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Farmers' consideration of soil ecosystem services in agricultural management - a case study from Saxony, Germany

Abstract

The ecosystem services (ES) concept has been increasingly considered in science and policy making. However, its consideration in agricultural management by farmers has not yet been fully investigated. This paper presents a theoretical framework based on available literature on how the concept of ES is likely established in agricultural practices and policies. We refine this framework based on a case study from Saxony, Germany. First, semi-qualitative interviews with farmers were conducted and a qualitative content analysis with a combination of a deductive and inductive category system executed. The results show that knowledge about the concept of ES is inherent in agriculture and that farmers implement various ES in agricultural management decisions even though their terminology may differ from ES definitions in research. Second, the paper evaluates existing agricultural policy instruments within the case study region related to their potential to enhance the provision of ES by asking which governance instruments are familiar with and would be accepted by the farmers for incorporating ES more prominently as a criterion in their management decisions. The paper concludes with an enriched conceptual framework about ES in farmers' decision making and on policy recommendations.

1. Introduction

Soils provide a wide range of ecosystem services (ES) (Adhikari & Hartemink, 2016), which are essential to nourish a growing world population and to provide regenerative resources for bio-based circular economies. The provision of soil ES depends on complex biological, physical and chemical soil properties and their interaction with crops and management techniques (Helming & Tabeau, 2018; Adhikari & Hartemink, 2016; Cowie et al., 2011). This means, also farmers' actions matter. For example, introduction of management practices, such as green manure, crop rotation, no-till or direct seeding, was shown to increase the quality and quantity of soil organic matter (Barrios, 2007), whereas contrarily agricultural intensification was found to be a key driver of soil degradation (Turpin et al., 2017).

Despite first insights on spatio-temporal trade-offs between ES resulting due to missing awareness in ES management (Bennett et al., 2009), we still cannot find an established body of literature on how farmers perceive ES and consider them in their land management practices. So far, only some notable studies – mostly applying empirical methods – were made to better understand farmers´ behaviour and decision making. Lamarque et al. (2011), for example, analyzed farmers' perception and values related to ES in the Central French Alps with the focus on mountain grasslands management with a quantitative and qualitative survey. Lewan & Söderqvist (2002) analyzed how people recognize different ES by conducting qualitative and quantitative interviews with farmers, which were located in a river drainage in Southern Sweden. Switek & Sawinska (2016), Schulz et al. (2014) and van Herzele et al. (2013) conducted a quantitative survey for analyzing farmers' opinion to greening and how it influenced agricultural management practices. Sattler & Nagel (2010) identified factors that are influencing farmers' acceptance of conservation measures. Bartkowski & Bartke (2018) provide a review of empirical studies investigating determinants of farmer´s decision making in the European context.

Our research interest is to better understand how farmers consider ES in their soil management. We extend a literature based conceptual framework by investigating the farmers' sources of knowledge about ES and the influence of existing policy instruments on farmers' decisions to implement soil conservation measures and the assessment of these policy instruments. The results shall enrich our conceptual framework and help to conclude on policy and research recommendations.

These questions could be addressed in a general theoretical or in a more contextualized approach. We take the latter approach and focus our investigation on the situation in Saxony, Eastern Germany. This case study offers an illustrative object of analysis. Saxony is known for critical impacts of industrial, intensive agriculture on societally required ES, such as flood protection and drinking water provision, but also for innovative ecological farming concepts.

Hence, here we find in a nutshell conflicts – as they are also prevailing in other parts of the world – regarding interests in sustainable soil management and requirements to utilize highest and best use potentials of land that form threats to soil functionality, e.g. through industrial agriculture pushed by a fundamental shift from fossil- to bio-based resources, which requires an intensification of agricultural production. This is unsustainable if the capacities of soils to provide a sustainable provision of all ES are not understood and considered thoroughly (BMBF, 2014). Although it has been increasingly recognized at the political level that sustainable conservation of soils requires greater attention in agricultural management (BMEL, 2015a), only few agricultural policy instruments support the protection of soil ES and the coherence between different land regulating policies in Europe and Germany is still vague (Schleyer et al., 2015; Glaesner et al., 2014) – with Saxony being no exemption.

Starting from a theoretical framework of how farmers consider ES, the paper studies farmers' knowledge and experience in actually considering soil ES in their daily work. Semi-structured in-depth qualitative interviews were conducted to learn in particular about: Which ES are important from the farmers' perspective? What is their source of knowledge about the concept of ES? And: Which governance instruments are accepted or seen as effective for considering soil ES in management decisions?

Our analysis shows 1) that ES are inherently known and applied by farmers, but their relevance to the implementation through adapted management is judged differently compared to societal goals. 2) that there is a need to balance funding for nature conservation with funding for other ES to prevent farmers from losing their role as key providers of food and fodder. Farmers require clear standards for which indicators and monitoring schemes are implemented so that farmers have an explicit understanding of criteria they are assessed by. 3) that sharing of experience and exchange of knowledge among farmers should clearly be more readily supported by funding sources, as well as governmental and non-governmental institutions in order to better connect management practices with their impact on specific ecosystem services.

The following of this paper is structured as follows: Section 2 introduces the theoretical framework for our analysis based on a literature review. The case study and interview methodology applied for the analysis are presented in Section 3, followed by presentation of the results in Section 4. Section 5 discusses the findings of the analysis towards a refined and enriched conceptual framework. Section 6 concludes on key lessons learned, provides policy recommendations and outline future research areas.

2. Theoretical Framework, assumptions and conceptual framework

Selection of soil ecosystem services

There is a large literature on soil ES that introduce in various existing concept of ecosystem services (Dominati, 2013; Potschin & Haines-Young, 2011, Adhikari & Hartemink; 2016; Breure et al., 2012; Haines-Young & Potschin, 2013; Calzolari et al., 2016; Fischer & Eastwood, 2016). The major concepts of ecosystem services in the literature are the Millennium Ecosystem Assessment (MEA) (2005), the Common International Classification of Ecosystem Services (CICES) (2016) and the study Economics of Ecosystems and Biodiversity (TEEB) (2010). We used this literature and focused on the concept MEA and CICES, because they are general known and the actual concept of ecosystem services, and classified soil ES into *Provisioning ES*, *Regulating ES* and *Cultural ES* (see figure in Annex A). The focus is on key ES in agricultural farming systems supported or endangered through soil functionality: *food, biomass as renewable energy, buffering and mediation of nutrient release, water purification, water regulation, erosion control and climate regulation*. We choose these ES because they are the most relevant for agriculture in the case study region to maintain soil functions and ensure food production. Cultural ES were not considered, because they are less related to the functioning of soils. In the literature, it is often argued that the concept of ES is well known by scientists but not by practitioners (Koschke et al., 2014), such as farmers (Dominati et al., 2010).

Sources of knowledge of farmers

The identification of knowledge sources of farmers is a key point in understanding why farmers choose a given management practice. This could be helpful for amending existing and for the implementation of new policy instruments, which might support alternative agricultural management practices. Some authors argue that the concept of ES is not perceived by practitioners such as farmers (Dominati et al., 2010; Koschke et al., 2014). Literature on sources of knowledge of farmers is scarce, but, for instance, Schüler (2016) found that farmers heard about the concept of ES in exchanges with extension officers and other specialists. Some studies show that farmers consider the input of nutrients in groundwater through the use of fertilizer (Tilman et al., 2002). The choice of tillage methods and suitable crops is often based on grey literature such as farmer's journals or practical training through sectorial research institutions (Ritter et al., 2017).

Relevance and consideration of soil ecosystem services in the farming system

Schüler (2016) states that provisioning ES are seen as the most important ES for farmers because they secure income. The selection of ES in his study was based on a few explorative talks with farmer associations and supported our assumption that the farmers to be interviewed would likely have no specific preferences to address further ES in their management.

We intended to consider the various agricultural management practices that influence soil functions and ES. **Soil tillage practices** such as ploughing can disturb the functions of soil fauna and have negative impacts on the provision of ES (Zhang et al., 2007). Minimal tillage so-called mulching, no-till seeding and direct seeding alleviate soil erosion and thus can increase crop yields (Bennett et al., 2009). Farmers mostly use minimal tillage (Tscharntke et al., 2005).

For a sustainable agricultural system, it is important to maintain an overall nutrient balance. Nitrogen is an important enhancement here for agricultural productivity and plays an essential role in plant growth (Barrios, 2007). **Fertilizers** are used to balance the nutrient content in soil. They maximize crop yields, but they may also have negative impacts on water and provoke losses in biodiversity and particularly in water quality (Bennett et al., 2009). Organic fertilizers increase the content of carbon in soil, which promotes the creation and conservation of soil organic matter (Tilman et al., 2002). Farmers utilize mostly mineral fertilizers (Tscharntke et al., 2005). For effective plant production, the **choice of crops** should be adopted to the local ecological conditions. This includes climate, soil properties and terrain, expectations in the productivity, trade-offs on soil functionality and biodiversity and other parameters (Cowie et al., 2011; Delzeit et al., 2016; Halbrendt et al., 2014; Wezel et al., 2013). The choice of crops depends on the crop yield (Halbrendt et al., 2014).

Sustainable land management is essential to address land degradation processes and to maintain soil (Cowie et al., 2011). In Saxony, farmers are mostly affected by water erosion (Schmidt, 2010). To protect soils against soil erosion, farmers often use intercropping (Wezel et al., 2013). But also cover crops and deeply-rooted crops protect against soil erosion and simultaneously improve crop yield (Bennett et al., 2009).

Influence of policy instruments on famers' agricultural management

Agricultural governance instruments such as cross-compliance standards and funding in the Common Agricultural Policy, market, brand and trade regulations at the EU and international level have the largest influence on the implementation of soil conservation measures (Nguyen-the et al., 2016). So far however, there is no common soil protection legislation in Europe (Glaesner et al., 2014), although soil as a topic is integrated into other sectorial policies such as the protection of water, air and biodiversity (Turpin et al., 2017). A summary of the most important soil-related and agricultural policy instruments at the European, national

(Germany) and regional (Saxony) level is provided in Annex C. To improve existing policies and to implement new policy instruments, it is important to know how farmers evaluate existing policy instruments. Also, they have to be integrated into policy decisions (Baur et al., 2015). Farmers mostly consider subsidies as a reasonable policy measure (Engel et al., 2008). Payments for the adoption of soil conservation measures could increase the willingness for the implementation of such measures (Tilman et al., 2002).

