



# Importance of different policy instruments in the introduction of sustainable innovation in fruit and vegetable value chains: The perception of coordinators of European research and innovation projects

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## ABSTRACT

The constant introduction of innovation along agri-food value chains is fundamental to increase their sustainability in environmental, economic and social terms and to allow the sector to contribute to sustainable rural development. Operating by means of financial, regulatory and informational instruments, public policies can play a central role in sustaining this process. However, not always all these instruments are perceived equally appropriate in this regard. The objective of this study is to explore the importance of the different policy instruments for the introduction of specific types of innovation and the improvement of specific dimensions of sustainability as perceived by 90 project coordinators retrieved on the platform of the European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI). The study shows that most of the analysed respondents – although belonging to different kinds of organisations (in terms of typology, provenience, area of work, etc.) – converge in recognising the financial instruments as the most important ones. On the contrary, educational and informational instruments, as for instance advisory/extension services and peer-to-peer initiatives, are largely seen as the ones most in need of a stronger public support. Most of the respondents, also demand reinforced public policies for improving the environmental dimension of sustainability and boosting technological innovations along agri-food value chains.

## 1. Introduction and objective

The constant introduction of innovation along agri-food value chains is fundamental to increase their sustainability in environmental, economic and social terms and to allow the sector to contribute to sustainable rural development (Anderson and Lent, 2019; OECD, 2019). The adoption of technological innovations – such as more efficient farming and processing techniques – can have important positive effects in terms of input use (i.e. increased environmental sustainability), costs saving (i.e. increased economic sustainability), and labour condition (i.e. increased social sustainability) (Cagliano et al., 2016; Piedra-Muñoz et al., 2016). Also the adoption of organisational innovations – such as new forms of collaboration among actors and logistic improvements – can positively impact value chain sustainability leading to reduced emissions along value chains, better distribution of the value generated, and creation of employment in areas otherwise marginalised (Mundler and Laughrea, 2016; Renner et al., 2008). Lastly, it should be also

recognised the positive effect triggered by introducing institutional innovations – a legitimate change in the cognitive, normative, or regulative rules of a social system (Cholez et al., 2021) – such as implementing new branding strategies (Di Fonzo et al., 2019) or employing new certifications (Howard and Allen, 2006). Adopting such innovations can enhance working conditions (both in terms of employee health and rights), reduce pressure on natural resources, as well as increase the final value of products (Chkanikova and Sroufe, 2021).

Acting by means of different types of instruments, public policies play a central role in boosting the adoption of innovation, especially with regard to sustainability (OECD, 2021). Subsidies and taxes, for instance, are recognised monetary policy instruments able to stimulate the adoption of innovation (Böcker and Finger, 2016; Nam et al., 2007). Also regulatory instruments can induce the development and uptake of innovation along value chains – such as in the case of fertilizer use, pesticides and circularity rules (Böcker et al., 2020). Lastly, it is also largely acknowledged the role played by public policies acting by means

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of educational and informational instruments. Training, advisory services, peer education, etc. are crucial in filling the skills/knowledge gap also allowing actors to become familiar with innovation, then encouraging its uptake (Charatsari et al., 2020; Dunne et al., 2019; EU SCAR, 2017; Flynn et al., 2013; Lans et al., 2004; Mayor et al., 2022; Sørensen et al., 2021; Trivellas et al., 2019).

Making agri-food chains more innovative and sustainable is the objective of numerous policies – sometimes even partly acting in contrast one with the other (Parsons and Hawkes, 2019). This is the case, just to mention one example, of the voluntary coupled support (pillar one of the Common Agricultural Policy) paid to sectors such as cotton and rice in Andalucía, Spain. The initiative, although contributing to strength the economic viability of such sectors, supports value chains driving the overexploit of water resources in regions vulnerable to drought thus potentially contributing to worse social conditions in such rural areas (European Commission et al., 2019). This is the reason why, when exploring such theme, it is crucial to gain the most all-encompassing view as possible, also embracing, when practicable, a comparative approach. To date, however, most of the literature focuses on the single effect of specific policy instruments impacting on the introduction of individual types of innovation or the improvement of individual dimensions of sustainability (Cholez et al., 2021). Looking at the adoption of technological innovations, for example, authors such as Barnes et al. (2019) and Foster and Rosenzweig (2010), focused on the sole role of monetary instruments (e.g. subsidies), recognising their positive effect, especially in encouraging and accelerating the uptake of precision agriculture technologies. Pierpaoli et al. (2013) and Tey and Brindal (2012) studied instead the specific impact of educational instruments, acknowledging that practitioners with higher education – but also the ones closer to consultants or with more access to information – were more likely to adopt new technologies. With regard to organisational innovations (such as participating in Interbranch or Producers Organisations), Hooks et al. (2018) and Martino et al. (2019) debated the relevance of EU regulations, recognising their current crucial importance in supporting horizontal and vertical collaborations along value chains. In relation to this type of innovations, further authors also explored the impact of educational instruments, underlying – in the specific case of short food supply chains – the importance of strengthening experience- and knowledge-sharing platforms (Chiffolleau and Dourian, 2020). Authors such as Shalley et al. (2015a,b) finally focused on the specific contribution of normative and regulatory instruments as principal lever to disseminate institutional innovations, as for instance in the case of designing better employment contracts. Looking instead at the improvement of the environmental sustainability, Nam et al. (2007), for instance, provided important reflections on potential drawbacks behind the sole employment of monetary instruments (e.g. input use taxes). Indeed, the authors rather suggested the use of a policy mix, encouraging also the employment of regulations and restrictions accompanied by public education programmes. Regarding the improvement of value chains in socio-economic terms, for example Renner et al. (2008) and Malak-Rawlikowska et al. (2019) focused on the importance of reinforced regulations for improving working conditions, and ensuring a fairer income distribution and bargaining power along value chains.

The objective of this study is therefore to assess the importance of the different mechanisms that typically compose the policy mix affecting the adoption of innovation along the agri-food chain. To do so, we surveyed coordinators of projects retrieved on the platform of the European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI) in light of their extensive experience in innovation along agri-food value chains. The study of their perspective is of primary importance for understanding which policy instruments are perceived as the most relevant for achieving specific objectives, as for instance improving individual facets of sustainability or sustaining the introduction of specific types of innovation along value chains. As in Gil et al. (2023), Kelly (2023), Podhora et al. (2013), and Zhovtonog et al. (2005), we chose to reach coordinators of projects as they are, in most of the cases, figures with a higher profile of knowledge and competences

compared to other participants involved in the projects. In addition, in our specific case of coordinators of projects participating in the EIP-AGRI, this choice was also instrumental in gaining a broader and comprehensive view potentially enclosing the perspective of other value chains' actors. After having collected information on their perception, we created clusters grouping the respondents with a similar view. Such clusters were then analysed to detect predominant characteristics in terms of respondent's typology, provenience, area of work, as well as other information related to the entities to which they belonged. Besides investigating the perceived importance of instruments currently in place, this study also explored the respondents' view in terms of needs for policy improvements. This aspect was also investigated by means of open questions. Lastly, we also tried to explore additional reasons behind the introduction of sustainable innovation along agri-food chains.

The main novelty of our work is to provide a comprehensive and comparative analysis of diverse types of policy instruments given the general focus of literature on their single impact on the introduction of individual types of innovations and the improvement of individual facets of sustainability. Moreover, the study explores the view of individuals participating in programmes less frequently investigated in literature. The perspective of participants involved in specific schemes such as Horizon 2020 and the Operational Groups is widely explored in the academic and grey literature – among the others Hermans et al. (2015), European Commission Directorate-General for Research and Innovation (2017), and Finco et al. (2018). Our study thus aims at gaining a new and broader understanding on the topic by also including the view of individuals involved in programmes such as – besides the ones already mentioned – the LIFE Programme, the European Regional Development Fund (ERDF) as well as other public (national and regional) research programmes. This allows to explore more widely the role of policies towards increasing the innovativeness and sustainability of agri-food chains in the context of rural areas.

The paper is organised into five sections in addition to this one. Section 2 illustrates the methodology, i.e. explains the rationale of the work, the structure of the questionnaire, how information was collected, and the analysis of data. Section 3 presents the results both referring to the whole sample and within the clusters. Section 4 provides the discussion and study limitations, while conclusions and policy recommendations are presented in Section 5.

## 2. Methodology

To study the perceived importance of different policy instruments, we designed a questionnaire. As a preliminary step, as in Reed et al. (2014), we interviewed different experts ( $n = 5$ ) to better frame the problem under investigation – in our case the relation between policies, innovation and sustainability in agri-food chains. Indeed, as also debated in Creswell and Plano Clark (2011) and Fischer (2000), the participatory design of a questionnaire, based on the inputs collected from a diversified sample of experts, is crucial to identify and formulate the most appropriate questions able to effectively explore a given topic. To gain a broader perspective, we chose experts from different countries (i.e., Italy, The Netherlands, Hungary and Spain) and belonging to different institutions both at national and regional level (i.e., regional ministry for agriculture, national union of small-scale farmers, regional crop research centre, national trade association, and national centre for technology and food safety) (see more details in Appendix A). The experts suggested to explore the perceived importance of each policy instrument with respect to each considered type of innovation and each dimension of sustainability, and then to compare them. Besides focusing on instruments currently in place, the experts also hinted at exploring respondents' view in terms of needs for policy improvements, and potential further reasons behind the introduction of innovation besides the role of public policies. Due to the potential risk of respondents' misunderstandings or low comprehension of some terminology at the basis

of the present study, the experts also underlined the importance of providing the clearest possible definition of the following terms: *financial policy instruments, regulatory policy instruments, informational and educational policy instruments, technical innovation, organizational (or managerial) innovation, institutional innovation, environmental sustainability, economical sustainability, and social sustainability*. Following their advice, a short glossary was developed and attached to the questionnaire (see more details at the bottom of page 4 of the questionnaire within the supplementary materials). Once distributed the questionnaire and collected the information, we first analysed them by means of descriptive statistics. Then, we grouped the respondents with a similar view employing a cluster analysis, to explore the presence of potential predominant characteristics within the clusters. This to see if different types of respondents would have diversely perceived the importance of the considered instruments in light to their specific characteristics and needs.

