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BIODIVERSITY INTEGRATION STRATEGIES IN ITALIAN OLIVE FARMING

A comparison of public and private governance strategies

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Abstract

Agriculture is one of the main drivers of biodiversity loss as a result of the intensification of cultivation practices and the transformation of natural habitats into farmed areas. Intensified production achieved through the use of agrochemicals has had a detrimental effect on ground flora and insect population, reducing their numbers and diversification, which in turn has led to a reduction of food accessible to mammals, reptiles and birds and, thus, has had a negative impact on habitats and wildlife present on the cultivated land.

This trend has also been observed in Italian olive production. Olive culture is of particular interest considering it is home of biodiversity rich habitats when plants are cultivated with traditional methods. Further, it accounts for the third largest land use in Italian agriculture.

One of the tools available to governments in order to reduce negative impacts is to integrate environmental concerns into agricultural policies. However, top-down governance does not portray the full spectrum of tools implemented in order to steer producers towards more environmentally sounds practices. Different types of strategies ranging from economical to informational and organizational have been implemented and other actors, such as retailers, consumers or non-governmental organizations, have developed different tools in this regard.

The goal of this research will be to compare different biodiversity integration strategies and evaluate their contribution to reducing the use of agrochemicals that have proven to have a negative impact on biodiversity.

Contents

1. Introduction

Biodiversity and agriculture in the European Union

Biological diversity, or in short biodiversity, can be defined as "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part: this includes diversity within species, between species and of ecosystems" (1, 2). Biodiversity is at the ground of healthy, resilient and functioning ecosystems (3, 4). Therefore, the loss of biodiversity may affect the ability of ecosystems to supply services. These services are understood as the benefits that support human survival and their quality of life, either directly or indirectly (5–12).

The major causes of loss of biodiversity have been determined to be climate change and land-use change (4). Particularly the latter is considered as an important driver for biodiversity loss due to the fact that ecosystems are increasingly becoming more fragmented as a consequence of these anthropogenic disturbances (4, 8, 13).

Agriculture is one of the main drivers of land-use change because of the transformation of natural habitats into farmed areas or through the intensification of cultivation practices on lands that were already utilized for this purpose (9, 10). Concerning the latter, various methods have been applied to enhance crop yields. In particular, intensified farming has led to an increase in the use of fertilizers, pesticides, herbicides, insecticides and agrochemicals in general (14). These practices have reduced ground flora and insect populations, impoverishing food supplies for wild animals, such as birds, reptiles and mammals, living on cultivated lands (14).

The European Union (EU) is a densely populated area where, according to the FAOSTAT, about 45% of the land is utilized for cultivation (4, 15). In the past sixty years, especially after World War II, land use in Europe has radically changed in order to ensure food security (4, 6). Policy implementation, such as the European Common Agricultural Policy (CAP), and technological progress enabled agricultural intensification through high mechanization and the use of synthetic fertilizers to increase crops yields and allow cultivation on soils poor of nutrients (6).

Biodiversity challenges in Italian olive production

Italy is a country of specific interest to investigate when talking about the impact of agriculture on biodiversity, since it has been reported as being the third state in the EU for number of businesses and labour force employed in farming (16, 17). Further, Italy is the second country for EU certified organic operators which prescribes, between other requirements, conservation of biodiversity and restrictions with regards to the use of agrochemicals (16, 18).

Olive production seems of particular interest within the Italian context. It has been estimated, in fact, that Italy is the second largest producer of olives worldwide, olive groves production is practiced in every region of the peninsula and, after cereals and grazing, it accounts for the largest land use in Italian agriculture (19, 20). Moreover, from a biodiversity point of view, olive tree cultivation, particularly if farmed with traditional practices, is considered home of a great variety of habitats and hosts many species of wild fauna, ranging from reptiles to mammals, insects and migratory birds (14, 21). This research will focus on the negative impact induced by agrochemicals utilized in olive farming on the above mentioned species living on cultivated land, from here on called wildlife biodiversity.

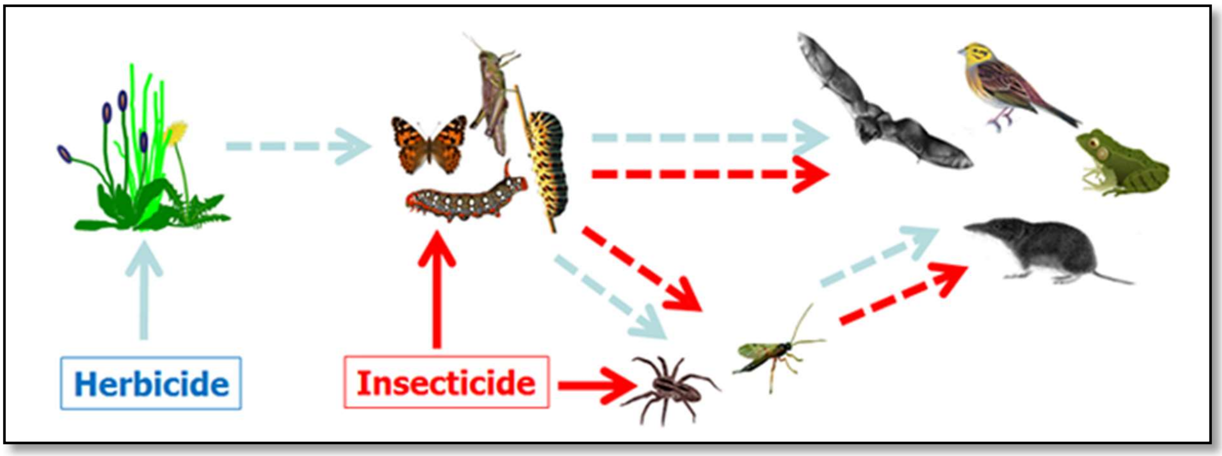

Figure 1. Impact of agrochemicals on ground flora, insect population, mammals, reptiles and birds

As mentioned above, the globalization of the market and CAP subsidies have led farmers to increase their production. This trend has also been followed by olive growers and, in the past three decades, production has been intensified (14, 22). This has led to an intense use of agrochemicals, especially to reduce possible insect pests and limit the growth of unwanted plants (23, 24). Further, traditional methods considered the production of other crops, as legumes, in between olive groves to enhance soil quality. These practices have been abandoned within intensive olive farming, in favour of increasing the land used for olive production and further depleted the soil (23). These techniques, particularly the high use of herbicides and insecticides, have had a detrimental effect on ground flora and insect population, reducing their numbers and diversification. This has led in turn to a reduction of food accessible to mammals, reptiles and birds and, thus, has had a negative impact on habitats and wildlife present on the cultivated land (14, 22, 25) (Figure 1).

Public and private strategies for integrating biodiversity concerns into olive farming

It has been argued in the literature that negative environmental impacts could be reduced if environmental consideration would be taken into account when designing sectoral policies (26). Public policy has largely determined and steered agricultural practices. Therefore, the inclusion of biodiversity concerns and goals within sectoral policy dedicated to agriculture could anticipate and, thus, hinder the negative impact on habitat losses and ecosystem services. At the same time, this practice could foster the establishment of a system of agricultural production, which enables biodiversity conservation.

Environmental Policy Integration (EPI) or mainstreaming is a concept that has enter the debate on sustainable development since the United Nations Environment Programme in 1972 (26–28). The Brundtland Report, published in 1987, reinforced the idea the EPI should be at the centre of the international political agenda (28).

Governments on European, Italian and regional level have, over the years, developed EPI strategies to reduce the use agrochemicals in olive farming. The EU has been one of the frontrunners in trying to integrate environmental concerns within unrelated sectoral policy, particularly, with the Cardiff and its effort to promote integration of environmental goals within agricultural policies (27). In 1973, the First Environmental Action Plan was the first act towards the adoption of the precautionary principle and contained an early version of the 'polluter-pays-principle'. As also quoted in Lafferty and Hovden (2003), the First Environmental Action Plan set a first milestone towards EPI by stating: "The environment cannot be considered as external surroundings by which man is harassed and assailed; it must be considered an essential factor in the organisation and promotion of human progress. It is therefore necessary to evaluate the effects on the quality of life and on the natural environment of any measure that is adopted or contemplated at national or Community level and which is liable to affect these factors" (29). Moreover, the EU 'constitutionalized' EPI and sustainable development giving them a legal status through the inclusion of such notions in Article 3 and 6 of the Amsterdam Treaty (26–28, 30).

Many biodiversity protection initiatives are regulated on the EU level, but they lack influence in comparison to sectoral policies (31). The importance of measures taken on a European level in regards to agricultural production is clear when considering the budget allocated for the 2014-2020 CAP reform which assigns almost 40% of the whole EU's total funds (31). This policy programme supports agricultural intensification, while, on the other hand, claiming a "greening" of their subsidies distribution that heavily supports such industry (31).

However, civil society as well as market actors have entered the policy arena and developed strategies that also aim at integrating wildlife biodiversity concerns into olive production. On one hand, private actors such food retailers, over the years increasingly gained power over the entire food supply chain. They are "the modern gatekeepers of access to the consuming public" and may hold the key towards more sustainable agricultural practices (32). On the other hand, "aware" consumers, recently, have increasingly formed Alternative Food Networks that allow them the access to products that are cultivated locally with environmentally sounds practices (33, 34).

Aim and research questions

The aim of this paper is twofold. First, it wants to evaluate the effectiveness of Biodiversity Integration Strategies (BIS) as a whole. To this regard, an approach that only takes into consideration EPI strategies developed by governments is not sufficient. Therefore, this research widens the spectrum of strategies commonly taken into consideration in EPI literature to include both public and private actors. Secondly, it seeks to assess the relative importance of each BIS. In this respect, this analysis can contribute to understand whether private strategies may be more effective than public ones or unravel synergies and conflicts that may arise between them. In order to be able to achieve the above mentioned goals, I performed an impact assessment on the mix of BIS and later evaluated their relative influence.

Therefore, in order to assess and compare biodiversity strategies regarding the degree to which they contribute to reducing the impact of agrochemicals on wildlife biodiversity in Italian olive farming, the following research question and sub-questions will be answered:

To what extent have public and private biodiversity integration strategies been effective in steering Italian olive farming practices to reduce their use of agrochemicals?

1. What strategies have been developed by governments, market and civil society actors to reduce the use of agrochemicals within olive farming (i.e. independent variable) and how can they be characterised?

2. Which agricultural measures have been implemented by olive farmers to reduce their use of agrochemicals (i.e. dependent variable)?
3. What has been the contribution of public and private strategies aimed at reducing agrochemical use by olive farmers to the actual reduction of agrochemicals, both individually and in combination?
4. What information can we gather from this study in order to give recommendations to governments, market and civil society actors to render their strategies more effective and, thus, remove barriers and seek opportunities to reduce the impact of agrochemicals on wildlife biodiversity?