As starting point for the investigation with farmers, a conceptual framework was created that is based on the body of literature review. The flowchart in Figure 1 introduces this conceptual framework that integrates the key research components *Concept of ES, Sources of knowledge, Cultivation practices* and *Policy measures.* It includes the various ES and soil conservation measures, which were presented to farmers as closed questions in the interview.

Place Figure 1 here

3. Methods

Case study area

Saxony is representative of highly intensive industrial agriculture as implemented mostly in the eastern parts of Germany and Europe. This dominance of industrial agriculture is a consequence of the former agricultural production cooperatives in the socialist planned economy (Beleites, 2012). After the reunification of Germany in 1990, industrial agriculture continued and is now sustained through new collaborations with management entities ranging from several hundred up to more than 10,000 ha with high impacts on biodiversity (Schulze, 2013). In total, 6,200 farms cultivate an area of approximately 715,200 ha arable land and 183,700 ha of permanent grassland (van der Ploeg et al., 2015; StLa Sachsen, 2015. Farms with an area of more than 500 hectares cultivate 64.6% of arable land in Saxony (Beleites, 2012). The gross value added (GVA) of agriculture, forestry and fishery amounts to about 0.6% (as of 2015) (SMUL, 2016a). The growing cultivation of bioenergy crops leads to further biodiversity losses and particularly high problems due to water erosion as a result of more and more shortened crop rotations. For instance, maize for bio energy represents about 21% of the overall maize production in Saxony (LfULG, 2015) and 66 % of Saxony's arable land is currently endangered by a high to very high threat of erosion with annually 2.5 million tons of soil losses. Consequently, since 2016 strip and direct seeding are funded to protect soil against erosion. Around 24 percent of Saxony's water bodies are in bad condition due to the high content of nitrate. Two- thirds of species and habitats are in insufficient or bad condition. However, there is a slowly growing trend towards intercropping and organic farming as well as more biodiversity conservation as a result of recent agricultural funding changes (SMUL, 2016b).

Data collection and analysis

For this study, semi-structured expert interviews (Bortz &; Döring, 2015; Gläser & Laudel, 2008) were conducted with farmers in the German Federal State of Saxony. Aim of the interviews was identification of the farmers' perceptions and soil management practices. Ten in-depth interviews were conducted with farmers who were located in different parts of Saxony and who represent industrial farming, organic farming, small (family) farming and large-scale agricultural companies. The average time of the interviews was about 45 minutes. The shortest interview took about 25 minutes, the longest about 2 hours, including a tour over the farm. Our selected farmers were identified by the Farmer's Association of Saxony, the Ministry of Environment and Agriculture of Saxony and a local Union of Organic Farming (GÄA). On their websites, farms are listed with phone numbers and addresses. In total 16 farmers were contacted by email to inform them that they will be called by phone to be asked if they were willing to participate in an interview. From the contacted farmers, ten of them agreed to be interviewed. The interviewed farmers were selected in a random selection process. No further interview participants were selected after theoretical saturation was reached, meaning that the last interview participants did not add any new information, which has not been mentioned by other interview participants in previous interviews. Two of the interviewees were family farmers practicing organic farming. The other interview participants were leaders of large industrial farms practicing conventional management, which were founded as cooperatives ("Genossenschaften") between 1990 and 1992 as follow-ups to industrial farm complexes in the former GDR. Eight of ten farms were mixed farms conducting arable and livestock farming. One farm permuted only arable farming and another farm conducted livestock farming. Table 1 provides an overview on the production areas of the interviewed farms. Farmer number 3 has no portion of grassland due to collaboration with his neighbor, who focused on livestock agriculture.

Table 1: Extent of area of interviewed farms (in bold organic farmers) (Source: Ten farmers' interview).

Number	Extent of area (ha)	Portion of arable land (ha)	Portion of grassland (ha)
1	2400	2260	180
2	2700	2150	550
3	1400	1400	-
4	2300	2150	150
5	920	870	50
6	**296**	**220**	**60**
7	1364	1157	207
8	5149	4476	673
9	**80**	**60**	**20**
10	1000	976,5	23,5

Interview guide, analysis and coding

The interview guide was based on a combination of open-ended and closed questions (see questionnaire in Annex d) and included questions that revealed preferences in ranking of selected soil ES. Based on our literature review we developed research questions and formulated different assumptions for each research questions. Adapted from the assumptions we expressed interview questions. In Table 2 is an overview with the research questions, the constructed assumptions and for this purpose developed interview questions. A selection of central questions in the interview is presented in Annex e. The same researcher conducted all interviews personally. The contacted farmers received an interview invitation explaining detailed the goals of the study and the import interrelation of farming and soil ecosystem services. The interviews began with a short description explaining the goals and background of the study. Interviews were recorded and later manually transcribed verbatim. The interviews were analyzed anonymously applying qualitative content analysis (Gläser & Laudel, 2008). A combination of a deductive and inductive category system was applied. Most of the codes were deductively derived based on the literature review, while some additional codes were added based on insights while conducting and coding the interviews (Bortz & Döring, 2015). Analysis of the closed questions was evaluated via descriptive statistics and an overview table. This was conducted by averaging calculations and frequency.

Table 2: Research questions, assumptions and interview questions (Source: Own compilation).

Research questions	Assumptions	Interview questions
1. Which ES are important from the farmers' perspective?	**H_0:** Farmers did not hear anything about the concept of ES (Koschke et al., 2014). **H_1:** Farmers hear anything about the concept of ES.	To what extent have you heard anything about the concept of ES?
	H_0: Farmers do not know all ES that are provided by soils (Dominati et al., 2010). **H_1:** Farmers know all ES that are provided by soils.	Which ES related to soil are known to you?
	H_0: Farmers do not know more ES than the considered one. **H_1:** Farmers do know more ES than the considered one.	Are there further ES that are known to you?
	H_0: Farmers regard provisioning ES "Food" and "Biomass as renewable resource" as very important (Schröter-Schlaack et al., 2016). **H_1:** Farmers do not regard provisioning ES "Food" and "Biomass as renewable resource" as very important.	Please order the ES according to their significance to you?
	H_0: Provisioning ES are important for farmers, because they increase farmers' income (Schröter-Schlaack et al., 2016). **H_1:** Provisioning ES are not important for farmers, because they increase farmers' income (Schröter-Schlaack et al., 2016).	Why are these ES highly relevant to you?
	H_0: Farmers consider the input of nutrients into groundwater through an appropriate fertilization (Tilman et al., 2002) **H_1:** Farmers do not consider the input of nutrients into groundwater through an appropriate fertilization.	How do you take these ES into consideration for your farm management?
	H_0: Farmers mostly implement intercropping for protecting against soil erosion (Wezel et al., 2013) **H_1:** Farmers do not mostly implement intercropping for protecting against soil erosion.	Which conservation measures are you implementing to protect against soil erosion?

2. What is their source of knowledge about the concept of ES, and also about tillage techniques and choice of crops?	**H_0:** Farmers did hear about the concept of ES through professional exchange (Schüler, 2016). **H_1:** Farmers did not hear about the concept of ES through professional exchange.	Where did you hear about this concept?
	H_0: Farmers inform themselves about method of tillage via journals. **H_1:** Farmers do not inform themselves about method of tillage via journals.	What are your sources of knowledge, for deciding, which method of tillage is the best for you?
	H_0: Farmers use expert conference to decide which crops they should choose. **H_1:** Farmers do not use expert conference to decide which crops they should choose.	What are the sources of knowledge for deciding which crop you should choose?
3. Which governance instruments are accepted or seen as effective for considering soil ES in management decisions?	**H_0:** Agricultural policy instruments at EU level have the biggest influence on the implementation of soil conservation measures to protect against soil erosion. **H_1:** Agricultural policy instruments at EU level do not have the biggest influence on the implementation of soil conservation measures to protect against soil erosion.	What kind of political instruments have an influence on your decision to apply technical measures for soil conservation?
	H_0: Subsidies are seen as sensible (Engel et al., 2008). **H_1:** Subsidies are not seen as sensible.	Which policy instruments that are responsible for the implementation of soil conservation measures do you seen as sensible?
	H_0: Payments increase the willingness to adopt sustainable agricultural management practices (Tilman et al., 2002) **H_1:** Payments do not increase the willingness to adopt sustainable agricultural management practices.	In your opinion, which incentives would have to be introduced for you to more readily take the ES into consideration for your farming practices?

4. Results

Where do farmers know about soil ES?

The two interviewed organic farmers were familiar with the concept of ES, because they were both formerly involved in a research project about ES. Five conventional farmers were knowledgeable about ES, without calling them “Ecosystem Services” but could guess what the concepts means by deriving it from the term “ecosystem”. One farmer defined ES as what agriculture is about in managing an ecosystem, and that using resources should be linked to protecting nature. Thus the productive capacity of ecosystems can be maintained. Two conventional farmers had not heard anything about the concept of ES before. The answers showed that the concept itself is not so well known by farmers but they are aware of the services nature provides. They were also familiar with the mentioned soil ES.

Farmers gather knowledge on ES from information about EU funding programs, for example Greening that requires crop rotation and intercropping, to scientific information about research projects, workshops and meetings. Other farmers mentioned their education and training, for example at the university or through extension services. None of the farmers received information about the concept by having exchanges with specialists (see Figure 2).

Place Figure 2 here

The most important source of knowledge about **tillage methods** is long-term experience. Thereby information is meant that is passed on from generation to generation and experiences that are made over the years. Other important sources of knowledge are education/ university and the exchanges with colleagues, neighbors and producers of agricultural machinery. Journals were not mentioned as a knowledge source. Sources of knowledge about tillage were cited 15 times, which suggests that farmers spend more energy on gathering this type of information than for ES.