Elaborating the suggestions of the policy experts, we organised the questionnaire in the following sections (see more details in supplementary materials):

1. Information on the study;
2. Information on the respondent and on his/her organization (open and multiple choices questions);
3. Information on the project coordinated (open questions);
4. Perception of the importance of different policy instruments for the introduction of different types of innovation and for the improvement of different dimensions of sustainability (five-point Likert scale questions);
5. Perceived needs for improved policy instruments for better supporting the introduction of innovation and improving sustainability along fruit and vegetable value chains (five-point Likert scale and open questions);
6. General reasons driving the introduction of sustainable innovation along fruit and vegetable value chains (multiple choices question).

To collect the information, between January and February 2022, we sent the questionnaire to coordinators of projects retrieved on the platform of the European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI). The platform collects from all across the European Union projects boosting innovation in the agri-food sector to foster competitiveness and sustainability (European Commission Directorate-General for Agriculture and Rural Development, 2020). However, for better focus on the role of policies addressing multiple actors, we choose to select in particular projects referring to the fruit and vegetable sector. Fruit and vegetable value chains, usually include a larger number of different steps and, as a consequence, a wider variety of actors such as input suppliers, farmers, processors, traders, retailers, etc. In addition, the production of fruit and vegetables is also probably one of the agri-food sectors currently facing the largest number of challenges in the transition towards sustainability (water use, food losses, packaging, use of chemicals, just to mention a few) appearing then particularly exposed to continual innovation processes (Fruit Logistica, 2020). To select only projects dealing with fruit and vegetable products we set a query searching in the platform's fields "Title (in English)", "Objective of the project (in English)", "Description of activities (in English)" and "Keywords" the terms *apple, blueberry, citrus, fruit, grape, horticulture, leguminous, lemon, olive, pea, peach, potato, raspberry, soybean, strawberry, tomato, vineyard, viticulture, wine, coconut and vegetable*. Once obtained the sample of projects of our interest ( $n = 989$ ), we sent to the corresponding project coordinators the questionnaire by means of the platform *Qualtrics*. As 90 project coordinators satisfactorily completed the questionnaire, we reached an overall response rate of approximately 9 %.

After having explored the collected information by means of descriptive statistics, we grouped the respondents according to their preferences in terms of importance of the different policy instruments.

The clustering was operated employing the Ward's method (Ward, 1963) and, by the study of the scree plot and the dendrogram (see Appendix B and C), we derived the number of clusters. In the analysis of the order of preference of the different policy instruments (studied by means of five-point Likert questions) we tested the statistical significance of the observed differences employing the multivariate test of means (Johnson and Wichern, 2007). To assess the significance of the association between the clusters and the explored characteristics we employed the Chi-square test (Cochran, 1952). The clusters were explored to appreciate any potential predominant characteristics in terms of respondents' typology, provenience, area of work, as well as other information related to the entities of which they were part. Lastly, the open question related to the perceived need for improved policies was explored by means of a content analysis (Hsieh and Shannon, 2005; White and Marsh, 2006). First, we studied the textual content of the answers identifying six main themes in line with the aim of the question, three regarding the policy instruments addressed all across this study (i. e. more educational, informational and demonstrative initiatives; regulatory improvements; more funding and monetary resources) and three identified exploring the answers provided (i.e. increased marketability and added value for sustainable productions; increased cooperation and sharing of risks; increased administrative and accounting support). Then, we coded the text according to the six categories and we analysed the recurrence of the themes across the answers. All statistical analyses were performed through the statistical software package Stata/MP, version 12.0.

### 3. Results

#### 3.1. Sample characteristics

The project coordinated by the respondents were mainly funded by Sub-Measure 16.1 of the Rural Development Programme (RDP) – in the overall framework of the Operational Groups (OGs) (Table 1). Then, the second most important programme mentioned across the questionnaires was Horizon 2020 (Research and Innovation Actions, Multi-Actor Initiatives, and Thematic Networks). Some coordinators also reported the participation in the LIFE Programme (i.e. the European funding instrument for the environment and climate action). Further schemes were also mentioned across the questionnaires such as INTERREG, POP3 and other programmes sustained within the EAFRD (European Agricultural Fund for Rural Development) and the Horizon 2020 Programme. Lastly, although the vast majority of the reported frameworks were linked to the European Union, it also emerged that some respondents reported initiatives funded (or co-funded) by national, regional and provincial authorities.

Analysing the type of organization to which respondents belong, the sample appeared quite evenly distributed among individuals from NGOs, private service provider companies and civil society

**Table 1**  
Schemes that supported the project coordinated by the respondents.

Reference programme	Frequency
Operational Groups (RDP)	55
Horizon 2020	13
LIFE	3
INTERREG (ERDF)	3
EAFRD	3
POP3	2
PRIMA (H2020)	1
Bio-based Industries (H2020)	1
Provincial funds	1
National Ministry of Agriculture and Forestry	1
Regional water authority	1
Swissaid	1
No response	5
<b>Total</b>	<b>90</b>

organisations (39 %), public organisations, research institutes and universities (34 %), but also being themselves value chain actors (27 %) (Table 2). Most of the entities to which they are part are operating for more than ten years (84 %) and appear quite small, with less than ten employees (40 %). The majority of respondents declared to be from the South of Europe (58 %) while a smaller share was from Western (29 %) and North-Eastern Europe (13 %). Finally, in terms of geographical area of work, it emerges that most of the respondent's organisations operate on national (32 %), regional (27 %) or global scale (25 %). Only 15 % of them, instead, work exclusively within the European borders.

### 3.2. Opinion on policy and clusters characterization

Looking at the global sample preferences in terms of policy instruments, the respondents appeared in general mostly oriented towards monetary policy instruments, both for the introduction of innovation and the improvement of sustainability along value chains (Table 3). Two exceptions to this trend were observed: regulatory instruments were recognised as the most important instruments for sustaining the introduction of institutional innovation; informational instruments emerged as the most relevant instruments for improving the social sustainability along value chains. In both cases, however, the difference among the observed means was not statistically significant.

To better explore the association between respondents' characteristics and their preferences in terms of importance of different instruments, we grouped the ones with a similar view by means of a hierarchical cluster analysis (Ward, 1963). The study of the scree plot (see Appendix B), derived from the analysis of the individual perception of the importance of the three policy instruments with respect to the introduction of the three types of innovation and to the improvement of the three dimensions of sustainability (Table 3), suggested to identify two clusters. Before choosing to consider two clusters, however, we also

**Table 2**  
Characteristics of the respondents' organisations (n=90).

	Frequency <sup>a</sup>	%
<b>Type of organization</b>		
Value chain actor (including farmer, processor, trader, etc.)	24	27.27
Public organisation, research institute or university	30	34.09
Private service provider, NGO, civil society organisation	34	38.64
<b>Number of employees</b>		
Less than 10 employees	34	39.53
10 to 250 employees	30	34.88
More than 250 employees	22	25.58
<b>Geographical area in which sell products and provide services</b>		
Regional	24	27.27
National	28	31.82
European	14	15.91
Global	22	25.00
<b>Age of the organisation</b>		
1–10 years	14	15.91
More than 10 years	74	84.09
<b>European area of provenience<sup>b</sup></b>		
North-East	12	13.33
South	52	57.78
West	26	28.89
<b>Total</b>	<b>90</b>	<b>100.00</b>

<sup>a</sup> Differences in the total number of observations is due to the presence of missing values.

<sup>b</sup> According to the United Nations Statistics Division (1996): North-East Europe includes Denmark, Estonia, Finland, Latvia, Sweden, Hungary; South Europe includes Spain, Greece, Croatia, Italy, Portugal; West Europe includes Austria, Belgium, Germany, France, The Netherlands.

tested other options considering a larger number of clusters, namely, three, four and five clusters (see supplementary materials, Tables S1–S6). These options were explored to see if a larger number of clusters would have allowed to gain more internal coherence. Such analyses show that a larger number of clusters provide clusters that are less internally coherent in terms of policies' preferences (see supplementary materials, Tables S1, S3, S5). In addition, accounting for a larger number of clusters does not provide a statistically significant gain in terms of association between identified clusters and respondents' characteristics (e.g., type of organization, number of employees, European area of provenience, etc.) (see supplementary materials, Tables S2, S4, S6). Lastly, the analysis of the dendrogram (see Appendix C) allowed to assign each respondent to the corresponding cluster.

Cluster 1 (n = 28) appeared mostly oriented towards monetary and regulatory policy instruments. In this cluster, in particular, monetary instruments were significantly acknowledged as the most important instruments for improving the economical dimension of sustainability. Regulatory instruments, instead, were recognised as the most relevant instruments for supporting the introduction of organisational innovations along fruit and vegetable chains. Cluster 2 (n = 59) appeared instead significantly more inclined towards monetary instruments for supporting the introduction of organisational and technological innovations, while oriented towards informational instruments for the improvement of the social and environmental dimensions of sustainability. Regulatory policy instruments were instead significantly recognised as the least important by the respondents belonging to this cluster, especially when looking at the overall improvement of sustainability along value chains. Further differences were also observed among the means across the two clusters; however, they did not appear statistically significant.

