a cross pattern. Give preference to **tine harrows** over disc ones

In the less sustainable experimental olive groves studied in SUSTAINOLIVE, an average of **16.6 kg of organic nitrogen** per hectare are lost each year due to soil erosion.

That would be equivalent to spending **€40** on 36 kilograms of crystalline urea and throwing it down the drain.

REDUCING SOIL EROSION

According to estimates of SUSTAINOLIVE

The economic losses associated with soil erosion in olive groves range **from €42 to €118 per hectare and year**, depending on the intensity of the erosive processes.

Recommended POLICY ACTIONS

- Pursue and punish harshly the impacts caused by the erosion of olive grove soils on **public infrastructures**
- Encourage the application of **corrective measures** with low environmental impact aimed at controlling erosive processes in olive groves that, in parallel, would help to enhance biodiversity:
  - Elimination or reduction of pre-existing **gullies** through non-impact technologies
  - Creation of **new natural boundaries** between farms
  - **Naturalization of spaces** on farms that, due to their orography or other conditions, are not suitable for cultivation
  - Implantation of **riparian vegetation** in watercourses, etc.
- Avoid **new authorizations** for planting olive groves on steep hillsides
- Promote **training actions** in olive cooperatives that educate and sensitize olive farmers in the development of agronomic practices that minimize or mitigate soil erosion

A **ton of soil** to replace erosion losses is currently valued at around **€55**.

When an olive grove loses 12 tons of soil per hectare and year, the cost of replacing it would amount to **€660 annually**.

OPTIMIZING CARBON ECONOMY

Contrary to popular belief, **not all olive groves behave as carbon sinks**. If no sustainable management practices are implemented such as those that imply enriching the soil with organic matter, olive grove soils can lose considerable amounts of organic carbon (in many cases as CO_2) and therefore, might have carbon balances.

It is true that providing the olive grove with a cover crop and patches of native vegetation does not translate into an immediate economic benefit (increased yield)...

...but it represents an excellent **investment for the future** by increasing the capital of carbon and nutrients available for further crops.

Recommendations for OLIVE FARMERS

- Optimize biomass production, especially by maintaining a spontaneous or planted **cover crop**, whose clearing is deposited on the soil
- Apply locally available **organic fertilizers** such as composted olive mill pomace or manure
- Avoid **burning tree pruning remains**. Instead, crush and deposit them on olive grove soils, especially in the inter-rows area where the effects of fertilizers do not usually reach
- **Apply intercropping** in the inter-rows area of olive groves. Aromatic plants for honey production are a good option
- Acquire awareness of the importance of **"carbon farming"** not only from a socio-environmental but also economic point of view
- Reduce the consumption of **external inputs** (fertilizers and pesticides)
- Reduce **machinery passes** and minimize **soil tillage**

OPTIMIZING CARBON ECONOMY

Recommended POLICY ACTIONS

- Establish an incentive system that rewards olive farmers whose farms behave as **net sinks** of atmospheric CO_2
- Establish a penalty procedure for olive farmers whose farms act as **net sources** of CO_2
- **Prohibit the burning** of olive pruning remains at any time of the year, unless visual symptoms of pests and diseases are detected
- Financially support the acquisition of **low-emission** agricultural machinery
- Encourage economically the use of **environmental friendly plant protection** products
- Encourage olive farmers to maintain a **minimum herbaceous cover** area (between 35 and 50% of the total farm area is suggested)

According to estimates of SUSTAINOLIVE

If all Andalusian olive farmers applied the sustainable management practices that are economically and technically feasible, **1.7 million tons of CO_2** would be retained in the soil more than is currently retained, which is equivalent to the CO_2 that would be emitted if all European cars circulated for 40 km.

If Andalusian farmers made the most of the different sources of organic matter available (cover crops, pruning remains, composted olive mill pomace, manure), the soils of the Andalusian olive groves could sequester an amount of CO_2 equivalent to 6.7% of emissions of this gas by the entire region of Andalusia during 2019.