Outline

In the next section, I will discuss the theoretical framework. The third chapter is dedicated to explaining the methodology employed for this research. In fourth part, the research cases will be presented and analysed. In the last segment, I will discuss the results and draw the main conclusions.

2. Theoretical framework

Integrating biodiversity into sectoral policy and practice

Policy integration of sustainable goals, particularly climate change, has been advocated in the past years as a principle to encourage the development of more environmentally sound sectoral policies (27, 35). This step is an essential prerequisite in order to understand the environmental impact of specialized policies as well as avoiding conflicts between the objectives set out by either one (35). Further, EPI might result in more effective environmental policy besides promoting efficiency.

EPI has become one of the main goals of policy-makers both on the EU and national level. Over the past years they have promoted the integration of environmental concerns and objectives within sectoral policies (e.g. Cardiff and Cologne process) (26–28, 30, 36–39). EPI scholars have often discussed over this topic and have provided several outlines encompassing examples of national EPI strategies (40–45).

However, governmental institutions are not the only actors that aim at fostering a behavioural change. Private actors have also developed strategies in this regard. Thus, the strategies considered by EPI literature give only a partial representation of possible approaches towards environmental integration. This study differs from most EPI research, in line with Runhaar et al (2014), focusing not only on public policies, but also on private strategies.

Concepts from EPI literature

Although, this notion is not a novelty to the debate, EPI literature does not agree on a definition of policy integration and no general accepted criteria that allow evaluating integration exist (26, 27, 30, 46, 35, 39, 44). Broadly, EPI entails the inclusion of environmental concerns within sectoral policies. This integration is considered vital to understand the impact on the environment of sectoral policies, to foster policy coherence and to avoid conflicts between specialized and environmental policies objectives (27, 35). Many authors believe that the concept of EPI is inherit to sustainable development, if not one of its key aspects. The idea itself of sustainable development, as defined from 'Our Common Future', could not be conceived without the inclusion of environmental goals within sectoral policy and the reconciliation of economic, social and environmental aspects of development (27, 28).

This research gives attention to a particular aspect of EPI, hence, the integration into agricultural practices of concerns regarding the impact of agrochemicals used in olive farming on mammals, reptiles and birds living on cultivated land.

Therefore, the first step is to outline what is understood by strategy. The concept of strategies can be seen as comprising five definitions, namely plan, ploy, pattern, position and perspective (47). This research focuses on the study of strategies as a plan and recognises them as a "consciously intended course of action, a guideline (or set of guidelines) to deal with a situation" (47). Further, strategies have to fulfil two basic conditions: strategies have to be drawn prior to any action and they have to be intentional (47).

Secondly, it is important to delineate the type of strategy. Literature highlights four main strategies ranging from legislative to economical and from informational to organizational (35). These typologies are categorized based on the steering approach used by the actors involved in the development of such strategies to foster a behavioural change (48). Regulatory strategies, also called "stick", enforce a specific behaviour and prescribe penalties for non-compliance. The second typology, the "carrot", establishes positive or negative economic incentives in order to achieve the meant behaviour. Informational strategies aim at providing knowledge regarding either the characteristic of products or the impact of certain behaviours (6, 35, 48, 49). Organizational strategies concern changing management procedures and structures in order to aid environmental integration (35).

Thirdly, Driessen et al. (2012) identify three main steering approaches based on the level of interaction between governmental, market and civil society actors: top-down, interactive and self-governance (35, 50).

Finally, strategies can be assessed on three level: output, outcome and impact. Outputs consist of the programmes and arrangements that yield from these strategies. Outcomes can be described as the change in the behaviour of the target population (51, 52). The change in the physical environment is defined impact (53). This research focuses on the first two steps of evaluation. Hence, it describes BIS and analyse the effect that these strategies have had in changing farmers' behaviour towards reducing their use of agrochemicals.

Measuring the degree to which biodiversity is integrated

It is important to explain what BIS entails. BIS are, here, defined as governmental, market and civil society strategies designed with the intent to integrate wildlife biodiversity concerns into agricultural policy. Moreover, levels of integration can vary based on the extent biodiversity goals and concerns are taken into consideration in agricultural strategies. Following Lafferty and Hovden (2003) these levels are operationalised based on three indicators:

- *Coordination* encompasses adapting agricultural strategies with the aim of achieving biodiversity goals and taking into consideration possible consequences of such strategies;
- *Harmonization* entails giving equal consideration to agricultural and biodiversity goals;
- *Prioritisation* implies giving 'principle priority' to biodiversity objectives over agricultural goals (27, 46).

Table 1 gives an example of some BIS identified following the above definitions of BIS and strategies, summarized based on governance mode involved and steering approach utilized.

	Top-down governance	Interactive governance	Self-governance
Regulatory	Legislation	Voluntary agreements	
Economic	Subsidisation	Green procurement	Alternative Food Networks
	Facilitated loans	Eco-labels	Green procurement
	Taxation wavers		
	Green procurement		
Informational	Awareness campaign for consumers and farmers	Eco-labels	Awareness campaign for consumers and farmers
			Monitoring and reporting
			Information sharing between farmers
Organizational	Minister of Environment	Consultancy firms and farmers' associations aiding the implementation of environmental practices	Corporate social responsibility
	Environmental departments within sectoral ministries		ISO certifications

Table 1. Biodiversity integration strategies (28, 30, 46, 35, 41, 54)

3. Research design

3.1 Research strategy

Case selection: Tuscany

Tuscany is of the nineteen region in Italy were olives are farmed. This area is particularly interesting because, although, it yields between 2% and 4% of the overall national production, olive production is practices by about 50,300 agricultural businesses, 69% out of the total regional farms (55). About 90% of the cultivation is localized in hill or low mountain areas, albeit there has been a tendency of abandoning the more remote plantations for valleys or level ground lands (55). Figure 2 represents the geophysical map of Tuscany. ISTAT census of 2010 indicates that an area of 91,200 hectares, about 12.2% of the region utilized agricultural land, is utilized for olive production (19). The average land cultivated per agricultural business is 1.83 hectares (55).

Figure 2. Geophysical map of Tuscany

About 15 millions of plants are maintained in the region mainly constituted by six different varieties. However, Tuscany is one of the region which portrays the most variety in olive trees species. Currently about 80 are registered within the Rural Development Plan of which 71 are at risk of extinction. Therefore, for this area biodiversity conservation practices are extended to include also agriculture species (55).

Most of the Tuscan olive culture fields derive from orchards that were planted between the 1800 and early 1900. Centuries-old olive trees farmed with low inputs practices have been recognised above other to have "high level of biodiversity" (21, 22, 24). Organic management and, consequently, a reduction in agrochemicals input has been found to have a positive impact on biodiversity conservation, particularly on ancient olive orchards (24).

Olive orchards in Tuscany host more than 300 different flora species among which the most common are "*herophytes (Anagallis arvensis L., Anthemis arvensis L., Avena barbata Pott. Ex Link, Briza maxima L., Calendula arvensis (Vaill.) L., Catapodium rigidum (L.) C. E. Hubb., Cerastium glomeratum Thuill., Cerinthe major L., Euphorbia helioscopia L. subsp. Helioscopia, Knautia integrifolia (L.) Bertol. Subsp. Integrifolia, Melilotus sulcata Desf., Papaver rhoeas L. subsp. Rhoeas, Scandix ectin-veneris L., Sherardia arvensis L., Sonchus oleraceus L., Veronica hederifolia L., Veronica polita Fries)"* (25). Further, in regards to fauna biodiversity, the diversity of habitats provided by olive groves allows a great variety of wildlife including butterflies, reptiles, invertebrates, mammals and birds. Particularly, they host numerous species of nesting birds such as *Upupa epops, Coracias garrulous, Otus scops, Athene noctua* and various passerines (14, 23, 25).

The above mentioned species are threatened by the intensification of olive farming and the incremental use of agrochemicals. The use of herbicides as well as the clearance of natural vegetation in the understorey has led to a decrement to reptiles, invertebrates and small mammals feeding on this source which in turn has entailed the loss of nourishment for birds and larger reptiles and mammals. Pesticides have perpetuated this trend by further endangering invertebrates and, as a consequence, all species sustaining on them (4, 21, 22, 24, 25).

3.2 Research methods and data collection

Considering the novelty of the study and the scarcity of scientific literature in regards, a sequential 'mixed strategy' is chosen, where survey research is informed by exploratory interviews. This two steps approach allows to obtain a greater understanding of the investigated problem and the targeted population while being able to generalize the results to a larger sample (56, 57).

In order to enhance the validity and reliability of the research, triangulation is used which is achieved by analysing multiple sources, combining different methods and using different analytical approaches (58–60).

The research evaluates whether the development of biodiversity integrations strategies has been successful in reducing the impact of agrochemicals on wildlife biodiversity and what measures can be taken for future improvements, and, for these reasons, can be characterized as empirically-oriented (61).

The aim of this research is to evaluate the effectives multiple BIS as implemented by olive farmers and is carried out following the methodological approach proposed by Weber et al (2013) to assess strategies mixes. Below I describe the conceptual approach, data collection and data analysis performed for this research for each of the three steps identified by the authors.

3.2.1 Step 1: identification and description of strategies

Conceptual approach

Strategies developed over the years have ranged from regulative to economic and informational, and have been categorised based on the level of enforcement and authoritative power they adopt (35, 50, 51, 62). The first step of the analysis has been to identify strategies available to olive farmers and classify them based on the Table presented in Chapter 2.

Data Collection

An online search has been performed that included terms such as "biodiversity conservation measures", "fostering biodiversity", "agrochemicals reduction agriculture", "olive farming agrochemicals" and "sustainable olive farming". Once a collection of strategies had been selected, two representatives of the regional government and two of Chamber of Commerce have been interviewed to delve into possible additional strategies available to olive farmers.

Data analysis

This section gives a brief description of all BIS that have been taken into consideration for this research.

3.2.2 Step 2: Intervention theory of strategies

Conceptual approach

Intervention theory is here defined, following Hoogerwerf (1990), as the cause-impact relationships and the set of implicit and explicit assumptions that stand behind the strategy (63–65). Literature on public policy, politics and administration has increasingly considered this aspect when assessing the effectiveness and evaluating legislations.

Relations between causes and effects that guide the creation of the strategy itself have to be rendered explicit (51, 52, 66). Hence, intervention theory provides insight in the assumptions and implicit goals that lay behind a strategy design. Further, this analysis can explain the reasons why particular strategies have been chosen to solve the problem at hand, explain why they have failed and set the ground for possible recommendations for improvement (51, 66). Finally, this step will help understand to what extent implemented strategies target the causes of the problem identified in the BIS theory and, thus, provides a key element to the effectiveness evaluation (51).

Data collection

A review of the scientific literature on the effectiveness of biodiversity integration measures is performed to gather knowledge on possible effects identified in prior research. Particularly, for this section, I analyse studies similar to the research at hand, BSI documents and audio-visuals to inform BIS theory reconstruction, determine impact variables and identify exogenous factors (52).

