EKLIPSE

Knowledge & Learning Mechanism
on Biodiversity & Ecosystem Services

How can environmental regulators support business to improve the outcomes of their operations for biodiversity, with a focus on small and medium-sized enterprises in the food and beverage sector in Europe?

An EKLIPSE Expert Working Group report

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How can environmental regulators support business to improve the outcomes of their operations for biodiversity, with a focus on small and medium-sized enterprises in the food and beverage sector in Europe?

An EKLIPSE Expert Working Group report

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Glossary of Key Terms

Term	Definition
CDP	Formerly the Carbon Disclosure Project, global disclosure system for environmental impacts of companies, cities, states and regions
DJSI	Dow Jones Sustainability Indices
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
MCA	Multi-Criteria Analysis
NGO	Non-Governmental Organization
QCA	Qualitative Comparative Analysis
QSR	Quick Scoping Review
SDG	Sustainable Development Goal
SEPA	Scottish Environment Protection Agency
SME	Small and Medium-Sized Enterprise
TEEB	The Economics of Ecosystems and Biodiversity
TEEBAgFood	The Economics of Ecosystems and Biodiversity for Agriculture and Food

Executive Summary

Biodiversity loss is one of the biggest challenges that humanity faces, given that many species and their habitats, as well as ecosystems that provide essential resources for human nutrition and wellbeing, are threatened by human activities. The conservation and sustainable use of biodiversity is the prerequisite for sustained future agricultural production and food supply since the resilience of food production systems relies on healthy ecosystems and natural resources (FAO, 2019). On the other hand, current agricultural systems are having a great impact on biodiversity, as described in the TEEB for Food & Agriculture Scientific and Economic Foundations Report (2018). Most notably, intensified consumption patterns in industrialized countries and emerging economies, growing demand for food and beverage products and an increasingly globalized food market have led to the vast exploitation of agricultural land, highly intensive production systems, and dramatic biodiversity loss through land-use change, overexploitation, pollution and the introduction of invasive alien species.

The EKLIPSE Working Group was tasked with the analysis of approaches that environmental regulators could use to support businesses to improve their outcomes for biodiversity, with a focus on small and medium-sized enterprises in the food and beverage sector in Europe. The Working Group was asked to develop a framework to analyse the different possible approaches and their effectiveness. As a second step, it was requested to use this framework to identify and analyse the most promising approaches, as well as to define under which conditions they work well.

The key research questions were:

- What approaches can improve the biodiversity outcomes of businesses?
- How do we know these approaches work / are effective in improving biodiversity outcomes and over what timeframe?
- What are the advantages and disadvantages of existing (and potential) approaches?
- Which of the approaches identified are most promising to be used by regulators?
- Which of these approaches work well under which conditions?

To answer these questions, the project was set out in three different tasks: define a framework of approaches and their effectiveness, identify the most promising approaches that regulators can use, and identify those conditions that could enhance their effectiveness.

The group performed the three different tasks using four different methods: a quick scoping review, a qualitative comparative analysis, an expert survey and a Bayesian decision analysis. Based on the scoping review, we categorized policy instruments into economic instruments, direct regulation, governmental planning, policy mixes, co- and self-regulation, capacity building and information-based approaches.

Based on our analysis, the two most promising policy approaches for safeguarding biodiversity in agri-food value chains were the use of economic instruments and direct regulation. Within the economic instruments, taxes and payments for ecosystem services ranked most effective. With

regards to direct regulation, protected areas and land used restrictions showed the greatest promise to protect biodiversity. It was also concluded that those policy instruments should mainly target farmers and consumers.

In general, our results hint at policy measures aimed at improving biodiversity will more effectively work under conditions of higher adaptability to local contexts and whenever policy development processes were characterized by a high degree of co-planning and participatory governance. Yet, our work also shows the limited evidence base specifically regarding biodiversity-related interventions targeting small and medium-scale enterprises, as well as the difficulty in linking policy interventions to biodiversity outcomes in a robust manner. Most studies focus either on policy implementation and adoption rate while other studies assess biodiversity outcomes as a result of implemented farming measures. Only few studies, however, assess the biodiversity outcomes from policies.

We conducted the Bayesian decision analysis with the goal to bridge this gap. While the literature review and expert survey highlighted the effectiveness of economic instruments, the results of the integrated Bayesian decision analysis revealed that direct regulation is likely to be the most effective policy option while economic instruments were less likely to achieve positive biodiversity outcomes. The probability of improving biodiversity outcomes was mainly dependent on the level of adoption rate. Higher adoption rates of market-based mechanisms are, therefore also more likely to result in better biodiversity outcomes. As direct regulation may not always be a feasible and short-term option, policy-mix options might be promising to generate better biodiversity outcomes in the food and beverage sector.

1. Introduction and scope

1.1 Background

The loss of biological diversity in ecosystems is one of the biggest challenges that humanity faces. Biodiversity conservation is the prerequisite for sustainable future agricultural production since the resilience of food systems relies on natural resources able to tackle vulnerability (FAO, 2019). On the other hand, the impact of agricultural practices on biodiversity is great (TEEB, 2018): intensified food and beverage consumption in industrialized countries and emerging economies and an increasingly globalized market have led to a highly intensive land use, with connected overexploitation, pollution and introduction of invasive alien species.

Companies are increasingly aware of their dependencies upon biodiversity and ecosystem services. Pushed also by several external factors (as consumers, investors and public opinion´s expectations for good environmental performance), they have started to take biodiversity protection into account when it comes, for instance, to the selection of raw materials or the reduction of production-negative environmental impacts.

Interventions to improve biodiversity outcomes of businesses span a multitude of approaches from command-and-control regulation to standards, voluntary and market-based approaches (Taylor et al., 2012). It is essential, however, to understand and evaluate how effective the various approaches are in changing the mind-sets of corporate decision-makers and employees, company culture and customer behaviour. Very often, it is not enough to pursue one single approach or incentive measure to overcome the barriers to conservation and sustainable use of biodiversity in the food sector; instead, a combination of them is necessary (FAO, 2019, p. 419).

1.2 Building on existing work

The intersection of biodiversity, food production and business has been recognised at both international and national level (FAO, 2019; TEEB, 2018; Food & Biodiversity, 2017; IPBES, 2016; Natural Capital Coalition, 2016; PBL 2014; ECNC, 2005). For instance, the Food and Agriculture (FAO) Commission on Genetic Resources for Food and Agriculture Assessments confirms that many drivers of loss of biodiversity for food production such as overexploitation, overharvesting and land use change are caused by inappropriate agricultural practices (FAO, 2019). It stresses the need to identify and strengthen incentive measures and to integrate them into a package which can help produce a greater impact in terms of promoting the sustainable use and conservation biodiversity in food and agriculture. Other resources of note are, inter alia, the final report of the “The Economics of Ecosystems and Biodiversity” project (TEEB, 2018); the EU Business @ Biodiversity Platform 2010 report “Food supply sector and biodiversity conservation. Best practice benchmarking”; and the EU LIFE Project “Biodiversity in Standards and Labels for the Food Industry”.

The present report draws upon these resources, scientific literature and the results from expert consultation with the aim to assess the potential impacts of various policy options on biodiversity to provide information relevant for policy makers and regulators targeting biodiversity outcomes from small and medium enterprises

BOX 1 Food SMEs that support biodiversity

ALB GOLD
https://www.alb-gold.de/unternehmen/wir-tun-was/oekologisch.html
ALB GOLD, based in Southern Germany, is a family business that produces fresh pasta. Part of their activities are the cultivation of seeds to find the best suitable crops for their region, thereby supporting crop diversity. They mainly use domestic crops such as durum wheat. These crops have a better CO_2 footprint, are more resistant to pests and better adapted to the local climate. Further, in order to determine the impact their business has on biodiversity, they conducted a Biodiversity Check. Based on the results strategies were developed and implemented. Among them the fostering of a more biodiversity-friendly cultivation with, e.g. wild field edges, flower strips and insect-friendly paths as well as a natural and green business premises. To assess the effect of those strategies, an external company is monitoring the first results on biodiversity, which will be published after a period of three years.

Berchtesgadener Land
https://bergbauernmilch.de/de/unsere-molkerei.html#nachhaltigkeit
Berchtesgadener Land is a cooperative for dairy products in Bavaria, Germany. They actively support the conservation of biodiversity and refuse the usage of total herbicides and gene technology. Farm terrains are kept natural and cultivation methods are sustainable to maintain a diversity of grasses and herbs. Apart from that, they obtain bee stocks and support the project "Wild and cultivated" which aims at sustaining flower meadows. In addition, they developed a flower seed mix that enriches grasslands. This mixture is distributed among their farmers and is sold in the farm shop. Also, farmers that want to switch to organic farming methods are being supported and the percentage of organically produced dairy products is gradually extended.

1.3 The EKLIPSE call for experts and its scope

In early 2017, following a request by the Scottish Environment Protection Agency (SEPA), EKLIPSE called for expertise on knowledge related to approaches that environmental regulators could use to support businesses to improve their outcomes for biodiversity, with a focus on small and medium-sized enterprises in the food and beverage sector in Europe[1].

The call asked the selected experts to perform three tasks:

Task 1: Define a framework of approaches and their effectiveness

The goal of this task is to provide a systematic overview of approaches that regulators could potentially use.

Task 2: Identify the most promising approaches to be used by regulators

[1] Call for Experts: Eklipse website

The goal of task 2 is to provide a comprehensible and expedient choice of approaches from task 1 for further in-depth analysis in task 3.

Task 3: Identify conditions that enhance effectiveness

This shall take into account different perspectives and can include, for example, the following conditions:

- Conditions related to the national policy and legal context (e.g. do integrated food policies as recently developed in some EU countries help to have a more holistic approach?),
- Conditions related to the specific scheme (different standards, governance schemes),
- Conditions related to corporate biodiversity and natural capital management practice, culture and mind-set,
- Conditions related to the socio-economic context, e.g. structure and interactions within the entire market chain, consumer awareness and choices, and
- Conditions related to the level of trust and partnership between the private and public sector.

1.4 The Expert Working Group

Thanks to the call for experts, the EKLIPSE team was able to form an Expert Working Group (EWG) made up of two co-chairs and six additional members coming from academia, civil society, and the small business community.

The EWG met for the first time in person on December 11th 2017 and has over the course of 2018 and 2019 met remotely for regular online meetings, as well as biannual in-person meetings, in order to prepare the present report.

Interpretation of the request

A preliminary step done by the Expert Working Group was to agree on the interpretation of the EKLIPSE call, its scope and specific terminology. We specifically agreed on the following interpretations:

- The focal group of "small and medium-sized enterprises in the food and beverage sector in Europe" includes all the small and medium enterprises present at each level of the supply chain, thus from the field to the final consumer.

- **Strategies available to public regulators** goes beyond legal compliance and traditional command-and-control regulation to include incentive- and market-based approaches, reduction of regulatory burdens, incentives for the direct achievement of biodiversity goals, support to voluntary and private standards and sourcing strategies, utilization of public procurement as a demand driver, and public opinion engagement.

Limitations and delimitation of the scope of business request:

- Whenever possible, we drew upon independent, scientific evaluations of existing approaches' effectiveness on biodiversity and ecosystem conservation; however, we recognized that existing evidence implementing a system perspective might be limited. Studies usually either assess

biodiversity outcomes of specific agricultural practices or adoption rates of policies. Biodiversity outcomes from policies are, however rarely assessed. We partly tried to close this gap by modelling the impact pathway for the example of agricultural policies on biodiversity based on expert opinions.

- A systematic database with studies and their findings under different conditions would have been necessary to assess biodiversity outcomes under different environmental and socioeconomic conditions for different actors of value chains in the food and beverage sectors. Although it is vital to pull together a database and data collection method to evaluate the biodiversity impact of businesses (both large and SMEs), this was out of scope and reach of the EWG. While this is part of the approaches that could be recommended to governmental bodies, the scope and length of this work has to be conducted separately.
- It is also out of scope to develop, apply or implement a biodiversity performance tool or a monitoring system.
- Due to time constraints on the project, there were no pilot projects or capacity building and training for the public sector or businesses.

2. Methodological approach

2.1 Overview of the methodological approach

To answer the EKLIPSE call, the Expert Working Group developed a mixed methodology made of literature review and several forms of expert consultation, conducted from December 2017 to March 2019. Such methods were originally defined in the EWG Methodological Protocol (in Appendix I) and continually adjusted and documented throughout the project implementation.

For each of the above-mentioned tasks assigned by the EKLIPSE call, the following methods were applied:

Table 1 Link between tasks and methods

Task	Methods
1. Define a framework of approaches and their effectiveness	Quick Scoping Review
2. Identify the most promising approaches regulators could use	Qualitative Comparative Analysis Expert Survey
3. Analyse under which conditions these approaches may work well	Qualitative Comparative Analysis Bayesian Decision Analysis

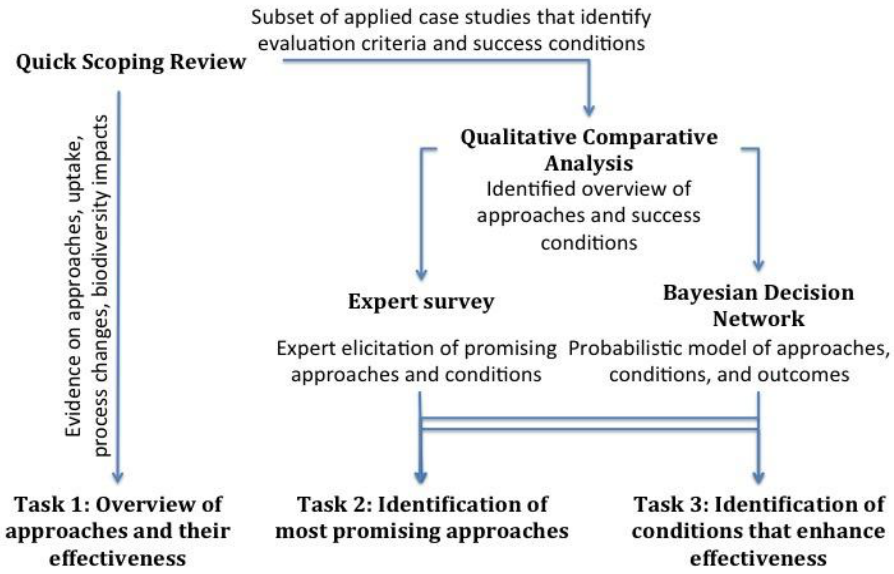


Figure 1: Conceptual overview of methods and their use in addressing the three requested tasks

The following paragraphs provide additional information on the methods we used.

2.2 Quick Scoping Review (QSR)

A QSR is a summary of the size and type of evidence available for a posed question (Collins et al., 2015), done usually in a stepwise process defined in an a priori protocol (Dicks et al. 2017).

We followed a number of steps in carrying out the QSR (Figure 2):

1. Writing a protocol to collect the literature from different sources (Appendix 2).

2. Searching and collecting the data, drawing on both academic literature and grey literature (reports from private governance, working groups, public sector, NGOs).

3. Sorting the data and providing a systematic view of the research evidence.

4. A critical assessment of the evidence, considering among others its relevance to the scoping review question.

5. Synthesis of evidence, describing a) volume and characteristics of the overall evidence base; b) what the evidence base indicates in relation to our question; c) findings and implications for policy and/or practice.

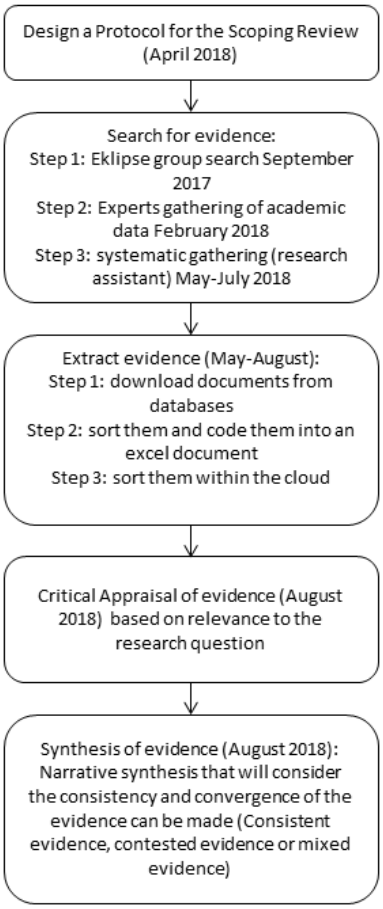


Figure 2: Steps undertaken in the quick scoping review

Appendix III provides more detailed information about the Quick Scoping Review conducted.

The Quick Scoping Review allowed us to identify a range of different approaches that can improve the biodiversity outcomes of small and medium enterprises operating in the food sector, specified in the Results section 3.1.

2.3 Qualitative Comparative Analysis (QCA)

In the next steps, we were asked to identify the most promising approaches for regulators and to identify conditions within which these approaches may work better or worse (Tasks 2 and 3). To do so, we built on the database created by the Quick Scoping Review and applied a Qualitative Comparative Analysis, to allow for the conditions to emerge.

Originally developed by Ragin (1987), the Qualitative Comparative Analysis was further applied in environmental studies as a meta-analytical technique to incorporate information focusing on a specific topic and based on a range of different sources.

In the context of our project, we followed the applications of QCA of Rudel (2008) and Scouvart et al. (2008) as a meta-analytical tool able to identify both *promising approaches* (to add evidence for our Task 2), and *conditions of success* (Task 3) from a range of heterogeneous case studies.

The target of the QCA is to generate a *truth table* where the complexity of the collected information is reduced to a list of conditions of success.

To prepare for the QCA two members of the working group worked through the 735 papers to identify all the case studies in which we could analyse success conditions in the implementation of policy tools for biodiversity improvement. Each member of the Expert Working Group was assigned a share of the selected articles and requested to undertake a QCA on them, using the following guiding question:

- What conditions contributed to the (broadly defined) success or failure of the interventions?
- Use these conditions to categorize the interventions as successful or not.

Results from the QCA constituted the baseline evidence to identify successful regulatory tools (Task 2), as well as to understand further which could be the supportive or hindering conditions for their success (Task 3).

In order to include more stakeholder voices, test the robustness of our findings and link various types of evidence, we enhanced our work with two additional methods: an expert consultation and a Bayesian Decision Analysis.

2.4 Expert consultation

Expert consultation (Slocum, 2003; Martin et al., 2012) is a consultation methodology to gather judgement, evaluation or opinions from a designated group of experts, either individually or in a group, used for enabling a group of individuals to collectively address a complex problem through a structured group communication process. It can be done online, in-person, through individual interviews or in-group meetings, as well as via written consultations.

There are three steps in an expert consultation: study design, elicitation design and method, and finally, output. The study design consists of elaborating the context of the study and the research question to answer. The second step consists in the elicitation design and method; in our case, a round of structured anonymous questionnaire was prepared. The final output is then given by the aggregation of responses and anonymous feedback from the participants.

We developed a questionnaire (in Appendix IV) to present the success criteria identified in the QCA and ask participants to rank them according to their perceived importance, while also to suggest other criteria we may have overlooked. The questionnaire was online, performed via the website SurveyCTO.

The respondents were selected among the experts contacted by EKLIPSE to set up the request and its Document of Work (Dow). We expanded this pool based on our own networks and via a snowballing method, so to reach 59 contacts. Moreover, we used social media to advertise the questionnaire and obtain more responses from diverse networks, including governance, SMEs, biodiversity and natural capital groups. The response rate represented the greatest challenge during the implementation of the expert survey since only 17 answers were collected at the end of the process. Nonetheless, their geographic distribution is broad in coverage at the European scale (UK 4, France 4, Germany 3, Spain, Finland, Greece, Belgium, Sweden, Other 1), and the range of sectors involved (academia 5, no-profit organisations 3, public administration 5, consultancy and practitioners 3, other 1).

2.5 Bayesian Decision Analysis

To evaluate successful regulatory tools and the conditions that may affect their effectiveness, we developed a portfolio of policy options that were subsequently fed into the Bayesian Decision Analysis.

A Bayesian Decision Analysis (BDA) models the probability of certain desired or undesired outcomes based on a set of defined decision options. In our case, we used this approach to model the probability that specific policy options could significantly improve biodiversity on a farm level.

At a conceptual level, the model consists of nodes and arcs. Nodes are variables, which may be discrete or continuous and might, in our example, represent conditions, policy options, business/farmer actions, and biodiversity outcomes. Arcs represent causal relationships between variables that are expressed in probabilities ranging from 0 to 1.

The relationship between each pair of a parent (predictor) and child (response) nodes is expressed in a conditional probability table for each child node. BDAs and their analysis can represent chains of causal relationships and uncertainty about these relationships. Probabilities can be based on observational data or elicited from experts. The design of the conceptual model (identifying nodes and their connections) and elicitation of expert-based probabilities are typically conducted during workshops, and this exercise can, therefore, help identify the most important *conditions*, as well as *policy tools* for our purposes.

The Bayesian Decision Analysis method has several advantages:

- Integrates distinct sources of knowledge, including expert judgements, numerical models, observational data, and literature.

- Models the complexity of a system, including chains of predictive relationships, in a visually appealing and analytically robust manner.
- Accounts for uncertainties, e.g. due to the limitations in empirical data collection and possible bias in expert judgements.

The general structure of the conceptual model for the Bayesian Decision Analysis was developed based on the QCA results. In particular, the conceptual model represented linkages between a set of policy options, policy attributes, adoption of policy tools, implementation of biodiversity-enhancing practices on farms, and significant improvements in biodiversity on farms. During a workshop in Brussels on 26 February 2019, the conceptual model was presented for discussion and validation, followed by questionnaire-based elicitation of probabilities based on expert judgements. A range of experts, practitioners and decision makers were selected and invited to the meeting. The selection of the groups of experts aimed at covering a wide range of expertise on biodiversity and enlarging the expertise covered by the EWG. Seventeen experts participated in the meeting, including eight external experts, a representative of the requester (SEPA), five members of the EKLIPSE EWG, and three representatives of the EKLIPSE Secretariat and Knowledge Coordination Body. After an introduction of the method and the discussion about the conceptual model, 14 questionnaires were filled in by the experts during the meeting to elicit probabilities for the Bayesian Decision Analysis (Appendix IV).

Median probabilities across all participants were used for making inferences from the BDA. To perform a sensitivity analysis, we replaced conditional probabilities with single expert values favouring the policy option with the second-highest utility value. The BDA was performed using the software Netica (Netica, 1992-2008) and data preparation, as well as consistency checks, were conducted with R (R Core Team, 2019) using package dplyr (Wickham et al. 2019), tidyr (Wickham and Henry, 2019), and rlist (Ren, 2016) to sort and handle data as well as binaryLogic (Dörrhofer, 2017) to create the consistency check. Additionally, data were compiled for the analysis using MS Excel (Microsoft Excel, 2016) and imported to R using the package readxl (Wickham and Bryan, 2016).

2.6 Integration of peer review and stakeholders feedback

Feedback on the findings presented in this draft report was sought from a range of stakeholders using the following engagement process:

- External expert review of the report – five external reviewers were invited by EKLIPSE to review the draft report on its content and structure. Reviewers represented different backgrounds (academia, policy and practice).
- The draft report was distributed among the participants of the Expert Survey, who provided feedback and inputs on the content and conclusions.
- Public consultation on the draft report – the draft report was placed on the EKLIPSE website allowing comments over one month.

- Thereafter, the EKLIPSE EWG formally responded to the comments made by reviewers, as well as the most important issues raised by the public consultation, resulting in the present document.

3. Results and Recommendations

3.1 TASK 1 - Define a framework of approaches and their effectiveness

As a first task, the EWG was asked for a conceptual framework to identify possible policy approaches that could help small and medium-scale companies improve their biodiversity impact, as well as to analyse and assess their effectiveness.

BOX 2 What is biodiversity in the context of food and beverage SMEs?

Biodiversity has been defined in many different ways. The most prominent definition is probably the one of the Convention on Biological Diversity (CBD) referring to biological diversity 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"* (CBD, 1992). This definition is quite comprehensive but often challenging to assess in its entirety, which is the reason why most studies use species richness as a proxy of biodiversity.

In the context of the food and beverage sector, biodiversity has to be seen in the environment of cultivated agricultural landscapes. The term agricultural biodiversity has been defined by the CBD as *"a broad term that includes all components of biological diversity of relevance to food and agriculture, and all components of biological diversity that constitute the agricultural ecosystems, also named agro-ecosystems: the variety and variability of animals, plants and micro-organisms, at the genetic, species and ecosystem levels, which are necessary to sustain key functions of the agro-ecosystem, its structure and processes*" (CBD, 2000). Therefore agricultural diversity includes not only wild but also harvested animals as well those species that support the production of food and beverages in wider landscapes such as pollination. Biodiversity may also include synanthrope species that would not be part of the pristine ecosystem but have benefitted from the cultural and artificial habitats created through land use by humans. Especially in highly modified cultural landscapes such as Europe, the question of whether biodiversity and conservation efforts should or should not include synanthrope species is not trivial and has not been answered conclusively (Forster, 2003).