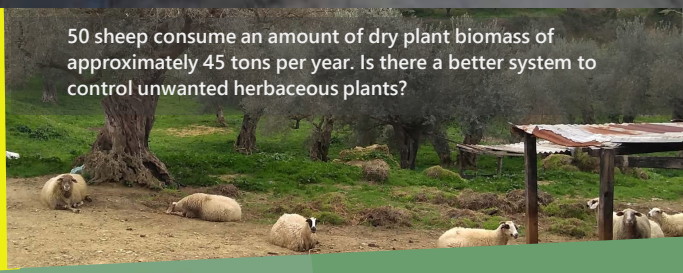
If the 2.5 million tons of tree pruning generated annually in the Andalusian olive groves were completely burned, the result would be the emission into the atmosphere of **4.22 million tons of CO_2**, which would be equivalent to 36% of CO_2 emissions of the entire Spanish agricultural, livestock and fishing sector in 2020.

REDUCING THE DEPENDENCE ON EXTERNAL INPUTS

One of the keys to the success of any company is the diversification of production. In the future, it is likely that olive groves will: i) be combined with other crops or aromatic plants resistant to drought, ii) have marketing lines for cosmetic products, iii) integrate livestock for milk and meat production, iv) organize guided tours and oleotourism events and/or v) reserve experimental plots (living labs) available for research, both private and public, with the purpose of improving their environmental and social legacy.

European legislation establishes **increasingly strict limitations** on intensive livestock systems.

The growing sensitivity of society for animal welfare together with the concern of consumers for health, make sustainable animal-based food a safe bet.



50 sheep consume an amount of dry plant biomass of approximately 45 tons per year. Is there a better system to control unwanted herbaceous plants?

Recommendations for OLIVE FARMERS

- Optimize **biomass production**, especially by maintaining a cover crop. If **legumes** are intercropped, protein of plant origin could be produced, very valuable to be included in the feed of an eventual livestock herd
- Avoid **burning tree pruning remains**. Instead, crush and deposit them on olive grove soils
- Apply **organic fertilizers** (composted olive mill pomace and manure)
- Intercropping by integrating **other crops** in the inter-rows area of olive groves. Aromatic plants for honey production are a good option
- Fertilize only when necessary, according to the results obtained by **foliar and soil analyses** (give the olive trees the amounts of nutrients and at the right time they need)
- Integrate **livestock** into olive groves (in addition to providing organic matter through droppings, it will help control the cover crop and give the possibility of marketing other food products such as milk, eggs or meat)

Since 2001, the Spanish authorities have withdrawn 665 plant protection products from the market (35% of those currently authorized).

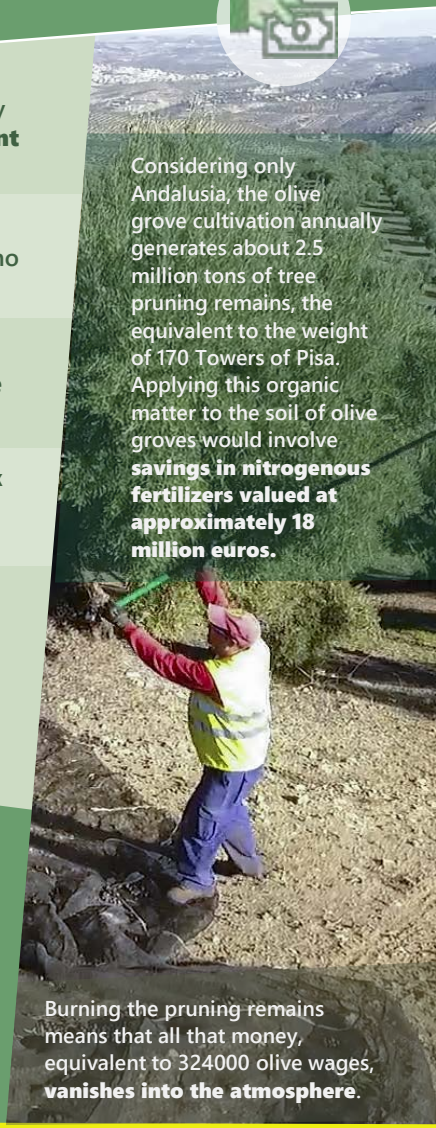
How should we interpret that only a few years after being authorized, an agrochemical product is withdrawn due to its effects on human health and/or the environment?