Long-term experience is also the most important source of knowledge for the **choice of crops**. The Saxon State Agency of Environment, Agriculture and Geology conducts seed experiments and provides extension services and training for farmers. Seed retailers are an additional knowledge source as well as again education/ university. The internal balancing of accounts supports farmers in identifying the most suitable crop for maximizing the yield. The exchange with neighbours and colleagues is also an important knowledge source, for example they advise each other on crop rotation. Advisers support farmers in making choices between crops. Two farmers mentioned journals as another source of knowledge. Meetings with experts are not the most important knowledge source. These sources of knowledge were cited 27 times. Advertising on soil ES should be more efficient if spread along with crop choice.

Relevance of soil ecosystem services for farmers

Eight farmers consider "**Food**" as income source as the most important ES that depends on the choice of crops. One farmer saw this ES as important and one farmer as unimportant (Figure 3). "**Buffering and Mediation of Nutrient Release**" is also seen as the second very important ES for farmers through the input of fertilizers by conventional farmers. One organic farmer mentioned that the input of nutrients in conventional farming is still too high. Reasons for the importance of this service were grounded in the costs for compensating nutrient leaching through fertilization and soil structure losses through water erosion. Consequently, "**Erosion Control**" is very important (six farmers had this opinion) for preventing and maintaining soil as a basis for food production. That is the reason why farmers implement soil conservation measures and conservation tillage to hinder erosion control. Five farmers identified "**Water Regulation**" as very important. They pointed out that plants require water for growth. Four farmers mentioned "**Water Purification**" as very important because it ensures the maintenance of clean drinking water. For that the interviewed conventional farmers are using fertilizers in an appropriate amount. In contrast to the ES "Food", only four farmers saw "**Biomass as Renewable Energy**" as a very important ES, notwithstanding that this ES also leads to an increase in income. Three farmers regarded this ES as important and three of them see it as unimportant. In this context one farmer mentioned that land should be used for the cultivation of food and not for biomass production. One farmer pointed out that biomass as renewable energy does not play an important role yet. Another farmer mentioned that it could be interesting for eco-farming. Only two farmers mentioned "**Climate Regulation**" as very important ES. One farmer mentioned that "Climate Regulation" is the basis for crop cultivation and growing. But most of the interviewed farmers considered this ES as unimportant. They pointed out that "Climate Regulation" is not unimportant but does not play a big role in their agricultural farming practices. Five farmers said that climate is not relevant for their agricultural farming practices and agricultural production cannot influence climate. One conventional farmer highlighted that he is interested in crops that lead to maximum yield and are not the best for climate.

Place Figure 3 here

The results show that farmers do not fully agree on the importance of highly important services, which leads to differentiated considerations in their management decisions.

Farmers were asked if they noticed any ES missing in the list (Figure 1) provided to them. Five farmers (two of them organic farmers) would add biodiversity (3 farmers), soil fertility (2), recreation (2), aesthetic (2), nature protection (1), agriculture as workplace (1) and landscape conservation (1). The result shows that farmers are not familiar with specific services and mentioned, for example biodiversity and soil fertility as ES, although these are ecosystem

functions. On the other hand their responses proved a deep awareness of contributions that nature provides to people and their responsibility to care for them.

Consideration of ecosystem services in agricultural management practices

The interviewed farmers are using diverse agricultural management practices that refer to *adaption of pedoclimate properties*, *type of crops*, *tillage*, *fertilization* and *soil conservation measures* (Figure 4). The arrows from the various ES to the agricultural management practices refer to how farmers consider ES by their agricultural management practices.

Place Figure 4 here

"Food" provision is mainly driven by crop choice and crop rotation. Crop rotation supports to keep soils healthy and eutrophic and thus prevents against pests and weeds. The choice of a specific field crop depends mainly on its fit into a crop rotation sequence. Other determinants for the choice of crops are field crop yields and the *pedoclimate properties*.

The ES **"Buffering and Mediation of Nutrient Release"** is mainly addressed through fertilization. Three farmers pointed out that they aim to limit apply fertilizer and not to apply more than necessary. 8 of 10 farmers cultivate arable land and livestock, thus they apply primarily organic fertilizer and additionally mineral fertilizer. The *type of crops*, *tillage*, *fertilization* and *soil conservation measures* are further practices applied to buffer and mediate nutrient release. With buffer stripes along water bodies, farmers aim to prevent nutrient leaching into surface water and groundwater. The integration of legumes into crop rotation or mixed cropping was considered to be essential to reduce the use of fertilizer because of their nitrate binding capacities. Nine farmers use mulching, continuing a measure from the former funding period for Agri-Environmental Measures (AEM)(SMUL, 2016b). Mulching also has a high acceptance by farmers because it reduces costs and time and it is of high environmental efficiency (Sattler & Nagel, 2010). Five farmers still plough because of environmental restrictions. None of the interviewed farmers applies direct seeding because of the increasing emergence of slugs and mice and the unavailability of technical equipment in Germany for drilling larger fields. One farmer mentioned that the machines for direct seeding have a width of only 5 meters maximum and thus are not applicable on larger management units. Also farmers pointed out that experiments with direct seeding at national and regional level came to the results that the yield is lower than with other tillage methods. Farmers consider **"Water Regulation"** with the *type of crops* and *crop rotation.*

"**Water Purification"** is linked to adequate *fertilization*. The results show that farmers are aware of the risks of higher costs and decreasing water quality. Also, they are using *soil conservation measures* such as crop rotation and intercropping to address this ES. "**Biomass as Renewable Energy**" is considered through the *type of crops*.

Two farmers know a lot about agricultural farming practices that influence "**Climate regulation"**. It includes. for example, the integration of legumes in crop rotation, cultivation of hedges and keeping fewer cows. Two other farmers mention a few agricultural measures, whereas the rest did not know how they could influence the provision of ES with agricultural practices.

Erosion is a problem in Saxony. The interviewed farmers were mainly affected by water erosion. Only one farmer is affected directly by wind erosion. Other farmers said that wind erosion is of minor importance. One organic farmer stated that organic farms have fewer problems with soil erosion than conventional farms because of higher organic content in soils. **"Erosion control"** is a problem in Saxony. The interviewed farmers were mainly considered by *soil conservation measures* and *tillage* (Figure 4). The most implemented soil conservation measure is crop rotation (Figure 5). Further measures are "mulching", "intercropping" and "avoiding soil compaction". Two farmers mentioned that they also count buffer strips among "Erosion protection strips". 'Transversal Management' is not a suitable option everywhere. Its use depends on the geological structure. And if a farm do not have any hill, it is not necessary to use transversal management. Five farmers are using "undersowing" but this measure provides ground for weeds and they have to apply glyphosate. It is remarkable that the interviewed organic farmers do not use methods for avoiding soil compaction. Other soil conservation measures are narrow-row spacing, and strip seeding.

Place Figure 5 here

<u>Influence of policy instruments on farmers' agricultural management</u>

The Common Agricultural Policy (CAP) and especially *Greening (5)* influence mostly famers' decision making regarding which measures and agricultural farming practices they apply to soil conservation. Greening prescribes particularly crop rotation, intercropping and cultivation of legumes. Through the erosion control regulation of *Cross Compliance (CC) (4)* farmers are committed to apply certain measures for example prescription of ploughing on certain areas of farmland in determined periods. Farmers perceive that Greening and CC influence the way they conserve soils, because one farmer stated that through Greening they are admonished to integrate a few more crops in crop rotation and another farmer pointed out that Greening also loosen up crop rotation through the integration of legumes. The *Nitrates Framework Directive has* also an influence on farmers' agricultural farming practices because the Directive restricts the application of organic fertilizer as well as the periods for application. Farmers also mentioned the incentive-based *Agri-environmental and Climate Measures* (*AECM) (2).* AECM fund farmers to implement nature conservation measures such as flower strips. Related to AECM one farmer mentioned the former program of Agri-Environmental Measures (AEM). This funded mulching but the measure was discontinued.

The organic farmers are funded separately by the “Joint Task for the Improvement of Agricultural Structure and Coastal Protection” (GAK).

Considering policy instruments, farmers criticized that the existing instruments are not adapted to regional contexts and specific farm conditions. They also criticized that their decision-making arena regarding where to apply what kind of tillage technique is now largely restricted. Farmers also mentioned the high administration efforts related to existing funding schemes. For instance, *Greening* is considered to have a great influence on farmers’ agricultural practices, but only two farmers consider it to be a contribution towards higher biodiversity or improved provision of soil ES, although the request to implement more diverse crop rotations contributes to a higher degree of crop diversity on the farmland.

The uptake of incentive-based measures of AECM by Greening was mostly considered to be negative due to less financial investment in the farms. Only one organic farmer noted that the *Federal Soil Protection Ordinance* has to be extended with a sanctioning catalogue, while another one mentioned the retention period for organic fertilizer as positive aspects of the *Nitrates Framework Directive*. Beside this positive impact of the Nitrates Framework Directive farmers also criticized this Directive. Especially the restriction of application periods of fertilizers was criticized by one farmer. He noted that instead of restriction farmers could be encouraged to cultivate more intercropping. Another farmer mentioned that the Directive also reduce the application of synthetic fertilizers, but these are in his opinion valuable nutrients. According to another farmer the storage of organic fertilizers shall be further promoted. A primary target of the Nitrates Framework Directive is to maintain and increase water quality. This has also positive effects on local and diffuse soil contamination. For example, the application of fertilizer during winter is prohibited. Consequently, soil compaction and water erosivity are positively affected. Moreover, the limited application of nitrogen fertilizer has also positive effects on soil organic matter (Louwagie et al., 2011). A critical point was also that, as a fundamental responsibility for agriculture, investment into nature conservation as opposed to production of food and fodder is no longer well-balanced, although all farmers admitted that payments for biodiversity and ecosystem services as additional income are relevant to them.

It attracts attention that five farmers use general terms such as “policy” and “policy measures”, when they were asked which policy instruments they see as sensible. Also 3 farmers named measures in context of the evaluation of policy instruments. For example, they regard intercropping or legumes sensible as policy instruments. Another farmer mentioned that he considers measures for protecting against erosion and crop rotation as reasonable.