Secondly, exploratory interviews with five farmers have been performed to refine the effectiveness assessment model derived from the literature, understand motivations that led farmers to the implementation of particular BSI over others and collect knowledge on possible exogenous factors that might have affected these decisions.

Thirdly, four interviews with experts have been carried out in order include variables that might influence the implementation of BIS and motivations of farmers (geophysical characteristics, farm size, cultivation type, region, intensity of production) (67–69).

Data analysis

This section illustrates the relation between causes and effects, and it describes the goals as identified within BIS. Further, impact model of the BIS mix is presented where I identify the relation between points of application, i.e. the behaviour that needs to be changed, BIS strategies, effects, goals and possible exogenous factors.

3.2.3 Step 3: Impact assessment of strategies mixes and their relative influence

Conceptual approach

In this section, it is necessary to distinguish between strategy effectiveness and goal attainment of the target set within the various strategies. The latter might not entirely be the consequence only of the strategy. Other factors might play a role. On one hand, goal attainment is measured by comparing the effects identified in section 3.2.2 in relation with the strategy goals. On the other hand, effectiveness is evaluated by establishing causal relations between the measured effects and the strategy intervention (51). Therefore, this step clarifies if there has been a change in the behaviour of the target population in line with the goals set within the strategy and explain to which degree this change is attributable to the strategy itself (51).

The effectiveness of BIS is evaluated based on three factors. First, all "points of application", as highlighted in steps 1 and 2, need to be addressed by BIS (51). Secondly, the effectiveness of the BIS mix is analysed by using binary linear regression, which describes how much of the reduction can be accounted for by the independent variable. This implies also the analysis of exogenous factors identified and controlling for the possible influence that these variables might have had on the overall reduction (53). Thirdly, the relative importance of each BIS in changing farmers' behaviour is assessed (53). The analytical framework is presented in Figure 3.

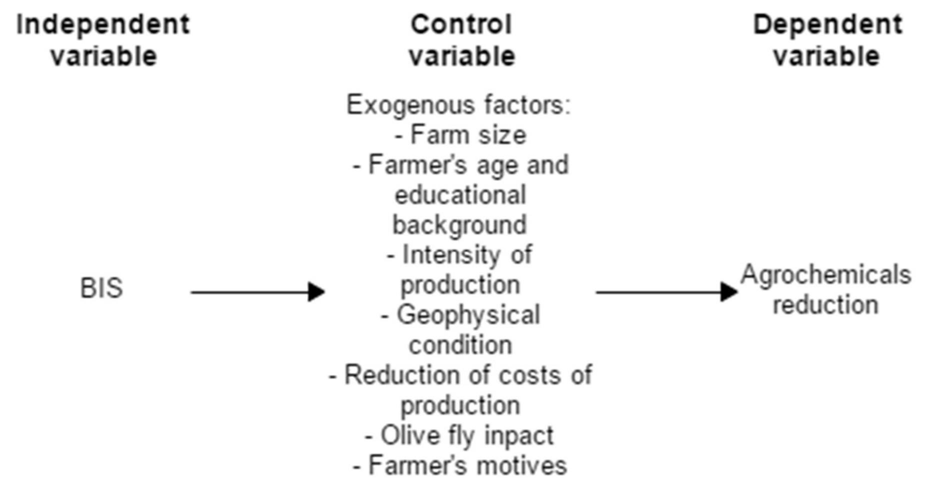

Figure 3. Analytical framework

For this research, I use an ex-post nonrandomized quasi-experiment to evaluate the effectiveness of BIS. Although this approach is believed to be less convincing than a randomized field experiment, in ex-post evaluation it is not possible to randomly assign the intervention (70). Further, a randomized field experiment was not feasible due to time and resources available to the researcher.

This research utilizes a reflexive pre-post design which entails that information regarding strategies effects are directly gathered from the target after participation to the program (70). Particularly, I take into consideration the period between 2010 and 2015 for two reasons: the impact of agriculture on biodiversity has risen in the past five years as well as the number of initiatives towards biodiversity integration; secondly the period is close enough to the present to avoid lapses of memory from the target group.

The single farmer or business is the targeted population each strategy analysed in this research, thus, the place mandated to assert a behavioural change. Moreover, here different strategies might come together and interact or hinder each other. Further, individual agricultural management practices are highly correlated to biodiversity conservation. For these reasons the chosen unit of analysis for the impact assessment performed during this study is the farm.

Data collection

Questionnaires were used (see Appendix 2) in order to collect the data necessary for this section and to evaluate the effectiveness of BIS mixes, farmers' motives and the importance of exogenous factors. Further, considering that the latter often relate to social, demographic characteristics, this information have been collected, also, through the questionnaire. The population taken into consideration is of 5,713 farmers which where categorized by the ATECO code (Italian classification for economic activities) as olive farmers. This number does not include all olive producers in Tuscany, which have been estimated to be around 50,328, but it encompasses all farmers registered as olive growers as primary occupation (55, 71). The disaggregated data gathered through questionnaires has been later aggregated using SPSS in order to conduct a statistical analysis of the results (72).

The questionnaire has been sent to 4,057 farmers using PEC (certified e-mails) which are mandatory for all businesses nationwide, except for individual enterprises for which it began to be required starting from the 1st of June 2016 (73). Although the response rate achieved was only 9%, I received 309 complete responses, which allowed a confidence interval of 95% with a standard error of 0.0542 based on 5,713 farmers (74). Confidence interval of 95% indicates that "if 100 samples were taken and means calculated, 95 of these samples would contain the true mean for the population" (74). The standard error indicates the representativeness of the sample means in relation to the population mean (74). Further information on data collection can be found in Appendix 1.

Data analysis

The statistical analysis of the data has been articulated in five stages: data entry, psychometric analysis, descriptive outlines, bivariate correlations and multi-variable correlations (75).

The variables used for both dependant, agrochemicals reduction, and independent, BIS mix, consist of discrete dichotomous data. Therefore, the data has been entered in SPSS using numerical categories and labels, in order to be able to use statistical analytical tools for which ordinal data is necessary. From the analysis performed during sections 4.3.2, 4.3.3 and 4.3.4 farmers that reported not using agrochemicals before the analysed period of time have been excluded since they lay outside the scope of this research.

The measure developed for the control variable, farmers' motives, was an 8-item scale devised to produce one score. Each question was designed to yield a number between 1 and 5 (from not important to extremely important), bringing the total scores from 8 to a maximum of 40. A psychometric analysis has been performed in order to insure that the items produced variation, correlation and internal validity (75). After performing a Cronbach's Alpha reliability test, I decided to exclude two items from the final score for farmers' motives in order to have a higher correlation and an alpha coefficient of .93.

3.3 Establishing causality

Causality is achieved if asymmetry, covariance and non-spuriousness show a positive correlation between BIS and the behavioural change reported (66, 76, 77). The asymmetry entails that there is a chronological relationship between cause and effect where the first should precede the latter. From data reported by the Italian statistical institute, in the past 15 years there has been a considerable reduction of agrochemical use in olive farming (Figure 4 and 5). BIS might be accountable for this effect since they have been implemented, for the major part, between 2000 and 2005.

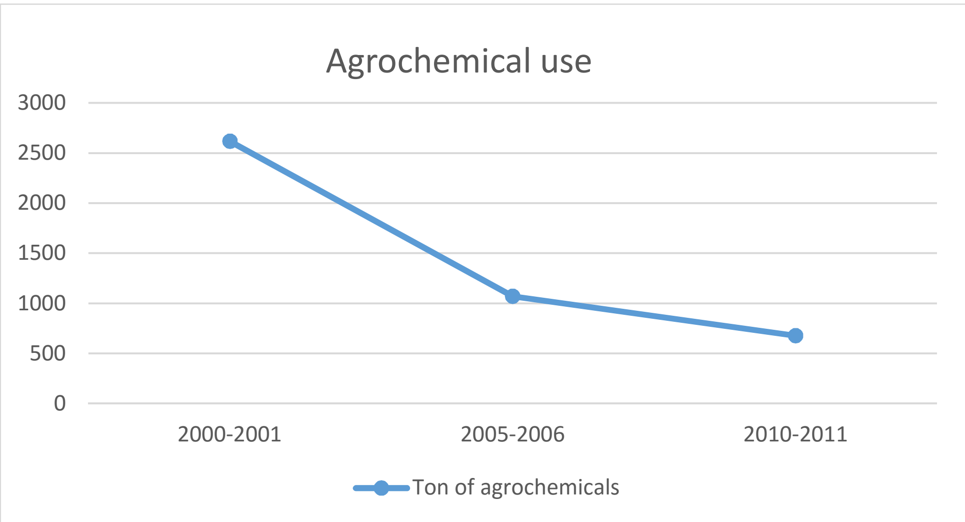

Figure 4. Agrochemical use in olive culture

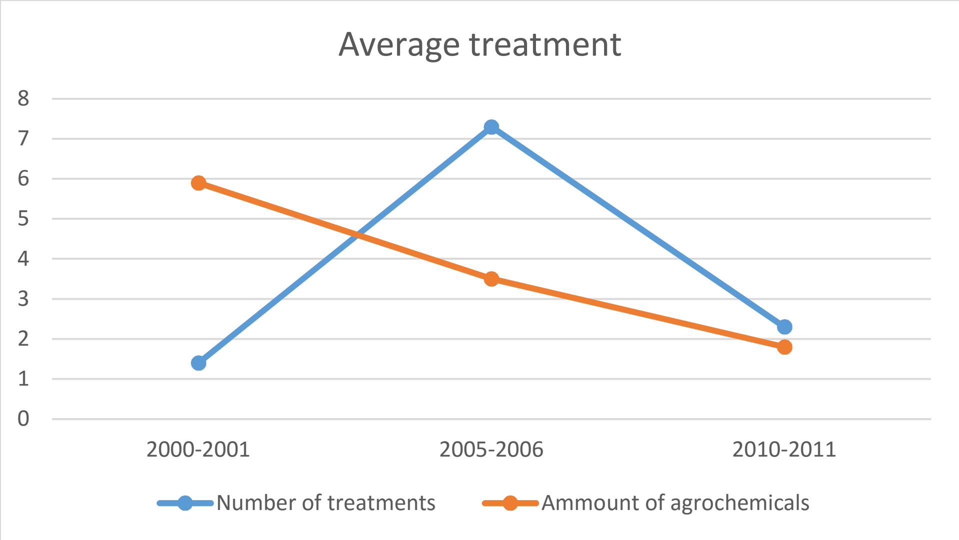

Figure 5. Average treatment olive culture

When there is a correlation between cause and effect, hence, a variation in the first results in a change in the latter, covariance is accomplished. Since part of this research consist in understanding which variables are effective in changing the behaviour of olive farmers, this factor has been evaluated during the analysis in sections 4.3.2 and 4.3.3.