REDUCING THE DEPENDENCE ON EXTERNAL INPUTS

Recommended POLICY ACTIONS

- Encourage financially the use of locally available **organic fertilizers and plant protection** products
- Reward olive farmers who recirculate biomass from their olive groves and who use local **organic fertilizers**
- Encourage communication and the establishment of **synergies** among olive farmers and local livestock farmers
- Encourage the incorporation of **livestock** in olive groves, especially those involving protected autochthonous breeds
- Promote **training actions** that publicize the benefits and methods of implementation of **non-chemical alternatives** to conventional fertilization and plant protection products

Thanks to savings in nitrogenous fertilizer (average €11 per hectare), a group of neighboring farmers who gathered 20 hectares of olive groves could **amortize a shredder valued at €2300 in just 10 years.**



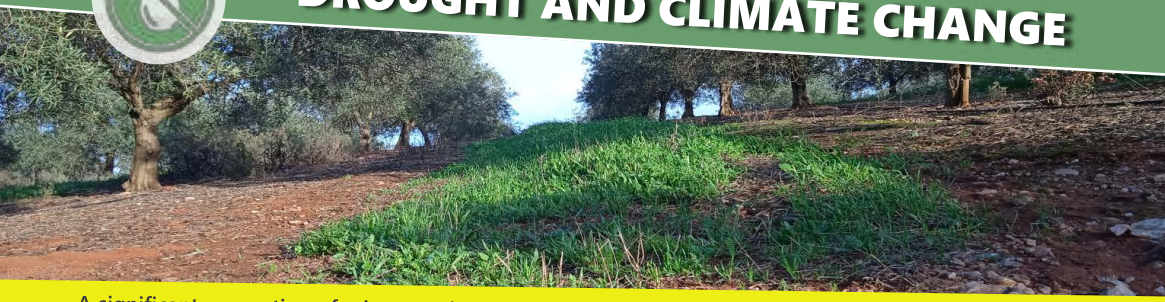
Considering only Andalusia, the olive grove cultivation annually generates about 2.5 million tons of tree pruning remains, the equivalent to the weight of 170 Towers of Pisa. Applying this organic matter to the soil of olive groves would involve **savings in nitrogenous fertilizers valued at approximately 18 million euros.**

Burning the pruning remains means that all that money, equivalent to 324000 olive wages, **vanishes into the atmosphere**.

According to estimates of SUSTAINOLIVE

Fungicides (mainly copper-based) constitute a family of plant protection products with high risk for the environment and human health, followed by herbicides and insecticides. The search of natural substitutes for copper is essential to reduce the impact of olive cultivation.

INCREASING RESISTANCE TO DROUGHT AND CLIMATE CHANGE



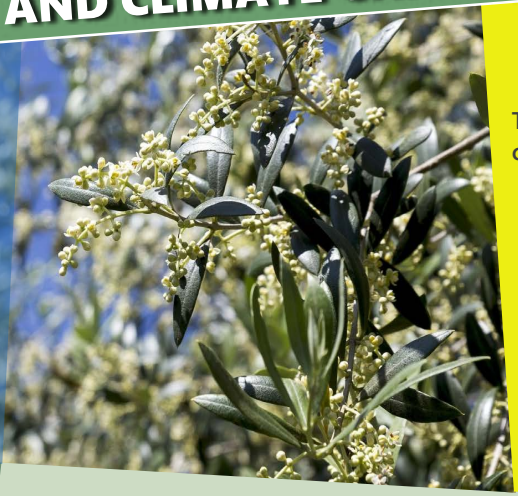
A significant proportion of rainwater that falls on olive groves is concentrated between autumn and early spring, a period of time in which biological activity of olive trees (thus, the need for water) decreases. The maintance of a **cover crop** as extensive as possible during these months is an excellent decision because it reduces water loss by surface runoff without implying, if it is properly controlled, a reduction in the amount of water available for olive trees.

Recommendations for OLIVE FARMERS

- Maintain a spontaneous or seeded **cover crop** and reduce soil tillage, at least until the end of March-beginning of April, depending on weather forecasts
- Apply a **rational fertilization** program, under technical advice
- Improve the **efficiency** of water supply and conduction systems, minimizing losses due to breaks in pipes and distribution channels
- Have irrigation water **control systems** (individual counters) that guarantee accurate information on the water flows actually used
- Improve **uniformity** in the application of irrigation (use of drip irrigation systems with proper maintenance)
- Employ controlled **deficit irrigation** strategies
- Optimize **irrigation schedules**, applying the amount of water appropriate at the most suitable time for cultivation
- Limit irrigation in the period **close to the olive harvest**
- In the case of new plantations, consider **climate forecasts** and maps of vulnerability to climate change
- Readjust **planting frames** to water availability predictions

INCREASING RESISTANCE TO DROUGHT AND CLIMATE CHANGE

When choosing early flowering varieties, high temperatures during oil accumulation can decrease the **amount of oleic acid** in the fruit, so it is advisable to choose varieties with a high content of such compound to mitigate this effect.