The question of how biodiversity should be defined in a study such as this also came up during the development of this assessment, especially during the Expert Workshop for the Bayesian Decision Analysis. We proposed adopting the definition of how to measure improvement of biodiversity on a farm according to the EU Habitats Directive referring to the so-called favourable conservation status of habitats and species: "The conservative status of a natural habitat will be taken as 'favourable' when: a) its natural range and areas it covers within that range are stable or increasing, and b) the specific structure and functions which are necessary for its long-term maintenance exist and are likely to continue to exist for the foreseeable future, and c) the conservation status of its typical species is favourable as defined [as follows]; The conservation status [of species] will be taken as 'favourable' when a) population dynamics data on the species

concerned indicate that it is maintaining itself on a long-term [2050 and beyond, own interpretation] basis as a viable component of its natural habitats, and b) the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future [2050 and beyond, own interpretation], and c) there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis [2050 and beyond, own interpretation]."

3.1.1 A comprehensive framework to understand policy measures

The EWG decided to apply a step-wise approach to identify, in the most comprehensive way, the existing research evidence covering the whole food chain. In order to do that, most of the interconnections occurring at each step of the chain, as well as across it, as between economic and societal drivers to biodiversity-related issues, were mapped through a participatory process on a visual of the food supply chain already developed by the EKLIPSE team during the first meeting.

The result of this mind-mapping exercise can be seen in Figure 3. The Figure shows that there are numerous actors (in black boxes) and approaches (in blue writing) that may influence biodiversity outcomes within the food supply chain. Regulators (in the blue box) were seen to intervene in a number of direct ways (e.g. using input restrictions or imposing environmental standards on food production and processing). The yellow boxes show networks of influence, and the orange ones represent stakeholder pressures.

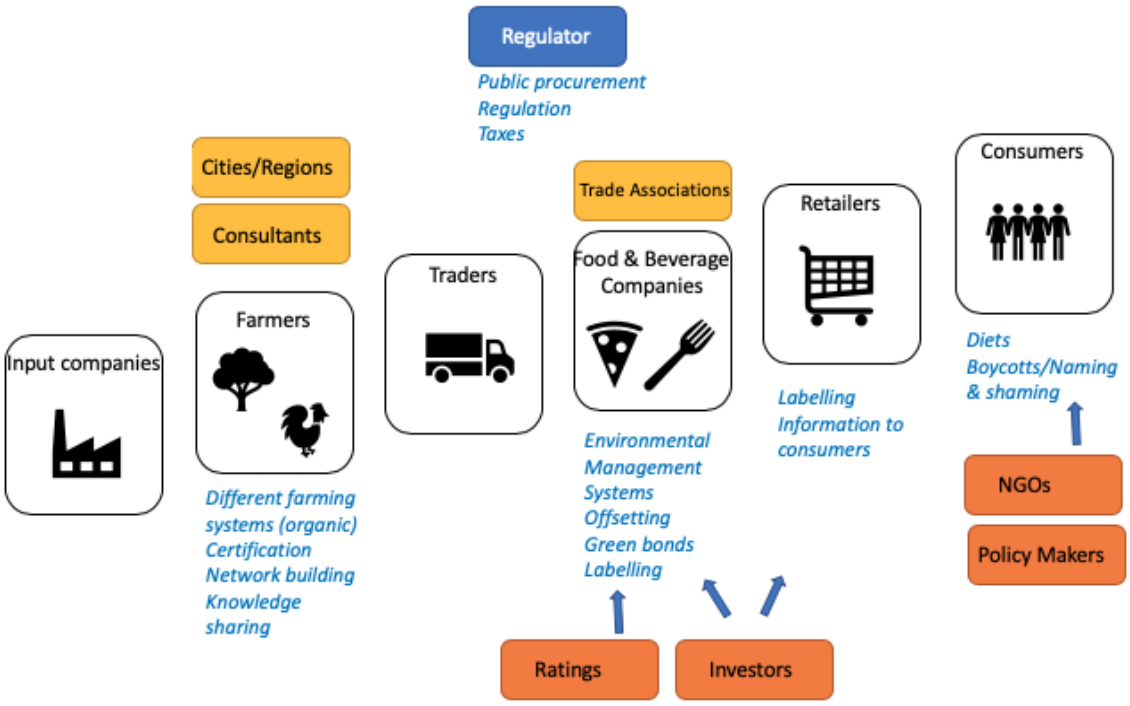


Figure 3: Mind map exercise from EWG kick-off meeting, updated with our results. Food and beverage supply chain based on Trucost (2016)

Figure 3 also shows that, though all actors in the supply chain are seen to play an important role, the most immediate impact of food and drink production on biodiversity continues to be at the farm and producer level, as it is here that direct decisions on land and input use are made. This insight was confirmed by the expert consultation (see Figure 4).

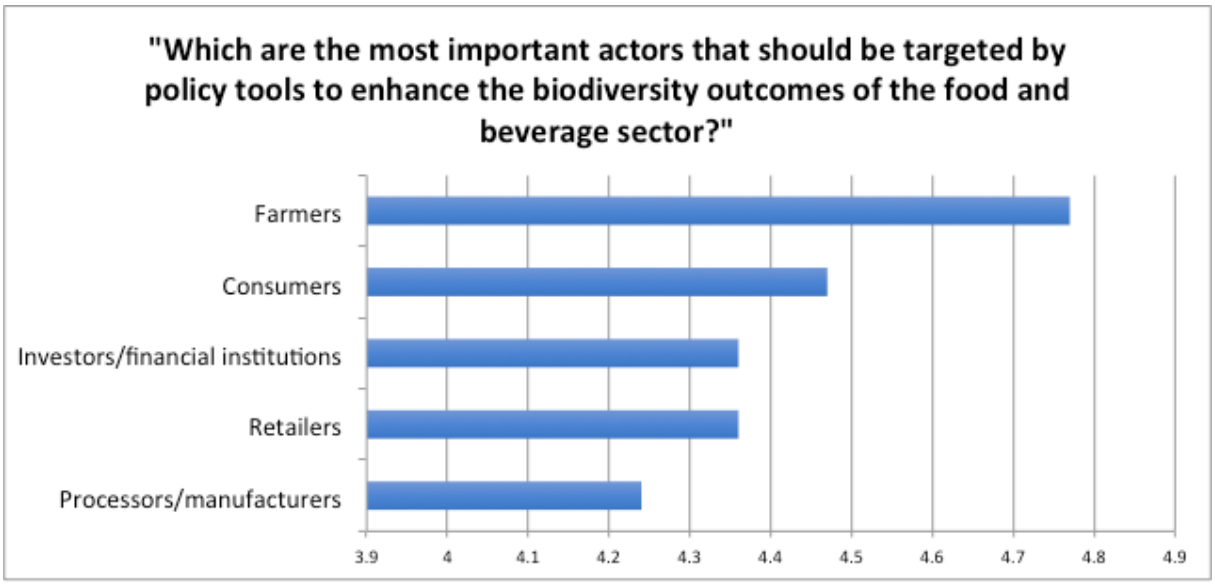


Figure 4: Important actors to be targeted by policy tools

3.1.2 Assessing the effectiveness of policy measures

In further discussions by the Expert Group, it was noted that for the policy measures under consideration to be effective, three conditions need to be fulfilled:

- They need to be adopted by the targeted actors;
- They need to affect behaviour change by targeted actors;
- These behavioural changes need to create positive biodiversity impacts.

Judging the effectiveness of policy approaches is complicated since they are context-related and it requires, furthermore, to take into account their political feasibility, the level of stakeholders' interest and engagement in them, to what extent changing behaviours lead to biophysical changes on the ground that have positive impacts for biodiversity.

In particular, linking biophysical changes on the ground to changes in biodiversity is empirically tricky, given the extensive time frame needed to restore habitats and their biological diversity. Furthermore, the evidence tends to be fragmented across disciplines, with public policy scholars and economists focusing on linking policies to behavioural change, impact evaluation scholars linking behavioural to biophysical changes, and ecologists and conservation scholars linking biophysical changes to broad-scale impacts on biodiversity.

The consideration of these complexities strongly influenced our research design, first by drawing evidence from multiple disciplines, and secondly by developing a methodological model able to integrate separate pieces of evidence, taking into account the uncertainty that characterises real-world problems.

3.1.3 Policy approaches and their effectiveness

Via a recursive process of comparing the identified interventions in the Quick Scoping Review (QSR) with pre-existing theoretical typologies, we decided to use Taylor et al. (2012)'s five types of regulatory policy to structure our analysis of the literature. This framework further frequently appears in the literature and show consistency with categorizations in use by governments such as the UK. The five types are: (i) direct 'command and control' regulation, (ii) economic instruments, (iii) information-based instruments, (iv) co-regulation and self-regulation, and (v) support mechanisms and capacity building.

Our QSR identified an additional policy approach specific to biodiversity protection that constitutes a specific type of policy mix: (vi) government planning for land use and development, for instance through the designation of Ecological Focus Areas. We thus decided to expand Taylor et al. (2012)'s categories by this additional approach.

Our findings from the existing literature identified through the Quick Scoping Review, report both individual policy instruments and policy mixes. It must be noted that most articles focus on some form of self-regulation (Figure 5). While this accounts for voluntary instruments applied by farmers, SMEs or supply chain companies, it also includes e.g. farm management measures such as organic production, agro-ecological production, or consumer behaviour such as sustainable diets, that can be applied voluntarily (and/or supported by regulators) but do not provide an explicit link to a government intervention. This implies that a variety of measures exist that government agencies may be able to support further.

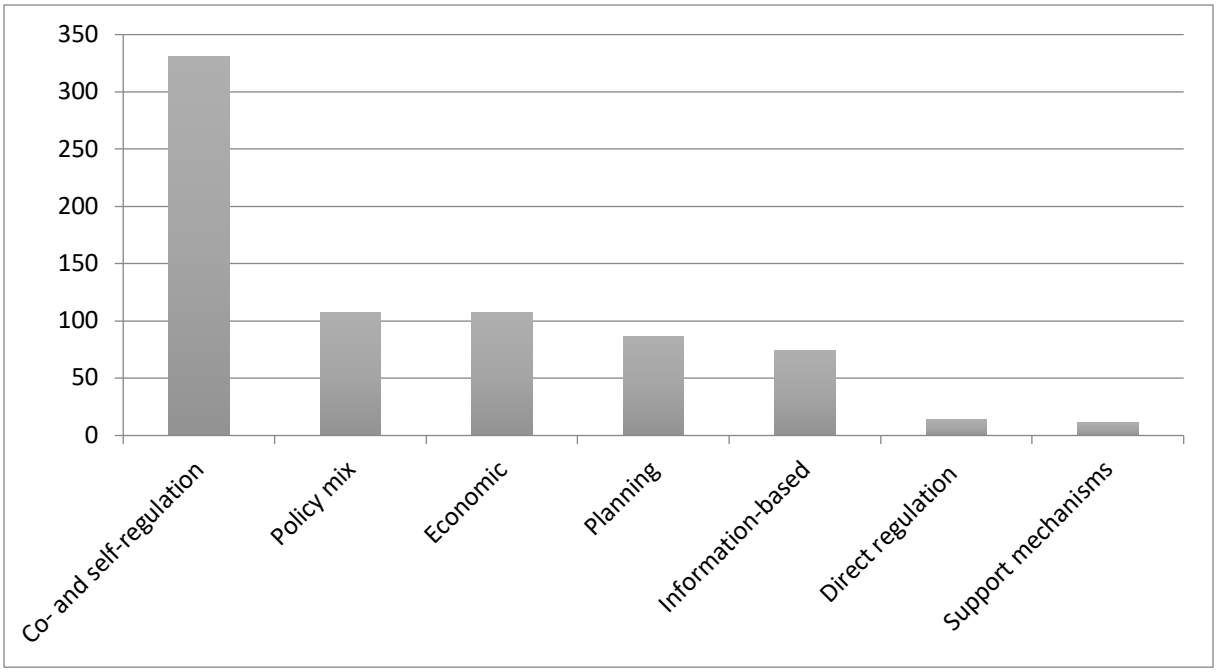


Figure 5 Article count reviewed in Quick Scoping Review per type of instrument

In the following, we report on the state of evidence of the effectiveness of various policy instruments on biodiversity outcomes based on our Scoping Review.

Direct 'command and control' regulation

Variants: Ambient pollution requirements, input restrictions and output quotas, non-transferable emissions licenses, technology controls, zoning/location controls

Background: Direct, or 'command and control' regulation, uses the rule-making power of the state to affect the behaviour of businesses and individuals by imposing mandatory obligations or restrictions. Mandating behaviour through law, when implemented effectively, allows for broad coverage and a relatively high certainty that businesses and individuals will comply. Yet, monitoring and enforcement are likely to be resource-intensive (and should therefore be focused on the highest risk); furthermore, some claim that direct regulation stifles innovation and places businesses at a disadvantage, particularly when competing with overseas firms.

Evidence: While the evidence for direct regulation in the QSR is not too extensive, it appears nonetheless that traditional regulation is a key driver for SMEs pro-environmental behaviour and can thus be considered a key pillar of comprehensive biodiversity support policies. Protected areas may be one example where, depending on the level of protection, different forms of land use restrictions and management requirements are into force. In such cases, biodiversity conservation depends mainly on the type of protection measure and, furthermore, literature suggests that direct regulation can make (additional) voluntary action less likely.

Economic instruments

Variants: Taxes and subsidies, tradable rights, payments

Background: Economic approaches change the incentives faced by firms or individuals in an effort to influence them to voluntarily change their behaviour. Broadly, the goal is to make socially undesirable behaviour more costly, while socially desirable behaviour should become more economically attractive. In economic terms, taxes and subsidies should "internalize" the negative "externalities" of the production process. For instance, this may be done through taxing undesirable practices or subsidizing those desired by the policy maker. Generally, they are seen to be more flexible and cost-effective than direct regulation, but also more uncertain to achieve the desired outcomes, given that regulates may not necessarily respond to market signals in ways intended by the policy-maker.

Evidence: Economic instruments such as agri-environmental schemes and other payment schemes are one of the most mentioned biodiversity-focused policy instruments. There is substantial evidence that they can have positive effects on biodiversity, but the leverage they could provide is larger than what they are used to. Part of the literature is concerned with crowding out self-motivated pro-environmental behaviour and other potential dangers of a commodification of public goods. Moreover, subsidies are commonly framed as "action-based" interventions (e.g. the CAP agri-environmental measures), which incentivise the adoption of practices that are deemed positive or less harmful for biodiversity (Hanley et al., 2012).

The literature suggests three major options to enhance subsidies' capacity in improving biodiversity: the coordination of biodiversity interventions at landscape scale, in order to maximise positive outcome (e.g. adopting "green" practices across different landholdings), the concentration of interventions in spatially targeted "biodiversity hotspots" (e.g. targeting red list species habitats), and the establishment of a clear connection between part or the whole payment and demonstrable biodiversity results.

In reality, the increased complexity of the policy design and higher transaction costs represent limiting factors in the effective adoption of agri-environmental schemes improvement measures. Despite encouraging results in a range of case study areas, their large-scale application is still quite limited (an exception being the landscape coordination agri-environmental schemes in the Netherlands).

Information-based instruments

Variants: Targeted information provision, naming-and-shaming/faming, registration, labelling, and certification

Background: Information-based instruments aim to change the behaviour of firms and individuals by providing them with better information on which to base decisions. Such approaches frequently target demand-side actors, for instance through the support of labeling schemes that signal above-average production practices, allowing consumers to 'vote with their dollar' and make informed purchasing decisions in order to drive production in specific directions. Naming-and-shaming/faming through the publication of performance information can also be used to harness public and investor pressure for better business practices. While low in cost and unintrusive, information-based instruments are likely to show low reliability (Gunningham and Sinclair, 1999). Yet, they can often complement and reinforce existing regulation (Taylor et al., 2012).

Evidence: Biodiversity-related information-based instruments cover a broad range of measures, from private biodiversity accounting (little application for SMEs) to governmental or scientific monitoring

programmes (a basic requirement for assessing effects and costs), to label-based information policies and certification schemes for consumers (some evidence for pro-biodiversity effects). Certification schemes in particular "could play an increasingly important role in biodiversity conservation if scaled up, prioritized to where it is most needed, and coordinated with public and corporate policy" (Tayleur et al., 2016, p. 617). Yet, concrete evidence on the causal relationship between certification schemes and enhanced biodiversity-protecting practices is still fragmented.

Co-regulation and self-regulation

Variants: Voluntary regulation, covenants and negotiated agreements, private corporate regulation, private professional regulation, self-regulation, civic regulation

Background: Self-regulation refers to an approach where those whose behaviour is to be regulated initiate and undertake the regulatory effort themselves; co-regulation is a similar concept, but with added minimal government involvement. Self-regulation through voluntary efforts is frequently undertaken by business associations in order to anticipate (and avoid) government regulation. On the positive side, such efforts ensure that agreed-upon codes of conduct and standards are adapted to business realities, including the best available technology and possible barriers to implementation that might make direct regulation less effective. On the other hand, there is the risk of a trend toward business-as-usual approaches that do not go far beyond the status quo or innovations that would have happened either way. Furthermore, if self-regulation is seen as a stand-in for public regulation, there is the danger of 'green-washing' business performance and preventing more effective direct regulatory efforts.

Evidence: While there is some literature on biodiversity governance, understood as cooperation between various rule-setting agencies with and beyond government, the effectiveness of co-regulation between non-state (included SMEs) and state actors has still little evidence. Self-regulation covers a broad range of voluntary activities that actors may undertake, but the range of their effects appears to be diverse: in the case of intensive and organic agriculture for instance, there is a relatively large consensus on the positive biodiversity effects of organic and, to some extent, integrated farming practices; nonetheless, these may rather be limited to field size effects with only some spill-overs (since in most cases landscape approaches are more promising). In turn, the more intensive the land and agro-chemical use to get increased yields, the greater the negative effects on biodiversity.

On the other side of voluntary agricultural measures, there is a suite of many positive extensive management practices, such as multi-functional production, agro-ecology and more holistic management regimes, based furthermore on organic agriculture and traditional farming practices. In general, the literature gives priority to a more integrated consideration of local physical features at different spatial scales, together with a system-oriented approach in which agricultural practices (and the connect context- specific knowledge owned by locals) are embedded in ecosystem functions, so that to play also a preventive role for biodiversity protection and preservation of past landscape elements and structures. Biodiversity accounting is another but far less extensive strand of literature, showing promise but little direct effectiveness. Dietary choices of consumers are another part of the literature with potentially positive but currently negative effects, i.e. due to land requirements for meat production.

While there is a potential in self-regulated biodiversity policies, the current institutional framework and (economic) constraints do not entirely support potentially positive individual producer or consumer choices. At the same time, innovative management arrangements based on new interactions and networks in the agro-food chain must be pursued.

Support mechanisms and capacity building

Variants: Research and knowledge generation, demonstration projects and knowledge diffusion, network building and joint problem solving

Background: Finally, the generation and diffusion of knowledge about best practices can be an important policy instrument. Other examples of support mechanisms may include demonstration projects that demonstrate the technical viability and financial profitability of novel techniques or technologies, or the provision of broader institutional structures that encourage innovations and behavioural change. Knowledge generation and capacity building however need to be well targeted in order to lead to widespread application.

Evidence: There is only one instrument categorized as a support mechanism in the QSR database: the UN decade on biodiversity, which seems to have caused an increase in Australian mining firm biodiversity reporting.
Capacity building activities include supply chain management trainings, science-policy interfaces, community learning, citizen science, stakeholder engagement, and various other participatory or collaborative approaches that enhance the understanding of biodiversity related issues.

Policy mixes

Background: Given that the problems that are targeted by policies are frequently multi-faceted, especially in the environmental realm, more recent work has furthermore highlighted the importance of considering instrument mixes, where several policies are combined to affect various aspects of the problem (Gunningham et al., 1998).

Evidence: Policy or instrument mixes regard a combination of two or more individual policies, and potentially a cumulative / multiplicative effect of these on biodiversity. A myriad of possible combinations is available and often already in place. A 'no net loss' requirement, is an example of direct regulation and / or planning because it imposes that losses have to be offset, while employing some economic features in the allocation of permits. Subsidies and agri-environmental schemes are another example, since they usually may come with some options for voluntary choice. Even though the evidence of instruments combination effects on biodiversity is little, there is however no evidence that such combination have negative outcomes.
One specific example of a policy mix in the case of biodiversity is *governmental planning for land use and development*. Such policies show high potential since effective approaches to biodiversity protection are done at a landscape level, taking into account patch matrix interactions between habitats. Such types of approaches vary, from rewilding to land sparing and land sharing for example, or Ecological Focus Areas where land use requirements for agricultural practices are specifically targeted to increase the species assemblage diversity.

3.1.4 Summary of insights on policy approaches and their effectiveness

Regardless several biases in the QSR (e.g. only English literature, mainly scientific literature, top journals and a corresponding citation bias) we are aware of, the evidence collected provides a relatively broad range of potential actions a regulator can apply and support in order to preserve, and even increase, biodiversity in the food-beverage value chain.

Considering the quantitative and narrative synthesis done in the QSR, the following insights may be gained:

- Agricultural practises are relatively well researched and many positive measures (whether voluntary, supported by subsidies or required by land use restrictions in protected areas) can be identified that are beneficial for biodiversity.
- Voluntary/self-regulating actions provide a large and diverse suite of potential measures for biodiversity support, ranging from individual farm management choices to corporate environmental responsibility and consumer choices.
- Direct regulation is a cornerstone of comprehensive biodiversity policies but, as any other instrument, its effectiveness must be contextualised and assessed in combination with other potentially conflicting or synergistic measures in place.
- Economic instruments provide incentives for behavioural changes, but such changes are likely not permanent (e.g. if the incentive ends, behaviour returns back). Incentives for adopting green technologies are expected to be more permanent, but unexpected outcomes may arise (e.g. increase in production, which counterbalance the effect of more green technologies). Economic measures may further enhance the desired voluntary measures, making restrictions less opposable through compensation, or phasing out undesired practices through taxes. Still, their strength is strictly dependent on their design.
- Little is known about the effectiveness of information-based and capacity-building measures in terms of biodiversity outcomes, but there is no evidence they would do any harm either.
- If the amount of research on both the agricultural sector and self-regulation is an indicator for potential leverage points with more or less well-known outcomes, this means that the most direct policy effects on biodiversity can be obtained by addressing the primary sector and through supporting ecological field, farm, and landscape biodiversity enhancing measures.
- While addressing actors further up the value chain can have important but indirect effects on biodiversity, they will instead be effective if they are designed so that their effect on trade, retail, and consumption reaches the productive and primary sectors.

3.2 TASK 2 – Identify the most promising approaches to be used by regulators

3.2.1 Qualitative Comparative Analysis (QCA) and general attributes of effectiveness

To identify the most promising approaches regulators could use it was necessary to understand which could be the attributes that increased or decreased their effectiveness. This task thus also encompasses a part of Task 3 relating to "conditions [for effectiveness] related to the specific scheme".

We conducted a joint QCA that identified a total of 110 possible attributes for success and failure across the reviewed literature.

Summary statistics from the QCA (Figure A19, Appendix V) indicate a bias in literature towards the evaluation of economic and regulatory policy instruments for biodiversity conservation. At the same time, there is not much evidence on capacity building and information-based instruments.

In general, the QCA results showed that the most commonly mentioned conditions for effective biodiversity policy implementation for SMEs in the food and drink industry were related to collaboration between participants in policy implementation, a systems orientation of the policy tool by taking the whole system into account, the ease of fit (or adaptation) within existing farm practices and design, flexibility, target's (farmers') environmental values and others shown in Figure 6 below.