Non-spuriousness is attained when there are no other possible causes that explain the analysed effect. Therefore, a fundamental step is to identify possible exogenous factors that might influence the dependant variable. Literature identifies several demographic characteristics that might affect the famers' decisions, namely farm size, farmer's age and educational background, intensity of production and geophysical condition of the farm location (67, 78–81). Further, during the exploratory interviews performed, two elements that have been brought to the attention by farmers were cost reduction and the seasonal impact of the olive fly.

Olive cultivation is considered an agricultural practice with very low revenues and often substantiated by other cultivations. Tuscan olive farming, as above explained, is mostly a result of old cultivations which have been laid down not considering the efficiency techniques that have been recently developed. Further, the geophysical conditions of the Tuscan territory rarely allow for machinery to aid the cultivation of the olives, thus, requiring manual work for pruning, harvest and maintenance. Further, the high competitiveness of the international market, particularly olives coming from Spain and North Africa, has mandated lowering the price of the final products. To this regard, frequently no or very few agrochemicals are used to reduce the costs of production in order to increase the saleability of their produce.

Olive fly is the parasite that most affect olive farming, particularly, highly humid and frost-free environments. This pest decimates the crops, impact the acidity of the oil and makes table olives unsaleable. In years where humidity levels are low and frost events are experienced the necessity for treatments decreases (82, 83).

The influence of the above exogenous factors has been tested during the analysis and is presented below in section 4.3.

4. Results

4.1 Step 1: description of biodiversity integration strategies

This section gives a description of the BIS taken into consideration during this research as highlighted in Table 2. The below overview is divided into four parts, based on steering approach.

Governance mode / Steering Approach	Top-down governance	Interactive governance	Self-governance
Regulatory	Traceability of food farming products Sustainable use of agrochemicals		
Economic	Rural Development Programme (RDP)	Eco-labels (EU Organic certification, Agriqualitá)	Farmers market Solidarity Purchasing Groups
Informational	Technical assistance provided by Centres of Agricultural Assistance (CAA)	Technical assistance provided by agronomist, trade associations, consumers associations, farmers associations or Universities	Self-directed trainings Information sharing
Organizational			Corporate social responsibility (CSR)

Table 2. BIS implemented in Tuscany in relation to olive farming

4.1.1 Regulatory strategies

Traceability of food farming products

Although this strategy does not directly tackle agrochemicals reduction, it may be considered as concurring to it by allowing tracing products from growth to distribution (84). Traceability is a regulatory strategy towards farmers. However, it can also provide information regarding the entire supply chain and origin of the product. For virgin and extra-virgin olive oils, it is compulsory to specify in the label the country where the olives were grown, harvested and this may allow consumers to make informed decision about the product the buy, including knowing whether olives where grown using agrochemicals (85, 86).

Further regarding olive farming, EU regulation states that "[n]atural or legal persons and groups of persons who hold olive oil and olive pomace oil from the extraction at the mill up to the bottling stage included, for whatever professional or commercial purposes, shall be required to keep entry and withdrawal registers for each category of such oils" (87–89).

Sustainable use of agrochemicals

This second regulatory strategy establishes a national plan of action for the sustainable use of agrochemicals that aims at reducing "risks and impacts on human health, environment and biodiversity" (translated from art. 1) (90). The plan prescribes training courses and licences for sales agents, consultants and final users. Further, it sets in place information programs and awareness campaigns for consumers on the short and long terms effects of exposure to agrochemicals on humans and the environment. Moreover, it requires commercial agents to provide annual sales records to the

SIAN (national agricultural information system). Finally, starting from 2014, all professional users of agrochemicals are required to apply the general principles of integrated conservation: crop rotation, use of resistant crops, balanced use of agrochemicals and irrigation, pests prevention, and protection of favourable organisms (90, 91). On the other hand, the national plan does not set in place any quantitative goals towards the reduction of agrochemical inputs (92).

Both these BIS yield from EU regulations or directives and are enforced on a national level.

4.1.2 Economic strategies

RDP

Rural Development Programme (RDP) is a BIS that originates from EU regulations and decisions and is implemented on a regional level, as illustrated in Table 4. This research follows in between two RDP, 2007/2013 and 2014/2020. Although, the definition of the objectives results more detailed in the second plan, the measures implemented are quite similar. The main economic strategies implemented are measures 214 (RDP 2007/2013) and 11 (2014/2020) which prescribe agri-environmental payments in order to foster environmentally sound agricultural practices and support farmers in the additional costs that this shift might arise (93–96). Further, the RDP sets a scale system to assign facilitated loans and taxation waivers, allocating a greater number of points to farmers using agricultural practices with a lower environmental impact, including reducing agrochemicals (97, 98). Finally, the RDP finances actions taken towards knowledge transfer, information sharing, creation of networks, eco-labels certification, consultancies and trainings (99–105).

Eco-labels

For this research I consider the two ecolabels that are most used with the Tuscan region: EU Organic certification and Agriqualitá (see Table 6 for legislation). The first has been implemented in 2007 and prescribes a voluntary certification for organic food and feed products to be displayed on the packaging. The label contains a particular design that should readily recognisable by consumers, the name of the last business who handled the product and the code of the certification authority (106, 107). Organic farming prescribes rigorous limits on agrochemicals and the use of on-site resources (18).

The second certifies products that are grown using agricultural integrated practices as stipulated by Council Regulation (EEC) n. 2078/92. It entails minimizing the use of agrochemicals and management of the productive chain. Agriqualitá is also recognisable by a distinctive label on the packaging (108, 109).

Farmers' market

The direct interaction between producers and consumers, where famers bring their products and attempt to sell it to the customers, is called farmers markets (110, 111). They have spread all over Europe during the past few decades because of the producer need to diversify his sources of revenues (111). Firstly, by creating this direct link between producer and consumer the mediation fees are removed. Secondly, buying directly from the farmers stimulates a social interaction that serves as an assurance on the high quality of the products, thus, discharging the costs of official certification (111). Literature reports that farmers markets tend to sell products cultivated with the awareness of the social and environmental impact of agriculture (112, 113). This relatively new sales approach might foster a reduction of agrochemicals in olive farming due to the requests from consumers for products cultivated using environmentally sound practices, and thus, farmers may change their cultivation practices to enhance the marketability of their products.

Solidarity Purchasing Groups (SPG)

SPG were born in Italy in 1994 (33). As reported by the main national website that coordinates these organizations, a SPG can be described as a group of citizens that together purchase food or daily household products based on the principle of solidarity. Based on this ethical standard they address small and local producers, socially responsible and environmentally conscious (114). Therefore, as for farmers' market, SPG might create a stimulus for farmers that want to increase their revenues or are in search of new markets for their products to reduce or eliminate their use of agrochemicals.

4.1.3 Informational strategies

Technical assistance, Training courses and Self-education

In the past years there has been an increment of trainings conducted by trade association, universities, regional and provincial governments and universities directed towards olive farmers with the aim of enhancing profitability and sustainability of agricultural practices. Particularly, there has been a greater interest in providing learning experiences regarding the impact of agriculture on biodiversity as well as tools for conservation (23, 37, 94, 115, 116). Further, agronomists have been increasingly employed and have provided professional technical assistance with the aim of agrarian advices towards more environmentally sound practices, including biodiversity preservation achieved through agrochemicals reduction, maintenance of understory and dry walls (117).

In addition, all the above mentioned actors can be seen as intermediaries between farmers creating a social network which is considered to foster the adoption of any other BIS (117). The network and technical assistance that intermediaries provide has been found to positively affect attitudes and behaviours of farmers towards biodiversity conservation as well as their participation in other strategies with the same aim. Moreover, social networks contribute to give access to a greater array of information and are source of information sharing with a high diffusion rate and a relatively low financial cost (117).

Finally, the increase awareness of the environmental footprint of agriculture has encouraged farmers to self-educate in order to lessen the effects of their production over wildlife living on the olive farmed land.

4.1.4 Organizational strategies

Corporate social responsibility

Corporate Social Responsibility (CSR) consists of explicit or implicit self-regulation regarding social and environmental issues. Literature identifies for type of CSR based on the combination of either internal moral or external stakeholders pressure (118). The inactive and reactive approaches use CSR as a "brand-building" approach to strengthen company reputation on the global market as well as linking the image of the business to positive values, legitimating the activities performed within the farm (118, 119). Both of them are not oriented towards changing the company philosophy, but are a response to the inward business context, the first, or external stakeholders pressure, the second (118). The active approach consists of companies who want to make socially responsible choices regardless of stakeholders' influence, while the pro-active approach aims at involving external actors when initiating any activities (118).

Several actions can be taken in order to foster biodiversity conservation practices including integrating biodiversity criteria into farming practices, creating a code of conduct, develop farmers' networks, design sectoral information platforms and establish partnerships with NGOs or suppliers that have comparable goals (118).

4.2 Step 2: description of intervention theory of biodiversity integration strategies

The use of chemical inputs in the cultivation of olives is one of the main contributor for wildlife biodiversity depletion. Here, it has been recognised as the main point of application. This can be further subdivided in pest control, weed control and soil management. The summary of all behavioural points of application identified by the literature can be found in Table 3.

Farming practices		Measures
Weed control and soil management	1	Understorey used to grow other crops (e.g. cereals)
	2	Permanent or semi-permanent grass cover maintained through mechanical mowing and/or sheep raising
	3	Mechanised tillage
Pest control	4	No pesticides
	5	Mass-trapping using baits and pheromones
	6	Traditional pest control products (e.g. copper, lime, white oils, Bordeaux mixture, etc.)
	7	Preventive pesticide treatment
	8	Tree density

Table 3. Behavioural points of application (14, 21, 22, 24, 82, 120)

Figure 6 graphically represents BIS and their effects as well as possible exogenous factors that might affect the achievement of BIS goals. RDP is here presented in purple because, although it is mainly an economic strategy, it promotes and incentivises informational campaigns, training courses and technical assistance.