The roots of the cover crops contribute to retain the soil. The aerial part of the cover crops protects the soil from the impact of raindrops.
Both together prevent the loss of between 2 and 3 mm of superficial soil per year (**2-3 cm every 10 years**).

Recommended POLICY ACTIONS

- Harshly persecute and penalize olive farms that use **unauthorized sources** of water for irrigation
- Promote the use of **treated wastewater** for irrigation of olive groves, especially in sites with water shortage
- Promote the change toward **less water-demanding** or precision irrigation systems
- Limit **authorizations** for new olive grove plantations in areas with scarcity of water supply, especially in those considered most vulnerable to climate change
- **Combine olive varieties** with different levels of resistance to drought
- Allocate economic resources to the research of olive tree varieties **more resilient** to climate change
- Encourage the combination of olive trees with either shrub species with commercial value and adapted to **semi-arid conditions**, or short-cycle winter herbaceous plants
- Create **advisory programs for irrigators** that include training actions in cooperatives

INCREASING BIODIVERSITY

The greater the density of the **native vegetation patches** in an olive grove and surrounding areas, the greater the guarantee that biodiversity corridors will be created.

Thirteen species of **solitary bees** (they do not form hives) have been identified that nest in cavities on the soils of Andalusian olive groves. Therefore, they depend on the implementation of cover crops to survive.

Recommendations for OLIVE FARMERS

- Maintain **patches** of native vegetation
- Maintain a spontaneous or seeded **cover crop**
- **Shred tree pruning remains** and apply them on top of the soil
- Intercropping by integrating **other crops** in the inter-rows area of olive groves. Aromatic plants for honey productions are a good option
- Avoid the use of **pesticides**, especially broad-spectrum ones. In case there is no other option:
  - Reduce the number of **applications**, avoiding those of a "preventive" nature
  - Reduce the **dosage**
  - Select **less aggressive** products
- Read the **technical data sheets** and **labels** of agrochemical products and avoid those involving a negative impact on biodiversity

Any agronomic practice that contributes to create habitat (i.e., **shelter and food**) for the optimal development of the life cycle of natural enemies of pests can be considered as a "natural insecticide".

INCREASING BIODIVERSITY

According to some SUSTAINOLIVE estimates

By applying 6 liters per hectarea of glyphosate at 67.9 % in two times, the **human risk is multiplied by 7.5** compared to a 3 liters single application at 35 % of glyphosate.

Recommended POLICY ACTIONS

- Promote the heterogeneity of the landscape, especially **mosaics of native vegetation** that create corridors of biodiversity
- Promote communication between companies that produce **auxiliary fauna** and olive farmers
- Promote the **naturalization** of the surroundings of the planned **irrigation ponds**. Apart from boosting biodiversity, this leads to attractive habitats that promotes other leisure activities and rural tourism. For existing ponds, establish economic aid or free technical advice that allows naturalization, especially for those located in protected areas
- Require the presence of a minimum percentage of herbaceous **cover crop** in olive groves
- Promote and encourage the creation of a "**Network of olive groves for biodiversity**"
- Incentivize the installation of **support infrastructures** for nesting and refuge for fauna (ponds and drinking troughs, dry stone walls, nest boxes and posts, insect hotels...)
- Incentivize the application of certified organic plant protection products that do not generate socio-environmental **externalities**

During 2021, residues of **more than 100 pesticides** were detected in fresh foods marketed in Spain. Sixty per cent of these pesticides were capable of causing alterations in the human endocrine system and, therefore, in our reproductive capacity, even in very small doses.

CAPITALIZING SUSTAINABILITY

The growing **global awareness** about the climate crisis and the loss of biodiversity, especially in developed countries with greater per capita income, is pressing all economic sectors to make a transition towards a more sustainable production model.