5. Discussion

Discussion about the conceptual framework

The rather simple conceptual framework (Figure 1) that we used at the beginning of the survey can now be enriched by a more complex picture of the perceived relationship between management and soil ES (Figure 6). Answers or additional information of farmers were added in the framework in orange. “Food” and “Buffering and Mediation of Nutrient Release” are highlighted with a bold frame, because these two are the most important ES for farmers. We added the named cultural ES of farmers as well as other perceived services of farmers. The knowledge sources of farmers related to concept of ES, tillage and crops of choice were added and “long-term experience” is highlighted as the most important knowledge source for farmers. The conceptual framework in figure 6 shows the forms of soil erosion the interviewed farmers are affected by. Soil conservation measures were extended with the colour orange that shall symbolize that farmers implement the given soil conservation measures. Crop rotation is highlighted with a bold outline as the most implemented soil conservation measures. Also, the policy measures were extended with the aforementioned in the interview of farmers, which have the biggest influence on their agricultural management practices.

Discussion of theoretical framework

Establishing the concept of ES in practice

Like the results of the studies from Lamarque et al. (2011); Lamarque et al. (2014) and Koschke et al. (2014) farmers were knowledgeable about all ES without calling them “Ecosystem Services”. The results of this study show that they use at least a very similar understanding of socio-ecological benchmarking in their management decisions. However, farmers frequently associate other ecosystem functions such as soil fertility with ES rather than “real” services as defined, for example in the context of CICES. A reason might be that there is still no standard definition for the term ES (Abson et al., 2014) and that more recent discussions are starting to use alternative terms again such as “nature’s benefit to people” or “nature’s contribution to people” (Pascual et al., 2017). The concept is still rather theoretical, and more comprehensive terms would contribute much to enable the implementation in practice.

Place Figure 6 here

Sources of knowledge of farmers

Education/ university, funding programs, workshops, meetings and research projects were mentioned as the most important sources of knowledge for farmers regarding the concept of ES.-In contrast, Schüler (2016) identified in his study that farmers get their information mainly from journals, exchanges with specialists, political strategy documents, scientific publications, media, their own projects and political regulation. The reason for this difference is that

Schüler (2016) used a closed questionnaire in which experts could choice their responses. In this study, open questions were asked to allow farmers to articulate their individual preferences. Due to the fact that education/ university is the most important knowledge source for farmers about the concept of ES, it should be integrated more into agricultural science curricula.

Farmers' knowledge sources about agricultural management practices vary between their preferences. Possible knowledge sources are colleagues, feed representatives, product salespeople, contractors, researchers, family, friends or neighbors (Ritter et al., 2017). Long-term experience was mentioned by the interviewed farmers as the most important knowledge source for selecting the tillage methods and the choice of field crops. This confirms the literature review of Ritter et al. (2017). She found out that farmers perceive often their knowledge from their experience of their farming work and less from educational training. But these experiences could be exchanges and discuss between farmers. Therefor conferences or workshops would be very attractive for farmers. On these events farmers could interact with each other and exchange their knowledge. But costs, time and location may hinder farmers to participate on such events (Ritter et al., 2017). So it is important to organize such events very attractive for farmers on local and regional level by the Farmers Associations or governmental institutions such as the State Federal Office for Agriculture, Environment and Geology, for example. Also workshops, field days or farm tours are a further possibility to share knowledge with each other. Discussions between farmers are a good way to explore different issues with the aim to create an ownership and to fill the gap between scientific information and farming practices (Ritter et al., 2017).

Farmers mentioned also seed retailers as knowledge source for the choice of crops. Here might be a conflict of interests between seed retailers and farmers, because seed retailers have the aim to sell seeds and they will not provide farmers with unbiased information. However, they are knowledgeable about the best crop choice and can support farmers in adapting to climate change.

Funding programs were also identified as a source of knowledge. To improve farmers' knowledge about the ecological functions of various measures and consideration of different ES such as "Climate Regulation" in agricultural farming practices, a combination of informal governance instruments such as non-governmental incentives through adapted certification standards or eco-labelling and more flexible funding schemes including mandatory training and education could be promising (Fürst et al., 2017). Mandatory training would obligate farmers to permanently attend further education or engage consultants who survey the implementation of respective management standards at the farm level. Additional public information through governmental and non-governmental organizations could also benefit farm-

ers in making the general public aware of the positive impact of agriculture on the availability of key ES. On such mandatory trainings farmers learn about the scientific state of the art and receive the current best management recommendations. This may be increase the awareness about new agricultural practices by farmers (Ritter et al., 2017).

The fact that farmers use different knowledge sources for ES than for farming practices means that agricultural advisory services need be aware of the concept and transfer it to farmers. This is necessary because ES provision by agriculture is a key contribution to society. At the same time the universities and professional training institutions need to take up the concept and raise awareness. This will also increase acceptance of famers and their cultivation practices.

Relevance and consideration of soil ES in agricultural farming practices

"Food" was seen as the most important ES for farmers, because it is the basis of farmers' income. This is supported by the study of Lamarque et al. (2014). They conclude that farmers ranked provisioning ES such as forage quality and quantity as very high, while regulating ES were valued lower. The reason of the very high ranking of forage quality and quantity is connected with the economic value. While "Buffering and Mediation of Nutrient Release" were ranked as the second most important ES in our study, it received lower values in the study of Lamarque et al. (2014), because farmers did not regarded it as a negative impact on nutrient leaching nor as a negative influence on water quality. Farmers considered "biomass as renewable energy" as a critical ES, being in competition with the provision of food and fodder. Also, other studies highlight this increasing competition and the self-understanding of farmers as relevant providers of existential resources (Baur et al., 2015). The interviewed farmers were mainly affected by water erosion. Farmers are aware of the risk of losing soil, but they do not see erosion as a threat to lose the production capacity of their soils. An explanation for this could be that farmers already know soil conservation measures and are already partially implementing them (Prager et al., 2011). Our results show that all interviewed farmers implement soil conservation measures. Sattler & Nagel, 2010 came to the same result. To protect their soils against erosion, farmers mostly implemented crop rotation as a soil conservation measure, which is also proposed by Greening. Farmers are called on to cultivate three different field crops in order to receive direct payments (Tangermann, 2014). Only two farmers mentioned "climate regulation" as very important. In the study of Lamarque et al. (2011) no farmer in three case study areas regarded this ES as very important. Our results show that farmers had only a limited understanding of how they could consider "climate regulation" in their agricultural practices. This result confirms the result of the study of Lamarque et al. (2014). He found out that farmers are knowledgeable about some ES but they have a lack of knowledge how they can consider them in their agricultural practices.

However, climate regulation and agricultural production are highly interlinked: The FAO estimates that about 10.6 giga tonnes (GT) of Greenhouse gas (GHG) emissions originate from agriculture and related land uses. The majority of these emissions come from deforestation, application of chemical fertilizer, and application of manure (FAO, 2016). The total emissions of agriculture in Germany amount to 64.2 million tons (6.7%) of GHG emissions composed of carbon dioxide (4.1%), methane (50.1%) and nitrous oxide (45.8%) (BMEL, 2015a). The interviewed farmers consider "climate regulation" through the integration of lucerne *(Medicago sativa)* in crop rotation and decreased livestock farming. Other practices such as intercropping (Steenwerth & Belina, 2008), extensification, mulching (Kantelhardt et al., 2015) or the direct injection of liquid manure (Neumann, 2017) are less practiced. Farmers in the study of Lamarque et al. (2014) recognized various factors that have an influence on ES. They recognized not only how ES are influencing each other, but also how one ES can have an influence on other services. But for some ES farmers don´t know how they can influence on them with agricultural practices. This is consistent with our results.

Assessment and suggestion for improvement of the existing policy instruments

The analysis revealed that the Common Agricultural Policy (CAP) and especially Greening exert the most influence on farmers' decision to implement soil conservation measures. The CAP is a prominent agricultural policy and a cornerstone of EU policies. It accounts for about 40% of the total budget between 2014-20 (Henke et al., 2018). CC has also a recognizable impact on farmers' agricultural management practices. The aim of CC is to protect, to conserve and to improve soils in order to promote more sustainable agriculture (Louwagie et al., 2011). Farmers are committed to implement a minimum standard of nature protection measures on their arable lands (Oppermann et al., 2013). A violation of Greening and CC means a reduction in, or even loss of, direct payments (Prager et al., 2011). But these regulations have come under criticism.

Further criticism was that the existing policy instruments are not very flexible and not adapted to regional conditions. For instance, there is no spatial prioritization where specific funding schemes are available, so that farmers are not forced to adapt their management in the best spatial context in order to improve ES provision or contribute to biodiversity (Baur et al., 2015, Fürst et al., 2017). This inflexibility makes it difficult to encompass (Garmestani et al., 2013) or cope with environmental problems (Baur et al., 2015). Further criticism were the inflexibility concerning the periods of cultivation, the short funding period of five years for such measures, which inhibits a longer phase of restructuring for whole farming systems, and the huge administrative and reporting effort require to get the funding which is particularly not feasible for small scale family farms (Joormann & Schmidt, 2017; Oppermann et al., 2013).

AECM are in contrast very popular for farmers because they are firstly on a voluntary basis and offer additional financial incentives (Lastra-Bravo et al., 2015) and they are secondly funding measures of farmers that are already implemented in their farming systems. AECM (previous AEM) were introduced to fund specific agricultural practices in order to promote the rural environment (van Herzele et al., 2013). They address individual needs of farms better and enable a site-specific implementation of nature protection measures (Zinngrebe et al., 2017), because there are developed at regional level. In the period between 2007-2013 around three millions farms were supported by payments of AEM. This accounts about 22% of the total agricultural area in EU Member States (van Herzele et al., 2013).

Incentive-based conservation policies thus can be considered to be appropriate for maintaining ecosystem services and slowing down the loss of biodiversity if they directly remunerate farmers for their provision of ES (Dörschner & Musshoff, 2015) and ensure their financial security (Karelakis & Tsantopoulos, 2017). For example the financial incentives for the measures of Pillar II of the CAP can reduce negative impacts on employments while receive less direct payments under Pilar I (Helming & Tabeau, 2018). Technical requirements and administrative obstacles need to be reduced (Zinngrebe et al., 2017). Also result-oriented remuneration (ROR) could be offered if, for instance, monitoring systems for the provision of ES were installed in the context of the European Biodiversity Strategy. Advantages of ROR would be that farmers are completely flexible regarding how they achieve these ecological objectives, and they are motivated to achieve these objectives (Dörschner & Musshoff, 2015).