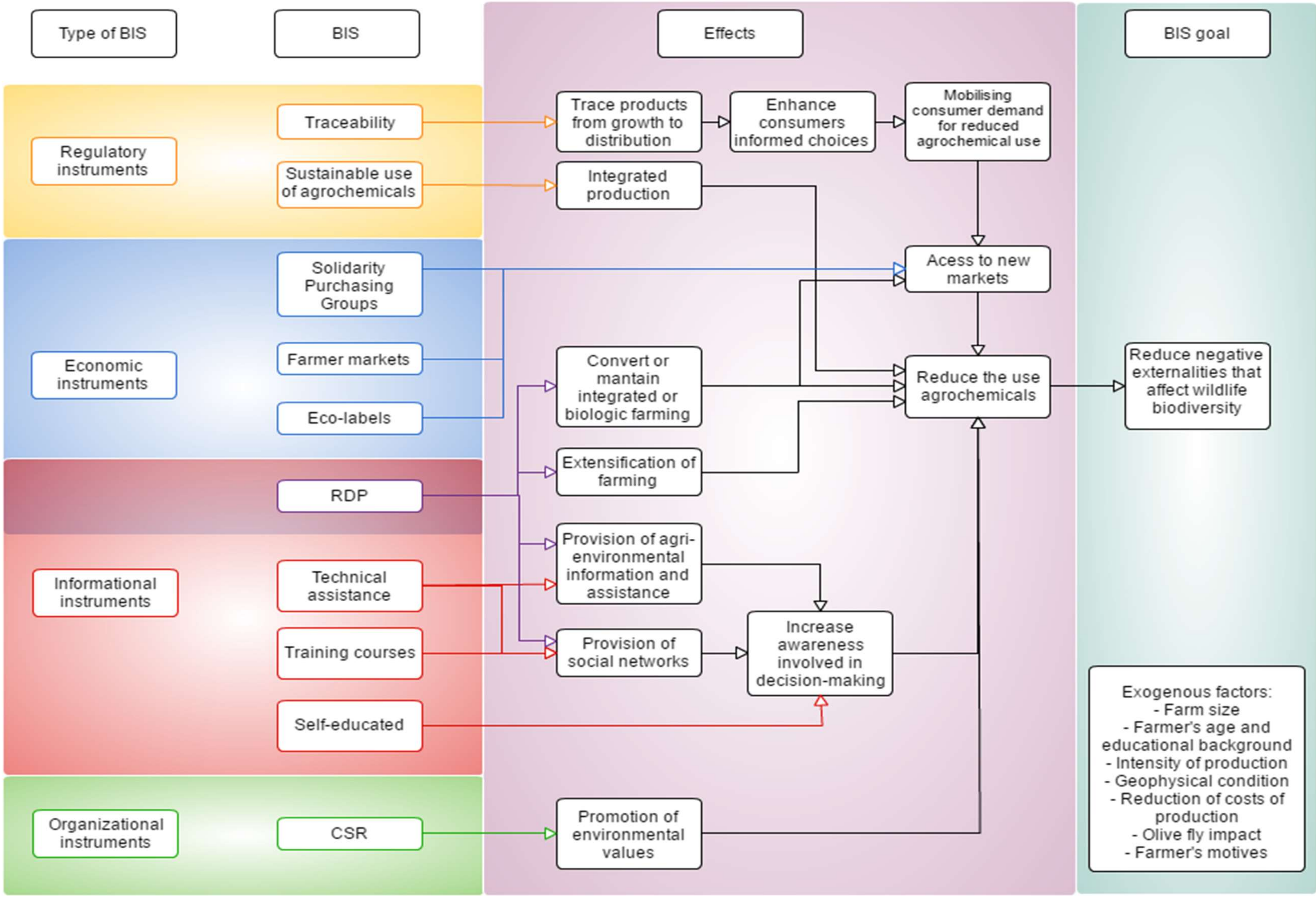

Figure 6. Biodiversity conservation in olive farming – BIS, effects and exogenous factors

All strategies assume that their contribution will either directly or indirectly result in a reduction of agrochemicals use due to legislation enforcement, economic incentives, information or company policy. This behavioural change will in turn lessen the amount of chemical input used in olive farming and later reduce negative externalities affecting wildlife biodiversity.

With the exception of traceability, regulatory, economic and informational BIS explicitly mention biodiversity conservation and enrichment within their body of text, where available, as the major or one of the most critical final effects of the strategy. They also seem to directly link the reduction of agrochemicals as the main behavioural change to be fostered in order to achieve the goal stated above. Traceability is here included because, as explained within Step 1, the goal of the strategy is to inform consumers of the origin of the products they purchase and it might indirectly affect olive production practices towards wildlife biodiversity conservation. Further, these strategies do not set specific targets in regards to biodiversity conservation.

In regards to informational and organizational strategies, questions were asked to olive farmers to identify whether these BIS specifically mentioned wildlife biodiversity or biodiversity in general and if agrochemicals reduction was mentioned as a possible factor aiding conservation. Results indicate that less than 40% had directly referenced biodiversity conservation. However, agrochemicals reduction was a topic highly considered within these BIS as a practice to better the quality of the product and the working environment.

In regards to weed control and soil management, none of the regulatory or economical BIS explicitly mentioned any of the points of application above identified. Most of the strategies only indicated the final goal, i.e. agrochemicals reduction (except for traceability), without suggesting possible alternative agricultural practices. When considering pest control, only Eco-labels and RDP gave indications on practices that are considered admissible to receive certification or contributions.

For informational and organizational strategies, the above considerations might not apply depending on the technical assistance, trainings, self-education and CSR that the individual olive farmer is seeking. Particularly, these strategies might address the above points of application if considering their practical nature. Table 4 schematically represents whether the specific points of application were addressed by the BIS, where X entails "Addressed" while ? entails "Potentially".

BIS \ Points of application	1	2	3	4	5	6	7	8
Traceability								
Sustainable use of agrochemicals								
SPG								
Farmers' markets								
Eco-labels				X	X	X		
RDP				X	X	X		
Technical assistance	?	?	?	?	?	?	?	?
Training courses	?	?	?	?	?	?	?	?
Self-education	?	?	?	?	?	?	?	?
CSR	?	?	?	?	?	?	?	?

Table 4. Points of application (numbers as identified in Table 3) addressed by BIS

4.3 Step 3: Impact assessment of strategies mixes and their relative influence

In the course of this part, a statistical analysis has been performed on the data recovered using the questionnaire The details of the below performed analysis can be found in Appendix 4.

I used Chi-square or a Spearman rho, depending on the type of variable, to test whether there might be a relationship between dependant variable and exogenous factors (i.e. farm size, farmer's age, educational background, intensity of production, geophysical condition of the farm location, reduction of costs of production, olive fly impact and farmers' motives) (75). This analysis yielded no statistical significant differences except for educational background, reduction of costs of production and farmers' motives which will be presented in section 4.3.2

further, Figure 7 highlights BIS that have been adopted from Tuscan farmers as self-reported during the questionnaire. All farmers have reported to fulfil the obligations mandated by the regulatory instruments above mentioned, sustainable use of agrochemicals and traceability. To date, no monitoring initiatives have been set out for either legislation in regards to compliance, thus, I had to exclude both from the below analysis since there was no variance in the reported data (121).

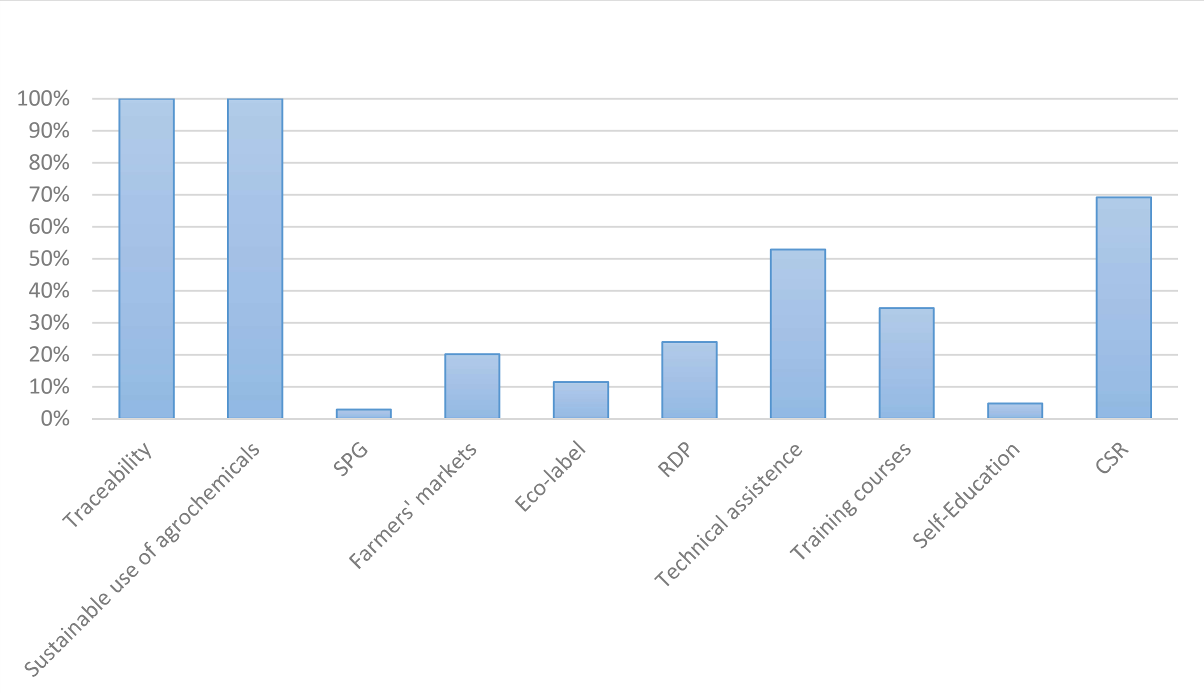

Figure 7. BIS strategies

4.3.1 Goal attainment

As explained above, goal attainment pertains the achievement of the targets set within the BIS (53). In this case, thus, goal attainment refers to any reduction of the use of agrochemicals in olive farming. As showed in Table 5 and 6, most of the farmers have not used any agrochemicals between 2010 and 2015, only 2.9% have increased, 14% have maintained and 12% have reduced. Of the ones that have lowered their consumption of agrochemicals, more than half have diminished it of at least 40% (Table 7). The reduction of agrochemicals in olive farming found in this research is further confirmed by national statistics, which report that olive farmers have reported decreasing their use of about 54.2%

since 2005-2006. Moreover, ISTAT states that only 27% olive farmers' use chemical inputs also corroborated by the data collected for this research which estimates it at 29.1% (122). Therefore, the sample is representative of the national average use and reduction rate of agrochemicals.

In the past five years (between 2010 and 2015) have you used agrochemicals in your olive cultivation?

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	219	70.9	70.9	70.9
	Yes	90	29.1	29.1	100.0
	Total	309	100.0	100.0	

Table 5. Agrochemicals use

In the same period of time, considering seasonality, have you increased or decreased your use of agrochemicals

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Increased	9	2.9	2.9	2.9
	Stayed the same	43	13.9	13.9	16.8
	Decrease	38	12.3	12.3	29.1
	I haven't used agrochemicals in the past 5 years	219	70.9	70.9	100.0
	Total	309	100.0	100.0	

Table 6. Change in the use of agrochemicals

Agrochemicals reduction

		Frequency	Percent	Cumulative Percent
Valid	I'm not using any agrochemicals	6	13.6	13.6
	More than 80%	7	15.9	29.5
	From 61% to 80%	5	11.4	40.9
	From 41% to 60%	9	20.5	61.4
	From 21% to 40%	9	20.5	81.8
	From 1% to 20%	8	18.2	100.0
	Total	44	100.0	

Table 7. Reduction of agrochemicals

The conclusion that can be drawn from the above results seems to validate the fulfilment of the targets set for the above BIS mix and, thus, goal attainment is achieved. The next step will be to determine the extent to which these accomplishments are a consequence of BIS or if they are the result of other exogenous factors.