Recommendations for OLIVE FARMERS

- Catch the attention of **demanding consumers** who reward responsibility and healthy nature of food they purchase
- Participate as partners or collaborators in national or international **research projects** that require experimental sustainable olive farms
- Offset the foreseeable decreased production by a high quality olive oil, therefore with a **higher price**
- Participate in **oleotourism** initiatives or even create a specific oleotourism department within the farm or at the cooperative level
- Participate in **voluntary carbon markets**

The 2023 CAP **conditionality** standards establish a series of good agricultural and environmental practices. Olive farmers will have no alternative but to implement more sustainable management methods if they want to receive the full economic subsidy.

According to results of SUSTAINOLIVE

If agriculture were included in the **CO_2 emissions market**, sustainable olive groves could expect an average annual income per hectare that would be €150 higher than that of olive groves that follow a conventional model.

ANDALUCÍA CAAE AGRICULTURA ECOLÓGICA

EVOO was the food product in the Spanish market that achieved the **highest market share** in 2016 for the "organic" category, with more than **6%**. Forecasts predict progressive growth.

CAPITALIZING SUSTAINABILITY

European consumers demand **healthy and eco-friendly food**, even more so as a result of the pandemic. The olive sector must not only exploit the health benefits of EVOO to open new market niches and consolidate existing ones, but must become aware that the application of sustainable management practices in the olive grove provides added value affecting positively the **farmer´s income**.

Recommended POLICY ACTIONS

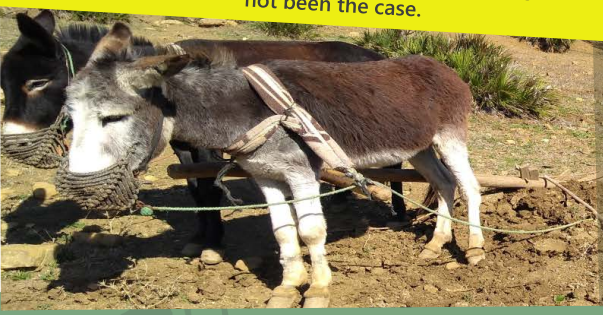
- Establish advantageous **tax mechanisms** for olive farmers who are committed to sustainable management practices, especially certified organic ones
- Create a **quality label** (similar to the energy efficiency scale) that awards olive farms according to a range of sustainable management practices, which could be reviewable at intervals of 3 to 5 years
- Create economic and tax incentives for the **internationalization** of small olive farmers who produce organically or wish to transit towards organic farming (e.g., through aid to hire advisory services or specialized staff)
- Announce **prizes** for the municipalities or cooperatives that most notably increase their area of organic olive cultivations (or subjected to other environmental quality certificates)
- Increase the number of **controls** to verify the application of the measures established in the CAP eco-schemes
- Increase information and promote technical and economic aid to those olive farmers who would like to transform traditional cultivation system to an organic one. Intensifying the supporting actions during the **first years** of conversion would be highly recommendable
- Articulate measures that encourage food markets to position sustainably produced food in **preferential places** on sales lines

It may be thought that modifying olive grove management routines in favor of sustainability is a **voluntary decision** resulting from the individual sensitivity of each farmer.

However, it will soon become a decisive stake of the **European Union**, which will support and reward those farmers who are committed to the transition towards a responsible agricultural model and which will penalize those who continue with the old unsustainable practices.

IMPROVING COMUNICATION STRATEGIES WITH OLIVE FARMERS AND SOCIETY

After decades of all kinds of presentations, talks, conferences and communication events, the educational community **should have obtained great results** regarding to the ecological transition of the agricultural sector in the Mediterranean basin. But this have not been the case.



It is time to **revolutionize the methodology** we use to communicate with farmers. Let's lose the fear of change and develop **original and motivating** tools and teaching methods that awaken farmers from the lethargy imposed by commercial brands and tradition.

Recommended POLICY ACTIONS

- Design and implement **environmental awareness programs** in the olive sector based on innovative, transgressive and participatory methodologies
- Promote **demonstrative studies** aimed at providing updated information to the farmer on the application of good environmental practices, with explicit references to productivity and profitability compared to conventional cultivation
- Create a **farmer service office** that provides information on organizations, training, subsidies and aid of interest related to the sustainability of olive farming
- Compile a **database platform with informative and didactic resources** (e.g., an URL or a mobile phone App) aimed at training in sustainable agroecological practices in the olive grove. Local organizations and entities (town halls, cooperatives, associations of integrated production, denominations of origin, etc.) should guarantee that farmers are aware of and have easy and fluent access
- Plan a **network of synergies** between olive farmers and universities, which allows both having a bank of experimental olive farms (**living labs**) and speeding up the flow of scientific knowledge to farmers
- Incentivize among local entities specific training actions in agroecology and environmental communication aimed at technicians responsible for the **institutional relationship** with the olive sector

IMPROVING COMUNICATION STRATEGIES WITH OLIVE FARMERS AND SOCIETY

Most farmers will **never** have the opportunity to receive rigorous scientific information on the harms caused by herbicides and pesticides on their health and the environment.