Exploring the respondents' characteristics within the clusters, it only significantly emerged that in cluster 2 the majority of respondents belonged to entities mostly operating within their national borders (i.e., at regional or national scale). Respondents in cluster 1 appeared instead more evenly distributed between organisations operating at national and supranational scale (Table 4). Although appearing not statistically significant, it also emerged that in cluster 2 value chain actors were slightly less abundant, while no marked difference was observed in cluster 1. Respondents belonging to organisations with less than 250 employees appeared slightly more present in cluster 1. No remarkable prevalence was instead appreciated in cluster 2. Neither the age of the organisation nor the geographical area of provenience were able to notably characterize the two clusters. Both appeared predominantly composed by respondents belonging to entities from South of Europe and aged more than ten years.

### 3.3. Needs for improved policies and general reasons behind the introduction of innovation

Looking at the needs for improved policies to better support the introduction of innovation, nearly all the respondents recognised the monetary instruments as the ones most in need to be improved, while the regulatory instruments as the ones less in need (Table 5). An exception to this were the value chain actors, that considered the educational and informational instruments the ones less in need to be improved. Conversely, public organisations, research institutes and universities recognised instead this type of instruments as the ones most in need of further reinforcements.

To complement the analysis, the perceived needs for improved policies were also observed across the single countries of provenience of the respondents (Table A2, Appendix D). In most of cases, their preferences appeared in line with what observed at supranational level, except for respondents from Italy and France, that recognised the educational and informational instruments as the ones most in need of further improvements. It should be remarked, however, that, as the respondents in many countries were very few, the differences among the means were

**Table 3**

Perception of the importance of different policy instruments on the introduction of different types of innovation and for improving the three dimensions of sustainability along value chains. Mean values within clusters. Multivariate test of means. Means respectively significantly different with P-value \*\*\* = < 0.01; \*\* = < 0.05; \* = < 0.1.

	Cluster 1	P-value	Cluster 2	P-value	Total <sup>a</sup>	P-value
<b>Technological innovation</b>						
Financial instruments	4.46	0.591	4.22	0.000***	4.30	0.000***
Regulatory instruments	4.39		3.34		3.68	
Informational instruments	4.32		3.78		3.95	
<b>Organizational innovation</b>						
Financial instruments	4.18	0.099*	3.51	0.027**	3.73	0.175
Regulatory instruments	4.39		3.12		3.53	
Informational instruments	4.25		3.36		3.64	
<b>Institutional innovation</b>						
Financial instruments	4.32	0.940	2.95	0.150	3.39	0.193
Regulatory instruments	4.32		3.20		3.56	
Informational instruments	4.29		3.14		3.51	
<b>Environmental sustainability</b>						
Financial instruments	4.61	0.285	4.15	0.054*	4.31	0.030**
Regulatory instruments	4.50		3.93		4.11	
Informational instruments	4.46		4.17		4.26	
<b>Economic sustainability</b>						
Financial instruments	4.36	0.016**	3.86	0.002***	4.01	0.002***
Regulatory instruments	4.32		3.41		3.70	
Informational instruments	4.04		3.76		3.85	
<b>Social sustainability</b>						
Financial instruments	4.36	0.582	3.49	0.091*	3.76	0.162
Regulatory instruments	4.36		3.32		3.66	
Informational instruments	4.29		3.63		3.84	
<b>Number of respondents</b>	<b>28</b>		<b>59</b>		<b>87</b>	

Perception expressed in terms of importance: not important = 1, extremely important = 5.

<sup>a</sup> The difference of the number of observations from the total is due to the presence of missing values.

almost always not statistically significant.

The study of the answers to the open question allowed to further explore the respondents' view in this regard (Table 6). It should be taken

**Table 4**

Characteristics of the respondents' organisations across the clusters. Relative frequencies per column (%). The significance of the association between clusters and characteristics was assessed through Chi-square test with P-value \*\*\* = < 0.01; \*\* = < 0.05; \* = < 0.1; ns = no significant difference.

	Cluster 1	Cluster 2	P-value	
<b>Type of organization</b>				
Value chain actor	35.71	22.03	0.390	ns
Public organisation, research institute or university	28.57	37.29		
Private service provider, NGO, civil society organisation	35.71	40.68		
<b>Number of employees</b>				
Less than 10 employees	48.15	34.48	0.247	ns
10 to 250 employees	37.04	34.48		
More than 250 employees	14.81	31.03		
<b>Geographical area in which sell products and provide services</b>				
Regional	32.14	25.42	0.022	**
National	17.86	38.98		
European	7.14	18.64		
Global	42.86	16.95		
<b>Age of the organisation</b>				
1–10 years	7.14	18.64	0.160	ns
More than 10 years	92.86	81.36		
<b>European area of provenience</b>				
North-East	10.71	11.86	0.538	ns
South	67.86	55.93		
West	21.43	32.2		

into account that this examination is based on 47 replies only. The missing observations are due to the lack of answer or – to a little extent – to answers not included in the analysis as not matching the objective of the question. Although the respondents were free to report any desired topic, we found that the themes emerged in the answers were in large part aligned to what observed in other sections of the questionnaire. Most of the respondents encouraged the establishment of more educational, informational and demonstrative initiatives, followed by demanding improvements of the current regulations, and the provision of more monetary support. However, the analysis of the answers enabled also to appreciate new themes not previously emerged such as the request of reinforcing the cooperation among value chain actors, improving the marketability of sustainable products, and increasing the administrative and accounting support to facilitate the introduction of innovation.

Although the differences among the means were often very small, the sample generally recognised the technological innovations as the ones most in need of reinforced policy support (Table 7), followed by the organisational and the institutional ones (although such differences appeared statistically significant only when looking at cluster 2, entities aged more than ten years, and from the North-East of Europe). Only organisations working at European scale appeared significantly differently oriented, considering the organisational innovations as the ones less in need of improved policy support.

Lastly, the sample emerged fully aligned in recognising the environmental dimension of sustainability as the facet most in need of reinforced policy support, and the economic dimension as the one generally less in need (Table 8). However, some tiny difference to this trend were also observed. Cluster 2 considered the social dimension of sustainability the one less in need of enhanced support, like the value chain actors, the respondents belonging to organisations with more than ten employees and operating within the national borders. It is important

**Table 5**

Comprehensive need for improved policy instruments. Mean values across clusters and organisations' characteristics. Multivariate test of means. Means respectively significantly different with P-value \*\*\* = < 0.01; \*\* = < 0.05; \* = < 0.1; ns = no significant difference.

	Financial instruments	Regulatory instruments	Informational instruments	P-value	
<b>Clusters</b>					
1	4.46	4.32	4.39	0.685	ns
2	4.15	3.46	3.93	0.000	***
<b>Type of organization</b>					
Value chain actor	4.39	4.04	3.96	0.073	*
Public organisation, research institute or university	4.13	3.63	4.17	0.005	***
Private service provider, NGO, civil society organisation	4.26	3.62	4.09	0.001	***
<b>Number of employees</b>					
Less than 10 employees	4.42	3.82	4.15	0.000	***
10 to 250 employees	4.20	3.70	4.00	0.048	**
More than 250 employees	4.05	3.59	4.05	0.011	**
<b>Geographical area in which sell products and provide services</b>					
Regional	4.46	3.92	4.08	0.022	**
National	4.21	3.39	4.11	0.000	***
European	4.23	3.85	3.77	0.389	ns
Global	4.09	3.91	4.23	0.138	ns
<b>Age of the organisation</b>					
1–10 years	4.31	3.54	3.92	0.038	**
More than 10 years	4.24	3.77	4.11	0.000	***
<b>European area of provenience</b>					
North-East	4.40	4.00	4.00	0.037	**
South	4.23	3.83	4.17	0.006	***
West	4.24	3.44	3.92	0.002	***
<b>Total</b>	<b>4.25</b>	<b>3.74</b>	<b>4.08</b>	<b>0.000</b>	<b>***</b>

Need expressed in terms of importance: not important = 1, extremely important = 5.

to acknowledge, however, that such differences – although statistically significant – were in most of the cases very small.

The sample emerged fully aligned (both across all the characteristics and the two clusters) also when asked to state the importance of additional reasons behind the introduction of sustainable innovation. Although with different levels of intensity, all respondents expressed “improved efficiency and saving costs” as the most important reason for introducing innovation, followed by “responding to the consumer demand for sustainability” (Table 9). The “support of public policies” appeared instead the least important among the three alternatives.

#### 4. Discussion

The main objective of this work was to explore the perceived importance of different policy instruments for supporting the introduction of various types of innovations and improving the three dimensions of sustainability along fruit and vegetable value chains. In general, the study showed that in most of the cases respondents recognised the financial instruments as the most important instruments both for sustaining the introduction of innovation and improving value chains sustainability. As also observed by Barnes et al. (2019) and Foster and

**Table 6**

Needs for improved public policies for better supporting the introduction of innovation along fruit and vegetable value chains.