4.3.2 How much of the reduction can be accounted for by the BIS mix?

The first step taken in the analysis is to determine statistically the relationship between dependent variable, i.e. agrochemicals reduction, and independent variables, i.e. BIS mix, as well as between dependant and control variables. I utilized a Spearman correlation coefficient where an ordinal variable was present while I used a Chi square test if both variables were only categorical (121, 123). Table 8 shows that there is a relationship between agrochemicals reduction and BIS mix (Chi^2 9.202 with a significance level of .010), educational background (correlation coefficient .243 with a significance level of .005 1-tailed), reduction of costs of production (Chi^2 4.669 with a significance of .031) and farmers' motives (correlation coefficient .295 with a significance level of .002 1-tailed).

		Agrochemicals reduction
BIS mix	Chi²	9.202*
	df	2
	Sig.	.010
Educational background	Spearman correlation	.243*
	Sig. (1-tailed)	.005
Reduction of costs of production	Chi²	4.669
	df	1
	Sig.	.031**
Farmers' motives	Spearman correlation	.295*
	Sig. (1-tailed)	.002
* Correlation is significant at the 0.01 level		
** Correlation is significant at the 0.05 level		

Table 8. Chi² test BIS mix and Spearman correlation coefficients farmers' motives

I further proceeded by looking at the R^2 of BIS mix and exogenous factors in relation to the dependant variable, in order to determine the extent to which agrochemicals reduction can be attributable to the BIS mix. Here I performed a binary logistic regression and calculated the R^2 for the control and dependant variable (Table 9) as well as for the combination of control, independent and dependant variables, after controlling for residuals (Table 10) (75, 121).

		Chi-square	df	Sig.
Step 1	Step	21.465	3	.000
	Block	21.465	3	.000
	Model	21.465	3	.000

Step	-2 Log likelihood	Cox & Snell R²	Nagelkerke R²
1	120.238	.186	.251

Table 9. Binary logistic regression of control variables and dependant variable

		Chi-square	df	Sig.
Step 1	Step	26.339	11	.006
	Block	26.339	11	.006
	Model	26.339	11	.006

Step	-2 Log likelihood	Cox & Snell R²	Nagelkerke R²
1	115.365	.224	.301

Table 10. Binary logistic regression of control variables, independent variable and dependant variable

Finally, I deducted the first form the latter to understand the extent to which the variance in the use of agrochemicals depends on BIS strategies implementation excluded the influence provided by farmers' motives (75). The resulting R^2 differs depending on the chosen statistical test, but for all of them it is noticeable that adding the variable BIS mix as predictor of agrochemicals reduction produces an improvement in the predictability of the generated model (Table 11). This can be further confirmed by the increment in the Chi-square detected when comparing the above tables.

Cox & Snell R²		Nagelkerke R²	
.038	3.8%	.05	5%

Table 11. Resulting R²

4.3.3 Relative importance of each BIS in changing farmers' behaviour

When taking a look at the single strategies, correlation can be found only for the BIS highlighted in green in Table 12 (121). This is further confirmed by the binary logistic regression performed above. Table 12 shows that the only variables that would have an influence on the model if not inserted are farmers' markets and CSR. For these variables the Chi square coefficient is higher than .05 while the significance levels are below .05 and .01.

		Agrochemicals reduction
SPG	Chi²	.102
	df	1
	Sig. (1-sided)	.616
Farmers market	Chi²	4.140
	df	1
	Sig. (1-sided)	.037
Eco-labels	Chi²	1.590
	df	1
	Sig. (1-sided)	.172
RDP contribution	Chi²	.536
	df	1
	Sig. (1-sided)	.310
Technical assistance	Chi²	.011
	df	1
	Sig. (1-sided)	.536
Training courses	Chi²	.009
	df	1
	Sig. (1-sided)	.546
Self-education	Chi²	.674
	df	1
	Sig. (1-sided)	.355
CSR	Chi²	7.906
	df	1
	Sig. (1-sided)	.004

Table 12. Chi squared coefficients BIS

Moreover, when taking into consideration the Wald statistic (Table 13), which if greater than 1 entails that the variable makes a significant contribution into predicting the outcome, it is clear that the only strategies that have influence agrochemicals reduction are farmers' markets and CSR (121).

			Wald
		SPG	.099
		Farmers' markets	1.090
		Eco-labels	1.120
		RDP	.536
		Technical assistance	.009
		Training courses	.011
		Self-education	.686
		CSR	1.298

Table 13. Wald statistic BIS

In order to further support the above analysis, I also performed a binary logistic regression using a forward stepwise method. Although this approach is highly criticised for theory testing, it is believed useful to understand the most significant predictors of the model (121). When imputing all BIS identified for this study into the analytical software, the yielded results confirm that no independent variables relate to predicting the outcome of the dependent other than the ones identified above (Table 14).

Model if Term Removed					
Variable		Model Log Likelihood	Change in -2 Log Likelihood	df	Sig. of the Change
Step 1	CSR	-70.852	8.325	1	.004
	Farmers' market	-70.852	4.102	1	.043

Table 14. Binary logistic regression with forward stepwise method

5. Conclusion and Reflections

General conclusions

Biodiversity conservation is the aim of all strategies, except for traceability, and agrochemicals reduction is identified as one of the main behavioural change to be addressed in order to achieve the goal mandate. On the other hand, possible agricultural practices, i.e. point of applications, alternative to the conventional ones are not directly addressed. Only in the case of Eco-labels and RDP there are some indications regarding pest control methods that are allowed in order to receive certifications or contributions. Therefore, for these strategies, biodiversity integration only achieves a level of *coordination.* Hence, their impact is taken into consideration and their goals have been partially adapted in order to also achieve biodiversity objective, but they have not been given priority or even an equal status as the agricultural ones (27).

However, this picture might not fully describe informational and organizational strategies. Since these BIS are custom made to fulfil the needs of each olive farmer and given their practical nature, there is a potential that the detailed points of application might be addressed. Thus, in these cases, strategies could reach *harmonization* or *prioritization* if equal consideration is given to agricultural and biodiversity objectives or even 'principle priority' (27).

Secondly, although the goal of the strategies has been achieved, hence, over the period of time considered agrochemicals use has been reduced, only about 5% of variation can be accounted for by the independent variables when controlling for exogenous factors. Further, if the control variables are added back into the model, the variation percentage increases to 30%, leaving about 70% of the behavioural change unexplained.

It is significant to notice that the only strategies fostering a variation in famers' agricultural practices are both forms of self-governance, thus, yielding directly from the farmers themselves. Further, when taking in consideration exogenous factors, cost reduction has been found to have a negative influence within the model, since all farmers that have reported this aspect have not actually reduced their use of agrochemicals. If, in addition to this result, the fact that economic strategies have not been found to have a correlation with agrochemicals reduction is taken into consideration, it seems evident that the stimuli to change behaviour towards wildlife biodiversity conservation cannot derive from an economic aspect alone. Other factors need to be taken into account.

With regards to educational level, the results confirm what has been found within the literature. Farmers with higher educational level tent to have a higher reduction rate. Additionally, farmers' motives seem to confirm that the behavioural change is more effective if is fostered by personal attitudes towards biodiversity conservation, and thus that self-governance strategies might yield a greater agrochemicals reduction.

Given the analysis, it is evident from the results presented that for the period between 2010 and 2015 the BIS mix considered has had a minor impact and has not been effective in changing farmers' behaviour.

Limitations within the approach and results

A first limitation of the research can be identified in the period of time taken into consideration for two reasons. Firstly, this study only considers farmers that have reduced their use of agrochemicals between 2010 and 2015, mandated by the time and resources available to the researcher.

Secondly, as above mentioned the most important economic strategy, RDP, has been implemented in 2007. Therefore, between 2007 and 2010 many farmers could have made use of the incentives given through this plan without being accounted for in this research

Further, this research does not take into account maintaining farming practices that avoid using agrochemicals, since it was considered outside the scope of the study. However, some of the economic incentives are also given for the maintenance of such agricultural practices. Therefore, future analysis might want to tackle the importance of BIS in regards to the support that these provide to farmers already using methods towards biodiversity conservation.

Moreover, considering the novelty of the research variables identified within the impact model only accounted 30% of the variation in the dependent variable. An additional step that could be taken by future research is to determine additional factors that might affect agrochemicals reduction within olive farming.

Finally, the choice of a survey, while ensuring a certain degree of external validity, may result in lower degrees of internal one, particularly in regards to more in depth research. The knowledge gathered solely concerns the variables taken into consideration during the research, hence, only an aspect of the topic of study has been examined (61).

Policy recommendations

As above explained, regulatory, economic or informational strategies, as they are designed, do not seem to be the turning point to foster agrochemicals reduction. Although, these research takes into account only a specific period of time while not taking into consideration previous years, it seems relevant to highlight that policy-makers should work towards enabling self-governance strategies.

Particularly, CSR appears to yield the most agrochemicals reduction. Therefore, supporting the implementation this BIS could be more effective in changing olive farmers' behaviour.

Contribution to the literature

The novelty of this research in relation to the theoretical debate on EPI lies in its attempt to evaluate biodiversity integration strategies developed by both public and private actors at various levels. To date, little studies have been performed that take into account challenges represented by the various modes of governance that yield from the multi-actors and multi-scale reality constituted by the olive tree farming system and this research wants to contribute to EPI literature in this regard (35).

Secondly, this study has a novel approach and attempts to compare biodiversity integration strategies by different actors. This allow not only evaluate the effectiveness of each strategy of biodiversity integration, but, also to understand their relative importance in relation to the pool of BIS designed for this purpose. Here, of particular interest is use of the methodological approach proposed by Weber et al (2013) extended to include private actors' strategies.

Finally, according to the literature, empirical research on EPI was needed in order to collect further knowledge on the issue. In particular, there was a lack of studies identifying factors that might influence farmers' behaviour towards more integrated agricultural practices other than EPI strategies (26, 44). This research addresses this point, particularly regarding exogenous factors that might foster or hinder integration.

Appendix 1. Data collection

Interviews

All interviews were performed following a semi-open questionnaire. The questions were revised and improved after each interview to test the variables identified for the impact model.