Institutions and educators are responsible for providing to farmers and society this information in an **accessible language** and through an original and **stimulating methodology.**

Environmental problems are **not yet a priority** for many olive farmers. If we limit our speech solely to environmental impacts, we will not succeed in capturing the attention of a sufficient representation of farmers. However, if we **link health and environment**, most olive farmers will be willing to listen.

Recommended POLICY ACTIONS

- Support olive **cooperatives** that implement training and awareness programs related to the ecological transition of olive grove cultivation (especially those that reach both producers and consumers)
- Incorporate into both formal and non-formal educational programs contents that deepen into **socio-environmental externalities** generated by the conventional olive cultivation model, as well as the benefits of sustainable olive groves on biodiversity, landscape and, above all, the health of farmers and consumers
- Promote **training activities** in olive oil producing municipalities that examine the differences between conventional and sustainable olive groves, with special emphasis on the benefits of the latter on biodiversity, landscape and the health of farmers and consumers
- Demand in any research project involving olive groves (regardless of the field or scope) the inclusion of a minimum package of **communication actions** that allow the results of the research to reach the actors of the olive sector (especially farmers) and society
- Promote workshops in **schools** from olive oil producing municipalities on the socio-environmental benefits of implementing sustainable management practices in olive groves

BE TRAINED, INFORMED, AND SKILLED

This year, Tomás will follow again the recommendations of the manufacturer of nitrogenous fertilizers (3 kg of fertilizer per olive tree), but he will select 3 groups of 9 olive trees each on which he will apply **smaller doses**. He will try to ensure that all the groups are homogeneous so that the only factor influencing olive production is the dose of fertilizer.

After harvesting, he will weigh the olives from the 3 groups of experimental olive trees and calculate the **average production** of each of them. Then, he will compare the yield with that obtained in nearby olive trees where the manufacturer's dose was applied. If things go well, the following Tomás' experiments will test the influence of the application of shredded remains of pruning and mainte-nance of cover crops on olive production.

Recommendations for OLIVE FARMERS

- Learn first-hand **examples** of other local olive farmers who apply sustainable management practices
- Participate actively in debate forums and training actions promoted by olive **cooperatives**
- Be wary of messages that come from untrustworthy or **compromised sources** (especially when commercial interests are involved)
- Participate in the wide range of online training and information events available related to agroecological approaches on olive farming, some linked to national and international **research projects**
- Acquire capacity in **sustainable agronomic techniques** for olive farming
- Let yourself be advised by **specialized technicians** with no conflicts of interest and, above all, by **researchers** in the sector
- Carry out simple **experimental tests** on the farm to take decisions about the most appropriate management practices

BE TRAINED, INFORMED, AND SKILLED

Recommended POLICY ACTIONS

- Promote olive farmers to receive **technical training** in olive grove sustainability (similar to that on handling plant protection products), organized into 3 levels: basic, intermediate and advanced. Link potential financial aid to the level reached
- Boost the role of olive cooperatives as a **uniting center** for training and information activities
- Promote training actions aimed at familiarizing olive farmers with the **scientific method** and learning to design their own field experiments (in order to test the impacts of applying sustainable management practices on their business)
- Encourage **synergies** between agricultural research centers and universities, and olive oil organizations and cooperatives, especially in terms of field experimentation and results analysis
- Include **specific topics on (self) experimentation** in olive farms within the programming of courses and university master´s degrees related to olive farming

One of the **main priorities of public institutions** must be to promote that the scientific findings collected by the academy are transferred without problems to society.

SUSTAIN OLIVE
PRIMA
Co-funded by the Horizon 2020 Framework Programme of the European Union
This project is part of the PRIMA programme supported by the European Union

It is time to stop perceiving the ecological transition of the olive sector only as a hard challenge. We are facing a great opportunity to transform olive cropping into a symbol of quality production and sustainability.