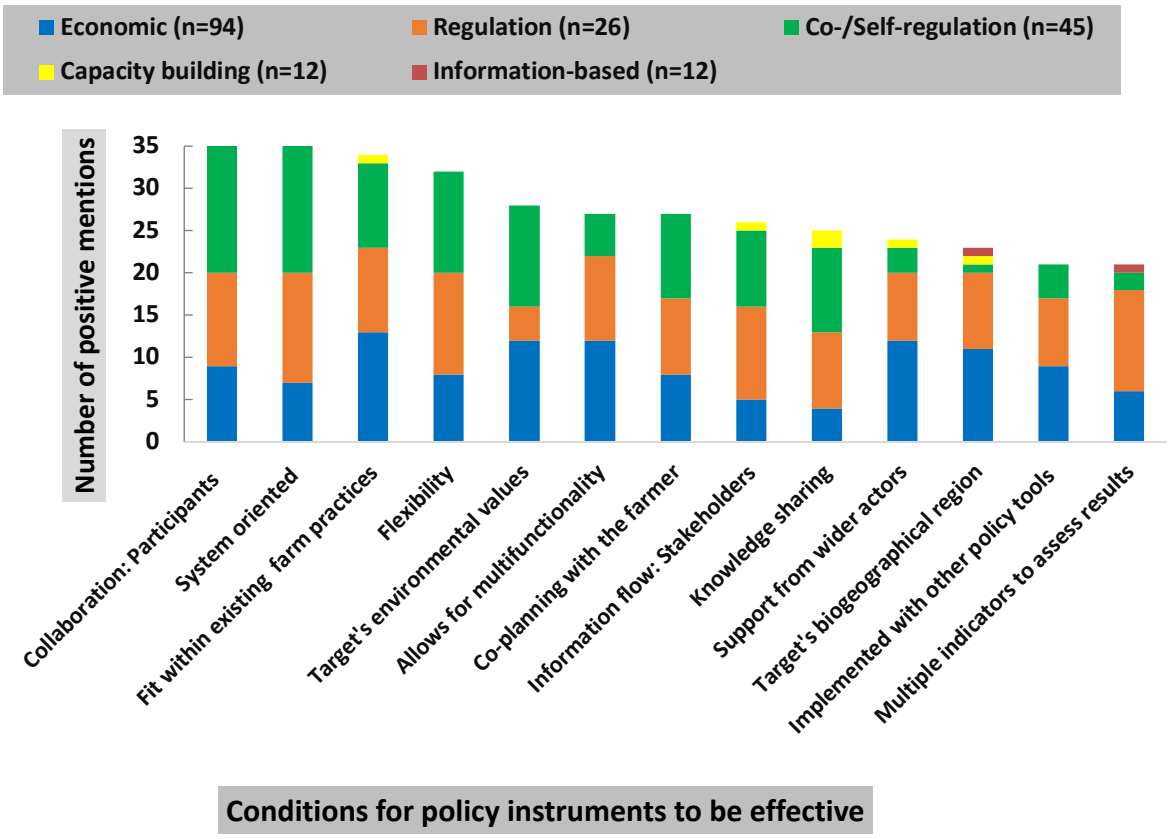


Figure 6: Most frequent positively evaluated conditions in all published papers (n=192), by policy instrument

There was limited evidence of failure or limitation in the implementation of the policy instruments evaluated, implying either that the use of policy instruments tends to have a more positive implementation, or that there is a bias in the research against evaluating failed policy experiments or inquiring after limiting conditions (Appendix V, Figure A20).

However, the top-down vertical organization of the policy instrument (rather than a co-created process with inputs by the targeted community) was found to be the most likely condition to lead to failure in the effectiveness of a policy tool. Complicated subsidy procedures (meaning bureaucratically time-consuming, disorienting and confusing procedures) were also reported to lead to failure of policy instruments.

These results show the importance of co-planning, co-production and sharing of knowledge in a bottom-up, collaborative manner for success in the implementation of biodiversity enhancing policy mechanisms. Holistic and multi-functional policies that target and adapt to different scales and practices, while at the same time being implemented with other tools rather than in isolation and using many indicators to assess results, are more likely to be a success.

3.2.2 Main findings on specific policy instruments

Economic instruments

Economic instruments had the majority of positively rated conditions for implementation in the QCA. The following conditions were found to be crucial for successful economic instruments regarding both implementation and positive biodiversity outcomes:

- Adaptation to regional/local context
- Flexibility and adaptability to existing (farming) practices
- High payment/compensation rate (that covers indirect and opportunity costs)
- System oriented, taking the whole ecosystem into account (holistic approach)
- Implementation in combination with other policy tools
- Allow for multifunctionality in dealing with ecological, economic and social complexities in farming
- Consider the environmental values of the target (i.e. farmer)
- Consider the biogeographical region of the target (i.e. farmer)
- Support from wider actors and systems (external to the main target of the policy tool).
- Use of multiple indicators to assess results
- Performance indicators are result-based (e.g. species diversity)
- Brand to protect
- Collaboration between participants

- Implementation in combination with other policy tools

Complicated subsidy procedures and vertical organisation of policy tools were found to lead to the failure particularly of economic instruments.

Direct regulation instruments

Direct regulation, included government planning on land-use policy, was the second most important policy instrument for positively rated conditions of implementation and likelihood of achieving positive biodiversity outcomes.

The following conditions were found to be crucial for successful direct regulation instruments:

- Adaptation to regional/local context
- Flexibility and adaptability to existing farm (farming) practices
- System oriented, taking the whole ecosystem into account
- Adopting a participatory governance approach in collaboration with targets
- Co-planning with the farmer
- Information flow between the different stakeholders
- Implementation in combination with other policy tools
- Associated price premiums (e.g. on certified goods)
- Knowledge sharing and information flow between stakeholders
- Consider the biogeographical region of the target (i.e. farmer)
- Support from wider actors and systems (external to the main target of the policy tool)

Nevertheless, for the proper successful implementation of regulations, there should be a positive relationship between the regulator and the regulated, helped by the offer of tailored, coherent mix of regulatory instruments (Taylor et al., 2015).

Co-regulation and self-regulation instruments

In the literature, the following conditions were found to be crucial for self-regulation and co-regulation instruments to be a success:

- Collaboration between participants
- System oriented, taking the whole ecosystem into account
- Flexibility and adaptability to existing farm (farming) practices
- Consider the environmental values of the target (i.e. farmer)

- Adaptation to regional/local context
- Co-planning with the farmers
- Knowledge sharing and information flow between stakeholders
- Information flow between the different stakeholders

Considering the characteristics and heterogeneity of SMEs emerges as an imperative for the success in co-/self-regulation policy implementation. Such heterogeneity, as their perception of gaining fewer benefits when engaging in environmental issues, compared to larger companies' mindset, has been shown to act as a deterrent for SMEs in cooperating with each other and with public bodies in biodiversity enhancement measures (Brammer et al., 2012).

Capacity building instruments

Due to limited evidence in the literature on the effectiveness of capacity building to enhance biodiversity, no condition was found to be particularly important in our QCA.

Information-based instruments

Similarly, little evidence has been found in the literature on the effectiveness of implementing information-based instruments.

In conclusion, the QCA results (coherent with the expert consultation findings shown in the following paragraphs) claim that economic and direct regulations appear to have the most likely conditions to contribute to the success of biodiversity enhancing interventions.

3.2.3 Expert survey – Identification of the most promising approaches

When asked to rank the likely effectiveness of the policy instruments introduced above, respondents to our expert consultation highlighted economic instruments as the most likely to bring positive biodiversity outcomes, followed by direct regulation (see Figure 7).

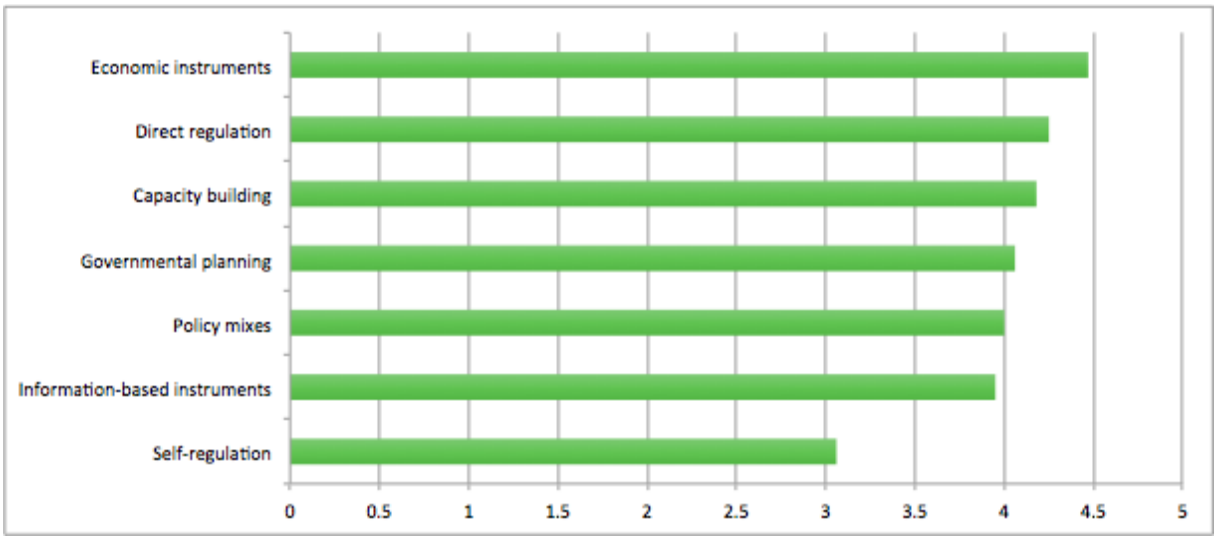


Figure 7: Mean estimated effectiveness of policy categories, 5 = most effective; 1 = least effective

Self-regulation was seen as least likely to lead to substantive improvements in the biodiversity impacts of small and medium enterprises. This mirrors the insights of the Quick Scoping Review, which sees limited promise in allowing businesses to set their own guidelines, and highlights the importance of regulatory 'sticks' and economic 'carrots' to move away from the status quo toward improved practices and results.

The category of policy mix was ranked in the middle in terms of its likely effectiveness, drawing attention to the imperative of making policy mixes coherent and consistent by integrating goals and instruments in a planned manner.

Finally, we also see that most respondents were quite optimistic in their overall assessment on the likelihood of regulatory tools to affect outcomes on the ground, as no instrument category was ranked on average to be 'not effective' or 'not effective at all'.

We furthermore asked respondents who had ranked a category as 'very effective' to point out what they think is the most effective policy instruments within this specific category (Figures A12 to A14, Appendix 4).

Taxes on goods that harm biodiversity (at a producer, processor, or consumer-level) are favoured by our respondents, followed closely by the provision of financial support for beneficial behaviours, such as payments for ecosystem services, subsidies, or agri-environmental schemes.

We can note that many of the instruments target the farm-level, but taxes or subsidies, in theory, could be levied at intermediate levels of the supply chain as well and encourage businesses to change their sourcing practice. However, even though this was an instrument favoured in the expert survey, its real social acceptability needs to be always considered carefully: taxes need to be carefully designed in a multi-stakeholder process and always contextualised, in order to be well-targeted and balanced in terms of objectives.

With regard to direct regulation, protected areas and land use restrictions showed the greatest promise to protect biodiversity, according to respondents.

A variety of capacity-building activities (from trainings on supply chain management or biodiversity management to community learning programs) are all seen as equally effective. Notably, according to the survey, these tools work best in combination with other measures to shift production and consumption behaviour, as the dissemination of more information about the biodiversity impacts of certain goods to consumers and other stakeholders.

Regarding governmental land use planning, in the survey land-sharing approaches (aiming to integrate agriculture into existing ecosystems) were seen as slightly more effective than land sparing (safeguarding diverse ecosystems through strict exclusion criteria and the intensification of existing agricultural areas).

Among individual tools, the governmental monitoring of business activities was the most favoured, followed by the assessment of effective information-based instruments, consumer guides and the creation and/or endorsement of certifications.

The respondents identified a number of possible avenues for self-regulation, including:

- industry associations;
- multi-stakeholder partnerships;
- industry-led standard-setting;
- internal voluntary biodiversity protection policies (within organizations);
- new business models (e.g. local supply chains); and
- research, development and innovation.

And, when asked their opinion about who are the most important actors that need to be targeted by the policy tools, respondents replied farmers, followed then by consumers.

In addition, survey participants mentioned policy actors (politicians; European Commission; overseas development assistance, certification organizations); actors engaged in knowledge generation and dissemination (researchers/universities; educationalists; agricultural extension agents and advisors along the food chain); and actors in adjacent policy areas (e.g. health professionals and health regulatory bodies that focus on cross-cutting issues such as pesticide use) as important actors that need to collaborate in improving the biodiversity outcomes of SMEs (Figure 7 above). Applying biodiversity-enhancing policies at the group and various integrated levels is, however more appropriate than at the single actor/organization scale for our respondents (Figure A17, Appendix 4).

When asked about which system between outcome- and process-based could best measure the success of biodiversity protection measures, survey respondents indicated both approaches as equally important, thus reflecting a continued debate in the literature over their comparative merit (Figure A16, Appendix 4). The preference is, however, for the combination of ecosystem preservation measurements at a holistic scale, rather than single-action/single species measurement systems (Figure A17, Appendix 4).

3.2.4 Summary of insights on most effective policy approaches

The expert consultation survey confirmed the same results obtained from the QCA.

To summarise, both the methods we used rated the adaptation to local context as the most successful approach that regulators could use to improve the biodiversity outcomes of SMEs in the food and beverage sector.

Quite coherently and following in order of importance, the flexibility and easy adaptability of such approach with existing farm practices were mentioned as additional instrument-specific success factors.

Policy mixes (a combination of tools), their holistic orientation in considering the whole ecosystems at integrated larger scales, participatory governance approaches and support and training measures for policy implementation follows.

Given the importance of context-specific policy measures, the Expert Working Group finds it difficult to recommend a 'most effective' policy approach. However, it may be possible to identify policy approaches that are more effective in specific circumstances. On the basis of the evidence base at hand, Table 2 shows a number of such propositions.

Table 2 Propositions regarding instrument effectiveness on biodiversity[2]

Intervention	Effective when …	Ineffective when …	Most effective for …
Direct regulation	standards need to be enforced	strongly opposed or circumvented	land use restrictions
Governmental planning	broader scale patterns need to be considered	individual actors are to be addressed	landscape approaches
Economic instruments	behavioural change is intended	leverage is too small	land management/production
Information based instruments	societal change is to be nudged	customary behaviour is stable	consumption / life-cycle assessments
Co-regulation	partnerships are synergistic	other instruments are adverted	trust-building
Self-regulation	status quo scenarios are desired	society is not pro-biodiversity	societal transitions
Support Mechanisms	institution building is needed	there is no uptake	already inclined parties
Capacity Building	knowledge and ability are missing	capacity is not the bottleneck	transdisciplinary processes
Instrument mixes	multiple effects need to be balanced	they cancel each other out	comprehensive approaches

[2] Adapted from Parker et al., 2009

3.3 TASK 3 - Identify conditions that enhance effectiveness

We applied a Bayesian Decision Analysis to evaluate the probabilities of different policy options to increase biodiversity.

In order to exemplify the approach, we analysed the impact of different policy options on biodiversity trends in farms; nonetheless, we tried to consider as much as possible the whole value chain in the design of the policy options.

Beyond the application in this work, we consider that the joint production and use of Bayesian Decision Analysis in a stakeholder-led and interactive process should be considered by SEPA and other environmental regulators as an innovative strategy to gain insights on complex policy decisions.

In the following, the conceptual model we developed is illustrated in details in 3.3.1 and 3.3.2, while its outcomes discussed in 3.3.3.

3.3.1 A conceptual model of impact pathways on biodiversity

The following conceptual model, developed and used as basis for the Bayesian Decision Analysis, describes the impact pathways that policy options could have on the biodiversity outcomes of farms, both at EU and national levels (Figure 8).

The model refers to the EU 2020 biodiversity strategy, which is going to be revised with a new time horizon of 2030; we adopted the same time frame in the model in relation to the adoption of biodiversity-enhancing practices on farms, with the year 2025 as the intermediate time horizon.

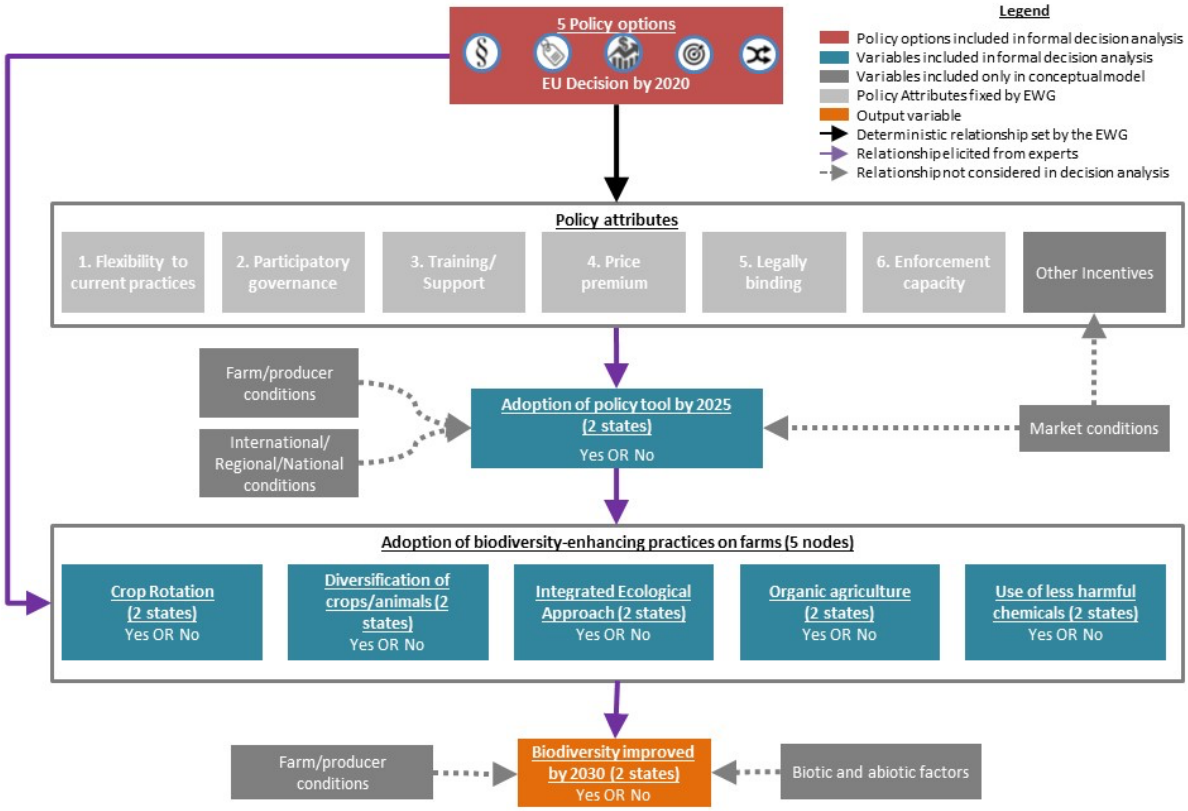


Figure 8 Conceptual model of biodiversity impact pathways

Once the government adopts a policy, depending on the policy type (specifically, whether it falls into the command-and-control or a more flexible category), farmers might have the option to adopt or not adopt a specific policy measure, such as subsidies.

From the previous steps done (Quick Scoping Review, QCA and expert consultation) it has emerged that a number of different policy attributes can play a role for the adoption or non-adoption of policy measures: the flexibility of the tool, the participation of practitioners during the policy design, the training and support given when implementing the measure, financial compensation for additional costs incurred, as of course also the general character of the policy (being either legally binding or not) and its enforcement.

Since many of these policy attributes are predetermined by the policy option itself, we decided to give these attributes a fixed value for each policy option, before eliciting the probabilities from expert opinions. Other factors such as additional social, ecological or economic incentives may also play a role but are often not directly influenced by the policy design, being instead dependent, for example, on national and international market conditions. Moreover, other conditions that influence the farmers' adoption or not of a policy measure may include farm size, producer attitudes, gender, age, family background, education, community support, and so on.

Once a farmer has made the decision to adopt or not adopt a specific policy measure, the application of different farming practices become more or less likely.

As the focus of our conceptual model was the improvement of biodiversity outcomes, we categorized biodiversity-friendly practices into five different categories: crop rotation, diversification of crops and animals, application of an integrated ecological approach, EU certified organic production, reduction of harmful chemicals. These practices may have an impact on farm biodiversity by themselves, but the magnitude of such impacts depends on additional factors such as farm/producer conditions, biotic and abiotic factors (climate and interactions with other species).

The different agricultural practices were predefined by the experts of the EKLIPSE Working group based on the results of the literature review and revised together with the experts during the expert workshop. The practice of organic agriculture, by definition, includes crop rotation and the use of less harmful chemical pesticides. Therefore, only combinations of farming practices that were valid options to the farmer were included in the final analysis. Those that were not regarded as valid options, such as practising organic agriculture but not doing crop rotation were excluded from the analysis. Inconsistencies between probabilities were fixed for each expert using mean imputation based on consistent probabilities.

During the expert workshop organised to conduct the Bayesian Decision Analysis, participants were initially asked to assess the model itself, giving comments and feedback which could help refine its design in real-time. The modifications suggested by the participants included mainly fine-tuning of policy options and clarifications of definitions. The most challenging discussion was about the definition of biodiversity since the one proposed by the EWG was not agreed upon by the invited experts. Discussions among experts did not yield a consensus and, due to the difficulties to reach one standard definition. The EWG purposefully decided to leave the definition of biodiversity open to interpretations.

The model distinguishes between different types of factors: internal factors (coloured boxes and arrows) and external ones (dark grey boxes). Since most of the external factors cannot or are hard to be directly influenced by the policy itself, is rather the result of environmental, social and economic factors, we decided to not include them in the decision analysis.

For all coloured boxes, we defined two distinct states a variable can take, i.e. yes or no.

Table 3 Definitions of nodes and terms used in the Bayesian decision analysis

Node label/term	Description/justification
Attributes of policy options	
Flexibility	The flexibility of a policy option refers to the flexibility to respond to local conditions and current farming practices, e.g. in terms of specific species or farming practices. On the one hand, this can have an impact on the likelihood that a farmer adopts a certain practice as well as the biodiversity outcomes. On the other hand, it might also cause them to adopt only those measures that give them the highest net financial benefits disregarding benefits for biodiversity. Furthermore, higher flexibility often leads to higher non-transparency making it difficult to apply those policy tools.
Participatory Governance	Under participatory governance needs of farmers are considered as part of the policy design. Through a process of horizontal decision, farmers and other stakeholders are consulted and encouraged to contribute their ideas for decision making. On the one hand, it is likely to increase acceptance of a policy tool but on the other hand, also increases the likelihood that final outcomes represent compromises and watered-down measurements.
Training/ Support	Training and support in terms of workshops and information sources can be provided to the farmer to help them adopt and implement policies. This might help farmers to adopt and implement policies and to avoid possible sanctions if they violate regulations.
Price Premium	A premium price is paid by customers to the farmers adopting the policy. Farmers and producers can market their produce, e.g. under specific labels for premium prices, thereby being compensated for higher production costs.

Node label/term	Description/justification
Legally Binding	Legally binding instruments are usually less flexible, but if enforced, they can be very effective. Some legally binding instruments are however only set as targets on the regional or national level without proper enforcement and therefore might have rather low adoption rates on the farm level.
Enforcement capacity	Enforcement capacity refers to the level that governments are able to enforce policies. Regulations and voluntary standards require a certain degree of enforcement to ensure compliance with regulations. Fines and sanctions are likely to play a role along with the frequency of controls, institutional structures, financial means and availability of trained employees. High levels of policy enforcement and enforcement capacities are likely to increase the adoption of policies.
Adoption	
Adoption of Policy	Whether a farmer adopts a policy tool depends on various factors, including policy attributes. The rate of adoption is highly relevant for the policy tool to be effective for biodiversity conservation as it increases the likelihood that farmers implement biodiversity-enhancing practices.
Implementation	
Crop Rotation	A farmer rotates the crops planted at least every three years (usually earlier). Nitrogen-fixing leguminous crops account for at least 25% of the crop rotation.
Diversification of Crops/ Animals	A farmer with between 10 and 30 hectares of arable land grows at least two crops, and anyone crop cannot exceed 75% of the arable land. A farmer with over 30 hectares of arable land grows at least three crops. The main crop covers up to 75% of the arable land; the two main crops together cover up to 95% of the arable land. Permanent grassland does not count as a crop for the three crop rules. Temporary grassland can be counted as a crop and therefore comes into the calculation if

Node label/term	Description/justification
	greening is required. (Regulation by the EU for Greening)
Integrated Ecological Approach	Farmers practising an Integrated Ecological Approach on their farm apply to set aside at least 5% of their area for conservation activities such as flower strips, hedgerows etc. (Ecological Focus Areas according to the EU regulations). Additionally, they incorporate agroecological solutions as much as possible to reduce the use of chemical pesticides and synthetic fertilizer to an absolute minimum level
Organic Agriculture	Farmers produce organically according to the regulations of the EU. This includes the prohibition of chemical pesticides and synthetic fertilizers, restrictions on the use of antibiotics, the prohibition of GMOs and crop rotation.
Use of less harmful chemicals	The use of less harmful chemicals refers to the use of harmful pesticides as well as synthetic fertilizer. Pesticides as defined by the WHO are "*chemical compounds that are used to kill pests, including insects, rodents, fungi and unwanted plants (weeds). Pesticides are used in public health to kill vectors of disease, such as mosquitoes, and in agriculture, to kill pests that damage crops. By their nature, pesticides are potentially toxic to other organisms, including humans, and need to be used safely and disposed of properly*." Synthetic fertilizers are produced by a technical treatment of natural raw materials and offered as single or multiple nutrient fertilizers. A farmer using fewer chemicals usually applies agro-ecological solutions or integrated pest management and uses organic fertilizers, e.g. manure.