Interviewee	Function
Az. Agricola La Gora	Farmer
Az. Agricola Il Cavallino	Farmer
Az. Agricola Aquiline	Farmer
Az. Agricola Fattoria di Grignano	Farmer
Tenuta di Capezzana srl	Farmer
Paolo Giomi	Agronomist
Annalisa Bioli	Agronomist
Claudio Corazzini	Agronomist
Luciano Zoppi	Tuscan region
Rita Turchi	Tuscan region
Marta Mancusi	Chamber of commerce of Livorno
Sergio Costalli	Chamber of commerce of Livorno

Table 15. Interviewees and functions

Survey

The Chamber of Commerce of Livorno agreed to collaborate with the project and to send out directly the initial pilot questionnaire. This partnership was mentioned in the presentation text of the questionnaire. Further, they communicated their participation to the remaining Chambers of Commerce of the Tuscan region and requested their collaboration with the research. All provinces granted their cooperation except for the Chamber of Commerce of Florence. Given this partnership, I added a new question regarding the province of the cultivation.

Following the suggestions of both experts and the Chamber of Commerce, the deadline of completion of the questionnaire was set at two weeks. The first data transmission of the questionnaire was performed over the period between the 14th of May 2016 and the 3rd of June 2016. A second reminder email was also sent to all farmers a week into the completion time. The acceptance of responses ended on the 19th of June 2016.

A search based on the ATECO registration *0126 - Coltivazione di frutti oleosi* (cultivation of oil-rich fruits) was performed in order to gather all registered email addresses utilized during the data transmission of the questionnaire (see Table 9 for an explanation of the ATECO code). Subscription to Chamber of Commerce is mandatory for all business (124). Registered emails are public record and were collected through the website of Registro Imprese (125). This search yielded only farms that are enlisted with olive cultivation as their primary occupation.

Divisione	01	Desc.Div.ne	Coltivazioni agricole e produzione di prodotti animali, caccia e servizi connessi
Gruppo	012	Desc.Gruppo	Coltivazione di colture permanenti
Classe	0126	Desc.Classe	Coltivazione di frutti oleosi
Categoria	01260	Desc.Cat.ria	Coltivazione di frutti oleosi
Cod. Istat	01.26		
Codatt	A0126		

Table 16. ATECO code (126)

Appendix 2. Questionnaire

I am a master student of Sustainable Development and Environmental Governance at the University of Utrecht (The Netherlands) and I am carrying out this survey in order to collect information for my final thesis research conducted in collaboration with the Chamber of Commerce of Livorno and Grosseto.

The study concerns strategies developed to reduce the use of herbicides and pesticides in olive growing. This research will focus its attention on the Tuscan region and will analyse the effectiveness of such strategies in order to give indications directed at coordinating and improving them.

The goal of this research is not only academic, but it will yield a report that will highlight the success of the above mentioned strategies and will be handed out to authorities collaborating with this study, such as the Chamber of Commerce of Livorno and Grosseto and the Tuscany Region.

The questionnaire is anonymous, the collected data will be analysed aggregated respecting the privacy legislation and will not be divulged.

You will receive a notification email after you have completed the questionnaire, which will include also contact details if you wish to receive further information about the study.

The completion of the questionnaire takes about five minutes.

Questionnaire:

1. Age
    a. 18 – 24
    b. 25 – 34
    c. 35 – 44
    d. 45 – 54
    e. 55 – 64
    f. 65 or more
2. Education level
    a. Up to Primary School
    b. Middle School Diploma
    c. High School Diploma ______
    d. University degree ______
    e. Other
3. Email ________
4. Do you farm or breed crops other than olives? (mark more than one if necessary)
    a. Olives only
    b. Orchards
    c. Vineyard
    d. Arable
    e. Horticulture
    f. Breeding
    g. Other
5. Dimension of farm (total) ha ____
6. Dimension of olive cultivation ha ____
7. Olive cultivation
    a. Extensive

   b. Intensive
   c. Super-Intensive
8. When did your business start? ____
9. Is it a family business?
   a. Yes
   b. No
10. In which province is your farm located? _________
11. Type of cultivation
   a. Conventional
   b. Biologic
   c. Integrated
   d. Biodynamic
   e. Other
12. When did you convert to biologic or biodynamic? ____
13. Do you have an integrated, biologic or biodynamic certification?
   a. Yes
   b. No
   c. Other
14. How do you sell the main share of your product? (mark more than one if necessary)
   a. Directly (locally)
   b. Directly (nationally)
   c. Directly (export)
   d. Indirectly via distributors
   e. Other
15. In the past five years (between 2010 and 2015) have you used agrochemicals in your olive cultivation?
   a. Yes
   b. No
   c. I haven't used agrochemicals in the past 5 years
16. In the same period of time, considering seasonality, have you increased or decreased your use of agrochemicals
   a. Increased
   b. Stayed the same
   c. Decreased
17. I reduced the use of agrochemicals by
   a. From 1% to 20%
   b. From 21% to 40%
   c. Form 41% to 60%
   d. From 61% to 80%
   e. More than 80%
   f. I'm not using any agrochemicals anymore
18. What are your motives for reducing or leave unvaried your use of agrochemicals in your olive cultivation? Rank from 1 to 5

	1 Not important	2 Slightly important	3 Moderately important	4 Very important	5 Extremely important

Access to new market					
Commercial interests					
Higher quality of the products					
Increase the safety and health of the workspace					
Increase the safety and health of the products					
Respect and development of the territory					
Conservation of the environment					
Conservation of wildlife biodiversity (e.g. pollinators, mammals, reptiles, birds etc.)					

19. Do you follow the legislation in regards to the traceability?
    a. Yes
    b. No
20. Do you follow the legislation in regards to the sustainable use of agrochemicals?
    a. Yes
    b. No
21. Do you receive the RDP contribution (agro-environmental payments)?
    a. Yes
    b. No
22. Are you enrolled with a Trade association or do you work with an agronomist?
    a. Trade Association
    b. Agronomist
    c. Both
    d. other
23. Which Trade Association are you enrolled in? ______
24. Do you participate to farmers' markets?
    a. Yes
    b. No
25. Do you sell to solidarity purchasing groups?
    a. Yes

b. No

26. Do you have in place a corporate social responsibility plan?
    a. Yes
    b. No
27. Did you consult any of the following in regards to your use of agrochemicals? (mark more than one if necessary)
    a. Trade association
    b. CAA
    c. Agronomist
    d. Consumers associations
    e. Farmers associations
    f. Universities
    g. None
    h. Other
28. Did you consult any of the following in regards to possible wildlife biodiversity (e.g. pollinators, mammals, reptiles, birds, etc.) conservation measures? (mark more than one if necessary)
    a. Trade association
    b. CAA
    c. Agronomist
    d. Consumers associations
    e. Farmers associations
    f. Universities
    g. None
    h. Other
29. Did you take part in any training seminars organised from any of the following in regards to your use of agrochemicals? (mark more than one if necessary)
    a. Trade association
    b. CAA
    c. Agronomist
    d. Consumers associations
    e. Farmers associations
    f. Universities
    g. None
    h. Other
30. Did you take part in any training seminars organised from any of the following in regards to the impact of your use of agrochemicals on wildlife biodiversity (e.g. pollinators, mammals, reptiles, birds, etc.)? (mark more than one if necessary)
    a. Trade association
    b. CAA
    c. Agronomist
    d. Consumers associations
    e. Farmers associations
    f. Universities
    g. None
31. Which of the following strategies will you say play a role in your decision to reduce your use of agrochemicals in your olive cultivation?

	1 Not important	2 Slightly important	3 Moderately important	4 Very important	5 Extremely important
Regional economic incentives					
Easier access to state and region based loans					
Taxation waivers					
Traceability of the products					
Farmers markets					
Corporate Social Responsibility					
Awareness campaign for consumers					
Training seminars on the impact of the use of agrochemicals on wildlife biodiversity (e.g. pollinators, mammals, reptiles, birds, etc.)					
BIO Certification					

32. What is the main motives in your decision of reducing or maintain the use of agrochemicals in your olive farm?
    a. Personal reasons
    b. BIS developed to foster the reduction or maintenance as above mentioned
    c. Other
33. Do you breed bees?
    a. Yes
    b. No
34. Is the farm located in an area highly affected by the oil fly?
    a. Yes
    b. No
35. Do you wish to have additional measures designed to support reduce your impact on wildlife biodiversity?
    a. Yes

b. No

36. If yes, what do you believe is more important?

	1 Not important	2 Slightly important	3 Moderately important	4 Very important	5 Extremely important
State wide commercial policy					
State protection against imported product					
Economic incentives					
Taxation discounts					
Trainings					
Other _______					

37. Would you like to receive the results of this research?
    a. Yes
    b. No

Comments: _______

Appendix 3. Legislative reference of BIS

BIS	*EU legislation reference*	*Italian legislation reference*	*Tuscan legislation reference*
Traceability	Regulation (EU) n. 178/2002 (84) Regulation (EU) n. 299/2013 (89) Regulation (EU) n. 23/2012 (85)	Linee guida sulla rintracciabilità degli alimenti e dei mangimi (127) DM 23 dicembre 2013 (87) DM n. 4075 8 luglio 2015 (88)	
Sustainable use of agrochemicals	Directive 2009/128/EC (91)	DLgs 14 agosto 2012, n 150 (90)	
RDP 2007/2013	Regulation (EU) n. 1698/2005 (128) Council regulation (EC) n. 1290/2005 (129) Council regulation (EC) n. 74/2009 (130) Council decision n. 2006/144/EC (131) Council decision n. 2009/61/EC (132) Decisione di esecuzione della Commissione del 16.10.2007 Decisione della Commissione del 30.11.2009 (133) Decisione di esecuzione della Commissione del 30.11.2012 (134)		VADEMECUM Programma Sviluppo Rurale (93, 135)
RDP 2014/2020	Regulation (EU) n. 1303/2013 (136) Regulation (EU) n. 1305/2013 (137) Regulation (EU) n. 1306/2013 (138) Commission implementing regulation (EU) n. 808/2014 (139) Decisione di esecuzione della Commissione del 26.5.2015 (140)		Italy – Rural Development Programme (Regional) – Toscana (94–96, 99–105)
Organic certification	Council regulation (EC) n. 834/2007 (107) Commission regulation (EC) n. 889/2008		
Agriqualitá	Council Regulation (EEC) n. 2078/92		L.R. 25/99 RR 47/2004 DPGR n. 60 del 14/12/2010 Delibera GR 104 del 28/02/2011 Decreto dirigenziale 865 del 11/03/2011 (All. C e D) (108, 109)

Table 17. Legislative references

Appendix 4. Detailed statistical analysis

In the next pages the details of the statistical analysis performed in order to draw the above results are presented.