HOW TO CITE

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APPENDIX 3

THE WAY WE PRODUCE OUR FOOD. SOMETHING TO IMPROVE?

Key drivers of agriculture ecological footprint

Sustainable solutions for the olive grove sector

Key messages and recommendations

A booklet related to Deliverable 6.1. `Recommendations to overcome barriers for STS implementation´

SUSTAIN OLIVE

PRIMA

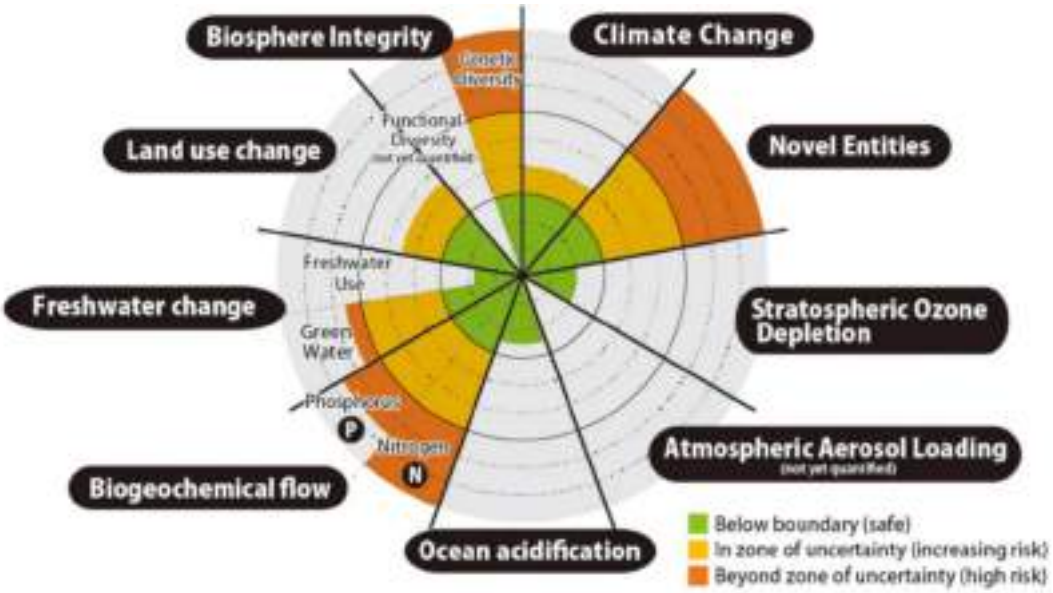
Co-funded by the Horizon 2020 Framework Programme of the European Union

This project is part of the PRIMA programme supported by the European Union

CURRENT STATUS OF PLANETARY BOUNDARIES

Five of the 9 planetary boundaries are in the high-risk zones, with agriculture being the main driver for four of them. The need for large-scale food production is an unquestionable fact, as is the need to move towards a more sustainable agricultural model.

Source: Azote for Stockholm Resilience Centre, based on analysis in Wang-Erlandsson et al 2022

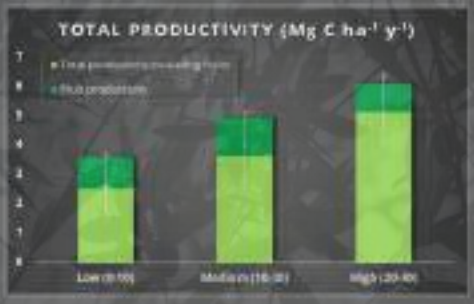


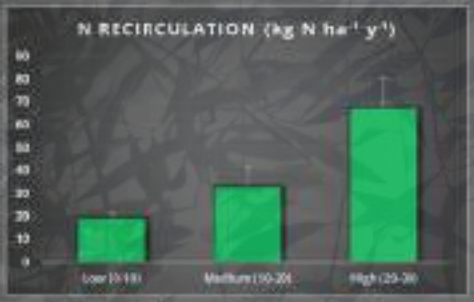
KEY DRIVERS OF AGRICULTURE ECOLOGICAL FOOTPRINT

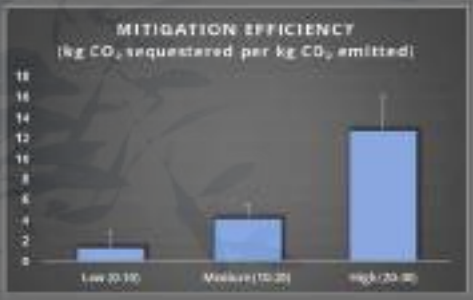
There is an urgent need for governments, farmers, local communities, NGOs and academics to work together to support effective local solutions involving an improvement in the olive grove sustainability, not only at the environmental but also social and economic.