Themes emerged across the open questions	Examples of answers	Number of respondents addressing each theme <sup>a</sup>	%
More educational, informational and demonstrative initiatives (including advisory/consultancy services, network events, peer-to-peer trainings, pilot farms/projects, information exchanges, prototypes, learning ecosystems, extension services)	“To support more demonstration actions in innovative pilot farms as peer-to-peer initiatives have higher impact in the adoption of innovation by growers.”	18	48.65
Regulatory improvements (including standardization of rules across countries, better taxations, enhanced legislation for sustainability, supranational legislative frameworks, reduced/faster bureaucracy)	“There are a lot of regulatory rules in each country and they are different. New innovations should fight against this old rules.”	15	40.54
More funding and monetary resources (including financial support, economic incentives, funds for investments, subsidies)	“Innovation and ideas need to be tested in absence of economic risks. Institutional fundings should be close to 100 %. More projects with lower budget would allow more innovations to be tested.”	15	40.54
Increased marketability and added value for sustainable productions	“Increasing the marketability of sustainable chains of production.”	3	8.11
Increased cooperation and sharing of risks	“Sharing/taking the risks together. If we don't do that things will stay the same and we won't solve our (great) problems.”	2	5.41
Increased administrative and accounting support	“Support for innovation for SME with administrative processes.”	2	5.41
No answer		53	58.88

<sup>a</sup> It can be possible that one respondent addressed more than one theme in the answer.

**Table 7**

Need for overall improved policy instruments to better support the introduction of different types of innovation. Mean values across clusters and organisations' characteristics. Multivariate test of means. Means respectively significantly different with P-value \*\*\* = < 0.01; \*\* = < 0.05; \* = < 0.1; ns = no significant difference.

	Technological innovations	Organizational innovations	Institutional innovations	P-value	
<b>Clusters</b>					
1	4.29	4.32	4.29	0.899	ns
2	3.75	3.39	3.36	0.010	**
<b>Type of organization</b>					
Value chain actor	3.96	3.78	3.74	0.454	ns
Public organisation, research institute or university	4.10	3.77	3.67	0.111	ns
Private service provider, NGO, civil society organisation	3.74	3.56	3.59	0.452	ns
<b>Number of employees</b>					
Less than 10 employees	3.91	3.79	3.82	0.528	ns
10 to 250 employees	3.87	3.57	3.57	0.184	ns
More than 250 employees	4.00	3.77	3.59	0.500	ns
<b>Geographical area in which sell products and provide services</b>					
Regional	3.96	3.92	3.83	0.729	ns
National	3.89	3.50	3.46	0.117	ns
European	3.92	3.38	3.54	0.051	*
Global	3.91	3.86	3.77	0.584	ns
<b>Age of the organisation</b>					
1–10 years	3.54	3.62	3.85	0.631	ns
More than 10 years	3.99	3.70	3.62	0.008	***
<b>European area of provenience</b>					
North-East	4.20	3.70	3.50	0.074	*
South	3.94	3.83	3.83	0.505	ns
West	3.76	3.40	3.36	0.252	ns
<b>Total</b>	<b>3.92</b>	<b>3.69</b>	<b>3.66</b>	<b>0.035</b>	<b>**</b>

Need expressed in terms of importance: not important = 1, extremely important = 5.

Rosenzweig (2010), especially in case of a long payback period and uncertain profitability, the financial support is still largely seen as the principal lever to overcome the fear of undertaking innovative actions.

To more deeply analyse the respondents' preferences, we segmented the whole sample in clusters. This allowed us to analyse more in-depth the respondents' preferences, suggesting that "belonging to entities

**Table 8**

Need for overall improved policy instruments to enhance the three dimensions of sustainability. Mean values across clusters and organisations' characteristics. Multivariate test of means. Means respectively significantly different with P-value \*\*\* = < 0.01; \*\* = < 0.05; \* = < 0.1; ns = no significant difference.

	Environmental sustainability	Economic sustainability	Social sustainability	P-value	
<b>Clusters</b>					
1	4.43	4.21	4.39	0.142	ns
2	4.05	3.61	3.56	0.000	***
<b>Type of organization</b>					
Value chain actor	4.17	3.96	3.83	0.083	*
Public organisation, research institute or university	4.13	3.83	3.87	0.130	ns
Private service provider, NGO, civil society organisation	4.21	3.68	3.79	0.001	***
<b>Number of employees</b>					
Less than 10 employees	4.30	3.88	4.03	0.025	**
10 to 250 employees	4.03	3.67	3.60	0.004	***
More than 250 employees	4.18	3.86	3.82	0.120	ns
<b>Geographical area in which sell products and provide services</b>					
Regional	4.04	3.75	3.96	0.118	ns
National	4.21	3.86	3.71	0.011	**
European	4.00	3.62	3.69	0.077	*
Global	4.36	3.91	3.91	0.011	**
<b>Age of the organisation</b>					
1–10 years	4.31	3.77	3.92	0.237	ns
More than 10 years	4.15	3.81	3.81	0.000	***
<b>European area of provenience</b>					
North-East	4.10	4.00	3.90	0.656	ns
South	4.15	3.90	3.96	0.037	**
West	4.24	3.52	3.52	0.000	***
<b>Total</b>	<b>4.17</b>	<b>3.80</b>	<b>3.83</b>	<b>0.000</b>	<b>***</b>

Need expressed in terms of importance: not important = 1, extremely important = 5.

**Table 9**

Perception of general reasons driving the introduction of innovation along value chains. Mean values across clusters and organisations' characteristics. Multivariate test of means. Means respectively significantly different with P-value \*\*\* = < 0.01; \*\* = < 0.05; \* = < 0.1; ns = no significant difference.

	Improved efficiency and costs saving	Support of public policies	Consumer demand for sustainability	P-value	
<b>Clusters</b>					
1	2.50	1.46	2.04	0.001	***
2	2.53	1.42	2.05	0.000	***
<b>Type of organization</b>					
Value chain actor	2.70	1.35	1.96	0.000	***
Public organisation, research institute or university	2.50	1.43	2.07	0.001	***
Private service provider, NGO, civil society organisation	2.41	1.50	2.09	0.000	***
<b>Number of employees</b>					
Less than 10 employees	2.58	1.48	1.94	0.000	***
10 to 250 employees	2.43	1.30	2.27	0.000	***
More than 250 employees	2.55	1.55	1.91	0.010	**
<b>Geographical area in which sell products and provide services</b>					
Regional	2.38	1.54	2.08	0.009	***
National	2.61	1.39	2.00	0.000	***
European	2.54	1.23	2.23	0.001	***
Global	2.55	1.50	1.95	0.012	**
<b>Age of the organisation</b>					
1–10 years	2.62	1.31	2.08	0.001	***
More than 10 years	2.50	1.46	2.04	0.000	***
<b>European area of provenience</b>					
North-East	3.00	1.30	1.70	0.223	ns
South	2.54	1.33	2.13	0.000	***
West	2.28	1.72	2.00	0.215	ns
<b>Total</b>	<b>2.52</b>	<b>1.44</b>	<b>2.05</b>	<b>0.000</b>	<b>***</b>

Perception expressed in terms of importance: least important = 1, most important = 3.

selling products or providing services at supranational level" (i.e. European and global scale) was the most relevant characteristic associated to the different respondents' perception of the relevance of the specific instruments. Respondents being part of organisations more oriented towards international contexts seemed to especially recognise the importance of regulatory instruments for supporting the introduction of innovation, and the role of financial instruments for improving value chains sustainability. At the same time, they also appeared generally less confident in the role of educational and informational instruments. Conversely, respondents mostly operating at regional and national scale appeared instead to more markedly recognise the importance of educational instruments for improving sustainability along value chains, and the role of financial instruments for sustaining the uptake of innovation – but considering regulatory instrument overall the least relevant. As also highlighted by Karali et al. (2014), the dynamics ruling the agri-food sector are increasingly becoming global (e.g. input market, labour force, etc.). Hence, it is reasonable that respondents more exposed to international contexts would perceive the leading factors behind the diffusion of innovation in a different way than the respondents in large part working within their regional and national borders. Just to mention one example, Di Fonzo et al. (2019) analysed the case of Zespri – a New Zealand corporate commercializing kiwifruits at global level – that experienced an important innovation stimulus as a response to the entry into force of the *Plant Variety Protection Regulations*, especially in terms of technological (e.g. breeding improvements) and organizational innovation (e.g. value chain governance). As also observed by Chiffolleau and Dourian (2020) and Karali et al. (2014), entities operating more at local level (as for instance the ones participating in short food supply chains) seem instead to generally recognise informational and educational instruments (e.g. extension services, public trainings, etc.) as the most relevant lever to stimulate innovation and to enhance sustainability. It should be remarked, however, that to

unleash their full potential such initiatives should be offered as much as possible in the form of non-formal and informal learning activities – much quicker, more specific and providing faster results than formal education and training (Lans et al., 2004; Sūmane et al., 2018). On the top of everything, however, it should be noticed that also after having grouped the respondents on the basis of their preferences, the financial instruments stayed in large part the most preferred instrument among the two clusters, meaning that in most of the cases money are still seen as the principal means to overcome the fear of "taking new avenues". Other characteristics such as type of organization, number of employees, age of the organisation, and European area of provenience, were not significantly associated with none of the two clusters – in line also with a mixed effect frequently emerged in literature (Barnes et al., 2019; Finco et al., 2018; Flynn et al., 2013; Lans et al., 2004; Tey and Brindal, 2012).