Incentives for implementing sustainable agricultural practices

Farmers mentioned that financial incentives would be a good initiative for implementing sustainable agricultural practices for considering more ES in their farming management. In the literature various recommendation are mentioned to enhance farmers' willingness to implement sustainable farming practices. In the process financial measures play an important role to encourage farmers to implement sustainable agricultural practices (Ritter et al., 2017; Weber & Lam, 2012). But it is also important that farmers need to believe that their current agricultural management cause problems or increase risk of future problems in their farm management. They need also to believe that they are responsible for implementing such sustainable agricultural practices (Ritter et al., 2017). To reach a higher participation on this implementation, it could be helpful to share experiences with a successful change of agricultural practices (Ivemeyer et al., 2015; Roche et al., 2015) and to recommend measures, which are feasible for their farm management (Roche et al., 2015; Toma et al., 2015).

6. Conclusion

The paper examined the role and consideration of ES in agricultural systems by farmers in Saxony. The focus was on farmers' sources of knowledge and the influence of existing policy instruments on farmers' decisions to implement soil conservation measures and the assessment of these policy instruments. The study also investigated, which incentives support farmers to implement more sustainable agricultural farming practices.

Key lessons learnt are:

- ES are inherently known and applied by farmers, but their relevance to the implementation through adapted management is judged differently compared to societal goals. For instance, climate regulation, which is directly related to farming practices, was not considered to be important for farmers so information about this ES are needed. Therefore, funding or regulatory instruments should clearly enhance this service in agricultural practices.
- There is a need to balance funding for nature conservation with funding for other ES to prevent farmers from losing their role as key providers of food and fodder. It should become clear that clean, sustainable and results-oriented environmental management is honored. This, however, also requires clear standards for which indicators and monitoring schemes are implemented so that farmers have an explicit understanding of criteria they are assessed by.
- Sharing of experience and exchange of knowledge among farmers should clearly be more readily supported by funding sources, as well as governmental and non-governmental institutions in order to better connect management practices with their impact on specific ecosystem services.

Policy recommendations

Along with Ring & Schröter-Schlaack (2013) and Trommler et al. (2013) our results show that for a successful implementation of new policy instruments or the amendment of existing policies a mix of mandatory, incentive-based and informational instruments is recommended, because mandatory instruments could regulate a level in using soil and its provision of ES. This need for a policy mix to improve environmental friendly agriculture is also represented in the current reform process of the CAP where standards for direct payments are still a prominent cornerstone that is supplemented by AECM.

Especially incentive-based instruments give additional incentives to implement sustainable agricultural practices on a voluntary basis (Trommler et al., 2013). A further important element of a policy mix is informational instruments, because they inform stakeholders about new regulation related to mandatory instruments or incentive-based measures. They can also help to increase the awareness and acceptance about environmental-friendly instru-

ments as well as the participation on voluntary-based environmental-friendly measures (Ring & Schröter-Schlaack, 2013).

AECM as a funding instrument is viewed by farmers as a very sensible policy instrument. But at the same time, they pointed out that funding was not always appropriate for the specific situation of the farms. Innovative funding schemes in the context of the CAP revision and the AECM funding opportunities should be co-developed with the farmers instead of being decided from above. In the current proposals for the CAP after 2020 a focus lies on allowing member states to better link measures to local conditions, being implemented effectively it can contribute to protecting agricultural soils.

Further education, consultation and training should be made mandatory in order to get access to investments. Implementation of ES in agricultural science curricula and permanently available scientific information that is easily accessible and transparently processed are key factors for promoting the concept of ES in practice. Part of the agricultural funding should therefore be invested to ensure the availability of up-dated information from actors who are easy to contact such as extension service personnel, rural development coordinators or other consulting services. Based on the criticisms and recommendations received from the interviews, the paper proposes the following policy recommendations, which are summarized in Box 1.

Box 1: Policy Recommendations

General recommendations:

- Development of new policy instruments has to be based on previous existing policy instruments.
- Adaption and implementation of policy instruments need to be more flexible to contribute efficiently to soil ES provision. More possibilities need to be in place for farmers to exit a program or change the measures.
- There should be more intensification of extension services regarding consultancy on policy instruments.
- There should be less administrative time and effort required for farmers.
- Standards for ES-oriented best practice management in certification systems and ecolabeling should be introduced.

Recommendations for mandatory policy instruments:

- There should be an improvement in CAP especially Greening and cross compliance with measures, which are more oriented towards results/ benchmarks in providing ES rather than purely “area-related”.
- Extension Federal Soil Protect Act should include a sanctioning catalogue.
- There should be more stringent regulation regarding the application of fertilizer.
- Further education, training or use of consultation should be obligatory.

Recommendations for incentive-based policy instruments:

- Voluntary measures such as AECM should be extended, because they are very flexible and adapted on regional conditions.

Further research

This paper considered only the agricultural farming practices tillage, crop rotation and fertilization, because of the limited scope of the study and the fact that some practices, such as irrigation, do not yet play a role in Saxony. There are still more agricultural practices such as application of pesticides or irrigation that could be recognized in another study. Moreover, the paper did not consider cultural ES, which are of high importance for agricultural landscape but difficult to assess.

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References

Abson, D.J., von Werden, H., Baumgärtner, S., Fisch, J., Hanspach, J., Härdtle, W., Heinrichs, H., Klein, A.M., Lang, D.J., Martens, P., Walmsley, D. 2014. Ecosystem services as a boundary object for sustainability. Ecological Economics, 103 (7), 29-37.

Adhikari, K., Hartemink, A. E. 2016. Linking soils to ecosystem services – A global review. Geoderma, 262, 101-111.

Albert, C., Hauck, J., Buhr, N., von Haaren, C. 2014. What ecosystem services information do users want? Investigating interests and requirements among landscape and regional planners in Germany. Landscape Ecology, 29 (8), 1301-1313.

Barrios, E. 2007. Soil biota, ecosystem services and land productivity. Ecological Economics, 64, 269-285.

Bartkowski, B., Bartke, S. 2018. Leverage points for governing agricultural soils: a review of empirical studies of European farmers' decision-making. Sustainability 10 (9), 3179.

Baur, I., Dobricki, M., Lips, M. 2015. The basic motivational drivers of northern and central European farmers. Journal of Rural Studies, 46, 93-101.

Beleites, M. 2012. Leitbild Schweiz oder Kasachstan? Zur Entwicklung der ländlichen Räume in Sachsen. Eine Denkschrift zur Agrarpolitik, Hamm: Weiterdenken – Heinrich-Böll-Stiftung Sachsen und AbL – Arbeitsgemeinschaft bäuerlicher Landwirtschaft e.V.

Bemelmans-Videc, M.-L., Rist, R. C., Vedung, E. 2003. Carrots, Sticks & Sermons. Policy Instruments & Their Evaluation, New Brunsrick, New Jersey: Transaction Publishers.

Bennett, E. M., Peterson, G. D., Gordon, L. J. 2009. Understanding relationships among multiple ecosystem services. Ecology Letters, 12, 1394-1404.

BMBF 2014. Nationale Politikstrategie Bioökonomie. Bundesministerium für Ernährung und Landwirtschaft, Berlin. Available at: https://www.bmbf.de/files/BioOekonomiestrategie.pdf (File accessed: 23/01/2018).

BMEL 2015a: Agrarpolitischer Bericht der Bundesregierung 2015. Available at: http://www.bmel.de/SharedDocs/Downloads/Broschueren/Agrarbericht2015.pdf?__blob=publicationFile (File accessed: 22.04.2016).

BMEL 2015b. Umsetzung der EU-Agrarreform in Deutschland. Referat 617 – Direktzahlungen, Bonn: Bundesministerium für Ernährung und Landwirtschaft. Available at: http://www.bmel.de/SharedDocs/Downloads/Broschueren/UmsetzungGAPinD.pdf?__blob=publicationFile (File accessed: 21.10.2016).

Bortz, J. & Döring, N. 2015. Forschungsmethoden und Evaluation. Für Human- und Sozialwissenschaftler, 4. Auflage, Berlin: Springer.

Breure, AM., de Deyn, GB., Dominati, E., Eglin, T., Hedlund, K., van Orshoven, J., Posthuma, L. 2012. Ecosystem services: a useful concept of soil policy making! Current Opinion in Environmental Sustainability, 4, 578-585.

Calzolari, C., Ungaro, F., Filippi, N., Guermandi, M., Malucelli, F., Marchi, N., Staffilani, F., Tarocco, P. 2016. A methodological framework to assess the multiple contributions of soils to ecosystem services delivery at regional scale. Geoderma, 261, 190-203.

Common Classification of Ecosystem Services (CICES). 2016. CICES V4.3, January 2013, Available at: http://cices.eu/content/uploads/sites/8/2015/09/CICES-V4-3-_-17-01-13a.xlsx (File accessed: 12.12.2016).

Cowie, A. L., Penman, T. D., Gorissen, L., Winslow, M. D., Lehmann, J., Tyrrell, T. D., Twomlow, S., Wilkes, A., Lal, R., Jones, J. W., Paulsch, A., Kellner, K., Akhtar-Schuster, M. 2011. Towards sustainable land management in the drylands: Scientific

connections in monitoring and assessing dryland degradation, climate change and biodiversity. Land Degradation & Development, 22, 248-260.

Delzeit, R., Zabel, F., Meyer, C., Václavík, T. 2016. Addressing future trade-offs between biodiversity and cropland expansion to improve food security. In: Cramer, W. & Ford, J.D. (Ed.). Regional Environmental Change, Heidelberg: Springer VS, 1-13.

Dominati, E. J., Patterson, M., Mackay, A. 2010. A framework for classifying and quantifying the natural capital and ecosystem services of soils. Ecological Economics, 69 (9), 1858-1868.

Dominati, E. J. 2013. Natural Capital and Ecosystem Services of Soils. Dymond, JR. (Ed.). Ecosystem Services in New Zealand – conditions and trends. Manaaki Whenna Press, Lincoln, New Zealand, 132-142.