Node label/term	Description/justification
Biodiversity outcome	
Biodiversity Improved	We adopt the definition of the EU for the favourable conservation status of habitats and species. "The conservative status of a natural habitat will be taken as 'favourable' when : a) its natural range and areas it covers within that range are stable or increasing, and b) the specific structure and functions which are necessary for its long-term maintenance exist and are likely to continue to exist for the foreseeable future, and c) the conservation status of its typical species is favourable as defined [as follows]; The conservation status [of species] will be taken as 'favourable' when a) population dynamics data on the species concerned indicate that it is maintaining itself on a long-term [2050 and beyond, own interpretation] basis as a viable component of its natural habitats, and b) the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future [2050 and beyond, own interpretation], and c) there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis [2050 and beyond, own interpretation]." This definition was proposed to the experts of the workshop, but not all experts agreed to this definition. We allowed experts to assess biodiversity outcomes based on their own definition. Although this approach might lead to inconsistencies, it also allowed considering different aspects of biodiversity which would not have been included in the original definition.
Pure external factors	
Farm/Producer Conditions	These conditions capture attributes that cannot directly be influenced by the policy makers, including farm size, producer attitudes, gender, age, family background, education, community support etc. These conditions are expected to influence the adoption rate of policies by farmers as well as the effect of biodiversity enhancing practices on biodiversity levels. Farmers with a positive attitude towards biodiversity might be more inclined to adopt biodiversity enhancing practices. Farm

Node label/term	Description/justification
	attributes such as farm size might influence the magnitude of biodiversity impacts as a result of the implementation of biodiversity conservation measures.
International/Regional/National Conditions	International, regional and national conditions refer to conditions that cannot directly be influenced by the policy maker including political stability, public support and interest, other policies that have an effect on the market and the enterprise itself etc. These conditions are expected to influence the adoption rate of policies by farmers. Public support is, for example, likely to increase the rate of adoption.
Market Conditions	Market conditions are crucial for the revenues generated through direct marketing of produce. These market conditions can be influenced by policies but only indirectly (e.g. through supporting labels, taxes, etc.). Unregulated market conditions (national as well as international) are conditioned by supply and demand. These market conditions are likely to impact the adoption rate of policies through the price of the product on the national and international market. Higher prices for premium produce might, for example, increase the adoption of policies that support the production of the premium products.
Other Incentives	Other incentives for farmers to adopt policies and to implement biodiversity-friendly strategies refers, for example, to direct benefits in terms of pollination, peer pressure from other farmers, increase in production, positive health impacts etc. These incentives might increase the probability that farmers adopt certain policies.

Node label/term	Description/justification
Biotic and Abiotic Factors	Biotic and abiotic factors are factors that can influence the success of biodiversity measures. Biotic factors include the general distribution of target species but also to interdependencies between species in biological communities. Abiotic factors are factors that refer for example, to climate and soil properties as well as extreme events. Abiotic and biotic factors can have a strong influence on the success of biodiversity enhancing practices, positive as well as negative.

3.3.2 Policy options for the decision analysis

In our model, we specified five different policy options:

1. Regulation of harmful chemicals (Regulation)

Harmful pesticides may only be used in exceptional cases; otherwise, only agroecological pest management may be used; small farmers are not excluded from these regulations.

2. Information and market-based labelling (Label)

A label is co-developed and renegotiated by an environmental protection agency together with farmers, scientists and policy makers to promote biodiversity-friendly produced products, sold at a premium price to the consumers.

3. Market-based approach/ Payment for ecosystem services (PES Market)

Farmers receive additional incentives based on the provision of ecosystem services, evaluated land use and farming practices.

4. Target-based subsidization & value chain regulations (Subsidies)

The EU adopts the target to reach a minimum 20% organic agriculture by 2030; organic farmers and other actors in the value chain are rewarded and subsidized if produce and/or process organic products.

5. Policy mix: regulation and target-based subsidization (Mix)

The most harmful pesticides are prohibited. Organic production is subsidized and additional incentives are given for high nature value farming. An initiative is started to better link certified producers to markets and green public procurement guidelines are obligatory.

We further defined a set of pre-defined attributes and their relevance for the adoption of each policy (Table 4).

Table 4 Policy attributes and their level of relevance for different policy options.

Policy Attribute	Policy Option 1 Regulation	Policy Option 2 Label	Policy Option 3 PES Market	Policy Option 4 Subsidies	Policy Option 5 Mix
Flexibility	●○○○○	●●○○	●●●○	●●●○○	●●●○
Participatory Governance	●○○○	●●●●	●●○○	●●○○	●●○○
Training/Support	●○○○	●○○○	●●○○	●●○○	●●●●
Price Premium	○○○○	●●●●	●●●○	●●●○	●●●●

Policy Attribute	Policy Option 1 Regulation	Policy Option 2 Label	Policy Option 3 PES Market	Policy Option 4 Subsidies	Policy Option 5 Mix
Legally binding	●●●●	○○○○	●○○○	●●●○	●●○○
Enforcement	●●●○	●●○○	●●○○	●●○○	●●○○

The participants in the Expert Workshop were asked to consider these attributes and their level of relevance (expressed in the table by the number of filled circles) when assigning probabilities to the adoption of different policy options.

Note: The practice of organic agriculture, by definition, includes crop rotation and the use of less harmful chemical pesticides. Therefore, only combinations of farming practices that were valid options to the farmer were included in the final analysis. Those that were not regarded as valid options, such as practising organic agriculture but not doing crop rotation were excluded from the analysis. Inconsistencies between probabilities were fixed for each expert using mean imputation based on consistent probabilities.

3.3.3 Bayesian Decision Analysis outcomes

As a result of the Bayesian Decision Analysis performed, the policy of regulating harmful chemicals had the highest probability (48%) of significantly improving biodiversity on farms. The policy mix had the second-highest probability, with a percentage of 40%. The other three options foreseen in the model scored lower, including the market-based policy (35%) followed by the market-based labelling approach (32%) and the policy using subsidies and value chain regulation to achieve its target (31%) (Figure 9).

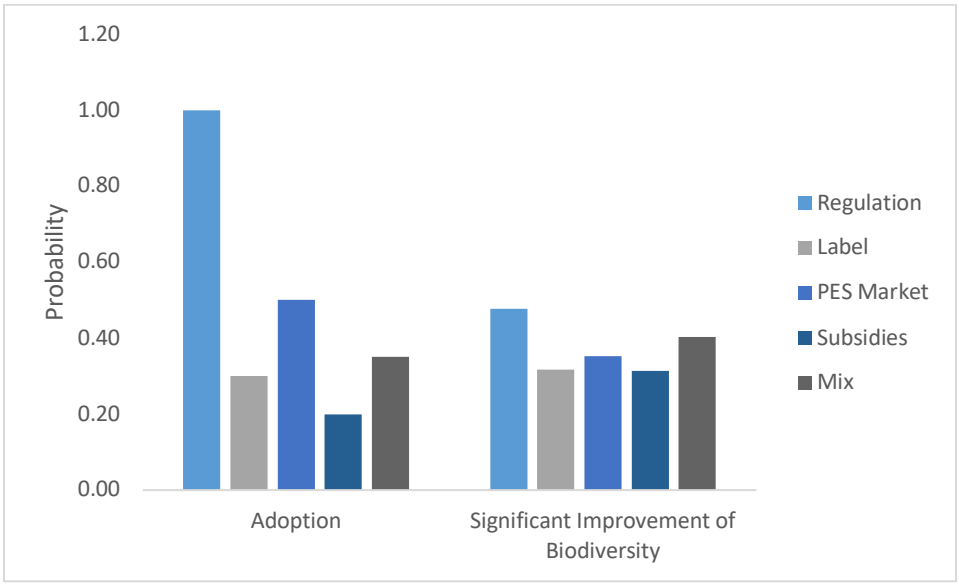


Figure 9 Probability for policy adoption by the farmers and significant biodiversity improvement on the farm for five different policy option

The main reason for the lower scores of policy options based on voluntary adoption seems to be the relatively low expected rate of engagement by farmers, while policy options that have a stronger regulatory character (as *Regulation* and *Mix*) show a higher likelihood of implementation as a result of our modelling exercise.

4. Conclusions

The EKLIPSE Working Group worked from December 2017 to April 2019 to answer the following questions posed by the EKLIPSE call:

- What approaches can improve the biodiversity outcomes of businesses?
- How do we know these approaches work / are effective in improving biodiversity outcomes and over which time frame?
- What are the advantages and disadvantages of existing (and potential) approaches?
- Which of the approaches identified are most promising to be used by regulators?
- Which are the conditions that allow these approaches to work well?

To answer such questions, the project was set out in three different tasks: 1) define a framework of approaches and their effectiveness, 2) identify the most promising approaches to be used by regulators and 3) identify conditions that enhance their effectiveness.

We performed the three different tasks using four different methods: a quick scoping review, a qualitative comparative analysis, an expert survey and a Bayesian decision analysis.

Our conclusions are that policies on biodiversity in the food and beverage sectors should target primarily farmers and consumers, on each end of the value chain. In addition to those two groups, along with our analysis, it emerged that they should be accompanied by a network of actors including politicians, certification organizations, actors involved in knowledge dissemination and in adjacent areas such as health.

The most promising policy approaches identified through our work are economic instruments and regulation. Within the economic instruments, taxes and payments for ecosystem services ranked as the most effective. With regards to direct regulation, protected areas and land used restrictions showed the greatest promise to protect biodiversity.

We were able to identify the conditions under which these instruments would be implemented most effectively: the policy tool should be adaptable to local context and conditions, implemented as part of a system of policies, and co-designed with actors, also through participatory governance. We found less evidence of what would cause failure; however, top-down vertical organization of policy instruments could be a likely cause of failure.

We investigated the conditions related to the measurement of success and scales of policy instruments. Our analysis did not see outcome-based measures are more promising than process-based measures. However, it was identified that holistic ecosystem preservation and a combination of biodiversity actions (in opposition with single actions) would have the most promising effect on biodiversity. These results were confirmed in our Bayesian decision analysis, where the policy of

regulating harmful chemical had the highest probability of significantly improving biodiversity, as well as the policy mix options. The other three options, payment for ecosystem scheme, labelling approach and subsidies for organic farming scored lowest. Clearly, voluntarism seems to be scoring low compared to options showing strong regulatory character.

To conclude, we emphasize the need for SMEs (farmers/producers) be accompanied by support mechanisms in the implementation of policy instruments that aim to improve their impacts on biodiversity. We argue that the geographical scale of policy instruments is key since the contextualisation, adaptability and flexibility of instruments have been emphasized from all the methodological tools we used. Furthermore, we have been able to collaboratively identify specific challenges faced by SMEs and regulators in the specific food and beverage sector, when it comes to biodiversity protection:

- **Support to SMEs:** small and medium-sized enterprises need support to understand, select and implement mandatory and voluntary approaches for biodiversity. They require incentives and resources to cover initial investments. It is also important to note that there might be a competitive issue with sharing innovative best practices; this clearly emphasizes the need for support mechanisms (consultants, education, working in groups & networks).
- **Language:** government agencies must communicate with companies using a language accessible to business operators and supply chain actors. Again, this emphasizes the need for any policy to be accompanied by training and support (chamber of commerce, local trade unions).
- **Time:** temporal aspects need to be taken into consideration, both in anticipating and piloting future regulation (what may be a standard today may become a regulation tomorrow) and the longevity of any biodiversity improvements (people want immediate results, but how effective is an approach in terms of long-term biodiversity outcomes?).
- **Geographical scale**: we took care to reflect on the level at which a measure or approach would work best – sub-national, national or EU. The question of scale also refers to what is relevant on the market in the food and drink retail industry, e.g. mostly global standards that reach many businesses vs regional initiatives and influences. The geographical scale needs to be thought of both at the measure/approach level but also in relation to potential impacts on biodiversity, which are most likely to be local.
- **Internal organizational change**: policies should ideally consider if certain approaches could change employee mindsets and company cultures. Notably, at the SME level, a group approach accompanied with external support seems adequate for any policy implementation, especially in the biodiversity sector. Working with local universities to increase more awareness for biodiversity via agricultural and business trainings would also be a possible support to policy implementation.
- **Influence on and from customers:** consumers were rated by our consulted experts as the second type of stakeholders having a strong influence on biodiversity outcomes. This could be because of their consumption choices, diets, and interactions with retailers and food producers; as a consequence, customers must be prioritised in being targeted by policy approaches.
- **Practicality of approaches**: Practical approaches for businesses to understand and manage their impacts on biodiversity and natural capital across their supply chains are lacking to

date. In this sense, ensuring traceability will be key in making sure that the supply chain (and not only the farmers) can work together in implementing biodiversity-friendly options.

- **First movers versus main-streaming**: two different strategies could be used: 1) Innovation leverage for businesses to go beyond regulation (i.e. pilots, first movers) or 2) main-streaming the variety of existing approaches beyond the minority of already committed businesses. This project has considered both types of strategies: while regulation (main-streaming) is considered the most efficient, there is however a need to support more innovative policy mixes and partnerships.
- **Implementation cost**: implementation costs of any policy measure is an important aspect for SMEs. In addition, it is important that the effectiveness of any new approach is appropriately monitored and measured by an independent third party; this is connected with the necessity to build networked and local approaches where, for example, costs of consultancy could be shared amongst actors.

5. Limitations and further research

5.1 Delimitation of the request scope

- Whenever possible, we drew upon independent, scientific evaluations of existing approaches' effectiveness on biodiversity and ecosystem conservation; however, we recognized that the existing evidence might be limited, and as needed also drew upon self-reported impacts and grey literature.
- Although it is vital to pull together a database and data collection method to evaluate the biodiversity impact of businesses (both large and SMEs), this was out of scope and reach of the EWG. While this is part of the approaches that could be recommended to governmental bodies, the scope and length of this work has to be conducted separately.
- It is also out of scope to develop, apply or implement a biodiversity performance tool or a monitoring system.
- Due to time constraints on the project, there were no pilot projects or capacity building and training for the public sector or businesses.

5.2 Methodological and general limitations

Given the impossibility to gather primary evidence, the conclusions are limited to existing evidence on policy interventions carried out or that could be carried out in the future.

We noticed that the literature is biased towards self-regulation and towards agriculture (farmers); yet, farmers remain the most appropriate actors to target due to the strong link between their behaviour and biodiversity protection or loss. Furthermore, policies that harness the power of other supply chain actors to influence farm-level behaviour have been comparatively overlooked and understudied. Also, the literature is siloed, and in many cases, we were not able to link policies (e.g. labelling) with biodiversity outcomes, as papers are written within different communities.

Search terms used in the literature review might not have been able to capture the complete body of scientific literature. But this was also never the goal of this study and we are confident that the

search terms were able to reflect the most important trends and ideas that have been studied in the last years on the topic.

Studies also differed widely in the method used to policy efficiency, including stakeholder interviews, field assessments of biodiversity and other comparative field studies. While we did not systematically assess the methodological approaches used, we acknowledge that their diversity makes it difficult to compare the studies with each other. This common limitation of meta-studies, however, is also reflecting the complexity of the topic and the diverse impact pathways, which need to be considered and assess.

Concerning the comparative analysis done within the QCA, we recognize that the process entailed a certain level of subjectivity, especially when the list of papers is reviewed by different persons. Nonetheless, the follow-up methods seeking expert opinions (expert consultation and Bayesian Decision Analysis) helped avoid subjectivity in the identifying effectiveness conditions for the policy approaches analysed.

The elicitation during the BDA workshop included only 17 experts, which limits the representativeness of the probabilities and the associated inferences. The lack of opportunity to engage more meaningfully with experts before the workshop may also compromise the eventual buy-in and uptake of the model results.

At a general level, the majority of existing case studies, particularly regarding the outcomes and impacts of possible policy measures, is only related to immediate outcomes of a measure, not their medium or long term impacts on biodiversity. Therefore, it is important to make a distinction in the report between strategies that regulators might use to support SMEs in reaching those immediate impacts, and strategies that could lead to long-term biodiversity improvements.

There exists a wide range of different circumstances influencing environmental regulators in their attempts to address biodiversity issues along whole food supply chains. While the EWG aimed to take into account of all existing evidence on the topic, the expected conclusions of this report necessarily had to concentrate on a subset of such circumstances by highlighting a number of recommended policy options. Geography and local circumstances matter in biodiversity outcomes.

5.3 Future research

Future research on policy-making for biodiversity should be transdisciplinary and cross-sectorial. Indeed, there is the need to build on teams able to analyse both governance, performance and biodiversity outcomes. Furthermore, we recommend the further development of research and consultation methodologies that allow for better involvement of the business sector to co-design and co-evaluate possible policy solutions.

The Bayesian Decision Analysis revealed that policy-adoption rate is a crucial uncertainty largely influencing the expected performance of policy options. Further work is, therefore, vital to address such uncertainty.

While direct regulation has been emphasized as the most promising approach for biodiversity impact, it is not always a quick or even feasible option. Additionally, regulatory policies are often causing high private costs for farmers while providing public gains. The regulatory approach proposed here does not include any compensating mechanism for farmers. Strong regulatory mechanisms might be more difficult to implement if farmers are not compensated for their costs.

Considering costs and benefits for farmers and society could improve the design of effective policy mechanisms to increase acceptance among farmers and design optimal policy mechanisms (Gomez-Limon et al. 2019). Further experimentations in policy-mix options, including academic support, would help devise relevant studies, on which to build scalable options for better biodiversity outcomes in the food and beverage sector.

References

Belton, V. and Stewart, T., 2002. *Multiple criteria decision analysis: an integrated approach*. Springer Science & Business Media.

Burton, R. and Schwarz, G., 2013. Result-oriented agri-environmental schemes in Europe and their potential for promoting behavioural change. *Land Use Policy 30*(1), pp. 628-641.

CBD, 1992. *United Nations Convention on Biological Diversity*. https://www.cbd.int/convention/text/default.shtml

CBD, 2000. *Agricultural biological diversity: review of phase I of the programme of work and adoption of a multi-year work programme*. COP 5 Decision V/5, United Nations Convention on Biological Diversity. https://www.cbd.int/decision/cop/default.shtml?id=7147

Collins, A., Coughlin, D., Miller, J. and Kirk, S., 2015. *The production of quick scoping reviews and rapid evidence assessments: a how to guide*. NERC.

Bødker, M., Pisinger, C., Toft, U. and Jørgensen, T., 2015. The rise and fall of the world's first fat tax. *Health policy*, *119*(6), pp.737-742.

Brammer, S., Hoejmose, S., and Marchant, K., 2012. Environmental Management in SMEs in the UK: Practices, Pressures and Perceived Benefits. *Business Strategy and the Environment, 21*(7), 423–434.

Daugbjerg, C. and Sønderskov, K.M., 2012. Environmental policy performance revisited: Designing effective policies for green markets. *Political Studies*, 60(2), pp.399-418.

ECNC, 2005. *Biodiversity and the Food Sector - An initial review of the extent to*

which biodiversity is protected through food standards in Europe. Tilburg: European Centre of Nature Conservation.

FAO, 2019. *The State of the World's Biodiversity for Food and Agriculture*, Bélanger, J., and Pilling, D. (eds.). FAO Commission on Genetic Resources for Food and Agriculture Assessments. Rome. 572 pp. http://www.fao.org/3/CA3129EN/CA3129EN.pdf

Food & Biodiversity, 2017. *Recommendations to provide biodiversity protection in policy and criteria of food standards and sourcing requirements of food companies and retailers*. http://www.business-biodiversity.eu/en/recommendations-biodiversity-in-standards

Geva-May, I. and Pal, L.A., 1999. Good fences make good neighbours: policy evaluation and policy analysis–exploring the differences. *Evaluation*, 5(3), pp. 259-277.

Gunningham, N., Grabosky, P. and Sinclair, D., 1998. *Smart Regulation: Designing Environmental Policy*. Oxford: Clarendon Press.

Gunningham N. and Sinclair, D., 1999. Integrative regulation: a principle-based approach to environmental policy. *Law and Social Inquiry 24*(4), pp. 853–896.

Fischer, J., Abson, D.J., Butsic, V., Chappell, M.J., Ekroos, J., Hanspach, J., Kuemmerle, T., Smith, H.G. and von Wehrden, H., 2014. Land sparing versus land sharing: moving forward. *Conservation Letters, 7*(3), pp.149-157.

Foster, D.R., 2002. Conservation issues and approaches for dynamic cultural landscapes. *Journal of Biogeography*, *29*(10-11), pp.1533-1535.

Haddaway, N.R., Macura, B., Whaley, P., and Pullin, A.S., 2017. *ROSES flow diagram for systematic maps*. Version 1.0. DOI: 10.6084/m9.figshare.6085940

Hanley, N., Banerjee, S., Lennox, G.D. and Armsworth, P.R., 2012. How should we incentivize private landowners to 'produce' more biodiversity?. *Oxford Review of Economic Policy, 28*(1), pp.93-113.

Hood, C., 1983. *The Tools of Government*. London: Macmillan.

Hood, C., 2007. Intellectual Obsolescence and Intellectual Makeovers: Reflections on the Tools of Government after Two Decades. *Governance, 20*(1), pp. 127–44.

Howlett, M. and Rayner, J., 2007. Design principles for policy mixes: cohesion and coherence in 'new governance arrangements'. *Policy and Society*, 26(4), pp. 1-18.

Jacobsen, H., 2012. Denmark scraps its infamous fat tax after only one year. *Euractiv*, November 12. URL: https://www.euractiv.com/section/agriculture-food/news/denmark-scraps-its-infamous-fat-tax-after-only-one-year/ (accessed: March 23 2019).

Kati, V., Hovardas, T., Dieterich, M., Ibisch, P.L., Mihok, B. and Selva, N., 2015. The challenge of implementing the European network of protected areas Natura 2000. *Conservation Biology, 29*(1), pp.260-270.

TEEB, 2015. *TEEB for Agriculture & Food: an interim report, United Nations Environment Programme*, Geneva, Switzerland.

IPBES, 2016. *The assessment report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services on pollinators, pollination and food production*. Potts, S.G., Imperatriz-Fonseca, V.L., and Ngo, H.T., (eds). Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Bonn, Germany.

Ledoux, L., Crooks, S., Jordan, A. and Turner, R.K., 2000. Implementing EU biodiversity policy: UK experiences. *Land use policy*, *17*(4), pp.257-268.

Mace, G.M., 2014. Whose conservation?. *Science*, *345*(6204), pp.1558-1560.

Maiorano, L., Amori, G., Montemaggiori, A., Rondinini, C., Santini, L., Saura, S. and Boitani, L., 2015. On how much biodiversity is covered in Europe by national protected areas and by the Natura 2000 network: insights from terrestrial vertebrates. *Conservation Biology*, *29*(4), pp.986-995.

Martin, T.G., Burgman, M.A., Fidler, F., Kuhnert, P.M., Low-Choy, Samantha, McBride, M. and Mengersen, K., 2012. Eliciting expert knowledge in conservation science. *Conservation Biology*, *26*(1), pp.29-38.

Mateo, J.R.S.C., 2012. *Multi criteria analysis in the renewable energy industry*. Springer Science & Business Media.

Mattison, E.H. and Norris, K., 2005. Bridging the gaps between agricultural policy, land-use and biodiversity. *Trends in Ecology & Evolution*, *20*(11), pp.610-616.

Mendoza, G.A. and Martins, H., 2006. Multi-criteria decision analysis in natural resource management: a critical review of methods and new modelling paradigms. *Forest ecology and management*, *230*(1-3), pp.1-22.

Mukherjee, N., Huge, J., Sutherland, W.J., McNeill, J., Van Opstal, M., Dahdouh-Guebas, F. and Koedam, N., 2015. The Delphi technique in ecology and biological conservation: applications and guidelines. *Methods in Ecology and Evolution*, *6*(9), pp.1097-1109.

Natural Capital Coalition. 2016. *Natural Capital Protocol – Food and Beverage Sector Guide*. (Online) Available at: www.naturalcapitalcoalition.org/protocol

PBL Netherlands Environmental Assessment Agency, 2014. *How sectors can contribute to sustainable use and conservation of biodiversity*. CBD Technical Series No. 79.

Pe'er, G., Dicks, L.V., Visconti, P., Arlettaz, R., Bàldi, A., Benton, T.G., Collins, S., Dieterich, M., Gregory, R.D., Hartig, F., Henle, K., Hobson, P.R., Kleijn, D., Neumann, R.K., Robijns, T., Schmidt, J., Shwartz, A., Sutherland, W.J., Turbé, A., Wulf, F., and Scott, A.V., 2014. EU agricultural reform fails on biodiversity. *Science 344*(6188), pp. 1090–1092.