The general higher preference for the financial instruments appeared also further remarked when respondents indicated such instruments as the ones most in need of being strengthened for better supporting the introduction of innovation and enhancing value chains sustainability. It should be noticed, however, that respondents belonging to public organisations, research institutes and universities perceive the educational and informational instruments as the ones most in need of reinforcements, while value chains actors considered such instruments as the ones overall less in need of further improvements. As also observed by Flynn et al. (2013), this preference appears quite reasonable given that respondents working in the field of research and education are not entrepreneurs, hence not directly experiencing the risk of making investments, and also because they "make their living" from providing educational and informational services. Continuing to analyse the type of measures perceived as most in need of further improvements, however, it should be also taken into account what emerged from the open questions – slightly different from what just observed. When asked to freely express their needs, "more educational, informational and demonstrative initiatives" (e.g. more advisory/consultancy services,

network events, peer-to-peer trainings, pilot farms/projects, information exchanges, prototypes, learning ecosystems, extension services) emerged as the policy improvement overall most demanded. This hints what also observed by Flynn et al. (2013): financial constraints not always represent the unique obstacle to the adoption of innovation, even if frequently neither the actors themselves are aware of that. After that, however, reinforced financial and regulatory instruments appeared also largely demanded. In the first case: incentives, funds for investments, and subsidies. In the second case: standardization of rules, better taxations, enhanced legislation, supranational legislative frameworks, and reduced/faster bureaucracy. It should be taken into account that this question was answered only by the 40 % of the sample. However, it still represented a key information for expanding the understanding of such a policy relevant issue. The study of this question allowed to observe themes otherwise not emerged in other sections of the questionnaire: the need for increased marketability and added value for sustainable productions, the need for improving the cooperation and the sharing of risks among actors, and the request for reinforced administrative and accounting support (especially for small and medium-sized enterprises, SMEs).

The study also showed that technological innovations were the type of innovation perceived as most in need of reinforced policy instruments. Implicitly, this information hints at the idea that non-technological innovations – and the measures aimed at their support – still attracts little consideration among actors, in spite of their amply recognised role in improving sustainability along agri-food value chains. This view could perhaps be grounded on the perceived lower upfront investments needed for implementing such forms of innovations, and also because they are somehow seen easier to be developed internally within the value chains. Authors such as Bavec et al. (2017), Charatsari et al. (2020), and Chiffolleau and Dourian (2020) underlined the major priority of better supporting the uptake of organisational innovations as for instance the implementation of innovative collective platforms, and the diffusion of short food supply chains. On the other hand, Hargrave and Van De Ven (2006) and Shalley et al. (2015a,b) stressed instead the great necessity of better supporting institutional innovations, such as implementing new branding strategies or employing new certifications. From this work it also emerged that the environmental sustainability of value chains seemed the dimension overall perceived as most in need of reinforced policy measures. However, strengthening instruments for improving the social dimension of sustainability seemed also highly acknowledged by large part of the sample. This high demand for increasing policy efforts for the socio-environmental sustainability of agri-food chains appeared also amply debated by Piedra-Muñoz et al. (2016) that remarked the major priority of intensifying these initiatives especially in the context of SMEs and family-owned activities. Another group of respondents (mostly composed by individuals belonging to medium and large-sized entities) considered a higher priority better supporting initiatives for improving the economic sustainability of value chains.

Finally, the last section of this work seemed to essentially support one of the main themes emerged all across this study: actors are principally concerned of being able to cope financially with undertaking innovative actions. The whole sample was fully aligned in considering the “improvement of efficiency and saving costs” as the leading reason for introducing innovation. Also in other works this explanation appeared among the main drivers behind such a decision – as for instance in the sample analysed by Barnes et al. (2019) – corroborating that saving money is in general one of the major hopes of innovation adopters (also for shortening the payback period and better coping with the risk of investment). The second reason for introducing innovation was instead “responding to the consumer demand for sustainability” – also in line with what recorded by Karali et al. (2014, p. 955) in its study: “responding to customer preferences (...) led to modifications in farm

management, such as switching to integrated production or organic farming”. Overall, what observed in our study thus suggested that for many actors the supportive role of public policies seems to not represent, at the moment, the main stimulus for introducing innovation, as other factors seem to play a more incisive role in orienting in this choice.

Some limitations of this study need to be acknowledged. First, it should be recognised that the overrepresentation of Southern Europe in the analysed sample can represent a potential limitation of this work. It should be acknowledged, however, that this coverage roughly reflects the distribution of EIP-AGRI projects across Europe – actually seeing Italy and Spain among the EU Member States hosting more projects (EU CAP NETWORK, 2025; European Commission Directorate-General for Agriculture and Rural Development, 2020). The decision to allocate more or fewer resources for establishing EIP-AGRI projects is almost completely in the hands of the Member States, according to their national strategic orientations for reinforcing specific facets of the agri-food sector. Given the focus of this project on fruit and vegetable value chains, the result of this strategic orientation can be therefore also recognised in the larger number of projects established in Southern Europe, compared to Western and especially North-Eastern Europe. However, we recognise that this overrepresentation, although reflecting the current picture of the projects’ distribution across Europe, could have potentially provided a slightly polarised view of the issue under study. For this reason, future research should improve the sample stratification across Member States to increase the generalisability of the findings across Europe. Second, we should provide a remark on the sample composition. In order to comprehend the impact of policies in making fruit and vegetable value chains more innovative and sustainable, we chose to reach coordinators of projects retrieved on the platform of the European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI). This choice was taken in light of the great opportunity offered by the EIP-AGRI platform to collect from all across Europe stakeholders closely involved in innovation and sustainability processes along agri-food chains. This enabled us to gain the perspective of respondents as the value chains actors (e.g., farmers, processors, etc.), but also the view of stakeholders not belonging, in the narrow sense, to value chains – e.g., stakeholders from civil society organisations, NGOs and also researchers and scholars. In our opinion, we believe that this choice helped the study to reach more effectively its objective by gaining an additional view of stakeholders dealing at first hand with innovation and sustainability, thus allowing to complement what gained from the perspective of value chain’s actors. However, future developments of the study should improve the sample composition also in terms of respondents’ representativeness, to account more for the value chain actors’ perspective.

## 5. Conclusions and policy recommendations

The objective of this research was to study from the perspective of coordinators of projects retrieved on the European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI) the perception of the importance of diverse policy instruments (i.e., financial, regulatory, and educational) for supporting the introduction of innovation along agri-food value chains and improving their sustainability. In general, financial instruments (e.g., subsidies, tax reduction) appeared the instruments recognised as most relevant across the whole sample, almost regardless of the type of respondent considered. The only characteristic that seemed to slightly differently orient the respondents’ preferences was belonging to entities more or less exposed to international contexts. Indeed, respondents that are part of organisations working (or providing services) at global level appeared more inclined to recognise, besides the role of the financial instruments, also the

relevance of the regulatory instruments. Conversely, respondents mostly operating within their national borders seemed instead to acknowledge, together with the importance of the financial instruments, also the relevance of educational and informational initiatives. This evidence can represent a valuable contribution also in terms of policy recommendations, especially in the framework of the EU Common Agricultural Policy that is reaching the core of its implementation period 2023-27. Observing, for example, that respondents mostly operating at local scale perceive educational and informational instruments as more relevant suggests the importance of strengthening the AKIS (Agricultural Knowledge and Innovation Systems) strategy, that lays its basis on the synergy of advisors, disseminators, researchers, etc. for promoting a better generation, share and use of the agriculture related knowledge. Actually, more advisory/consultancy services, network events, peer-to-peer trainings, information exchanges, extension services, etc. emerged also among the initiatives more demanded when asked to openly express the perceived needs for policy improvements, a sign that stakeholders are aware that the adoption of innovation is not exclusively hampered by financial factors. In addition, evidences from the current research can also suggest the consolidation of the LEADER (Liaison Entre Actions de Développement de l'Économie Rurale), the local development approach based on the engagement of local actors in the decision-making and resource allocation for the development of rural areas. Indeed, one of the pillars of this approach is bringing actors together for developing peer support, knowledge sharing, capacity building, and, last but not least, to overcome isolation in rural areas.

Despite the crucial role that they play in promoting sustainability along agri-food value chains, the study showed that non-technological innovations (i.e., organisational and institutional) are still seen as less relevant than the technological ones, and the initiatives aimed at their support consequently less a priority. The environmental dimension of sustainability instead appeared acknowledged by any type of respondent as the dimension most in need of reinforced public support. This evidence suggests another important policy reflection. Strategies at the core of the European agricultural policy making, such as for example the Farm to Fork Strategy – largely focusing on the centrality of the role of each value chain actor – seem to have not yet succeeded in bringing sufficient awareness (especially among practitioners) on the importance of pursuing other avenues than solely focusing on technological innovations and environmental sustainability to attain better agri-food value chains. As also emerged in some open answer, public policies should therefore put greater emphasis in communicating the importance of improving value chains also in organisational terms (e.g., strengthening the cooperation among actors – also to cope better with risks) encouraging also institutional innovations (e.g., simplified administrative processes for SME). In addition, recognising the relevance of pursuing more sustainable value chains also in economic and social terms would support strategies at the hearth of the

European policy agenda such as the European Green Deal, closely linked to the prosperity of the agri-food sector.

To better put in context the discussion above, however, this study also showed that, overall, the sample perceived the improved efficiency and saving costs as the principal reason behind the choice of undertaking innovative actions, followed by responding to the consumer demand for sustainability. This suggests that, from the perspective of the analysed sample, the current public policies appear to not represent a primary lever for encouraging the adoption of innovation along agri-food value chains, as other factors seem to actually play a more incisive role in orienting this choice. This points at the need to carefully consider policy action in the context of other drivers, and to design policy instruments as appropriate.