Dörschner, T. & Musshoff, O. 2015. How do incentive-based environmental policies affect environment protection initiatives of farmers? An experimental economic analysis using the example of species richness. Ecological Economics, 114, 90-103.

Engel, S., Pagiola, S., Wunder, S. 2008. Designing payments for environmental services in theory and practice: An overview of the issues. Ecological Economics, 65, 663-674.

FAO 2016. The State of Food and Agriculture. Climate Change, Agriculture and Food Security. Available at: http://www.fao.org/3/a-i6030e.pdf (File accessed: 09.11.2017).

Fischer, A. & Eastwood, A. 2016. Coproduction of ecosystem services as human-nature interactions – An analytical framework. Land Use Policy, 52, 41-50.

Frelih-Larsen, A., Bowyer, C., Albrecht, S., Keenleyside, C., Kemper, M., Nanni, S., Naumann, S., Mottershead, D., Landgrebe, R., Andersen, E., Banfi, P., Bell, S., Brémere, I., Cools, J., Herbert, S., Iles, A., Kampa, E., Kettunen, M., Lukacova, Z., Moreira, G., Kiresiewa, Z., Rouillard, J., Okx, J., Pantzar, M., Paquel, K., Pederson, R., Peepson, A., Pelsy, F., Petrovic, D., Psaila, E., Šarapatka, B., Sobocka, J., Stan, A.-C., Tarpey, J., Vidaurre, R. 2016. Updated Inventory and Assessment of Soil Protection Policy Instruments in EU Member States. Final Report to DG Environment. Berlin: Ecologic Institute.

Fürst, C., Luque, S., & Geneletti, D. 2017. Nexus thinking–how ecosystem services can contribute to enhancing the cross-scale and cross-sectoral coherence between land use, spatial planning and policy-making. International Journal of Biodiversity Science, Ecosystem Services & Management, 13 (1), 412-421.

Garmestani, A. S., Allen, C. R., & Benson, M. H. 2013. Can law foster social-ecological resilience? Ecology and Society, 18 (2), 37, http://doi.org/10.5751/ES-05927-180237.

Glaesner, N., Helming, K., de Vries, W. 2014. Do Current European Policies Prevent Soil Threats and Support Soil Functions? Sustainability, 6 (12), 9538-9563.

Gläser, J. & Laudel, G. 2008. Experteninterviews und qualitative Inhaltsanalyse als Instrument rekonstruierender Untersuchungen, 3. Auflage, Wiesbaden: VS Verlag für Sozialwissenschaften.

Haines-Young, R. & Potschin, M. 2013. Common International Classification of Ecosystem Services (CICES): Consultation on Version 4, August-Dezember 2012. EEA Framework Contract No EEA/IEA/09/003. Available at: www.cices.eu (File accessed: 18.07.2016).

Halbrendt, J., Gray, S. A., Crow, S., Radovich, T., Kimura, A. H., Tamang, B. B. 2014. Differences in farmer and expert beliefs and the perceived impacts of conservation agriculture. Global Environmental Change, 28 (2014), 50-62.

Hallmann, C. A., Sorg, M., Jongejans, E., Siepel, H., Hofland, N., Schwan, H., Stenmans, W., Müller, A., Sumser, H., Hörren, T., Goulson, D., de Kroon, H. 2017. More than 75 percent decline over 27 years in total flying insect biomass in protected areas. PLOS ONE, 12 (10), https://doi.org/10.1371/journal.pone.0185809.

Helming, J. & Tabeau, A. 2018. The economic, environmental and agricultural land use effects in the European Union of agricultural labour subsidies under the Common Agricultural Policy. Reg Environ Change, 18, 763-773.

Henke, J. M. 2007. Information as an Environmental Policy Instrument. A Case Study for the Economics of Eco-Labeling. Berlin: dissertation.de – Verlag im Internet GmbH.

Henke, R., Benos, T., de Flippies, F., Giua, M., Pierangeli, F., Rosaria, M., D'Andrea, P. 2018. The New Common Agricultural Policy: How do Member States Respond to Flexibility? JCMS 56 (2), 403-419.

Ivemeyer, S., N. J. Bell, J. Brinkmann, K. Cimer, E. Gratzer, C. Leeb, S. March, C. Mejdell, S. Roderick, G. Smolders, M. Walkenhorst, C. Winckler, and M. Vaarst. 2015. Farmers taking responsibility for herd health development—stable schools in research and advisory activities as a tool for dairy health and welfare planning in Europe. Org. Agr., 5, 135–141.

Joormann, I. & Schmidt, T. 2017. F.R.A.N.Z.-Studie – Hindernisse und Perspektiven für mehr Biodiversität in der Agrarlandschaft. Thünen Working Paper 75. Braunschweig: Bundesforschungsinstitut für Ländliche Räume, Wald und Fischerei.

Kantelhardt, J., Liebersbach, H., Matzdorf, B., Reutter, M., Röder, N., Schaller, L. 2015. Landwirtschaft: Emissionen reduzieren, Grünlandumbruch vermeiden und Bioenergie umweltfreundlich nutzen. In: Hartje, V., Wüstemann, H., Bonn, A. (Ed.): Naturkapital und Klimapolitik – Synergien und Konflikte. Naturkapital Deutschland – TEEB DE, Berlin: Technische Universität, Berlin, Leipzig: Helmholtz-Zentrum für Umweltforschung, 100-123.

Karelakis, C. & Tsantopoulos, G. 2017. Changing land use to alternative crops: A rural landholder's perspective. Land Use Policy, 63, 30-37.

Koschke, L., Van der Meulen, S., Frank, S., Schneidergruber, A., Kruse, M., Fürst, C., Neubert, E., Ohnesorge, B., Schröder, C., Müller, F., Bastian, O. 2014. Do You Have 5 Minutes To Spare? – The Challenges Of Stakeholders Processes In Ecosystem Services Studies. Landscape Online, 37 (1), 1-25.

Kovács-Hostyánszki, A., Espíndola, A., Vanbergen, A. J., Settele, J., Kremen, C., & Dicks, L. V. 2017. Ecological intensification to mitigate impacts of conventional intensive land use on pollinators and pollination. Ecology letters, 20(5), 673-689.

Kutter, T., Louwagie, G., Schuler, J., Zander, P., Helming, K., Hecker, J.-M. 2011. Policy Measures for Agricultual Soil Conservation in the European Union and its member states: Policy Review and Classification. Land Degradation & Development, 22, 18-31.

Lamarque, P., Tappeiner, U., Turner, C., Steinbacher, M., Bardgett, R. D., Szukics, U., Schermer, M., Lavorel, S. 2011. Stakeholder perceptions of grassland ecosystem services in relation to knowledge on soil fertility and biodiversity. Reg Environ Change, 11, 791-804.

Lamarque, P., Meyfroidt, P., Nettier, B., Lavorel, S. 2014. How Ecosystem Services Knowledge and Values Influence Farmers' Decision-Making. PLOS One, 9 (9), 1-16.

Lastra-Bravo, X. B., Hubbard, C., Garrod, G., Tolón-Becerra, A. 2015. What drives farmers' participation in EU agri-environmental schemes?: Results from a qualitative meta-analysis. Environmental Science & Policy, 54, 1-9.

Lemaire, D. 2003. The Stick: Regulation as a Tool of Government. In: Bemelmans-Videc, M.-L., Rist, R. C., Vedung, E. (Ed.). Carrots, Sticks & Sermons. Policy Instruments & Their Evaluation, New Brunsrick, New Jersey: Transaction Publishers, 59-76.

Lewan, L. & Söderqvist, T. 2002. Knowledge and recognition of ecosystem services among the general public in a drainage basin in Scania, Southern Sweden. Ecological Economics, 42, 459-467.

LfULG 2015. Energiepflanzenanbau in Sachsen. Daten und Fakten. Landesamt für Umwelt, Landwirtschaft und Geologie, Pflanzliche Erzeugung, Referat 72, Available at: https://www.smul.sachsen.de/LfULG/download/DuF_Energiepflanzenanbau_Endfassung_070815.pdf (File accessed: 25.10.2017).

Louwagie, G., Gay, S. H., Sammeth, F., Ratinger, T. 2011. The Potential of European Union Policies to address soil degradation in agriculture. Land Degradation & Development, 22, 5-17.

Millennium Ecosystem Assessment (MEA) 2005. Ecosystems and Human Well-being: Biodiversity Synthesis. A report of the Millennium Ecosystem Assessment, Washington, DC: World Resources Institute.

Meyer, C., Schomers, S., Matzdorf, B., Biedermann, C., Sattler, C. 2016. Civil society actors at the nexus of the ecosystem services concept and agri-environmental policies. Land Use Policy, 55, 352-356.

Möckel, S., Köck, W., Rutz, C., Schramek, J. 2014. Rechtliche und andere Instrumente für vermehrten Umweltschutz in der Landwirtschaft. Heft 42. Dessau-Roßlau: Umweltbundesamt. Available at: https://www.umweltbundesamt.de/sites/default/files/medien/378/publikationen/texte_42_2014_rechtliche_und_andere_instrumente.pdf (File accessed: 31.08.2016).

Möckel, S. 2015. Politische und rechtliche Ziele zum vorsorgenden Schutz der Böden in Deutschland. Natur und Landschaft, 90 (11), 497-502.

Neumann, H. 2017. So viel Klimaschutz liefert Bioenergie wirklich. Top Agrar, 09/2017, 110-114.

Nguyen-the, C., Bardin, M., Berard, A., Berge, O., Brillard, J., Broussolle, V., Carlin, F., Renault, P., Tchamitchian, M., Morris, C.E. 2016. Agrifood systems and the microbial safety of fresh produce: Trade-offs in the wake of increased sustainability. Science of the Total Environment, 562, 751-759.

Oppermann, R., Kasperczyk, N., Matzdorf, B., Reutter, M., Meyer, C., Luick, R., Stein, S., Ameskamp, K., Gelhausen, J., Bleil, R. 2013. Reform der Gemeinsamen Agrarpolitik (GAP) 2013 und Erreichung der Biodiversitäts- und Umweltziele. Naturschutz und Biologische Vielfalt, Heft 135, Bonn – Bad Godesborg: Bundesamt für Naturschutz.