Pressey, R.L., Cabeza, M., Watts, M.E., Cowling, R.M. and Wilson, K.A., 2007. Conservation planning in a changing world. *Trends in ecology & evolution*, *22*(11), pp.583-592.

Ragin, C., 1987. *The Comparative Method: Moving Beyond Qualitative*

and Quantitative Strategies. University of California Press, Berkeley.

Ragin, C.C., 2009. Qualitative comparative analysis using fuzzy sets (fsQCA). In: Rihoux, B., and Ragin, C.C. (eds.) *Configurational comparative methods: Qualitative Comparative Analysis (QCA) and Related Techniques*, London: SAGE, pp. 87 - 122.

Rudel, T.K., 2008. Meta-analyses of case studies: A method for studying regional and global environmental change. *Global Environmental Change* 18, pp. 18–25.

Schlaepfer, M.A., 2018. Do non-native species contribute to biodiversity?. *PLoS biology*, *16*(4), p.e2005568.

Scouvart, M., Adams, R.T., Caldas, M., Dale, V., Mertens, B., Nédélec, V., Pacheco, P., Rihoux, B. and Lambin, E.F., 2008. Causes of deforestation in the Brazilian Amazon: a qualitative comparative analysis. *Journal of Land Use Science, 2*(4), pp.257-282.

SEPA, 2016. *One Planet Prosperity – Our Regulatory Strategy*. Scottish Environmental Protection Agency. https://www.sepa.org.uk/media/219427/one-planet-prosperity-our-regulatory-strategy.pdf

Slocum, N., 2003. *Participatory Methods Toolkit. A practitioner's manual*. United Nations University, King Baudouin Foundation and the Flemish Institute for Science and Technology Assessment.

http://archive.unu.edu/hq/library/Collection/PDF_files/CRIS/PMT.pdf

Solé, R.V., Alonso, D. and Saldaña, J., 2004. Habitat fragmentation and biodiversity collapse in neutral communities. *Ecological complexity*, *1*(1), pp.65-75.

Tayleur, C., Balmford A., Buchanan G., M., Butchart, S. H., Ducharme H., Green, R. E., Milder J. C., Sanderson F. J., Thomas, D. H. L., Vickery, J., and Phalan, B., 2016. Global Coverage of Agricultural Sustainability Standards, and Their Role in Conserving Biodiversity. *Conservation Letters 10*(5), pp. 610–618.

Taylor, C., Pollard, S., Rocks, S., and Angus, A. 2012. Selecting policy instruments for better environmental regulation: a critique and future research agenda. *Environmental Policy and Governance, 22*(4), pp. 268-292.

Taylor, C., Pollard, S., Rocks, S., & Angus, A., 2015. Better by design: business preferences for environmental regulatory reform. *Science of the Total Environment, 512*, pp. 287-295.

TEEB, 2018. *TEEB for Agriculture & Food: Scientific and Economic Foundations*. Geneva: UN Environment.

Trucost, 2016. *Environmentally extended input-output (EEI-O) model*; cited in the Natural Capital Coalition. 2016. «Natural Capital Protocol – Food and Beverage Sector Guide ».

van der Ven, H., Rothacker, C. and Cashore, B., 2018. Do eco-labels prevent deforestation? Lessons from non-state market driven governance in the soy, palm oil, and cocoa sectors. *Global environmental change*, *52*, pp.141-151.

Software references:

Dörrhöfer, D., 2017. binaryLogic: Binary Logic. R package version 0.3.9. https://CRAN.R-project.org/package=binaryLogic

Microsoft Excel 2016 (16.0.4738.1000) 32 bit, Microsoft Cooperation. Netica 1992-2018 Version 6.05 For MS Windows 7 to 10, Norsys Software Corp.

R Core Team, 2019. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/.

Ren, K., 2016. rlist: A Toolbox for Non-Tabular Data Manipulation. R package version 0.4.6.1. https://CRAN.R-project.org/package=rlist

Wickham, H. and Bryan, J., 2019. readxl: Read Excel Files. R package version 1.3.1. https://CRAN.R-project.org/package=readxl

Wickham, H. and Henry, L., 2019. tidyr: Easily Tidy Data with 'spread()' and 'gather()' Functions. R package version 0.8.3. https://CRAN.R-project.org/package=tidyr

Wickham, H., François, R., Henry, L. and Müller, K., 2019. dplyr: A Grammar of Data. Manipulation. R package version 0.8.0.1. https://CRAN.R-project.org/package=dplyr

Appendix I: –Methodological protocol

Our methodological approach follows standard practice in policy analysis by 'starting with what you know' (as summarized by Figure A1 below), followed by the location of relevant sources – both published document and expert opinions – and by the identification of malleable criteria used to categorize alternative courses of action and intervention strategies (Geva-May and Pal, 1999). To achieve these aims, we settled on the following methods to achieve the tasks set out in the Document of Work:

1. Overview of Methodology

The EWG methodological approach involved a quick scoping review of the literature (Collins et al. 2015) and expert consultation. We anticipate the following methods to achieve tasks 1 to 3:

Task 1: Define a rough framework of approaches and their effectiveness

6. What approaches can improve biodiversity outcomes of businesses?
7. How do we know these approaches work/are effective in improving biodiversity outcomes and over what timeframe, i.e. regarding accounting for biodiversity impacts, identifying the most relevant parts of the value chain, and keeping track of interactions across complex value chains?

The method used: Non-systematic Literature Review (or Quick Scoping Review), supported by a part-time research assistant following an agreed-upon scoping protocol, that leads us to develop a solution scanning of approaches that environmental regulators can use to improve outcomes for businesses.

Task 2 & 3: Identify the most promising approaches to be used by regulators, and analyse under which conditions the chosen approaches work well

8. What are the advantages and disadvantages of existing (and potential) approaches?
9. Which of the approaches identified in task 1 are most promising to be used by regulators?
10. Which of these approaches work well under which conditions?

This shall take into account different perspectives and can include, for example, the following conditions:

11. conditions related to the national policy and legal context (e.g. do integrated food policies as recently developed in some EU countries help to have a more holistic approach?),
12. conditions related to the specific scheme (different standards, governance schemes),
13. conditions related to corporate natural capital management practice, culture and mind-set,
14. conditions related to the socio-economic context, e.g. structure and interactions within the entire market chain, consumer awareness and choices, and
15. conditions related to the level of trust and partnership between the private and public sector.

Methods used:

1. To identify criteria used to classify advantages and disadvantages: Building on the QSR, undertake a Qualitative Comparative Analysis, accompanied by a Delphi process of experts to narrow down the most important criteria

2. To identify the most promising approaches to be used by regulators: Multi-Criteria Analysis

3. To identify under which conditions these approaches work well: Draw on existing evidence regarding the concrete effectiveness of the identified most promising approaches as gathered by the Quick Scoping Review and the Qualitative Comparative Analysis.

4. To allow for peer-review of the final outcome: Request for written feedback of experts contacted for the Delphi process.

The connection between the different methods and the planned outputs can be seen in Figure A1.

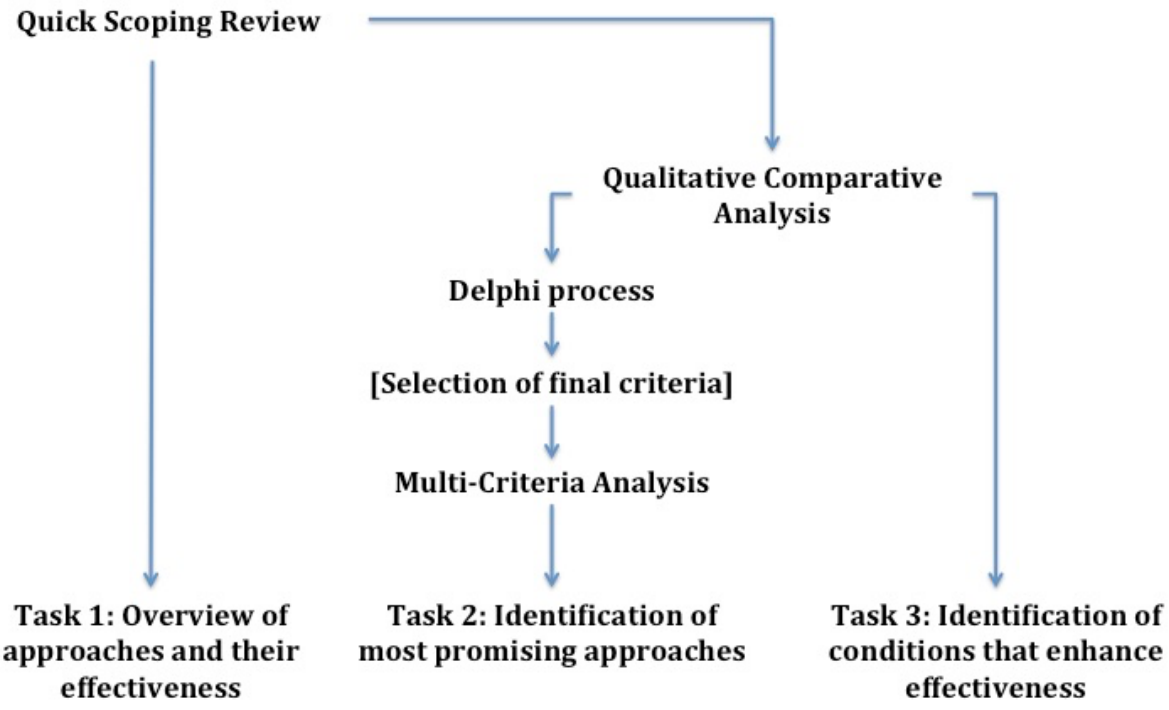


Figure A1: Conceptual overview of methods and their use in addressing the three requested tasks

a. Quick Scoping Review (QSR)

A QSR aims to provide "an informed conclusion of the size and type of evidence available and a summary of what that evidence indicates with respect to the question/s posed" (Collins et al., 2015). It is defined as "a structured, step-wise methodology, preferably following an a priori protocol to collate and describe existing research evidence (traditional academic and grey literature) in a broad topic area, following a systematic map methodology but with components of the process simplified or omitted to produce information in a short period of time" (Dicks et al. 2017).

The different steps include:

1. Writing a protocol to collect the literature from different sources. The protocol will contain the following (Collins et al., 2015):

16. Authors – Team members and report authors;
17. Background – Outlining the rationale behind the evidence review, including the policy context;
18. Objective – Clarify the primary question and secondary questions if used, detailing the PICO (Population, Intervention, Comparator, and Outcome) elements;
19. Scope – Provide clear limits to the question elements such as geographic range, topic, language, and time period;
20. Conceptual model – A conceptual model of the interactions that are the focus of the evidence review (see Figure A1);
21. Methods - Outline of how the following search, extraction and synthesis steps are to be carried out, including:

- Search keywords. These search keywords will be tested against the literature already collected by the EWG (see below) to make sure they are appropriate. However, given the interdisciplinary nature of the policy request, we also anticipate this to become a recursive process which we will undertaken along with the research assistant;
- A strategy for where evidence will be searched for, covering peer-reviewed, grey literature and unpublished evidence. A list of focal journals and academic databases used will be provided. For grey literature, we will list the places to be searched (websites), giving the rationale in order to ensure transparency. Furthermore, given that the Expert Working Group has already collected a number of publications that may be relevant, the first step of the QSR will be to review and sort these publications before moving to the search of new material;
- Outline inclusion and exclusion criteria (Any types of evidence that will not be considered should also be stated in the protocol with justification of the reasons why) – these criteria may also need to be revised in due course and all such revisions will be documented;
- Strategy for extracting information: build our database of included evidence to extract information relevant to the scoping review's question in a systematic manner;

22. Strategy for critical appraisal;
23. Indication of how information will be synthesised;
24. References and sources of information used in the protocol.

2. Collecting the data

Literature will be collected from three sources: academic literature, grey literature on the themes in the knowledge synthesis framework and the different approaches (reports from private governance, working groups, public sector, NGOs..) and case studies and lessons learned to capture the variety of approaches used.

The data collection proceeds in three steps, two of which have already been undertaken:

a) the EKLIPSE team collected a number of academic papers on behalf of the project group.

b) Each of the experts of the group collected documents from their academic background based on their expertise from the conceptual map (Figure A1).

c) A research assistant will assist in systematically collecting additional academic literature and grey literature (reports, case studies) based on the scoping review protocol (with keywords, boundaries, inclusion and exclusion criteria).

3. Sorting the data and provide a systematic view of the research evidence (an excel file)

a) Articles and reports will be downloaded from the databases

b) We will develop an excel template for information extraction

c) We will sort the outputs from the search on the "cloud" according to the excel template information.

4. Critical assessment of the evidence

a) We will assess the relevance of the studies. We should consider:

25. The relevance of the method used to the scoping review question
26. The relevance of the evidence to the target subject/population
27. The relevance of the intervention assessed
28. The relevance of the outcome measured

b) We will assess the robustness of the evidence returned by the scoping review.

c) Finally, we will build a matrix, whereby the weighting of relevance and methodological quality are combined to prove a combined weighting (Collins et al., 2015).

5. The synthesis of evidence

The synthesis of the evidence will describe three aspects:

a) The volume and characteristics of the overall evidence base

b) What the evidence base indicates in relation to our question.

c) The implications of the findings for policy and/or practice

We will write the **final output for Task 1** (providing answer on "what approaches can improve biodiversity outcomes of businesses? And how do we know these approaches work / are effective in improving biodiversity outcomes and over what timeframe") with a systematic map of evidence on the different approaches. This corresponds to the solution scanning, "a structured, step-wise methodology to identify a long list of available actions, interventions or approaches, in response to a broad challenge" (Dicks et al. 2017). The final output will be the input for the first phase of the qualitative comparative analysis.

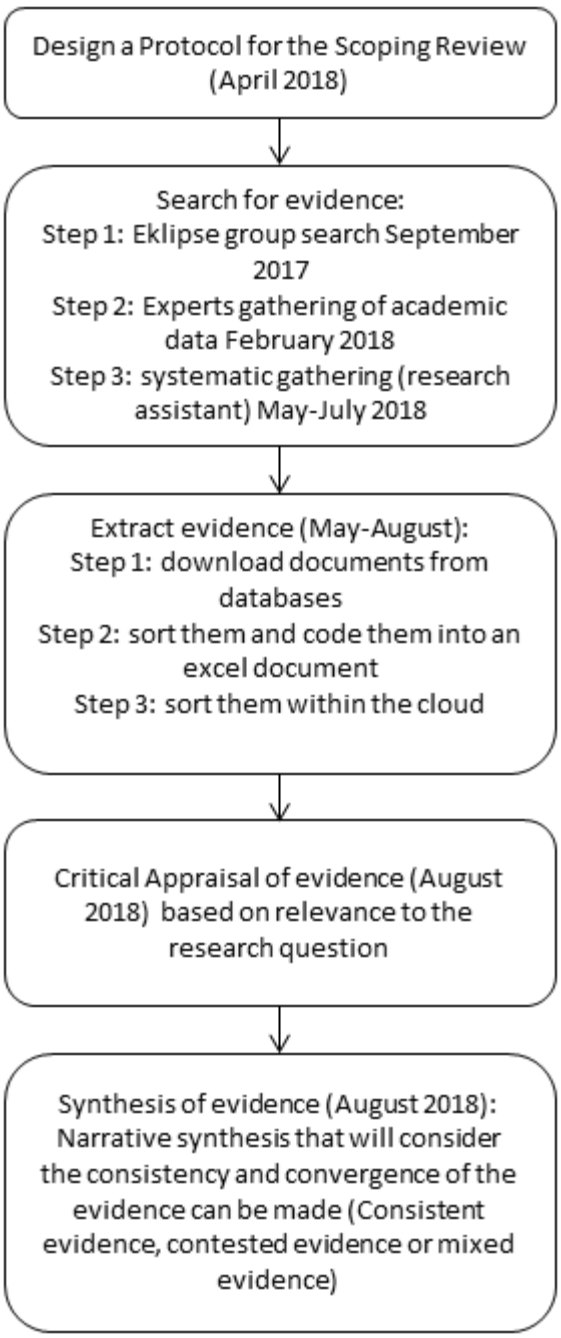


Figure A2: Quick Scoping Review for the project (adapted from Collins et al., 2015)

In the next step, we are asked to identify the most promising approaches for regulators and to identify conditions within which these approaches may work better or worse. To do so, we plan on building on the database created by the QSR and applying a number of techniques that lead up to implementing a Multi-Criteria Analysis. In a first step, we will combine a streamlined qualitative comparative analysis of the identified literature with a Delphi process to arrive at appropriate criteria that will then be applied in the MCA.

b. Qualitative Comparative Analysis (QCA)

This step is crucial to both Task 2 and Task 3, as the quality of the multi-criteria analysis for Task 2 (subsequent step d), as well as the insights on conditions of success, is directly linked to the capacity

to identify lessons learned from the literature review. Therefore, adding this analytical step will allow us to increase the consistency of the multi-criteria analysis as well as prepare our conclusions on Task 3 in a streamlined manner, given that the heterogenous pool of studies and contexts would otherwise make it complicated to identify the whole range of conditions and factors linked to successful practices.

The Qualitative Comparative Analysis (QCA) method was originally proposed by Rudel (2008) as a meta-analytical technique for environmental studies to incorporate information focusing on a specific topic and based on a range of different sources, such as reported evidence based on heterogeneous variables and measures from different studies.

In the context of our project, we suggest to consider the applications developed by Rudel (2008) and Scouvart et al. (2008) as a meta-analytical tool able to identify both *criteria* of success that should flow into the multi-criteria analysis of most promising approaches, and *conditions* of success that will flow into Task 3, from a range of heterogeneous case studies.

The target of the QCA **is to generate a *truth table* where the complexity of the collected information is reduced to a list of criteria and/or conditions of success.** That should help the analytical identification of a specific combination of factors that are related to a particular condition and to a specific objective of analysis.

There are different phases to a qualitative comparative analysis:

1) Identify relevant cases (as done in the Quick Scoping Review) and causal connections. For this, we need to determine the outcome that we are looking for. Then we need to look for "positive" cases and "negative cases". From there, we need to determine the causal relations that lead to the outcome.

2) Construct the truth table and resolve contradictions. A truth table "sorts cases by the combinations of causal conditions they exhibit. All logically possible combinations of conditions are considered, even those without empirical instances" (Ragin 2009).

3) Analyse the truth table.

4) Evaluate the results.

In a nutshell, the QCA is used to support an analytical identification of a specific combination of factors that are related to a particular condition and to a specific objective of analysis.

Strengths:

29. Provide a rigorous method for reducing the complexity of available information and –hence- a more focused analysis in the subsequent steps
30. May suggest "hidden" factors of success that are not evident at first sight

Limitations:

31. Time-consuming
32. Not all papers fit, there should be a "case" description and the possibility to find reasons/factors of success or failure

Table A1 Step 1: identify the statements in the papers.

	Ruysshaert 2016	Arcuri 2015	Khan 2014
Objective	Impact of palm oil certification RSPO	Impact of "publicization" on organic regulation	Biodiversity accounting framework
Region	Global (palm oil producers)	Europe USA	Indonesia (Kalimantan)
Top-down approach			
Room for strategic behaviour			
Bias towards corporative farming			
Consider landscape-level scale (e.g. ecological corridors)			
External control			
Providing "precise" indicators			
Promoting consumerism choices			
Seeking to support for smallholders and inclusive			
Certification premium below opportunity costs			
Strong control by downstream firms			
"Cheap" label			
Promoting ethical and moral understanding and awareness			
Financial report only			
Reporting benefits for society			
Science-based analytics			
Businesses reporting			
Strict biodiversity protective legislation			
Coexistence with private higher more stringent private standards			
"monopolistic" effect			
Social normative transformation			
Conventionalization "corporative" watering down rules			
Enhance regulatory capability			
Label protection			
Remain in a voluntary framework			

Table A2 Step 2: identifying the least common denominator.

The statements are revised and "clustered" until a satisfying configuration is found. For each statement "+" means that the statement is considered to be a factor of success; "-" is considered a factor of failure or a limitation; "?" means no evidence provided.

	Biased towards corporative business	Seeking to support smallholders	Link with moral and ethical values (e.g. anti-consumerism)	Provide " precise" and comprehensive reporting (indicators)	" Precise" regulatory capability, not leaving room for strategic behaviour	Leave room for coexistence of more stringent certifications	Low certification cost but covering opportunity costs	Label protection	Voluntary framework
Ruysschaert 2016	-	+	+	+	+	+	+	?	?
Arcuri 2015	-	?	+	?	+	+	?	+	+
Khan 2014	?	?	+	+	+	?	?	?	?

From the basic example, it is clear that providing a clear "strict" regulation and linking with moral/ethical values are relevant. The importance of informative reporting of impacts, and the attention to facilitate the involvement of smallholders is also highlighted.

We intend to use this method in the following way: Once we have arrived at a core set of literature from the Quick Scoping Review, each member of the Expert Working Group will be given a share of the identified articles and requested to undertake a simplified QCA, using the following two guiding questions:

33. What criteria (e.g. uptake, cost-effectiveness, impact, ...) can be identified that constituted advantages or disadvantages of the intervention for the policy-maker in question? Use these criteria to categorize the interventions (+/-/?) as described above.
34. What conditions (see Task 3 for examples) contributed to the (broadly defined) success or failure of the interventions? Use these conditions to categorize the interventions (+/-/?) as described above.

The results of guiding question 1 will then be aggregated across the experts' QCAs and constitute the pool of possible criteria, derived from the literature, that may be used for the Multi-Criteria Analysis (MCA). Given the limited number of criteria that MCA is able to handle, as well as the importance of

including stakeholder voices into the selection of criteria, we intend to introduce a simplified Delphi process at this step of the process to finalize the criteria used in the MCA.

The results of guiding question 2, in turn, will constitute the baseline evidence that will be incorporated into the final report on supportive or hindering conditions for policy success, with a focus on the approaches that are identified as most promising within the MCA.

c. Delphi Process

The Delphi technique is a method used for enabling a group of individuals to collectively address a complex problem through a structured group communication process. The Delphi technique comprises two or more rounds of structured anonymous questionnaires, each followed by aggregation of responses and anonymous feedback to the participants (Martin et al., 2012; Mukherjee et al. 2015):

We plan to follow the structure of a simplified Delphi process as follows:

Preparation of the first round of the questionnaire (questionnaire may be unstructured, i.e. with open-ended questions to gather opinions, so that participants can elaborate on and discuss the issues being addressed). We would use this questionnaire to both presents the criteria identified in the QCA and ask participants to rank these criteria in order of their perceived importance, as well as allow them to suggest other criteria we may have overlooked.

Selection and invitation of respondents (from 7- 50 persons). We are planning to include the experts that have been contacted by EKLIPSE to set up the call and Document of Work and expand on this pool based on our own networks as well as the snowballing method. Given that the policy request comes from the Scottish Environment Protection Agency, the inclusion of stakeholders particularly from the United Kingdom is highly desirable.

Collection and analysis of the completed questionnaire for the first round. Participants answer to the questionnaire and the results are compiled into a short report, which is used as the basis for the second questionnaire round.

Preparation and analysis of the second round of questionnaire: The collated responses of the first round are used to prepare a structured questionnaire used in the second round. In our case, this questionnaire would include the aggregated ranking of the criteria from the first round, as well as a presentation of extra criteria that participants have suggested. Participants will be asked to provide their final ranking of all criteria in view of this additional information.

On the basis of the final outcome, we will select the most highly ranked criteria as criteria that will be compared and contrasted in the Multi-Criteria Analysis (below) to arrive at the most promising approaches for environmental regulators to support small and medium-sized enterprises in improving their biodiversity impacts.

d. Multi-Criteria Analysis

Multi-Criteria Decision Analysis (MCDA) evaluates the performance of alternative courses of action with respect to criteria that capture the key dimensions of the decision-making problem, considering the preferences and judgments of the decision-makers (Belton and Stewart, 2002). MCDA comprises

a family of tools which were developed in the context of Operations Research to provide a formalized method to assist decision-making in complex situations that involve multiple criteria. However, MCDA has been increasingly used in a wide range of other fields, including environmental planning, management and policy advice (Mendoza and Martins, 2006). Multi-criteria decision-making methods have several advantages in dealing with complex decision problems:

35. They allow for the investigation and integration of interests and objectives of multiple actors and stakeholders since the use of multiple criteria and weights accounts for the quantitative and qualitative input of each actor;
36. They provide output information that is consistent, comparable, and ordered in a simple format, which makes it easy to communicate to stakeholders;
37. And they allow for objectivity and inclusiveness of different perceptions and interests of actors without being energy- and cost-intensive (Mateo, 2012; Tsoutsos et al., 2009).