Overall, the results of the study show the need to address the policy mix as a whole, with two main motivations: a) having a variety of instruments that can actually fit the needs of different actors and different types of innovation; b) ensuring complementarity between different components of public policy. In this respect, internal consistency between different CAP measures (in particular financial support to modernisations, cooperation measures and AKIS) is key for the future of innovation in agriculture. Also, consistency between CAP and non-CAP measure (e.g. trade and environmental regulation) is a key point of attention.

#### CRedit authorship contribution statement

**Riccardo Borgia:** Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Matteo Zavalloni:** Writing – review & editing, Supervision, Methodology, Investigation, Conceptualization. **Davide Viaggi:** Writing – review & editing, Supervision, Methodology, Conceptualization.

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#### Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Riccardo Borgia reports financial support was provided by Horizon (2020). If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Appendix A

**Table A1**

List of the organisations of the interviewed policy experts.

Organisation	Country	Contact
Regional Ministry for Agriculture, Hunting and Fishing	Italy	<a href="https://agricoltura.regione.emilia-romagna.it">https://agricoltura.regione.emilia-romagna.it</a>
Fresh Produce Centre	The Netherlands	<a href="https://freshproducecentre.com">https://freshproducecentre.com</a>
Kislépték - National Union for Representing the Interests of Small-scale Farmers	Hungary	<a href="http://www.kisleptek.hu">http://www.kisleptek.hu</a>
CRPV - Centro Ricerche Produzioni Vegetali	Italy	<a href="http://www.crpv.it">http://www.crpv.it</a>
CNTA - Centro Nacional de Tecnología y Seguridad Alimentaria	Spain	<a href="https://www.cnta.es/en/">https://www.cnta.es/en/</a>

Appendix B

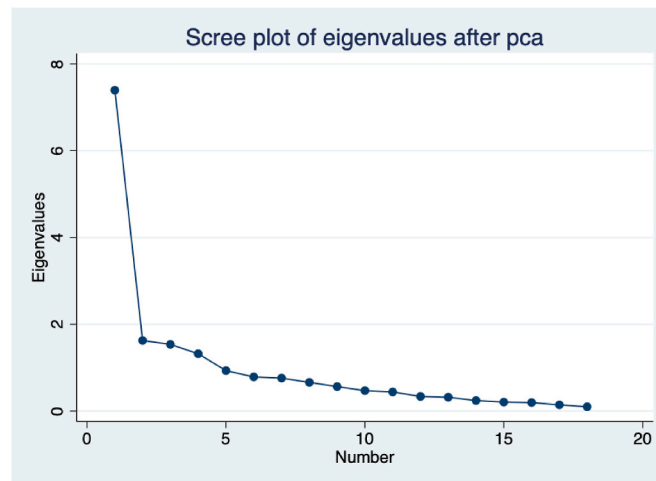


Fig. A1. Scree plot of eigenvalues after principal component analysis.

Appendix C

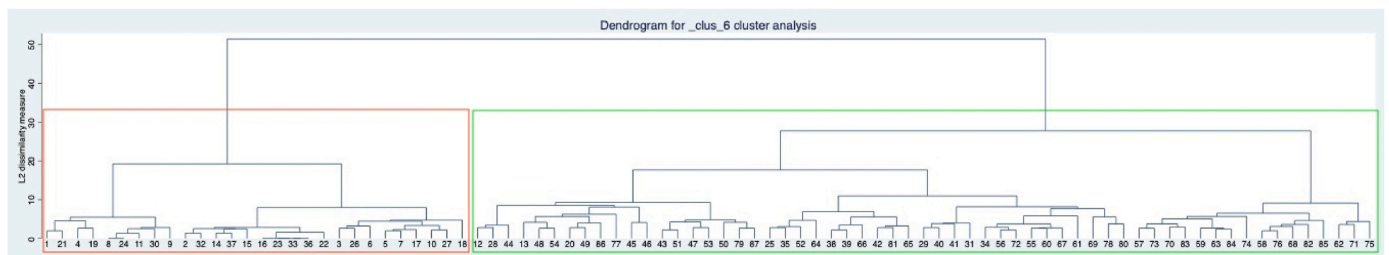


Fig. A2. Dendrogram showing the respondents collocation in the clusters.

Appendix D

Table A2

Comprehensive need for improved policy instruments. Mean values across respondents' countries of provenience. Multivariate test of means. Means respectively significantly different with P-value \*\*\* = < 0.01; \*\* = < 0.05; \* = < 0.1; ns = no significant difference; na = not applicable.

Country of provenience	Frequency	%	Financial instruments	Regulatory instruments	Informational instruments	P-value
<b>North-East</b>	<b>12</b>	<b>13.33</b>	<b>4.40</b>	<b>4.00</b>	<b>4.00</b>	<b>0.037 **</b>
Denmark	1	1.11	5.00	5.00	5.00	na
Estonia	1	1.11	4.00	4.00	4.00	na
Latvia	1	1.11	4.00	4.00	4.00	na
Finland	1	1.11	4.00	3.00	3.00	na
Sweden	6	6.67	4.40	4.00	4.00	0.177 ns
Hungary	2	2.22	5.00	4.00	4.00	na
<b>South</b>	<b>52</b>	<b>57.78</b>	<b>4.23</b>	<b>3.83</b>	<b>4.17</b>	<b>0.006 ***</b>
Greece	2	2.22	4.50	4.50	4.50	na
Portugal	7	7.78	4.29	4.00	4.57	0.120 ns
Croatia	2	2.22	5.00	4.00	4.50	0.500 ns
Italy	19	21.11	4.11	3.53	4.11	0.015 **
Spain	22	24.44	4.23	3.95	4.05	0.552 ns
<b>West</b>	<b>26</b>	<b>28.89</b>	<b>4.24</b>	<b>3.44</b>	<b>3.92</b>	<b>0.002 ***</b>
Austria	2	2.22	4.00	4.00	3.00	na
Belgium	1	1.11	5.00	2.00	5.00	na

(continued on next page)

**Table A2** (continued)

Country of provenience	Frequency	%	Financial instruments	Regulatory instruments	Informational instruments	P-value
Germany	7	7.78	4.71	3.86	3.86	0.007 **
France	8	8.89	3.88	3.13	4.00	0.093 *
The Netherlands	8	8.89	4.13	3.50	3.88	0.184 ns
<b>Total</b>	<b>90</b>	<b>100.00</b>	<b>4.25</b>	<b>3.74</b>	<b>4.08</b>	<b>0.000 ***</b>

Need expressed in terms of importance: not important = 1, extremely important = 5.

**Table A3**

Need for overall improved policy instruments to better support the introduction of different types of innovation. Mean values across respondents' countries of provenience. Multivariate test of means. Means respectively significantly different with P-value \*\*\* = < 0.01; \*\* = < 0.05; \* = < 0.1; ns = no significant difference; na = not applicable.

Country of provenience	Frequency	%	Technological innovations	Organizational innovations	Institutional innovations	P-value
<b>North-East</b>	<b>12</b>	<b>13.33</b>	<b>4.20</b>	<b>3.70</b>	<b>3.50</b>	<b>0.074 *</b>
Denmark	1	1.11	5.00	3.00	3.00	na
Estonia	1	1.11	4.00	3.00	3.00	na
Latvia	1	1.11	3.00	3.00	3.00	na
Finland	1	1.11	5.00	5.00	4.00	na
Sweden	6	6.67	4.00	4.00	3.80	0.373 ns
Hungary	2	2.22	5.00	3.00	3.00	na
<b>South</b>	<b>52</b>	<b>57.78</b>	<b>3.94</b>	<b>3.83</b>	<b>3.83</b>	<b>0.505 ns</b>
Greece	2	2.22	4.50	4.50	4.50	na
Portugal	7	7.78	4.43	4.29	4.00	0.264 ns
Croatia	2	2.22	4.00	4.00	5.00	0.500 ns
Italy	19	21.11	3.79	3.79	3.68	0.599 ns
Spain	22	24.44	3.86	3.64	3.73	0.335 ns
<b>West</b>	<b>26</b>	<b>28.89</b>	<b>3.76</b>	<b>3.40</b>	<b>3.36</b>	<b>0.252 ns</b>
Austria	2	2.22	4.00	4.00	4.00	na
Belgium	1	1.11	5.00	3.00	3.00	na
Germany	7	7.78	4.00	3.57	3.57	0.199 ns
France	8	8.89	3.75	3.38	3.25	0.561 ns
The Netherlands	8	8.89	3.38	3.25	3.25	0.957 ns
<b>Total</b>	<b>90</b>	<b>100.00</b>	<b>3.92</b>	<b>3.69</b>	<b>3.66</b>	<b>0.035 **</b>

Need expressed in terms of importance: not important = 1, extremely important = 5.

**Table A4**

Need for overall improved policy instruments to enhance the three dimensions of sustainability. Mean values across respondents' countries of provenience. Multivariate test of means. Means respectively significantly different with P-value \*\*\* = < 0.01; \*\* = < 0.05; \* = < 0.1; ns = no significant difference; na = not applicable.