Pascual, U., Balvanera, P., Díaz, S., Pataki, G., Roth, E., Stenseke, M. & Maris, V. 2017. Valuing nature's contributions to people: the IPBES approach. Current Opinion in Environmental Sustainability, 26, 7-16.

Pfaff, S. 2010. Gütesiegel auf Lebensmitteln. Was sagen Labels wie Bio, Halal oder IFS aus? Hamburg: readL.media GmbH.

Potschin, M. B. & Haines-Young, R. 2011. Ecosystem services: Exploring a geographical perspective. Progress in Physical Geography, 35 (5), 575-594.

Prager, K., Hagemann, N., Schuler, J., Heyn, N. 2011. Incentives and Enforcement: The Institutional Design and Policy Mix for Soil Conservation in Brandenburg (Germany). Land Degradation & Development, 22 (1), 111-123.

Ring, I. & Schröter-Schlaack, C. 2013. Zur Auswahl des geeigneten Politikmixes. In: Grunewald, K. & Bastian, O. (Ed.). Ökosystemdienstleistungen. Konzept, Methoden und Fallbeispiele. Heidelberg: Springer Spektrum, 156-166.

Ritter, C., Jansen, J., Roche, S., Kelton, D. F., Adams, C. L., Orsel, K., Erskine, R. J., Benedictus, G., Lam, T. J. G. M., Barkema, H. W. 2017. Invited review: Determinants of farmers' adoption of management-based strategies for infectious disease prevention and control. J. Dairy Sci., 100, 1-19.

Roche, S. M., A. Jones-Bitton, M. Meehan, M. Von Massow, and D. F. Kelton. 2015. Evaluating the effect of Focus Farms on Ontario dairy producers' knowledge, attitudes, and behavior toward control of Johne's disease. J. Dairy Sci., 98, 5222–5240.

Sattler, C. & Nagel, U. J. 2010. Factors affecting farmers' acceptance of conservation measures – A case study from north-eastern Germany. Land Use Policy, 27, 70-77.

Schleyer, C., Görg, C., Hauck, J., Winkler, K. J. 2015. Opportunities and challenges for mainstreaming the ecosystem services concept in the multi-level policy-making within the EU. Ecosystem Services, 16, 174-181.

Schmidt, W. 2010. Was machen die Nachbarn – Erosionsschutz in Sachsen. In: Bayerische Landesanstalt für Landwirtschaft (LfL) (Ed.). Erosionsschutz – Aktuelle Herausforderungen für die Landwirtschaft. 8. Kulturlandschaftstag, Freising-Weihenstephan, 23.03.2010, 63-74, Available at: https://www.lfl.bayern.de/mam/cms07/publikationen/daten/schriftenreihe/p_38585.pdf (File accessed: 23.08.2016).

Schröter-Schlaack, C., & Blumentrath, S. 2011. Direct regulation for biodiversity conservation. In: Ring, I. & Schröter-Schlaack, C. (Ed.). Instrument Mixes for Biodiversity Policies. POLICYMIX Report 2/2011, Leipzig: Helmholtz Centre for Environmental Research – UFZ, 36–58, Available at: http://policymix.nina.no (File accessed: 21.10.2016).

Schröter-Schlaack, C., Albert, C., von Haaren, C., Hansjürgens, B., Krätzig, S., Albert, I. 2016. Naturkapital Deutschland – TEEB DE. Ökosystemleistungen in ländlichen Räumen. Grundlage für menschliches Wohlergehen und nachhaltige wirtschaftliche Entwicklung. Schlussfolgerungen für Entscheidungsträger, Hannover: Leibnitz Universität; Leipzig: Helmholtz-Zentrum für Umweltforschung (UFZ).

Schüler, S. 2016. Ökosystemleistungen – ein Instrument des Umwelt- und Ressourcenmanagements in Deutschland? Begriffliche Grundlagen, ethische Motive und partizipative Handlungsstrategien. Stuttgart: ibidem-Verlag.

Schulz, N., Breustedt, G., Latacz-Lohmann, U. 2014. Accept "Greening": Insights from a Discrete Choice Experiment in Germany. Journal of Agricultural Economics, 65 (1), 26-48.

Schulze, E. 2013. Nachhaltigkeit, ökologischer und konventioneller Landbau. Eine Erwiderung auf die Denkschrift "Leitbild Schweiz oder Kasachstan?" von Michael Beleites. Veröffentlichungen der Leipziger Ökonomischen Societät e.V. Leipzig, Heft 22.

SMUL 2016a. Landwirtschaft. Bruttowertschöpfung der Landwirtschaft, Available at: https://www.landwirtschaft.sachsen.de/landwirtschaft/download/AS_Indikator_73.png (File accessed: 25.08.2016).

SMUL 2016b. Agrarbericht in Zahlen. Berichtsjahr 2015. Dresden: Staatsministerium für Umwelt und Landwirtschaft. Available at: https://publikationen.sachsen.de/bdb/artikel/26607/documents/37178 (File accessed: 28.09.2016).

Steenwerth, K. & Belina, K.M. 2008. Cover crops and cultivation: Impacts on soil N dynamics and microbiological function in a Mediterranean vineyard agroecosystem. Applied soil ecology, 40 (2), 370-380.

StLa Sachsen 2015. Sachsen in Karten. Ausgabe 2015, Kamenz: Statistisches Landesamt des Freistaates Sachsen, Available at: https://www.statistik.sachsen.de/download/300_Voe-Sonderpublikation/SachsenInKarten_2015.pdf (File accessed: 21.06.2016).

Switek, S. & Sawinska, Z. 2016. Farmer rationality and the adoption of greening practices in Poland. Scientia Agricola, 74 (4), 275-284.

Tangermann, S. 2014. Direktzahlungen: Ein bleibender Bestandteil der EU-Agrarpolitik? In: Schmid, E. & Vogel, E. (Hrsg.): Europäische Agrarpolitik im 21. Jahrhundert, Wien: Facultas, 19-42.

Tilman, D., Cassman, K. G., Matson, P., Naylor, R., Polasky, S. 2002. Agricultural sustainability and intensive production practices. In: Nature, 418, 671-677.

Toma, L., J. C. Low, B. Vosough Ahmadi, L. Matthews, and A. W. Stott. 2015. An analysis of cattle farmers' perceptions of drivers and barriers to on-farm control of *Escherichia coli* 0157. Epide- miol. Infect., 143, 2355–2366.

Trommler, K., Plieninger, T., Bieling, C., Gerdes, H. 2013. Ökosystemleistungen. Landnutzung, Lebensqualität und Marktbasierte Instrumente in land- und forstwirtschaftliche genutzten Kulturlandschaften. Nachwuchsgruppe Ökosystemleistungen, Berlin: Berlin-Brandenburgische Akademie der Wissenschaften.

Tscharntke, T., Klein, A. M., Kruess, A., 2005. Landscape perspectives on agricultural intensification and biodiversity – ecosystem service management. Ecology Letters, 8 (8), 857-874.

Turpin, N., Ten Berge, H., Grignani, C., Guzman, G., Vanderlinden, K., Steinmann, H.-H., Siebielec, G., Spiegel, A., Perret, E., Ruysschaert, G., Laguna, A., Giraldez, J.-V., Werner, M., Raschke, I., Zavattro, L., Costamagna, C., Schlatter, N., Berthold, H., Sanden, T., Baumgarten, A. 2017. An assessment of policies affecting Sustainable Soil Management in Europe and selected member states. Land Use Policy, 66, 241-249.

van der Ploeg, J. D., Franco, J. C., Borras Jr, S. M. 2015. Land concentration and land grabbing in Europe: a preliminary analysis. Canadian Journal of Development Studies, 36(2), 147-162.

van Herzele, A., Gobin, A., van Gossum, P., Acosta, L., Waas, T., Dendoncker, N., de Frahan, B. H. 2013. Effort for money? Farmers' rationale for participation in agri-environment measures with different implementation complexity. Journal of Environmental Management, 13, 110-120.

Vedung, E. 2003. Policy Instruments: Typologies and Theories. In: Bemelmans-Videc, M.-L., Rist, R. C., Vedung, E. (Ed.). Carrots, Sticks & Sermons. Policy Instruments & Their Evaluation, New Brunsrick, New Jersey: Transaction Publishers, 21-58.

Weber, M. F., & T. J. G. M. Lam. 2012. Milk quality assurance programme for paratuberculosis results in increasing proportion of test-negative dairy herds. Page 305 in Proc. 13th International Symposium on Veterinary Epidemiology and Economics, Maastricht, the Netherlands.

Wezel, A., Casagrande, M., Celette, F., Vian, J.-F., Ferrer, A., Peigné, J. 2013. Agroecological practices for sustainable agriculture. A review. Agronomy for sustainable development, 34 (1), 1-20.

Zhang, W., Ricketts, T. H., Kremen, C., Carney, K., Swinton, S. M. 2007. Ecosystem services and dis-services to agriculture. Ecological Economics, 64 (2), 253-260.

Zinngrebe, Y., Pe'er, G., Schueler, S., Schmitt, J., Schmidt, J., Lakner, S. 2017. The EU's ecological focus areas – How experts explain farmers' choices in Germany. Land Use Policy, 65, 93-108.