One can differentiate between two broad groups of MCDA tools: *Multi-objective decision-making methods* (which are used during multi-objective planning problems when the range of final design solutions is a priori infinite, but constrained by the decision variables) and *multi-attribute decision-making methods*, where a small number of discrete alternatives are compared and evaluated against a set of attributes that are frequently difficult to quantify, and the most appropriate is chosen based on the ranking and/or aggregation method chosen (Mateo, 2012; Mendoza and Martins, 2006). Given our goal of identifying the most promising approaches to be used by regulators on the basis of our scoping review and qualitative comparative analysis, multi-attribute decision-making methods appear most appropriate for our purposes.

It should, however, be acknowledged that even within this group, there exist a number of different methods which are based on different axiomatic and model assumptions in terms of the construction and aggregation of preferences, and which are not directly comparable. Broadly, one can distinguish value measurement models (in which numerical scores are constructed in order to represent the degree to which one decision option may be preferred to another; e.g. the Analytic Hierarchy Process); goal, aspiration, or reference level models (which seek to discover options which are closest to achieving previously determined desirable goals or aspirations; e.g. the goal programming method); and outranking models (in which alternative courses of action are compared pairwise, initially in terms of each criterion, and finally in aggregation, to determine the strength of evidence favoring selection of one alternative over another; e.g. the ELECTRE or PROMETHEE methods) (Belton and Steward, 2002; Mendoza and Martins, 2006). Given the close familiarity of one of the EWG's members with the Analytical Hierarchy Process, alongside this method's low need for data, an intuitive set-up that makes it easy to understand for policy-makers, and widespread usage, the expert working group settled on using the Analytic Hierarchy Process as its aggregation method.

In general, a multi-criteria decision-making process involves the following steps to be followed (Mateo, 2012):

1. Identifying the objective/goal of the decision-making process, defining the problem, identifying decision-making actors, and defining constraints and the degree of uncertainty.

2. Establishing the evaluation criteria/parameters/factors.

Criteria must be coherent with the decision, independent of each other, represented in the same scale, quantitatively or qualitatively measurable, and not unrelated to the alternatives.

3. Selecting the alternatives that will be evaluated in the process. This corresponds to the policy alternatives to support businesses in improving their biodiversity impact.

4. Selecting the weighting method which will determine the relative importance of criteria in the multi-criteria problem under consideration, and assign criteria weights. Here we will use the Analytical Hierarchy Process.

5. Constructing the evaluation matrix, which in its simplest form consists of alternatives, criteria, their weights, and the corresponding evaluation of each criterion. This can be expressed in matrix form as follows (Mateo, 2012):

Criteria: C_1, C_2, C_3, … C_N

Weights: W_1, W_2, W_3, … W_N

$$\begin{bmatrix} A_1 \\ A_2 \\ A_3 \\ \dots \\ A_m \end{bmatrix} \begin{bmatrix} x_{11}\ x_{12} \dots x_{1n} \\ x_{21}\ x_{22} \dots x_{2n} \\ x_{31}\ x_{32} \dots x_{3n} \\ \dots \\ x_{m1}\ x_{m1} \dots x_{mn} \end{bmatrix}$$

where x_{ij} is the evaluation given to alternative *i* with respect to criterion *j*, w_j is the weight of criteria *j*, *n* is the number of criteria and *m* is the number of alternatives. In an extended form of the policy analysis, if requested, it may also be possible at this step to construct different scenarios with different stakeholder weights to showcase the underlying normative underpinnings of different societal trade-offs.

6. Selecting the appropriate multi-criteria method of aggregation in order to rank alternatives. The appropriateness of the final method chosen will depend inter alia on the final data availability and the degree of uncertainty both of the decision-makers' preferences (in which case is outranking methods or the use of sensitivity analyses may be considered) and of the likely outcomes (in which case probability-based, stochastic, or fuzzy logic methods might be chosen).

7. Finally, the aggregation method is applied, alternatives are ranked, and the recommended solution alternatives are presented based on the aggregation results.

This concludes the overview of analytical tools used to construct the report as planned by the EWG. The members of the EWG will write the final report, addressing Tasks 1 – 3, on the basis of the overview of existing evidence gathered in the Quick Scoping Review, the ranking of alternatives and their advantages and disadvantages (by criteria chosen through the Delphi Process) arrived at during the Multi-Criteria Analysis and the knowledge of external conditions of success identified during the Qualitative Comparative Analysis.

2. Review of the Draft Report

Feedback on the findings presented in a draft report will be sought from a range of stakeholders using the following engagement process:

External expert review of the report – approximately five external reviewers will be invited by EKLIPSE to review the draft report on its content and structure. Reviewers will represent different backgrounds (academia, policy and practice).

The draft report will be distributed among the participants of the Delphi Process, who will be asked for their feedback and input on the content and conclusions.

Public consultation on the draft report – the draft report will be placed on the EKLIPSE website allowing members of the public to comment on it over a one-month period. The EKLIPSE EWG will formally respond to the comments made by each of these five reviewers, as well as the most important issues raised by the public consultation.

3. Final Reporting

The final report will be submitted to the Scottish Environmental Protection Agency alongside an Executive Summary that highlights the most important insights and policy recommendations. If requested by the Agency, members of the EWG will make an oral presentation of the report and its conclusions to members of EKLIPSE, SEPA and key stakeholders as part of a workshop/conference organised by the requesters of the work.

4. Expected outputs and formats

4.1. Outputs and Formats

There will be three outputs of this work:

1) A peer-reviewed report providing the key findings related to the three main steps taken in the review.

2) An Executive Summary which can be used in the awareness-raising process.

3) A PowerPoint presentation to members of EKLIPSE, SEPA and key stakeholders as part of a workshop/conference organised by the requesters of the work.

We are not ruling out the possibilities for members of the group to publish academic papers partly grounded in the working group's work.

4.2. Limitations of the expected conclusions

At this stage of the process, the members of the EWG anticipate the following limitations of the expected conclusions, given the time frame and resources available for this request:

Given the impossibility of gathering primary evidence, the conclusions will be limited by existing evidence on policy interventions that have been carried out or could be carried out in the future. The EWG anticipates that this evidence base, particularly for the target group of SMEs in the food and drink sector in Europe, may be limited, particularly regarding the proven biodiversity outcomes such interventions may achieve.

There exists a wide range of different circumstances within which environmental regulators may address biodiversity in food supply chains, both regarding the different stages of the supply chain as well as sectoral and national differences. While the EWG will take into account all existing evidence on the topic matter at hand, the expected conclusions of this report will necessarily have to concentrate on a subset of such circumstances, for instance through highlighting a number of scenarios within which we may recommend optimal policy options.

The depth of engagement, both with the literature and with experts within the Delphi process, will need to be adjusted subject to time constraints of the request as a whole and of the contributing experts.

4.3. Expected recommendations

While our primary objective is to provide recommendations to the requester, the Scottish Environment Protection Agency, we hope to be able to address a number of stakeholders with this report and its expected recommendations. This includes both other regional, national and supranational environmental regulators in Europe, as well as business practitioners and scientists who work on related issues. This goal also defines our expected outputs. The Executive Summary is intended inter alia to be a practical and easily accessible resource that can be used to raise awareness on possible avenues for biodiversity-improving management options among businesses and other stakeholders alike. As regards reaching out to scientists, we anticipate the possibility of collaborating on an academic paper that may highlight both the existing evidence and continuing research gaps regarding the impacts of SMEs' business activities on biodiversity, as well as regulatory options to address these, and provide concrete recommendations where to focus future research.

Appendix II: –Quick Scoping Review Protocol

Quick Scoping Review protocol to assess regulatory tools and criteria to improve biodiversity outcomes of small and medium-sized enterprises in the food and beverage sector

The EWG aims to respond to the primary question ("How can environmental regulators support businesses to improve the outcomes of their operations for biodiversity, with a focus on small and medium-sized enterprises in the food and beverage sector in Europe?") through analyzing the following questions in turn:

38. What approaches can improve biodiversity outcomes of businesses?
39. How do we know these approaches work / are effective in improving biodiversity outcomes and over what timeframe?
40. What are the advantages and disadvantages of existing (and potential) approaches?
41. Which of the approaches identified are most promising to be used by regulators?
42. Which of these approaches work well under which conditions?

While the aim of the Quick Scoping Review is to identify written evidence that can provide insights into all sub-questions, the strategy to identify appropriate literature to include into the overview that will constitute the first output will focus on the first two questions, which have been re-specified as follows:

What approaches can be taken by environmental regulators to improve the biodiversity outcomes of small and medium enterprises in the food and drink sector of Europe?

What evidence exists of their effectiveness (ranging from uptake to process changes to associated biodiversity outcomes, and including both short-term and long-term perspectives)?

The other sub-questions will subsequently be answered by the members of the EWG by basing themselves on the identified literature and applying Qualitative Comparative Analysis and Multi-Criteria Analysis, as explained in greater detail in the Methodological Protocol.

Using the PICO (Population, Intervention, Comparator, and Outcome) model, the objective of this scoping review can be defined as follows:

Table A3 Scoping review

Questions	- What approaches can be taken by environmental regulators to improve the biodiversity outcomes of small and medium enterprises in the food and drink sector of Europe? - What evidence exists of their effectiveness (ranging from uptake to process changes to associated biodiversity outcomes, and including both short-term and long-term perspectives)?
Population The subject or unit of study	Small and medium enterprises situated along with the food and drink value chain (ranging from farmers/primary producers to retailers), with a focus on Europe

Intervention/Exposure The proposed management regime, policy or related intervention/exposure applied or investigated	Any strategy available to regulators in supporting businesses up to and beyond legal compliance, including but not limited to the use of traditional command-and-control regulation, incentive- and market-based approaches, the reduction of regulatory burdens or incentives that stand in the way of farmers' achievement of biodiversity outcomes, the support of voluntary and private standards and sourcing strategies, the utilization of public procurement as a demand driver, and the use of sector-wide engagement with other factors within the regulators' "influence map" (SEPA, 2016) such as consumer demands, industry bodies and NGO programs
Comparator The control with no intervention or an alternative to the intervention	The regulatory status quo without the intervention (as specified above) in place.
Outcome The effects of the intervention	Identified outcomes can range across the output – outcome – impact spectrum, including but not limited to the adoption/uptake of programs or standards by businesses; internal process changes or individual behaviour changes; measurable changes in sourcing, production, or consumption patterns; and (ideally and importantly) associated biodiversity impacts.

Scope and inclusion criteria

To identify and collect informative literature that is appropriate for the above methodological treatment, it is important to clearly define the scope of the scoping review as well as inclusion criteria. Literature that should be included in the scoping review will fit the following criteria:

Topical and geographic range: The scope of this review includes all and any evidence that may reasonably affect European SMEs in the food and drink sector along with their supply chains. Taking the example of biodiversity outcomes of organically certified coffee in Latin America, such evidence may be included if there is a reasonable link to Europe-based businesses (such as retailers which may stock such coffee). Ideally, the scoping review will work backwards in identifying causal evidence chains from the environmental regulator's approach (focusing on European SMEs) to possible biodiversity outcomes, as the figure A3 illustrates:

Figure A3: Proposed scoping review mechanism to identify appropriate literature

Language: The QSR should be conducted in English.

Time period: The first round of the search should be contained to publications from the years 2010 – 2018. This time period can be adjusted in collaboration between the Research Assistant and the EWG on the basis of the evidence identified.

Types of evidence: The QSR will include both academic literature, as well as grey literature (reports from private governance, working groups, public sector, NGOs..), unpublished work, and case studies and lessons learned to capture the variety of approaches used. A particular focus should be put on practice-based case studies and evaluative literature, as well as literature reviews, meta-analyses and summary reports on policy options. Purely theoretical work should not be included in this evidence review.

Inclusion criteria

On the basis of this presentation of objectives and scope, criteria for inclusion in the literature review include:

43. Some aspect of biodiversity protection, conservation or enhancement as focal goal or impact of the intervention
44. A plausible impact or applicability for European SMEs
45. A plausible impact or applicability to the food or drink value chain
46. A plausible intervention potential for regulators (viewing regulatory actions in a broad and pluralistic way as explained above)

Other types of scope conditions and inclusion criteria may be defined in due course and in collaboration with the Research Assistant.

Conceptual model

In its first meeting, the EWG created a conceptual model of the central interactions that should be the focus of the Evidence Review. This model is reproduced in Figure A4 (next page). Note that this figure is not exhaustive, but provides an overview both of the sectoral scope of the review – containing the entire food and drink value chain – and examples of the types of approaches members of the EWG expect to find in practice.

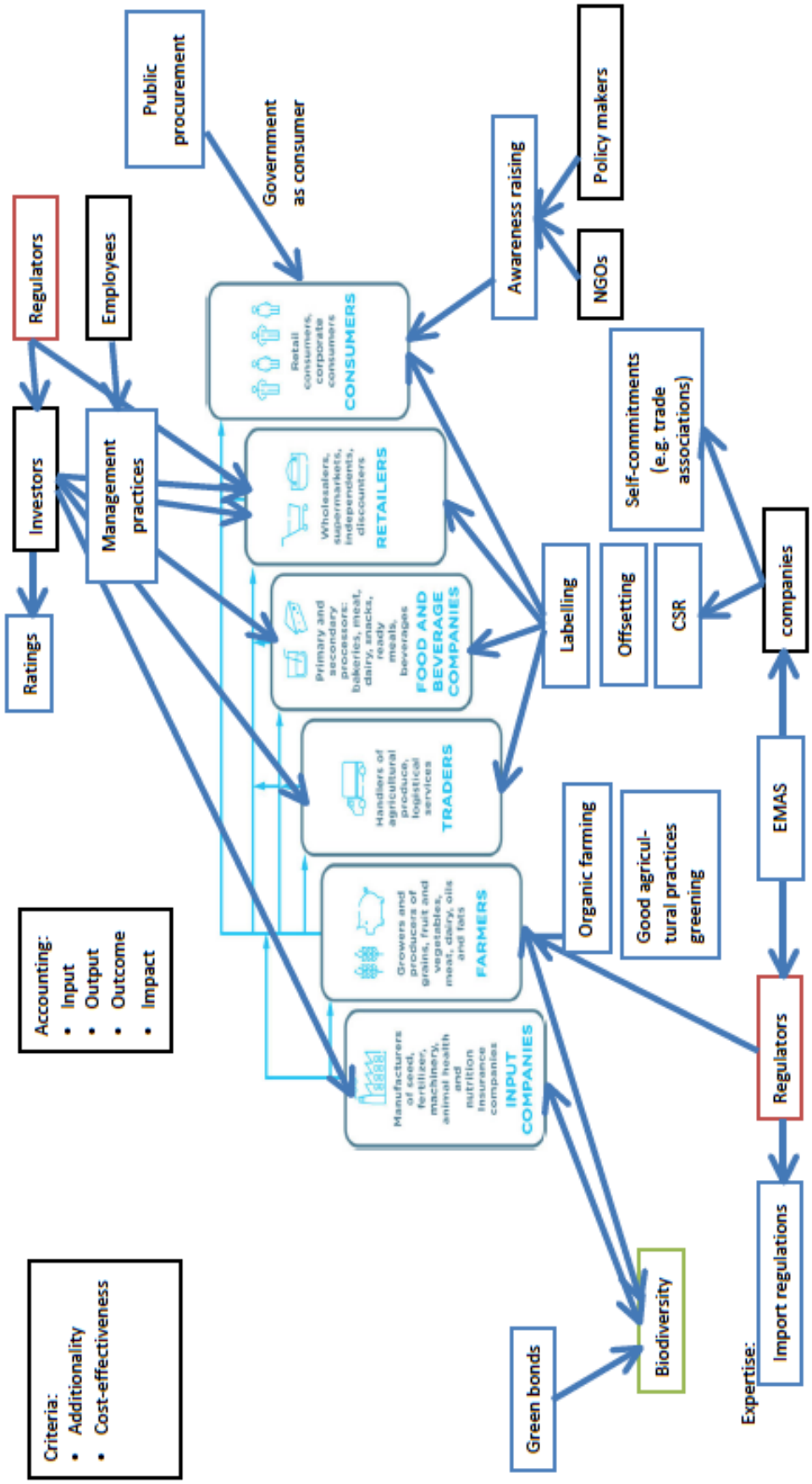


Figure A4: Mind map exercise from EWG kick-off meeting. The food and beverage supply chain. Source: Trucost. 2016. Environmentally extended input-output (EEI-O) model; Natural Capital Coalition. 2016. «Natural Capital Protocol – Food and Beverage Sector Guide ».

Timeline and broad overview

Figure A5 (this page, across) presents a broad timeline and overview of the steps envisioned during the Quick Scoping Review. These steps will be further detailed in the next sections. Outputs of the Quick Scoping Review are expected at the end of July 2018, with the possibility of extending the synthesis of the evidence into August 2018, as agreed upon by the EWG and the Research Assistant.

Precursory steps and existing literature

In preparing the call for experts and this protocol, a number of potentially relevant documents have been assembled both by the EKLIPSE team as well as the members of the EWG, who collected documents from their academic background based on their expertise from the conceptual map. All documents collected to present have all been uploaded to the Owncloud EKLIPSE server, to which the Research Assistant will receive access. Reviewing these documents will form the starting point for the classification and overview exercise of the QSP. The Research Assistant is expected to apply the inclusion criteria and appraisal methods, as outlined below, first to the existing number of documents before turning in a second step to conducting a broad literature scan to include further evidence. The methodological steps to be taken are detailed further below.

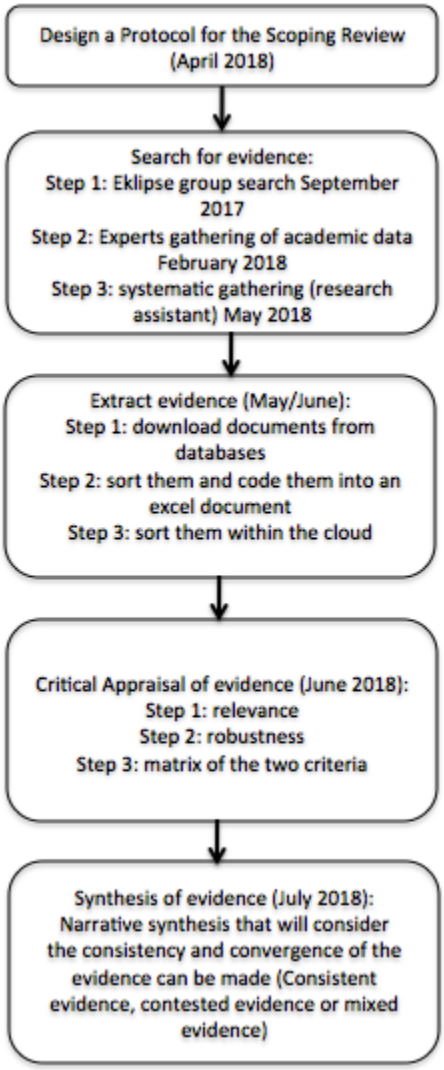


Figure A5: Timeline and overview of scoping review

Methods

The following methods shall be applied in conducting the QSP.

Search strategy

The QSP will be built on a four-step search strategy.

1.In a first step, existing literature (as explained above) is submitted to a first appraisal, using inclusion and exclusion criteria listed below, and categorized in an overview Excel document (as detailed below).

2. In a second step, key journals are identified (applying an identification strategy described below), of which the table of contents of issues published during the time scope of analysis (2010 – 2018) are reviewed. The abstracts of articles whose titles appear to match the scope of

the analysis are reviewed and the article, if relevant, downloaded, saved on the Owncloud and categorized in the overview Excel document.

3. In a third step, relevant websites will be reviewed to extract appropriate grey literature and centrally collected publications.

4. In a fourth step, a keyword search will be conducted on Google Scholar to include both academic and grey literature. Literature appearing on the first five pages (50 results) of every combination of keywords will be reviewed by title and, if seemingly relevant, by the abstract. If deemed relevant, this literature will be downloaded, saved on the Owncloud and categorized in the overview Excel document.

Identification of relevant key journals

The identification of relevant key journals is a further task of the Research Assistant. This task shall be executed as follows: Identify the ten leading journals on each of the following topics: SMEs; Conservation/conservation biology; Food; Environmental Studies/management; Business Ethics/CSR; Regulation/Policy making; Agriculture/Agroecology; Environmental/ecological economics. Further, review the articles that have been included from the existing literature in step 1 and find repetitions in their publication journal. Review these journals' aims and core foci to arrive at a list of maximum 40 journals that are most likely to include content that will meet the inclusion criteria. This list shall be submitted for review by the EWG before moving forward with the review of tables of contents and abstracts of these key journals.

Identification of relevant websites

Relevant websites for step three (such as https://www.conservationevidence.com/) will be collected based on the expertise of the members of the EWG as well as the Research Assistant. The list of relevant websites shall be submitted for review by the EWG before moving forward with their review.

Search keywords

It is recognized by the members of the EWG that the topical scope at hand is difficult to condense into a small number of keywords, given that very specific information is sought that however may cover an entire sector and outcome linkage. To conduct the fourth step of the literature review, we therefore suggest to use the below matrix of key word combinations as a starting point. When reviewing the already existing literature, one simultaneous task of the Research Assistant shall be to revisit and expand upon the below search keyword matrix, and submit the final matrix for approval by the EWG before starting the keyword search.

Table A4 Strategy for extracting information

Agri-environment*	AND	Food	AND	Business
Biodiversity				Business organization*
Conservation				Farm
Ecosystem services				Regulat*
Environment				SMEs

Literature that has been found to conform to the inclusion criteria (according to a scan of its title and abstract/executive summary) will be saved in a central folder of the Owncloud and logged in an Excel overview document that will include, at the least, the following categories/columns:

Author name(s); Title of publication; Year of publication; Journal name; Abstract (copy-paste).

If found in the abstract, the following categories should also be filled out:

Intervention type; Region; Specific SME focus? (yes/no); Outcome or impact assessment

Further useful categories for the overview document may be suggested by the Research Assistant in collaboration with the EWG. Such categories may include types of evidence, references, main research focus (topical, geographical, size, etc.), main research outcomes and insights, policy recommendations, as well as other categories as derived from the protocol and agreed upon by the EWG and RA.

This overview document will be considered **Output 1** of the Research Assistant, to be delivered at the latest by **July 31st 2018,** unless agreed upon otherwise by the EWG and RA.

Strategy for a critical assessment of the evidence

Once the scoping part of the Quick Scoping Review has concluded, the EWG, with support by the Research Assistant, will assess the relevance of the studies and robustness of the evidence collected by the scoping review. Under consideration will be:

47. The relevance of the method used with respect to the scoping review question
48. The relevance of the evidence with respect to the target subject/population
49. The relevance of the intervention assessed
50. The relevance of the outcome measured
51. The quality of methods used.

As a final outcome, the EWG, with support by the Research Assistant, will build a matrix wherein the weighting of relevance and methodological quality are combined to prove a combined weighting of the evidence (Collins et al., 2015).

Strategy for the synthesis of the evidence

The synthesis of the evidence will describe three aspects:

1) The volume and characteristics of the overall evidence base

2) What the evidence base indicates in relation to our question.

3) The implications of the findings for policy and/or practice

With support by the Research Assistant, we will write the **final output of the QSP** (providing answers on "What approaches can be taken by environmental regulators to improve the biodiversity outcomes of small and medium enterprises in the food and drink sector of Europe? And what evidence exists of their effectiveness (ranging from uptake to process changes to associated biodiversity outcomes, and including both short-term and long-term perspectives)?"), including a systematic map of evidence on the different approaches. This corresponds to the solution scanning,

“a structured, step-wise methodology to identify a long list of available actions, interventions or approaches, in response to a broad challenge” (Dicks et al. 2017). This final output will constitute our answer to Task 1 of the overall call and Document of Work. It will further be the input for the first phase of the qualitative comparative analysis. It's final, proofread and referenced version will be considered **Output 2** of the Research Assistant, to be submitted by **August 31st 2018** at the latest, unless agreed upon otherwise by the EWG and RA.

References

Collins, A., Coughlin, D., Miller, J. and Kirk, S., 2015. The production of quick scoping reviews and rapid evidence assessments: a how-to guide. NERC.

Appendix III: Quick Scoping Review implementation

Search strategy: The QSR builds on a three-step search strategy.

1. In a first step, a number of potentially relevant documents were assembled both by the EKLIPSE team as well as the members of the EWG, who collected documents from their academic background based on their expertise. This body of literature was submitted to a first appraisal, using inclusion and exclusion criteria listed above, and categorized in a QSR database.