Country of provenience	Frequency	%	Environmental sustainability	Economic sustainability	Social sustainability	P-value
<b>North-East</b>	<b>12</b>	<b>13.33</b>	<b>4.10</b>	<b>4.00</b>	<b>3.90</b>	<b>0.656 ns</b>
Denmark	1	1.11	5.00	5.00	4.00	na
Estonia	1	1.11	4.00	3.00	3.00	na
Latvia	1	1.11	3.00	3.00	2.00	na
Finland	1	1.11	4.00	3.00	4.00	na
Sweden	6	6.67	4.00	4.20	4.20	0.373 ns
Hungary	2	2.22	5.00	5.00	5.00	na
<b>South</b>	<b>52</b>	<b>57.78</b>	<b>4.15</b>	<b>3.90</b>	<b>3.96</b>	<b>0.037 **</b>
Greece	2	2.22	4.50	4.50	4.50	na
Portugal	7	7.78	4.57	4.57	4.57	1.000 ns
Croatia	2	2.22	4.50	3.00	4.00	0.500 ns
Italy	19	21.11	4.05	3.84	3.84	0.428 ns
Spain	22	24.44	4.05	3.77	3.82	0.041 **
<b>West</b>	<b>26</b>	<b>28.89</b>	<b>4.24</b>	<b>3.52</b>	<b>3.52</b>	<b>0.000 ***</b>
Austria	2	2.22	4.00	3.00	4.00	na
Belgium	1	1.11	4.00	4.00	4.00	na
Germany	7	7.78	4.43	3.71	3.86	0.159 ns
France	8	8.89	4.38	3.50	3.50	0.045 **
The Netherlands	8	8.89	4.00	3.38	3.13	0.143 ns
<b>Total</b>	<b>90</b>	<b>100.00</b>	<b>4.17</b>	<b>3.80</b>	<b>3.83</b>	<b>0.000 ***</b>

Need expressed in terms of importance: not important = 1, extremely important = 5.

**Table A5**

Perception of general reasons driving the introduction of innovation along value chains. Mean values across respondents' countries of provenience. Multivariate test of means. Means respectively significantly different with P-value \*\*\* = < 0.01; \*\* = < 0.05; \* = < 0.1; na = not applicable.

Country of provenience	Frequency	%	Improved efficiency and costs saving	Support of public policies	Consumer demand for sustainability	P-value
<b>North-East</b>	<b>12</b>	<b>13.33</b>	<b>3.00</b>	<b>1.30</b>	<b>1.70</b>	<b>0.223 ns</b>
Denmark	1	1.11	3.00	1.00	2.00	na
Estonia	1	1.11	3.00	1.00	2.00	na
Latvia	1	1.11	3.00	1.00	2.00	na
Finland	1	1.11	3.00	2.00	1.00	na
Sweden	6	6.67	3.00	1.40	1.60	0.704 ns
Hungary	2	2.22	3.00	1.00	2.00	na
<b>South</b>	<b>52</b>	<b>57.78</b>	<b>2.54</b>	<b>1.33</b>	<b>2.13</b>	<b>0.000 ***</b>
Greece	2	2.22	3.00	1.00	2.00	na
Portugal	7	7.78	2.86	1.14	2.00	0.001 **
Croatia	2	2.22	2.50	1.00	2.50	1.000 ns
Italy	19	21.11	2.53	1.47	2.00	0.002 **
Spain	22	24.44	2.41	1.32	2.27	0.000 ***
<b>West</b>	<b>26</b>	<b>28.89</b>	<b>2.28</b>	<b>1.72</b>	<b>2.00</b>	<b>0.215 ns</b>
Austria	2	2.22	3.00	1.00	2.00	na
Belgium	1	1.11	2.00	1.00	3.00	na
Germany	7	7.78	2.14	1.86	2.00	0.913 ns
France	8	8.89	2.75	1.50	1.75	0.072 *
The Netherlands	8	8.89	1.88	2.00	2.13	0.923 ns
<b>Total</b>	<b>90</b>	<b>100.00</b>	<b>2.52</b>	<b>1.44</b>	<b>2.05</b>	<b>0.000 ***</b>

Need expressed in terms of importance: not important = 1, extremely important = 5.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jrurstud.2025.103695>.

## Data availability

The data that support the findings of this study will be deposited in a public open data repository and will be made openly accessible according to the Data Management Plan of the CO-FRESH project

## References

- Anderson, A.R., Lent, M.D., 2019. Enterprising the rural; creating a social value chain. *J. Rural Stud.* 70, 96–103. <https://doi.org/10.1016/j.jrurstud.2017.08.020>.
- Barnes, A.P., Soto, I., Eory, V., Beck, B., Balafoutis, A., Sánchez, B., Vangeyte, J., Fountas, S., van der Wal, T., Gómez-Barbero, M., 2019. Exploring the adoption of precision agricultural technologies: a cross regional study of EU farmers. *Land Use Policy* 80, 163–174. <https://doi.org/10.1016/j.landusepol.2018.10.004>.
- Bavec, S., Bouroullec, M.D.M., Raynaud, E., 2017. Analysis of short food supply chain governance: innovative collective platforms supplying local produce. <https://doi.org/10.22004/ag.econ.258169>.
- Böcker, T., Finger, R., 2016. European pesticide tax schemes in comparison: an analysis of experiences and developments. *Sustainability* 8, 378. <https://doi.org/10.3390/su8040378>.
- Böcker, T., Britz, W., Möhring, N., Finger, R., 2020. An economic and environmental assessment of a glyphosate ban for the example of maize production. *Eur. Rev. Agric. Econ.* 47, 371–402. <https://doi.org/10.1093/erae/jby050>.
- Cagliano, R., Worley, C.G., Caniato, F.F.A., 2016. The challenge of sustainable innovation in agri-food supply chains. In: *Organizing Supply Chain Processes for Sustainable Innovation in the Agri-Food Industry, Organizing for Sustainable Effectiveness*. Emerald Group Publishing Limited, pp. 1–30. <https://doi.org/10.1108/S2045-06052016000005009>.
- Charatsari, C., Kitsios, F., Lioutas, E.D., 2020. Short food supply chains: the link between participation and farmers' competencies. *Renew. Agric. Food Syst.* 35, 643–652. <https://doi.org/10.1017/S1742170519000309>.
- Chiffolleau, Y., Dourian, T., 2020. Sustainable food supply chains: is shortening the answer? A literature review for a research and innovation agenda. *Sustainability* 12, 9831. <https://doi.org/10.3390/su12239831>.
- Chkanikova, O., Sroufe, R., 2021. Third-party sustainability certifications in food retailing: certification design from a sustainable supply chain management perspective. *J. Clean. Prod.* 282, 124344. <https://doi.org/10.1016/j.jclepro.2020.124344>.
- Cholez, C., Bijman, J., Borgia, R., Dentoni, D., Giagnocavo, C., Mahdad, M., Mehrabi, S., Pérez-Mesa, J.C., Turri, R., Viaggi, D., Zavaioni, M., 2021. Drivers and Constraints of sustainability-oriented innovation in agri-food Value Chains; Key Findings from CO-FRESH Task 1.1.
- Cochran, W.G., 1952. The  $\chi^2$  test of goodness of fit. *Ann. Math. Stat.* 23, 315–345.
- Creswell, J.W., Plano Clark, V.L., 2011. *Designing and Conducting Mixed Methods Research*, second ed. SAGE Publications. SAGE Publications, Los Angeles, Los Angeles <https://worldcat.org/title/558676948>.
- Di Fonzo, A., Nardone, V., Fathinejad, N., Russo, C., 2019. The impact of plant variety protection regulations on the governance of agri-food value chains. *Soc. Sci. Res.* 8, 91. <https://doi.org/10.3390/socsci8030091>.
- Dunne, A., Markey, A., Kinsella, J., 2019. Examining the reach of public and private agricultural advisory services and farmers' perceptions of their quality: the case of county Laois in Ireland. *J. Agric. Educ. Ext.* 25, 401–414. <https://doi.org/10.1080/1389224X.2019.1643746>.
- EU CAP NETWORK, 2025. EIP-AGRI project database [WWW Document]. URL. [https://eu-cap-network.ec.europa.eu/projects/search\\_en](https://eu-cap-network.ec.europa.eu/projects/search_en). accessed 4.11.25.
- EU SCAR, 2017. SWG SCAR-AKIS Policy Brief on New Approaches on Agricultural Education Systems.
- European Commission, Alliance Environnement, Directorate-General for Agriculture and Rural Development, Pražan, J., Nanni, S., Redman, M., Vedrenne, M., Martin, I., Panarin, M., Allen, B., Gerritsen, E., Milliard, P., Menadue, H., Brenner, V., Bresson, C., Lóránt, A., Daydé, C., Bowyer, C., Coulon, A., Mottershead, D., Karoglan Todorovic, S., Keenleyside, C., Maréchal, A., Frelüh-Larsen, A., Toma, I., Ittner, S., Wiltshire, J., Znaor, D., Martineau, H., Zemeckis, R., 2019. Evaluation study of the impact of the CAP on climate change and greenhouse gas emissions – Final report. Publications Office. <https://doi.org/10.2762/54044>.
- European Commission Directorate-General for Agriculture and Rural Development, 2020. EIP-AGRI – 7 years of innovation in agriculture and forestry – an overview of EIP-AGRI network results. Addressing Future Challenges, and Many Network Voices from Across Europe. Publications Office of the European Union. <https://doi.org/10.2762/466938>.
- European Commission Directorate-General for Research and Innovation, 2017. Key findings from the Horizon 2020 interim evaluation. <https://doi.org/10.2777/708544>.
- Finco, A., Bentivoglio, D., Bucci, G., 2018. Lessons of innovation in the agrifood sector: drivers of innovativeness performances. *Econ. Agro-Alimentare* 20, 181–192. <https://doi.org/10.3280/ECAG2018-002004>.
- Fischer, F., 2000. *Citizens, Experts, and the Environment: the Politics of Local Knowledge*. Duke University Press.
- Flynn, K., Wahnström, E., Popa, M., Ruiz-Bejarano, B., Quintas, M.A.C., 2013. Ideal skills for European food scientists and technologists: identifying the most desired knowledge, skills and competencies. *Innov. Food Sci. Emerg. Technol.* 18, 246–255. <https://doi.org/10.1016/j.ifset.2012.09.004>.
- Foster, A.D., Rosenzweig, M.R., 2010. Microeconomics of technology adoption. *Annu Rev. Econ.* 2, 395–424. <https://doi.org/10.1146/annurev.economics.102308.124433>.
- Fruit Logistica, 2020. *DO THE RIGHT THING (RIGHT)*.
- Gil, A., Brennan, M., Chaudhary, A.K., Maximova, S.N., 2023. Evaluation of cacao projects in Colombia: the case of the rural Productive Partnerships Project (PAAP).