Psychometric analysis

At this stage I performed a consistency analysis, highlighting standard deviation, correlation and Cronbach's Alpha to identify if there was variation, relationships and internal reliability between the items utilized to describe farmers' motives. The first test yielded the results showed below in Tables 18 and 19. The Alpha coefficient is of .886, which already indicates a high level of consistency. However, Table 19 highlights that removing items "Access to new market" and "Commercial interest" will have a higher consistency level. Further, the correlation value for both these items is lower than the others. Therefore, I decided to remove these two items in order the have a higher consistency and correlation, as showed in Tables 20 and 21.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.886	.895	8

Table 18. Reliability statistics farmers' motives 8-items

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Access to new market	26.56	37.744	.471	.556	.893
Commercial interests	26.40	39.350	.393	.516	.900
Higher quality of the products	24.75	37.743	.609	.493	.876
Increase the safety and health of the workspace	24.86	34.435	.732	.596	.864
Increase the safety and health of the products	24.44	36.424	.797	.784	.860
Respect and development of the territory	24.63	35.751	.835	.860	.856
Conservation of the environment	24.59	36.070	.828	.903	.857
Conservation of wildlife biodiversity (e.g. pollinators, mammals, reptiles, birds etc.)	24.69	35.691	.725	.733	.865

Table 19. Cronbach's Alpha farmers' motives 8-items

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.930	.934	6

Table 20. Reliability statistics farmers' motives 6-items

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
Higher quality of the products	20.31	24.079	.657	.479	.934
Increase the safety and health of the workspace	20.41	21.837	.736	.571	.928
Increase the safety and health of the products	20.00	22.913	.872	.776	.908
Respect and development of the territory	20.18	22.753	.864	.849	.909
Conservation of the environment	20.14	22.629	.904	.900	.904
Conservation of wildlife biodiversity (e.g. pollinators, mammals, reptiles, birds etc.)	20.25	22.306	.789	.730	.918

Table 21. Cronbach's Alpha farmers' motives 6-items

Systematic differences between exogenous variables categories

Age

Age * Have you reduced your use of agrochemicals? Crosstabulation

			Have you reduced your use of agrochemicals?		Total
			No	Yes	
Age	18 - 24	Count	1	1	2
		Expected Count	1.2	.8	2.0
	25 - 34	Count	7	2	9
		Expected Count	5.5	3.5	9.0
	35 - 44	Count	18	9	27
		Expected Count	16.5	10.5	27.0
	45 - 54	Count	18	13	31
		Expected Count	18.9	12.1	31.0
	55 - 64	Count	14	12	26
		Expected Count	15.9	10.1	26.0
	65 or more	Count	11	7	18
		Expected Count	11.0	7.0	18.0
Total		Count	69	44	113
		Expected Count	69.0	44.0	113.0

Table 22. Crosstabulation variable *Age*

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	2.204[a]	5	.820
Likelihood Ratio	2.283	5	.809
Linear-by-Linear Association	.766	1	.382
N of Valid Cases	113		

a. 3 cells (25.0%) have expected count less than 5. The minimum expected count is .78.

Table 23. Chi² test variable *Age*

Intensity of cultivation

Olive cultivation * Have you reduced your use of agrochemicals? Crosstabulation

			Have you reduced your use of agrochemicals?		
			No	Yes	Total
Olive cultivation	Extensive	Count	41	25	66
		Expected Count	40.3	25.7	66.0
	Intensive	Count	27	19	46
		Expected Count	28.1	17.9	46.0
	Super-Intensive	Count	1	0	1
		Expected Count	.6	.4	1.0
Total		Count	69	44	113
		Expected Count	69.0	44.0	113.0

Table 24. Crosstabulation variable *Intensity of cultivation*

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	.777[a]	2	.678
Likelihood Ratio	1.125	2	.570
Linear-by-Linear Association	.014	1	.907
N of Valid Cases	113		

a. 2 cells (33.3%) have expected count less than 5. The minimum expected count is .39.

Table 25. Chi² test variable *Intensity of cultivation*

Area

In this instance I used as representation of the geographical areas identified by the provinces. Although they define fictional political borders (in orange in Figure 2), they can be a useful tool to highlight the geophysical conditions in which the olive farms are located.

In which province is your farm located? * Have you reduced your use of agrochemicals? Crosstabulation

			Have you reduced your use of agrochemicals?		Total
			No	Yes	
In which province is your farm located?	Arezzo	Count	3	3	6
		Expected Count	3.7	2.3	6.0
	Firenze	Count	19	13	32
		Expected Count	19.5	12.5	32.0
	Grosseto	Count	13	6	19
		Expected Count	11.6	7.4	19.0
	Livorno	Count	10	9	19
		Expected Count	11.6	7.4	19.0
	Lucca	Count	1	2	3
		Expected Count	1.8	1.2	3.0
	Pisa	Count	10	7	17
		Expected Count	10.4	6.6	17.0
	Pistoia	Count	6	3	9
		Expected Count	5.5	3.5	9.0
	Prato	Count	2	1	3
		Expected Count	1.8	1.2	3.0
	Siena	Count	5	0	5
		Expected Count	3.1	1.9	5.0
Total		Count	69	44	113
		Expected Count	69.0	44.0	113.0

Table 26. Crosstabulation variable *Area*

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	5.701[a]	8	.681
Likelihood Ratio	7.411	8	.493
Linear-by-Linear Association	1.133	1	.287
N of Valid Cases	113		

a. 9 cells (50.0%) have expected count less than 5. The minimum expected count is 1.17.

Table 27. Chi^2 test variable *Area*

Farm size

In regards to farm size, I have used the categorization proposed by the ISTAT during the 2010 census of agriculture.

Dimension of olive farm category * Have you reduced your use of agrochemicals? Crosstabulation

			Have you reduced your use of agrochemicals?		Total
			No	Yes	
Dimension of olive farm (ha)	<1	Count	2	3	5
		Expected Count	3.1	1.9	5.0
	1<x<2	Count	10	10	20
		Expected Count	12.2	7.8	20.0
	2<x<5	Count	28	16	44
		Expected Count	26.9	17.1	44.0
	5<x<10	Count	14	7	21
		Expected Count	12.8	8.2	21.0
	>10	Count	15	8	23
		Expected Count	14.0	9.0	23.0
Total		Count	69	44	113
		Expected Count	69.0	44.0	113.0

Table 28. Crosstabulation variable *Farm size*

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	2.529[a]	4	.639
Likelihood Ratio	2.482	4	.648
Linear-by-Linear Association	1.623	1	.203
N of Valid Cases	113		

a. 2 cells (20.0%) have expected count less than 5. The minimum expected count is 1.95.

Table 29. Chi² test variable *Farm size*

Olive fly

Have you reduced your use of agrochemicals? * Is your area higly impacted by olive flyes? Crosstabulation

			Is your area higly impacted by olive flyes?		Total
			No	Yes	
Have you reduced your use of agrochemicals?	No	Count	23	46	69
		Expected Count	23.8	45.2	69.0
	Yes	Count	16	28	44
		Expected Count	15.2	28.8	44.0
Total		Count	39	74	113
		Expected Count	39.0	74.0	113.0

Table 30. Crosstabulation variable *Olive fly*

Chi-Square Tests

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	.109[a]	1	.741
Likelihood Ratio	.109	1	.741
Linear-by-Linear Association	.108	1	.742
N of Valid Cases	113		

a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 15.19.

Table 31. Chi² test variable *Olive fly*

Examination of the residuals

After performing the binary logistic regression, the next step is to isolate cases for which the model is a poor fit and points that influence the model unduly (121). For the former I used standardized residual, while for the latter, the Cook's distance.

Regarding the first parameter, as showed by Table 32 only one case out of the 104 considered is above 1.96. further, as below described by Table 32, the Cook's distance yielded two cases with a coefficient of 1 which entails that there are some influential cases that have an undue effect on the model. After controlling those cases, I decided to remove them from the analysis, since in both cases the data had no variation.

Case Summaries

	Standard residual
1	-.65047
2	-.38482
3	-.83116
4	-.71408
5	1.07729
6	1.07729
7	.88850
8	.96649
9	1.07729
10	1.07729
11	.88850
12	1.07729
13	1.66511
14	1.07729
15	1.78004
16	1.23979
17	1.20178
18	1.20178
19	1.20178
20	1.91663
21	1.33855
22	1.33855
23	1.07729
24	1.33855
25	1.96280
26	.88850
27	.92675
28	1.07729
29	1.07729
30	1.64892
31	1.29158
32	1.05073
33	-.82156
34	-1.52179
35	-1.52179
36	-1.31719
37	-1.13326
38	-1.56977
39	-.93551
40	-.65047
41	-1.09099
42	-1.31719
43	-1.22222
44	-1.31719
45	-.82156
46	-.34864
47	-.65047
48	-.89968
49	-.62078
50	-1.01067
51	-.46734
52	-1.66511
53	-1.09229
54	-.42431
55	-1.25534
56	-.93551
57	-.51418
58	-1.09860
59	-1.13326
60	-1.31719
61	-1.29703
62	-.78397
63	-1.04116
64	-.71408
65	-.78397
66	-1.26896
67	-1.05015
68	-.93551
69	-1.31719
70	-.46734
71	-.97248
72	-1.31719
73	-1.17699
74	-.59237
75	.88850
76	1.53897
77	1.53897
78	1.91663
79	1.64892
80	.88850
81	.96649
82	1.15895
83	1.33855
84	1.15895
85	1.24598
86	.92675
87	1.33855
88	-.36633
89	-.86492
90	-.99259
91	-1.31719
92	-1.31719
93	-.65047
94	-.89968
95	-1.56977
96	-1.09099
97	-1.31719
98	-1.09099
99	-.82156
100	-.59237
101	1.15895
102	1.15895
103	-.89968
104	.92675
Total N	104

Case Summaries

	Analog of Cook's influence statistics
1	.00815
2	.00343
3	.02254
4	.01081
5	.02266
6	.02266
7	.02574
8	.03144
9	.02266
10	.02266
11	.02574
12	.02266
13	1.00000
14	.02266
15	.13971
16	.08889
17	.02100
18	.02100
19	.02100
20	.17470
21	.03243
22	.03243
23	.02266
24	.03243
25	.19534
26	.02574
27	.02818
28	.02266
29	.02266
30	.13641
31	.02641
32	.04163
33	.01953
34	.11195
35	.11195
36	.03958
37	.01750
38	.12555
39	.01942
40	.00815
41	.01654
42	.03958
43	.02393
44	.03958
45	.01953
46	.00287
47	.00815
48	.02062
49	.00730
50	.01719
51	.00464
52	1.00000
53	.08677
54	.00402
55	.08396
56	.01942
57	.00532
58	.08522
59	.01750
60	.03958
61	.08459
62	.01571
63	.06738
64	.01081
65	.01571
66	.03033
67	.01654
68	.01942
69	.03958
70	.00464
71	.01822
72	.03958
73	.01982
74	.00665
75	.02574
76	.09184
77	.09184
78	.17470
79	.13641
80	.02574
81	.03144
82	.02065
83	.03243
84	.02065
85	.02277
86	.02818
87	.03243
88	.00314
89	.02168
90	.05221
91	.03958
92	.03958
93	.00815
94	.02062
95	.12555
96	.01654
97	.03958
98	.01654
99	.01953
100	.00665
101	.02065
102	.02065
103	.02062
104	.02818
Total N	104

Table 32. Standardized residual and Cook's distance

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