2. In a second step, key journals were identified (applying an identification strategy described below), of which the table of contents of issues published during the time scope of analysis (2010 – 2018) are screened. The abstracts of articles whose titles appear to match the scope of the analysis were screened and the article, if relevant, downloaded, saved on the server and categorized in the overview Excel document. The identification of relevant key journals was conducted as follows: Eight broad fields with relevance to the research question were identified by the EWG: 1) SMEs; 2) Conservation/conservation biology; 3) Food; 4) Environmental Studies/management; 5) Business Ethics/CSR; 6) Regulation/Policy making; 7) Agriculture/Agroecology; and 8) Environmental/ecological economics. For each of the fields, top journals were searched in appropriate rankings, mainly SCOPUS but also through blog entries. The journals' aims and core foci were screened to arrive at a list of 80 journals that were most likely to include content in accordance with the inclusion criteria. The resulting list of top 10 journals per field was subjected to review by the EWG. Out of these 80 journals, 40 (5 per field) were pre-selected by the EWG and 20 were used for the QSR based on preliminary results and according to adaptations during the QSR process such that both most promising and relevant journals were included with a broad range of perspectives and a focus on policy interventions. For each of these journals keyword searches were conducted to arrive at a pre-selection of potentially relevant articles that were screened and processed further. Appendix 1 gives an overview of the top 20 journals included in the QSR, the quantity of screened article titles, abstracts and selected and downloaded articles.

3. In a third step, a keyword search was conducted on Web of Science to balance and complement the literature identified through the key journals (as specified below). Titles of articles were then screened, and the most promising abstracts were screened in a second round. Following that search, the additional relevant literature was downloaded, saved on the server, and categorized in the QSR database. That second search process added 182 papers to the first round of literature search.

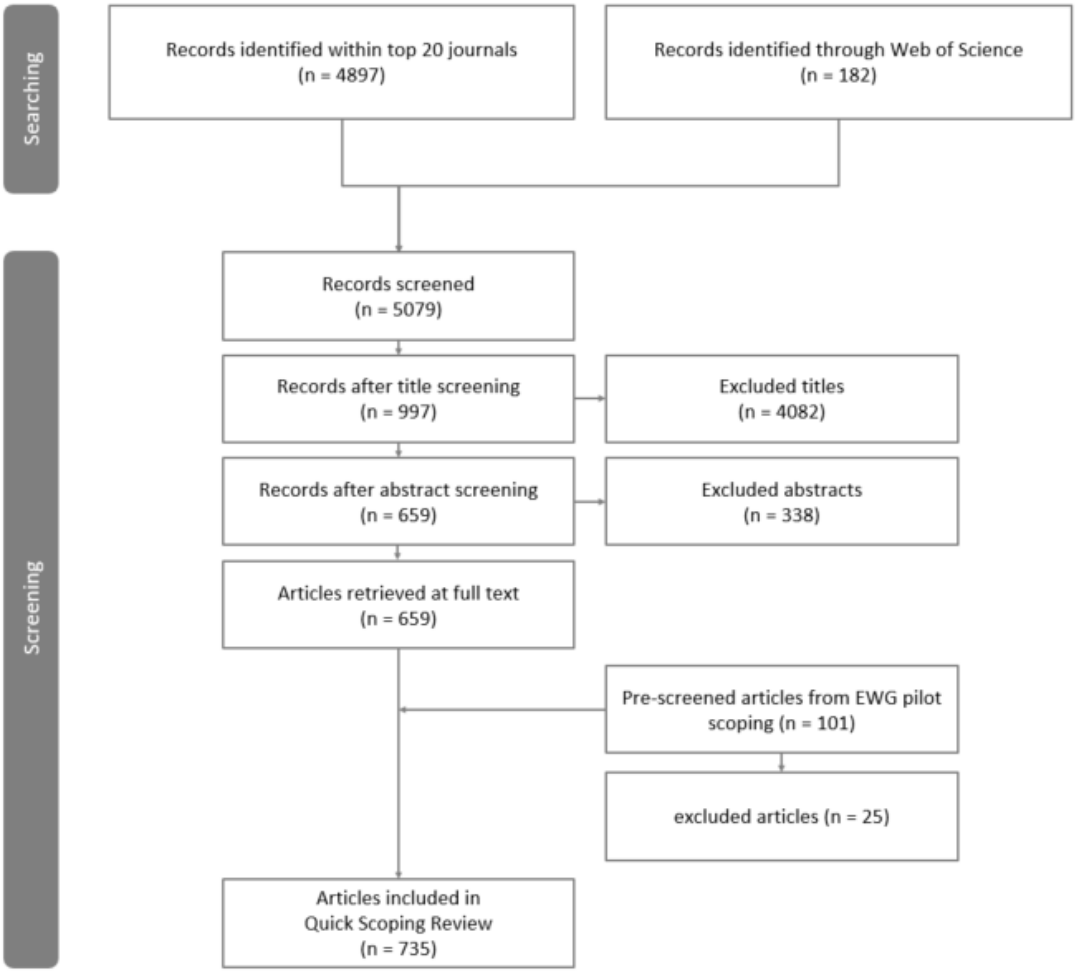


Figure A6: Systematic map flow diagram of information processed for the Quick Scoping Protocol, based on and adapted from the ROSES standard (Haddaway et al., 2017).

Table A5: Top 20 journals as sources for the Quick Scoping Review. Links to the searches have been stored

Journal:	search terms (wild cards not always permitted)	years	screened titles	screened abstracts	selected	date accessed
Small Business Economics	biodivers* food	2010-2018	3	3	3	06.07.18
Conservation Letters	biodivers* food	2010-2018	233	26	20	06.07.18
Food Policy	biodiversity	2010-2018	92	14	4	09.07.18

Annual Review of Environment and Resources	biodivers* food	2010-2018	85	11	8	09.07.18
Journal of Cleaner Production	biodiversity food	2010-2018	730	58	22	10.07.18
Global Environmental Change	biodiversity food	2010-2018	281	30	11	10.07.18
Agriculture, Ecosystems and Environment	biodiversity food	2010-2018	670	275	244	13.07.18
Journal of Environmental Economics and Management	biodiversity food	2010-2018	20	5	1	18.07.18
Local Economy	biodivers* food	2010-2018	13	3	2	19.07.18
International Journal of Biodiversity Science, Ecosystem Services and Management	biodivers* food	2010-2018	180	35	25	19.07.18
Global Food Security	biodiversity food	2010-2018	58	11	9	19.07.18
Current Opinion in Environmental Sustainability	biodiversity food	2010-2018	275	35	18	19.07.18
Ecology & Society	agricultur* biodivers* food	2010-2018	556	79	39	23.07.18
Land Use Policy	biodiversity food	2010-2018	780	154	70	24.07.18
Agroecology and Sustainable Food Systems	biodivers* food	2010-2018	210	32	15	25.07.18
Ecological Economics	biodiversity food	2010-2018	519	44	23	26.07.18
Journal of Business Ethics	biodivers* food	2010-2018	77	29	14	30.07.18
Journal of Small Business Management	biodivers* food	2010-2018	1	1	1	30.07.18
Environmental Policy and Governance	biodivers* food	2010-2018	58	33	24	30.07.18
Sustainability	biodivers* AND food	2010-2018	56	25	24	30.07.18

Table A6: Entries from the Web of Science searches

Keywords	years	screened titles	screened abstracts	selected	date accessed
biodivers* AND food AND retail*	2010-2018	25	10	10	01.08.18
biodivers* AND food AND instrument	2010-2018	73	27	20	01.08.18
biodivers* AND food AND chain AND europe*	2010-2018	47	19	15	01.08.18
biodivers* AND food AND trade* AND europe*	2010-2018	74	38	37	02.08.18

Figure A7 gives an overview of the count of articles per year of publication of documents in the QSR database. It shows that a few pre-2010 articles have been included in the QSR, originating from the pre-selection of articles by the EWG. The main body of articles has, according to the inclusion criteria, been published between 2010 and 2018, with an increase over time except for 2018, which is only half way through yet.

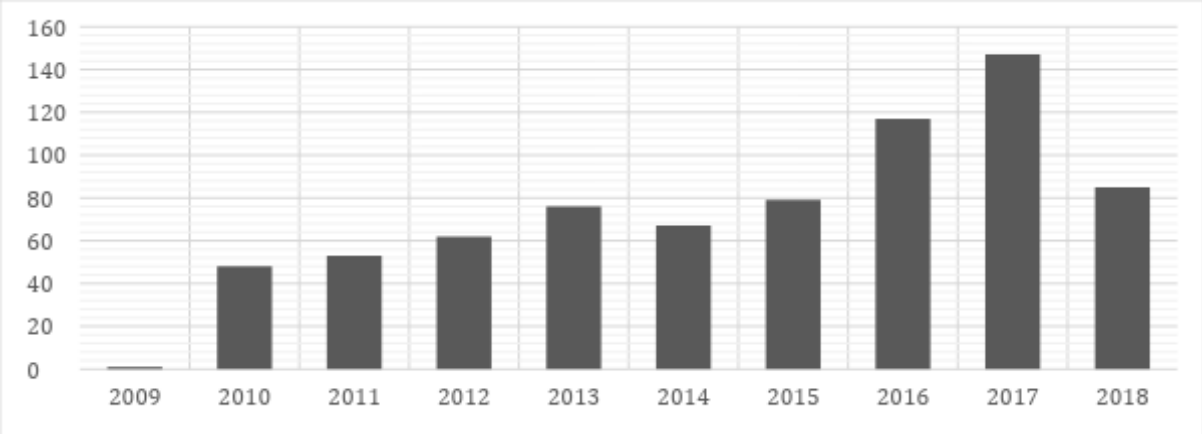


Figure A7: Article count per year of publication within QSR database

Figure A8 gives an overview of article counts per study region, aggregated to the country level. It shows that the majority (n=428) of articles address one or more European countries (defined geographically), about a seventh part of the articles (n=98) address other regions or countries or have global scope (n=104). 123 articles provided no information on the study region.

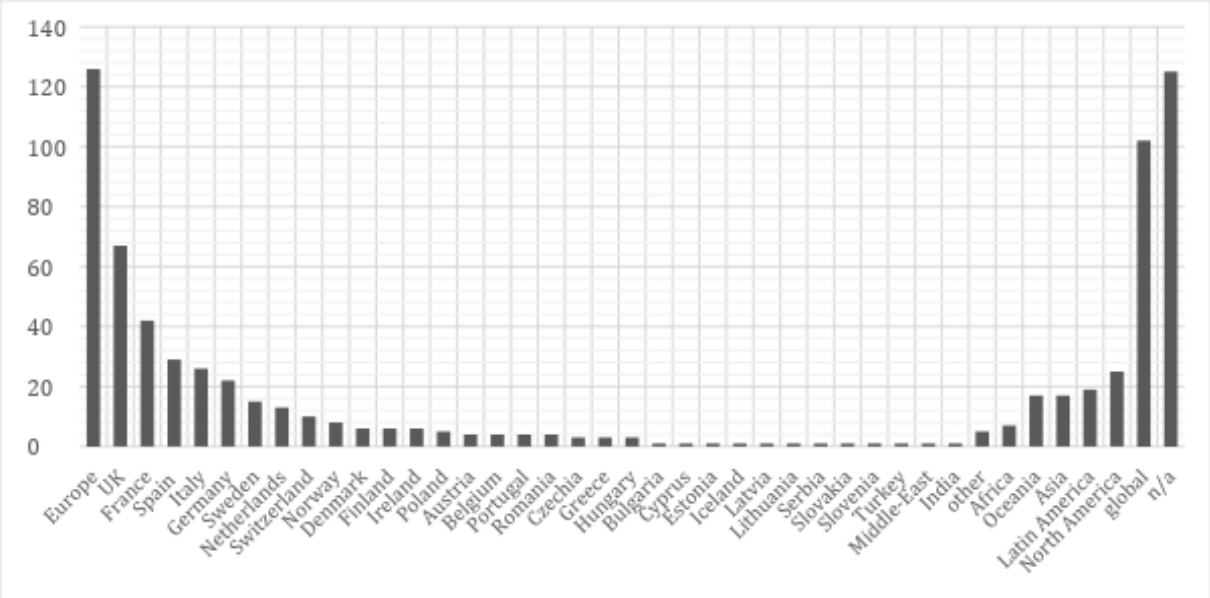


Figure A8: Count of articles per study region

If only the study only covers one European country, this has been categorized accordingly. If a study covers more than one or (a subset of) all European countries, this has been categorized as "Europe". If a non-European country has been addressed, this is categorized with the corresponding continent. If it is a global assessment, this has been labelled accordingly. "other" indicates multiple or badly defined sites. "n/a" indicates no information of the study region was indicated in the abstract.

Figure A9 provides an overview of sectors addressed by the studies within the QSR database. It shows that a great majority of articles assesses biodiversity impacts of agricultural production (n=506). Some address various sectors (n=94), a little less address public bodies such as planning or conservation agencies (n=75), and n=32 address consumer behaviour. "Science" deals with new applications or frameworks for assessments from a scientific perspective (n=15), and very little evidence is provided for either input (n=13), retail (n=8), processing (n=2) or trade companies (n=1) in the food-beverage value chain. Fisheries impact on biodiversity is also a little present in the QSR database (n=7).

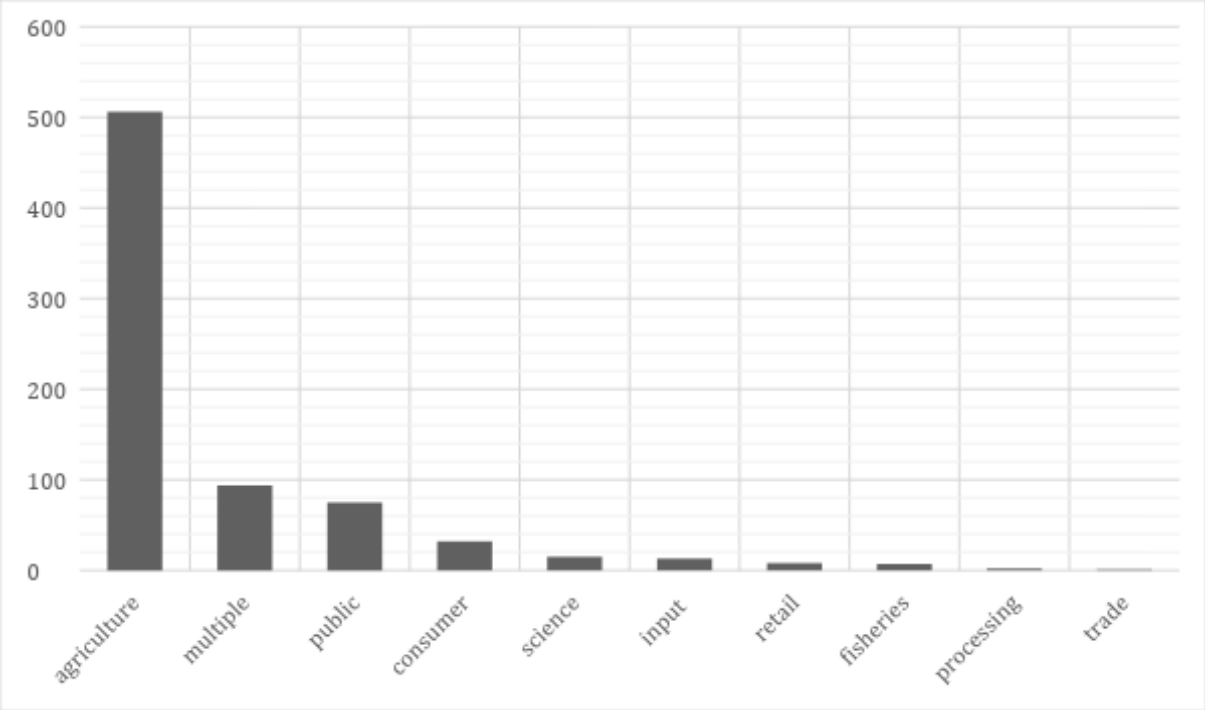


Figure A9: Article count per sector addressed

Appendix IV: Expert Survey Questionnaire and Results

1. In your opinion, which are the most important actors that should be targeted by policy tools to enhance the biodiversity outcomes of the food and beverage sector? For each actor, please select an answer ranging from very important to not important at all.

1 – most important; 4 – least important

Farmers
Consumers
Investors/financial institutions
Retailers
Processors/manufacturers

1. Among experts, there is disagreement whether biodiversity policies and their success metrics should be focused on outcomes (e.g., species prevalence) or processes (e.g. specific conservation actions). In your opinion, which approach is more promising to lead to enhanced biodiversity outcomes of the food and beverage sector?

Generally, outcome-based measures are more promising.
Generally, process-based measures are more promising.
Both are equally promising.

2. In your opinion, how appropriate are the following outcome targets and assessment criteria of policy tools that enhance biodiversity outcomes of the food and beverage sector? For each option, please select an answer ranging from very appropriate to not appropriate at all.

1 – very appropriate; 4 – not appropriate at all

Holistic ecosystem preservation
A combination of biodiversity protection actions
Species prevalence
Procedural changes (e.g. introduction of environmental management systems)
Single actions for biodiversity protection (e.g. removal of pesticides, flowering)

3. In your opinion, how appropriate are the following scales for policy tools that enhance biodiversity outcomes of the food and beverage sector? For each option, please select an answer ranging from very appropriate to not appropriate at all.

1 – very appropriate; 4 – not appropriate at all

An integration of all these scales
A group of organizations (e.g. cooperatives, all retailers in Brittany)
All organizations in a landscape (e.g. all food sector organizations in Brittany)
A single organization (a single farm or retailer)

4. Regulators may use a range of different policy tools to help small and medium-sized enterprises in the food and beverage sector in Europe achieve positive outcomes on biodiversity. In your opinion, how effective are the following policy mechanisms for helping businesses to achieve biodiversity outcomes? Note that for all mechanisms you deem "very effective", you will be able to assess more specific tools in the next question.

Economic instruments
Direct regulation
Capacity building
Governmental planning for land use and development
Co-regulation and policy mixes
Information-based instruments
Self-regulation

5. Within the following policy mechanisms, which you deemed to be very effective, which tools would be more effective for a regulator to achieve positive outcomes on biodiversity (with a specific focus on small and medium-sized enterprises in the food and beverage sector in Europe)?

Direct regulation

Protected areas
Land use restrictions
Input use restrictions

Import restrictions

Governmental planning for land use and development

Land sharing plans/zoning
Land sparing plans/zoning
Ecological Focus Areas

Economic instruments

Taxes
Payments for Ecosystem Services
Subsidies
Agri-environmental schemes
Biodiversity offsets
Establishment of markets/cap-and-trade
Set-aside schemes

Information-based instruments

Monitoring programs
Consumer guides targeting for instance dietary habits
Eco-labeling/certification
Environmental management systems
Biodiversity accounting

Self-regulation

Industry associations
Multi-stakeholder partnerships
Industry-led standard-setting

Internal voluntary biodiversity protection policies (within organizations)
New business models (e.g. local supply chains)
Research, development and innovation

Capacity building

Supply chain management trainings
Training on biodiversity management
Community learning

Refer back to the policy mechanisms/tools you chose as being 'very effective' in question 5/6. For each mechanism, please select the 5 conditions you deem most important for the selected mechanisms/tools to work effectively, or suggest other conditions that would be important for policy effectiveness in your opinion.

Direct regulation

Adaptation to regional/local context
Flexibility and adaptability to current (farming) practices
System-oriented, taking the whole ecosystem into account
Adopting a participatory governance approach
Implementation in combination with other policy tools
Better support in understanding environmental legislation or policy tool
Support from wider actors and systems external to the main target of the policy tool
Producer trainings and skill development
Brand to protect
Associated price premiums (e.g. on certified goods)
High payment/compensation rate (that covers indirect and opportunity costs)

Performance indicators are action-based (e.g. hedgerow planting)
Performance indicators are result-based (e.g. species diversity)
Use of multiple indicators to assess results
Government supervision of voluntary schemes or policy tool

Governmental planning for land use and development

Adaptation to regional/local context
Flexibility and adaptability to current (farming) practices
System-oriented, taking the whole ecosystem into account
Adopting a participatory governance approach
Implementation in combination with other policy tools
Better support in understanding environmental legislation or policy tool
Support from wider actors and systems external to the main target of the policy tool
Producer trainings and skill development
Brand to protect
Associated price premiums (e.g. on certified goods)
High payment/compensation rate (that covers indirect and opportunity costs)
Performance indicators are action-based (e.g. hedgerow planting)
Performance indicators are result-based (e.g. species diversity)
Use of multiple indicators to assess results
Government supervision of voluntary schemes or policy tool

Economic instruments

Adaptation to regional/local context
Flexibility and adaptability to current (farming) practices

System-oriented, taking the whole ecosystem into account
Adopting a participatory governance approach
Implementation in combination with other policy tools
Better support in understanding environmental legislation or policy tool
Support from wider actors and systems external to the main target of the policy tool
Producer trainings and skill development
Brand to protect
Associated price premiums (e.g. on certified goods)
High payment/compensation rate (that covers indirect and opportunity costs)
Performance indicators are action-based (e.g. hedgerow planting)
Performance indicators are result-based (e.g. species diversity)
Use of multiple indicators to assess results
Government supervision of voluntary schemes or policy tool

Information-based instruments

Adaptation to regional/local context
Flexibility and adaptability to current (farming) practices
System-oriented, taking the whole ecosystem into account
Adopting a participatory governance approach
Implementation in combination with other policy tools
Better support in understanding environmental legislation or policy tool
Support from wider actors and systems external to the main target of the policy tool
Producer trainings and skill development
Brand to protect

Associated price premiums (e.g. on certified goods)
High payment/compensation rate (that covers indirect and opportunity costs)
Performance indicators are action-based (e.g. hedgerow planting)
Performance indicators are result-based (e.g. species diversity)
Use of multiple indicators to assess results
Government supervision of voluntary schemes or policy tool

Self-regulation

Adaptation to regional/local context
Flexibility and adaptability to current (farming) practices
System-oriented, taking the whole ecosystem into account
Adopting a participatory governance approach
Implementation in combination with other policy tools
Better support in understanding environmental legislation or policy tool
Support from wider actors and systems external to the main target of the policy tool
Producer trainings and skill development
Brand to protect
Associated price premiums (e.g. on certified goods)
High payment/compensation rate (that covers indirect and opportunity costs)
Performance indicators are action-based (e.g. hedgerow planting)
Performance indicators are result-based (e.g. species diversity)
Use of multiple indicators to assess results
Government supervision of voluntary schemes or policy tool

Capacity building

Adaptation to regional/local context
Flexibility and adaptability to current (farming) practices
System-oriented, taking the whole ecosystem into account
Adopting a participatory governance approach
Implementation in combination with other policy tools
Better support in understanding environmental legislation or policy tool
Support from wider actors and systems external to the main target of the policy tool
Producer trainings and skill development
Brand to protect
Associated price premiums (e.g. on certified goods)
High payment/compensation rate (that covers indirect and opportunity costs)
Performance indicators are action-based (e.g. hedgerow planting)
Performance indicators are result-based (e.g. species diversity)
Use of multiple indicators to assess results
Government supervision of voluntary schemes or policy tool

Co-regulation and policy mixes

Adaptation to regional/local context
Flexibility and adaptability to current (farming) practices
System-oriented, taking the whole ecosystem into account
Adopting a participatory governance approach
Implementation in combination with other policy tools
Better support in understanding environmental legislation or policy tool

Support from wider actors and systems external to the main target of the policy tool
Producer trainings and skill development
Brand to protect
Associated price premiums (e.g. on certified goods)
High payment/compensation rate (that covers indirect and opportunity costs)
Performance indicators are action-based (e.g. hedgerow planting)
Performance indicators are result-based (e.g. species diversity)
Use of multiple indicators to assess results
Government supervision of voluntary schemes or policy tool

Expert survey results

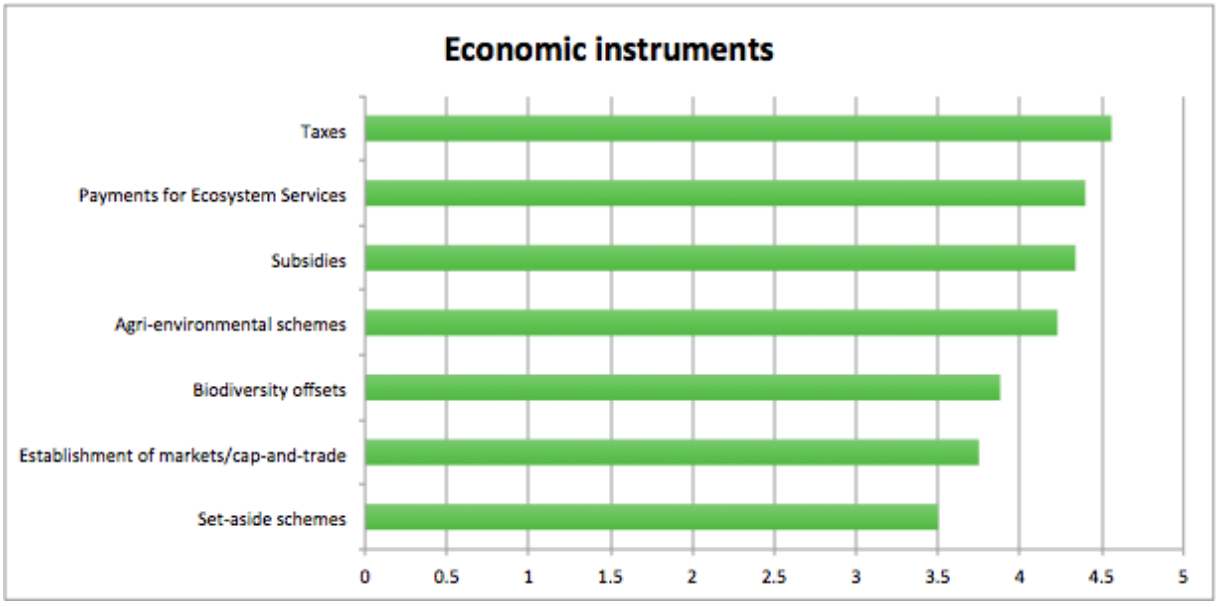


Figure A10: Ranking of economic instruments, 5 = most effective; 1 = least effective