- Eval. Progr. Plann. 97, 102230. <https://doi.org/10.1016/j.evalprogplan.2023.102230>.
- Hargrave, T.J., Van De Ven, A.H., 2006. A collective action model of institutional innovation. *Acad. Manag. Rev.* 31, 864–888.
- Hermans, F., Klerkx, L., Roep, D., 2015. Structural conditions for collaboration and learning in innovation networks: using an innovation system performance lens to analyse agricultural knowledge systems. *J. Agric. Educ. Ext.* 21, 35–54. <https://doi.org/10.1080/1389224X.2014.991113>.
- Hooks, T., Macken-Walsh, A., McCarthy, O., Power, C., Henchion, M., 2018. Co-Operation among Irish beef farmers: current perspectives and future prospects in the context of new Producer Organisation (PO) legislation. *Sustainability*. <https://doi.org/10.3390/su10114085>.
- Howard, P.H., Allen, P., 2006. Beyond organic: consumer interest in new labelling schemes in the central Coast of California. *Int. J. Consum. Stud.* 30, 439–451. <https://doi.org/10.1111/j.1470-6431.2006.00536.x>.
- Hsieh, H.-F., Shannon, S.E., 2005. Three approaches to qualitative content analysis. *Qual. Health Res.* 15, 1277–1288. <https://doi.org/10.1177/1049732305276687>.
- Johnson, R.A., Wichern, D.W., 2007. *Applied Multivariate Statistical Analysis*. Pearson Prentice Hall, Pearson Prentice Hall.
- Karali, E., Brunner, B., Doherty, R., Hersperger, A., Rounsevell, M., 2014. Identifying the factors that influence farmer participation in environmental management practices in Switzerland. *Hum. Ecol.* 42, 951–963. <https://doi.org/10.1007/s10745-014-9701-5>.
- Kelly, D.C., 2023. Committing to change? A case study on volunteer engagement at a New Zealand urban farm. *Agric. Human Values*. <https://doi.org/10.1007/s10460-023-10434-6>.
- Lans, T., Wesselink, R., Biemans, H.J.A., Mulder, M., 2004. Work-related lifelong learning for entrepreneurs in the agri-food sector. *Int. J. Train. Dev.* 8, 73–89. <https://doi.org/10.1111/j.1360-3736.2004.00197.x>.
- Malak-Rawlikowska, A., Majewski, E., Waś, A., Borgen, S.O., Csillag, P., Donati, M., Freeman, R., Hoàng, V., Lecoquer, J.-L., Mancini, M.C., Nguyen, A., Saïdi, M., Tocco, B., Török, A., Veneziani, M., Vittersø, G., Wavresky, P., 2019. Measuring the economic, environmental, and social sustainability of short food supply chains. *Sustainability* 11, 4004. <https://doi.org/10.3390/su11154004>.
- Martino, G., Toccaloni, D., Pacciani, A., Ascani, M., 2019. The interbranch organizations in the cap reform: institutional nature, opportunities and limits. *Econ. Agro-Alimentare* 21, 315–334. <https://doi.org/10.3280/ECAG2019-002008>.
- Mayor, L., Lindner, L.F., Knöbl, C.F., Ramalho, A., Berruto, R., Sanna, F., Rossi, D., Tomao, C., Goodburn, B., Avila, C., Leijdens, M., Stollewerk, K., Bregler, M., Koidis, C., Morin, A., Milčić, V., Fadini, G., Lazaro-Mojica, J., Busato, P., 2022. Skill needs for sustainable agri-food and forestry sectors (I): assessment through European and national focus groups. *Sustainability* 14, 9607. <https://doi.org/10.3390/su14159607>.
- Mundler, P., Laughrea, S., 2016. The contributions of short food supply chains to territorial development: a study of three Quebec territories. *J. Rural Stud.* 45, 218–229. <https://doi.org/10.1016/J.JRURSTUD.2016.04.001>.
- Nam, C.W., Parsche, R., Radulescu, D.M., Schöpe, M., 2007. Taxation of fertilizers, pesticides and energy use for agricultural production in selected EU countries. *Eur. Environ.* 17, 267–284. <https://doi.org/10.1002/eet.444>.
- OECD, 2019. *Innovation, Productivity and Sustainability in Food and Agriculture*. Paris.
- OECD, 2021. *Making Better Policies for Food Systems*. OECD Publishing, Paris. <https://doi.org/10.1787/dfba4de-en>.
- Parsons, K., Hawkes, C., 2019. *Policy Coherence in Food Systems*.
- Piedra-Muñoz, L., Galdeano-Gómez, E., Pérez-Mesa, J.C., 2016. Is sustainability compatible with profitability? An empirical analysis on family farming activity. *Sustainability*. <https://doi.org/10.3390/su8090893>.
- Pierpaoli, E., Carli, G., Pignatti, E., Canavari, M., 2013. Drivers of precision agriculture technologies adoption: a literature review. *Procedia Technol.* 8, 61–69. <https://doi.org/10.1016/J.PROTCY.2013.11.010>.
- Podhora, A., Helming, K., Adenauer, L., Heckeles, T., Kautto, P., Reidsma, P., Rennings, K., Turnpenny, J., Jansen, J., 2013. The policy-relevancy of impact assessment tools: evaluating nine years of European research funding. *Environ. Sci. Policy* 31, 85–95. <https://doi.org/10.1016/j.envsci.2013.03.002>.
- Reed, M.S., Stringer, L.C., Fazey, I., Evely, A.C., Kruijssen, J.H.J., 2014. Five principles for the practice of knowledge exchange in environmental management. *J. Environ. Manage.* 146, 337–345. <https://doi.org/10.1016/j.jenvman.2014.07.021>.
- Renner, M., Sweeney, S., Kubit, J., 2008. *Green Jobs: Working for People and the Environment*. Worldwatch Paper 1–57.
- Shalley, C., Hitt, M.A., Zhou, J., Raffaelli, R., Glynn, M.A., 2015a. Institutional innovation. In: Shalley, C.E., Hitt, M.A., Zhou, J. (Eds.), *The Oxford Handbook of Creativity, Innovation, and Entrepreneurship*. Oxford University Press. <https://doi.org/10.1093/oxfordhb/9780199927678.013.0019>.
- Shalley, C.E., Raaelli, R., Glynn, M.A., 2015b. The Oxford handbook of creativity, innovation, and entrepreneurship 22 institutional innovation: novel, useful, and legitimate. <https://doi.org/10.1093/oxfordhb/9780199927678.001.0001>.
- Sørensen, L.B., Germundsson, L.B., Hansen, S.R., Rojas, C., Kristensen, N.H., 2021. What skills do agricultural professionals need in the transition towards a sustainable agriculture? A qualitative literature review. *Sustainability* 13, 13556. <https://doi.org/10.3390/su132413556>.
- Sūmane, S., Kunda, I., Knickel, K., Strauss, A., Tisenkopfs, T., Rios, I. des I., Rivera, M., Chebach, T., Ashkenazy, A., 2018. Local and farmers' knowledge matters! how integrating informal and formal knowledge enhances sustainable and resilient agriculture. *J. Rural Stud.* 59, 232–241. <https://doi.org/10.1016/j.jrurstud.2017.01.020>.
- Tey, Y.S., Brindal, M., 2012. Factors influencing the adoption of precision agricultural technologies: a review for policy implications. *Precis. Agric.* 13, 713–730. <https://doi.org/10.1007/s11119-012-9273-6>.
- Trivellas, P., Reklitis, P., Marinagi, C., Tsoulfas, G.T., 2019. In: Kavoura, A., Kefallonitis, E., Giovanis, A. (Eds.), *Examining Gaps in Business and Logistics Skills and their Performance Implications in the Agrifood Supply Chain in Greece BT - Strategic Innovative Marketing and Tourism*. Springer International Publishing, Cham, pp. 199–205.
- United Nations Statistics Division, 1996. *Standard Country or Area Codes for Statistical Use (Rev. 3)*. UN, New York.
- Ward, J.H., 1963. Hierarchical grouping to optimize an objective function. *J. Am. Stat. Assoc.* 58, 236–244. <https://doi.org/10.1080/01621459.1963.10500845>.
- White, M.D., Marsh, E.E., 2006. Content analysis: a flexible methodology. *Libr. Trends* 55, 36–45. <https://doi.org/10.1353/lib.2006.0053>, 22-23,27-34.
- Zhovtonog, O., Dirksen, W., Roest, K., 2005. Comparative assessment of irrigation sector reforms in central and eastern European countries of transition. *Irrig. Drain.* 54, 487–500. <https://doi.org/10.1002/ird.208>.