The information collected and the research developed by the SUSTAINOLIVE project may help to clarify some of the key strategies and levers of change to definitively drive the transformation of the olive grove and olive oil sector.

sustainolive.eu







Nature-based solutions Index

The SUSTAINOLIVE project team has conclusively demonstrated how the implementation of a combination of eco-friendly technological solutions leads olive farms to competitive advantages.

SUSTAINABLE SOLUTIONS FOR THE OLIVE GROVE SECTOR

The overwhelming amount of scientific evidence compiled by SUSTAINOLIVE should be a compeling incentive for politicians to make decisions aimed to promote and foster the implementation of sustainable technological solutions in the olive cultivation. Ultimately, new guidelines on ecological transition of olive grove should be treated as a key priority across the Mediterranean olive grove sector.

Besides the research grounded in science, collaboration with social sectors involved in researching is crucial to making efficient decisions.

KEY MESSAGES AND RECOMMENDATIONS

At SUSTAINOLIVE, a number of participatory events (workshops and meetings) with all the stake-holders of olive oil sector allowed us to select the recommendations to overcoming the barriers that farmers face when implementing sustainable technological solutions.

To process the valuable information provided by stakeholders, multi-criteria methods were used. These methods support decisions based on a comparative assessment of alternative options, allowing us to identify the preference order into a policy recommendations list.

Stakeholders of the olive oil sector believe that among the most important policy actions to foster a sustainable agriculture are initiatives to...

1 ... carry out effective processes to communicate updated information on environmental and health impacts of intensive agriculture.

It is important to raise awareness on how our actions and activities produce impacts on the environment and how those also impact our health. The Paris Agreement recognizes the "right to health", and also the "social, economic and environmental value of voluntary mitigation actions and their co-benefits for adaptation, health and sustainable development".

2 ... accelerate the training and formation of farmers with courses on cover crop identification and implementation.

Cover crop is recognized as one of the most effective agronomic solutions to be implemented in olive cultivation. It improves soil organic matter content, prevents from soil erosion, reduces nutrient leaching, etc. How to manage cover crops should be a basic knowledge accessible to olive farmers.

Stakeholders of the olive oil sector believe that among the most important policy actions to foster a sustainable agriculture are initiatives to...

...invest in training courses for farmers on reusing/composting the by-products generated by olive groves.

3

A training program for organic composting would reduce the lack of specific skills of olive farmers on this issue. Regional and local governments are called to design **specific courses** to improve rural development under the European agriculture policy (CAP Pilar II).

...promote specialized training for advisor technicians on sustainable technological solutions.

4

Investing in **agricultural technician training** is an effective approach to sustainable agriculture. The know-how involving sustainable technological solutions would be carried out by universities, colleges and research centers specialized in applied agroecology.

...invest in communicating potential cost savings using sustainable technological solutions.

5

It is important to aware farmers on how sustainable agriculture can lead to **increased productivity and profitability** by reducing costly inputs (e.g. fertilizers and herbicides) and boosting a better use of renewable energy sources. Additionally, sustainable agriculture practices lead **to mitigate climate change** by sequestering carbon in the soil and reducing greenhouse gas emissions.

Stakeholders of the olive oil sector believe that among the most important policy actions to foster a sustainable agriculture are initiatives to...

6 ...arise awareness on farmers on the advantages of heterogeneous agroecosystems through specific target courses.

Under the climate change future scenarios, heterogeneity in agroecosystems will be beneficial to farmers as a low risk betting strategy. However, the policies for the adaptation to climate change need to include and favor the heterogeneous agroecosystems approaches and initiatives.

7 ...promote and protect cultural heritage of local ecological knowledge related to olive groves.

Knowledge on sustainable management of olive groves acquired by local communities over generations contributes to preserve and boost the provision of ecosystem services which, in turn, may assure the resilience of the socioecological system to disturbances.