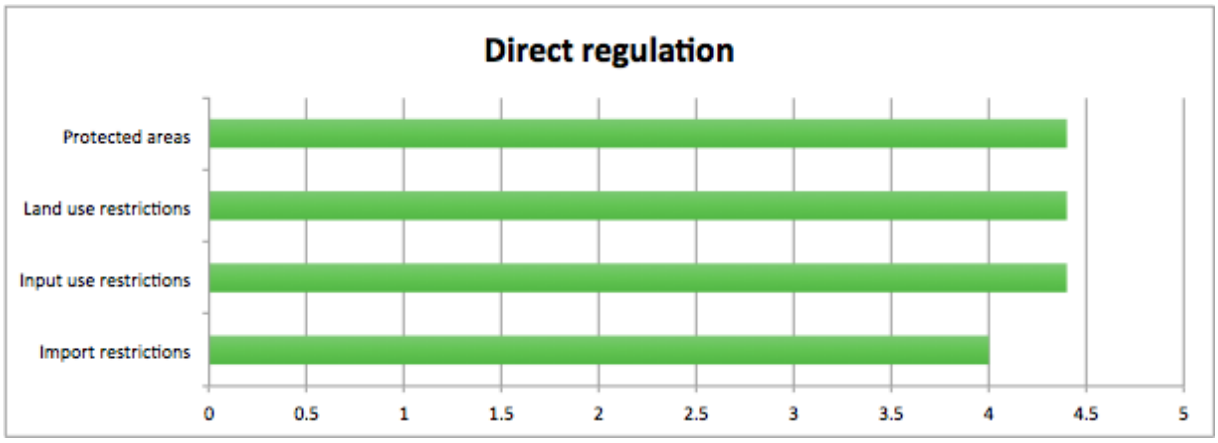


Figure A11: Ranking of direct regulatory instruments, 5 = most effective; 1 = least effective

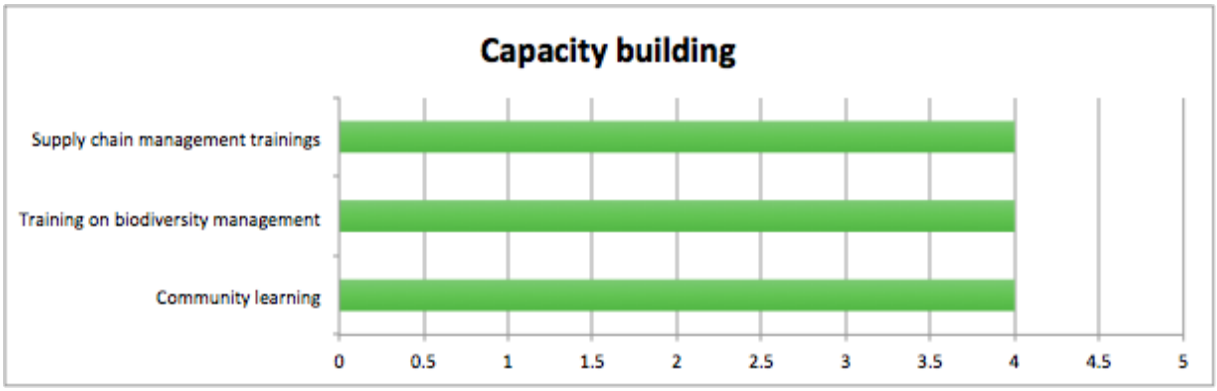


Figure A12: Ranking of capacity-building instruments, 5 = most effective; 1 = least effective

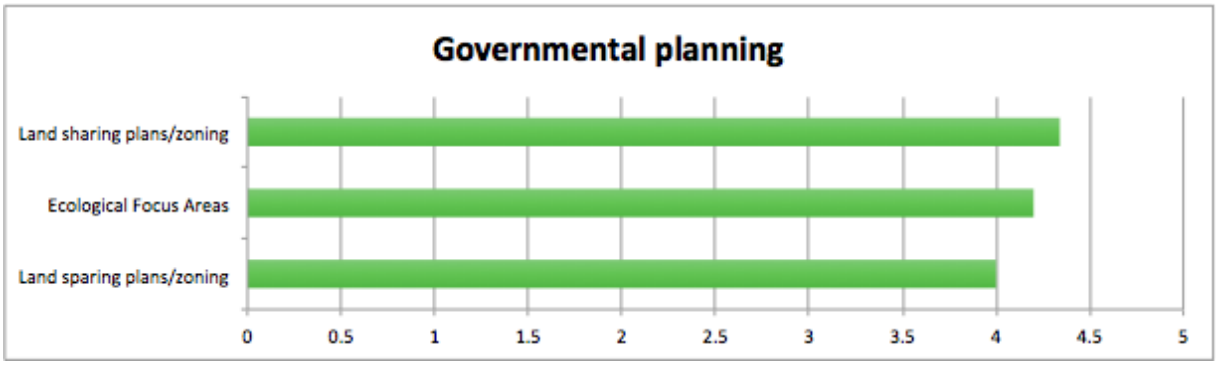


Figure A13: Ranking of governmental land use planning instruments, 5 = most effective; 1 = least effective

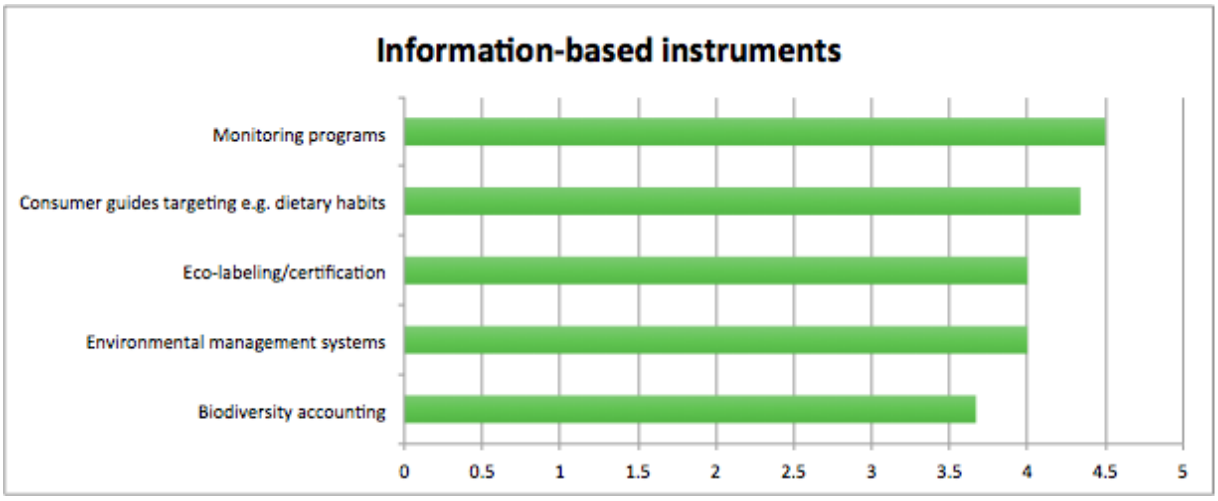


Figure A14: Ranking of information-based instruments, 5 = most effective; 1 = least effective

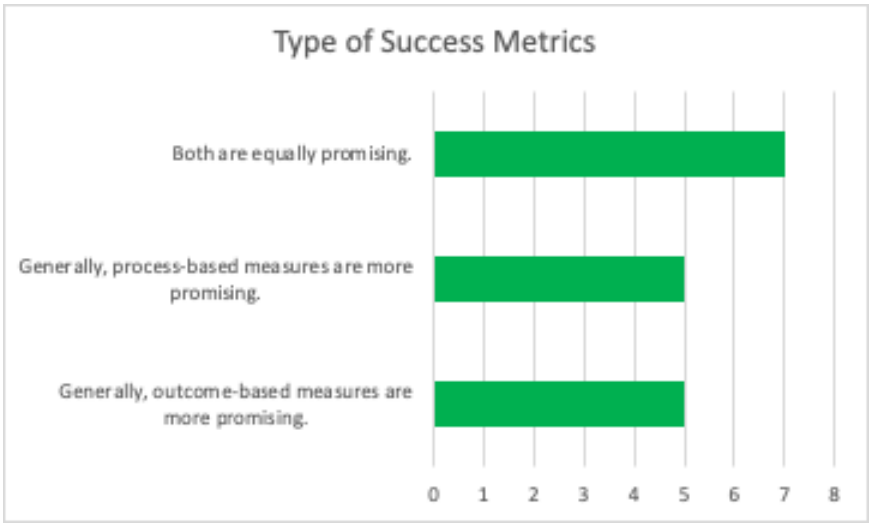


Figure A15: Type of success metrics for biodiversity enhancement policies

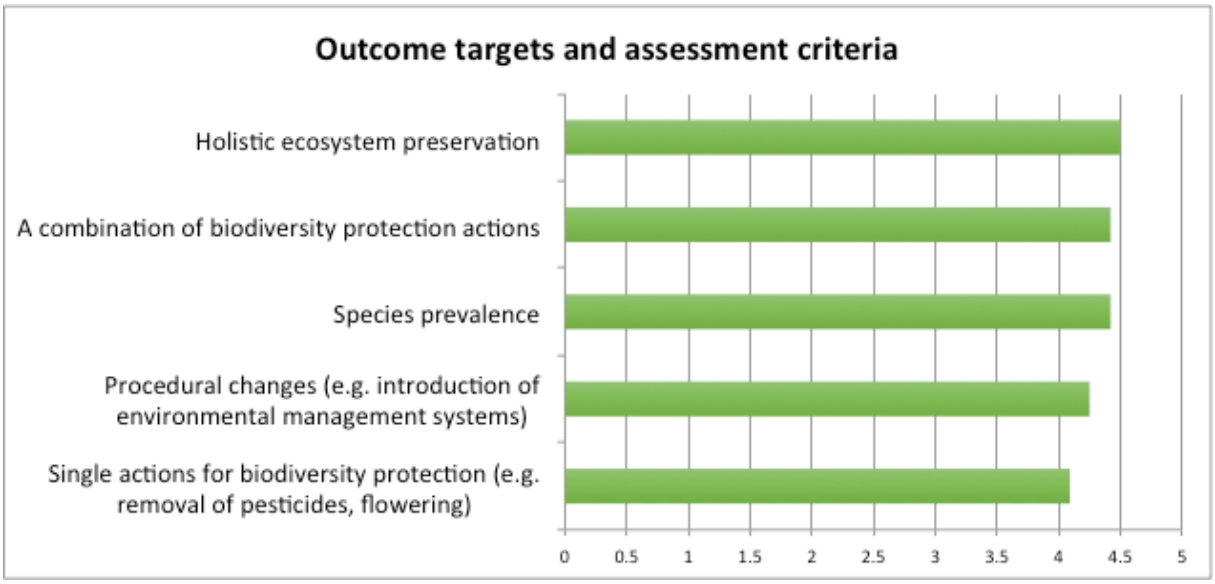


Figure A16: Outcomes targets and assessment criteria of biodiversity enhancing policies; 5 = very appropriate, 1 = not appropriate at all

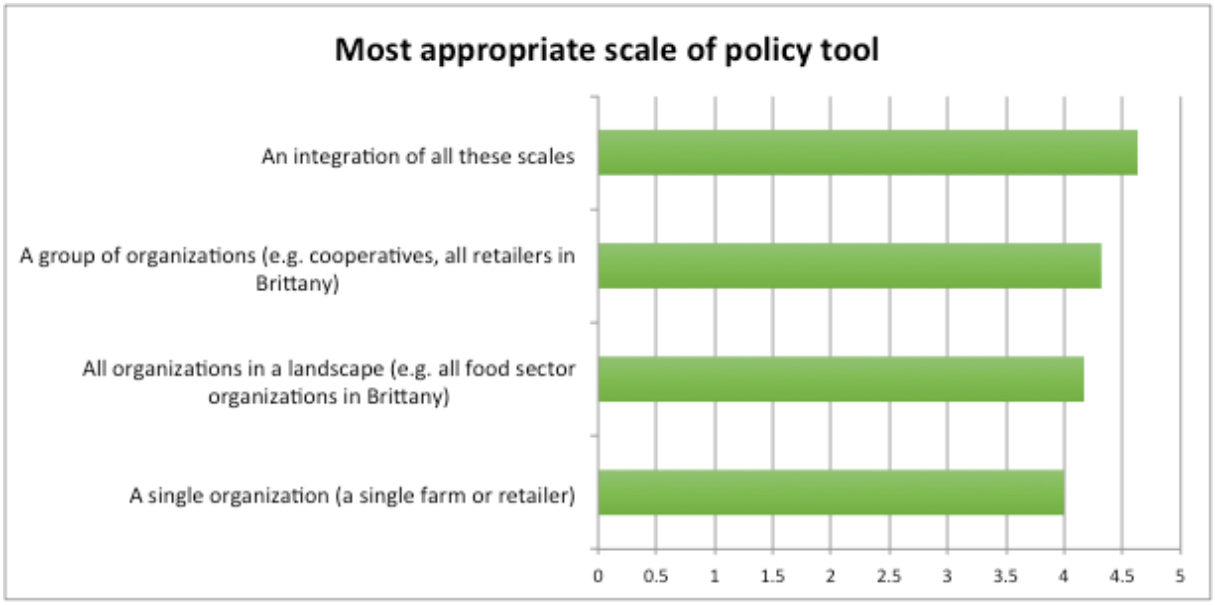


Figure A17: Appropriate scale of application of policy tool; 5 = very appropriate, 1 = not appropriate at all

Appendix V: Additional QCA results

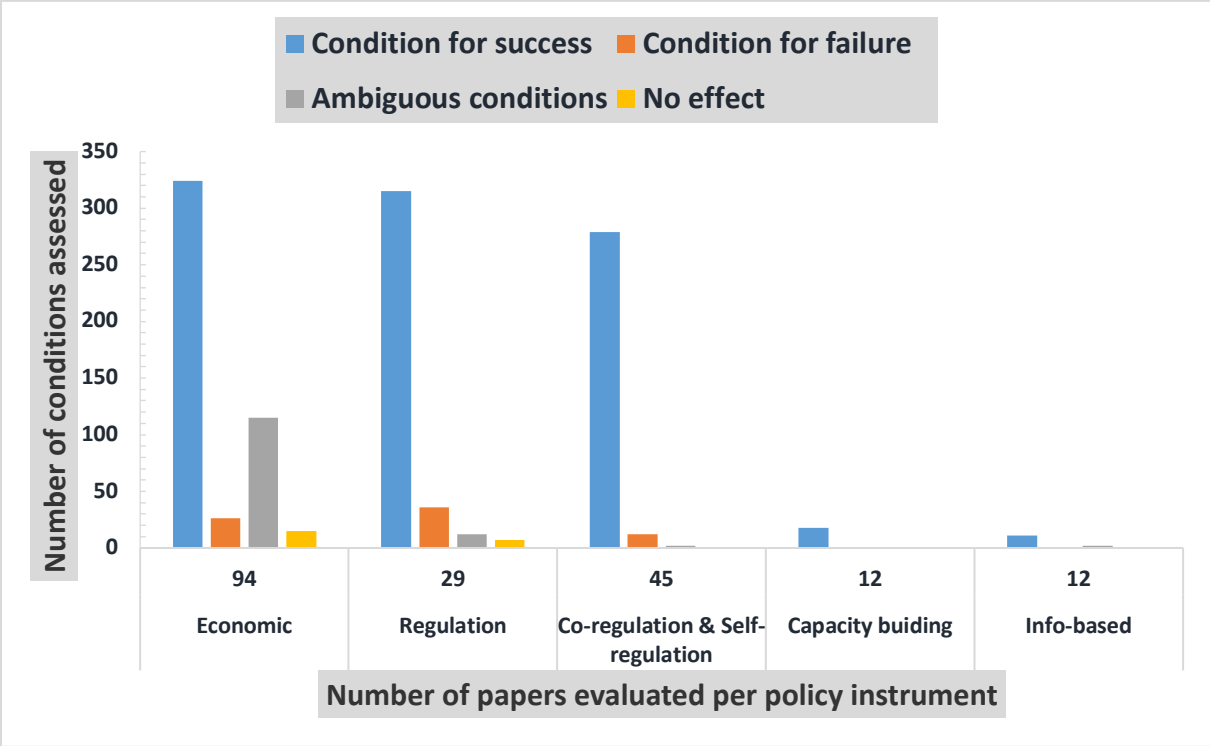


Figure A18: Number and rating of conditions in all published papers evaluated (n=192), by policy instrument

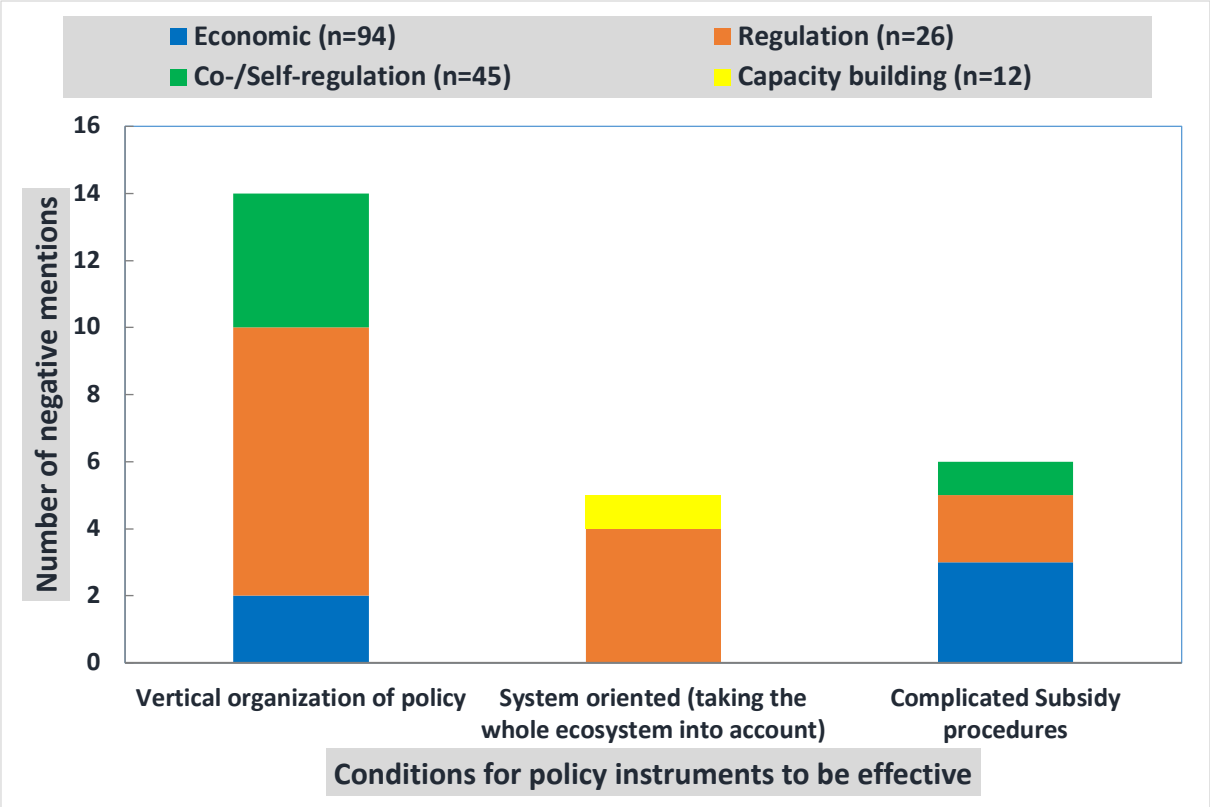
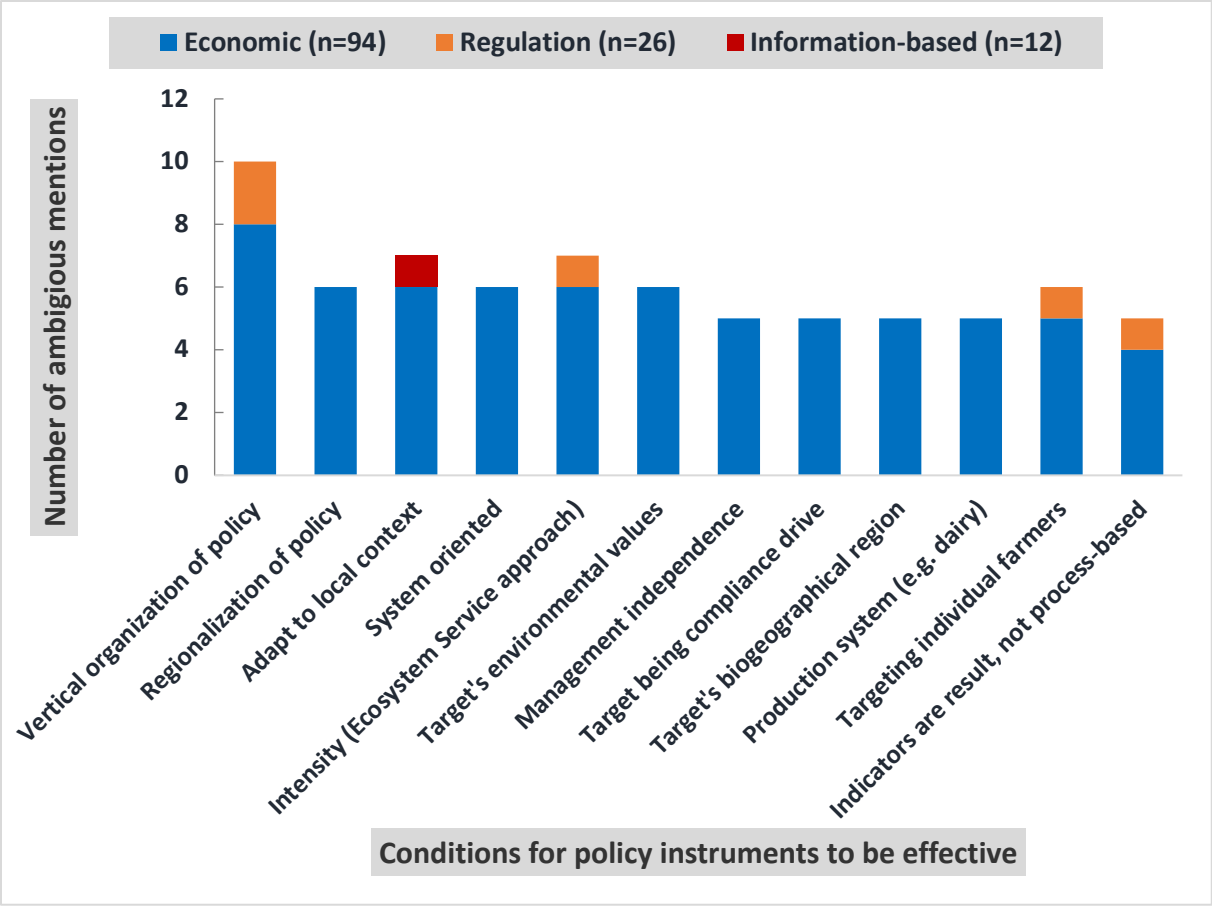


Figure A19: Most frequent negatively evaluated conditions in all published papers (n=192), by policy instrument

A few papers assessed provided evidence that a specific condition had a 'null effect' on the policy's success; that is, that the condition did not matter for its success. Studies on economic instruments showed more ambivalence than those of other instruments on weather conditions such as a target being compliance-driven, targeting individual farmers, the targets environmental values, their biogeographical regions or management independence, could lead to success or failure in policy tools (Figure A20).

Figure A20: Most frequent evaluated ambiguous conditions in all published papers (n=192), by policy instrument


Economic (n=94)
Regulation (n=26)
Information-based (n=12)
Number of ambigious mentions
12
10
8
6
4
2
0
Vertical organization of policy
Regionalization of policy
Adapt to local context
System oriented
Intensity (Ecosystem Service approach)
Target's environmental values
Management independence
Target being compliance drive
Target's biogeographical region
Production system (e.g. dairy)
Targeting individual farmers
Indicators are result, not process-based
Conditions for policy instruments to be effective

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Knowledge & Learning Mechanism
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