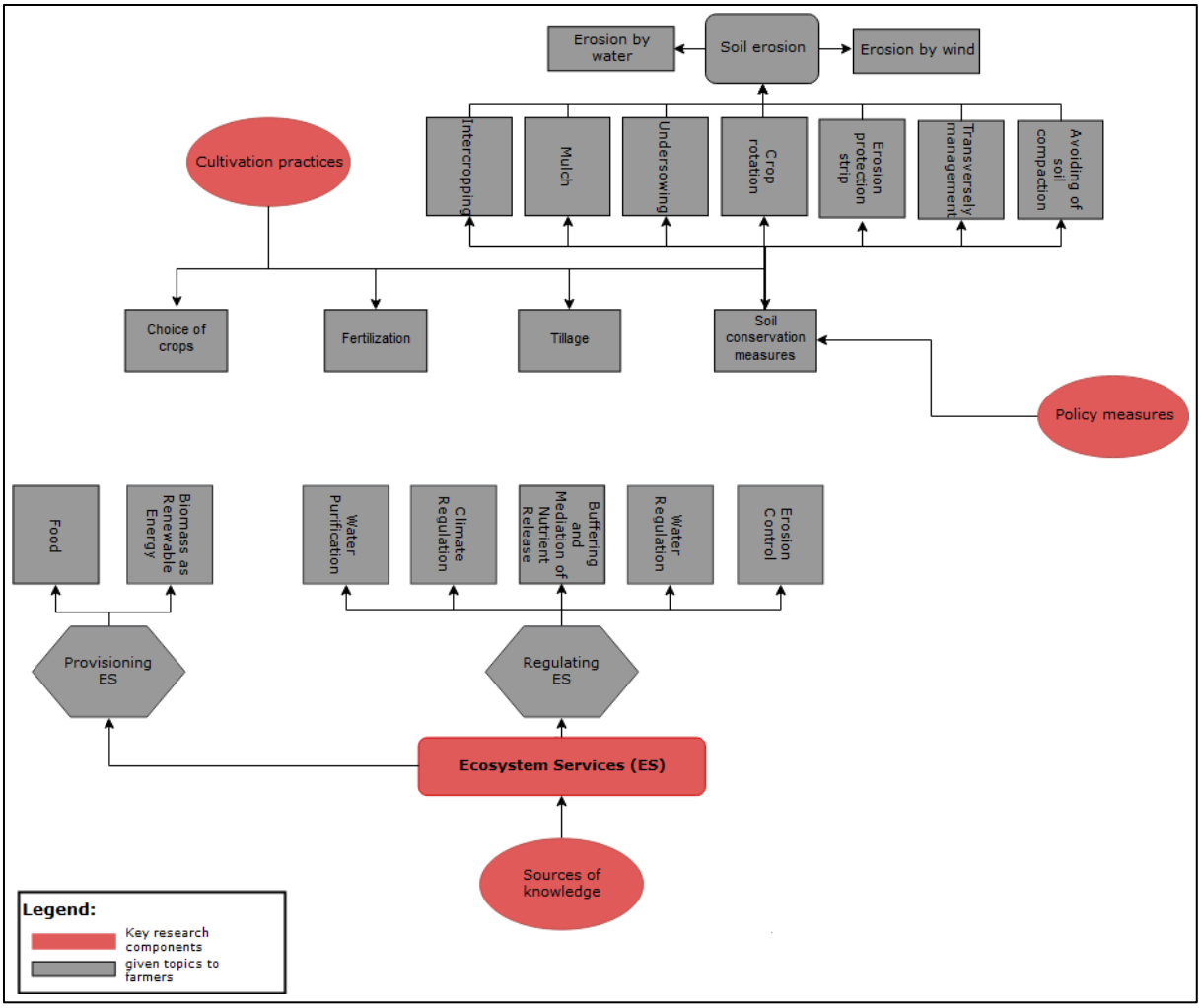


Figure 1: Conceptual Framework (Source: Own compilation based on literature review).

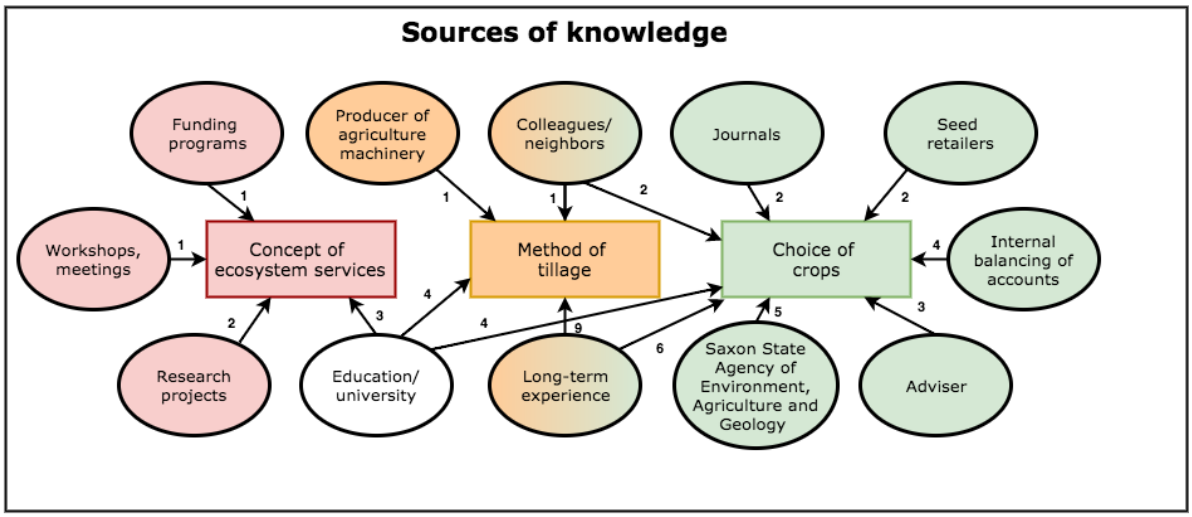


Figure 2: Sources of knowledge of farmers (Numbers are the quantity of naming) (red refers to 'Concept of ecosystem services'; orange refers to 'method of tillage'; green refers to 'Choice of crops') (Source: Ten farmers' interviews).

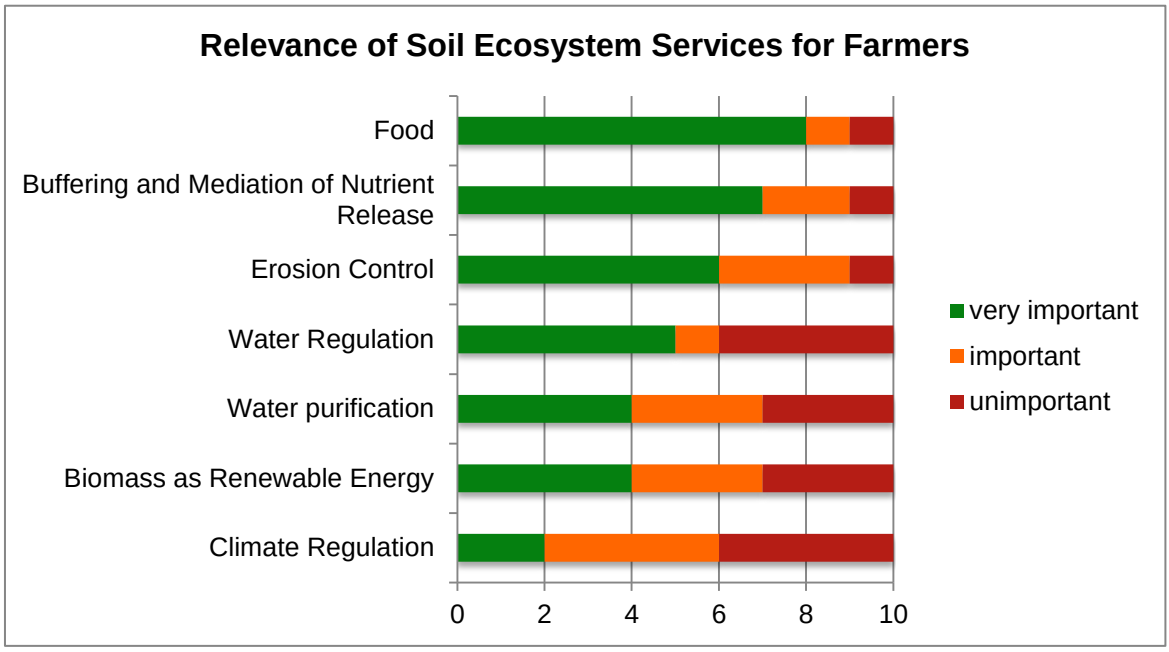


Figure 3: Relevance of soil ecosystem services for farmers (Source: Ten farmers' interviews).

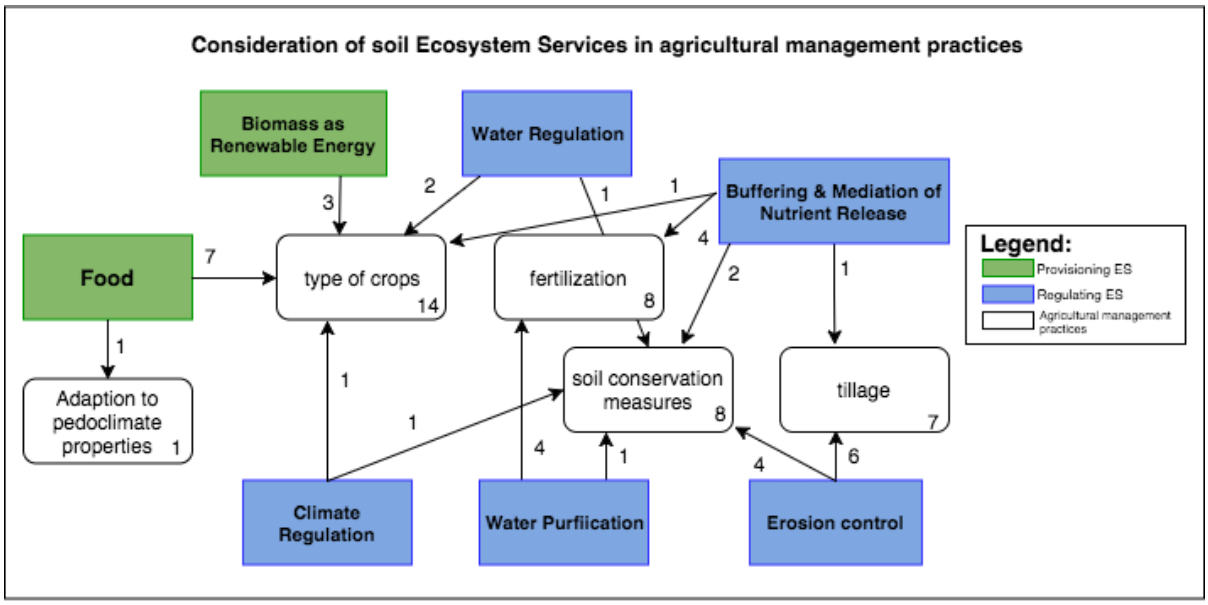


Figure 4: Consideration of soil ecosystem services in agricultural management practices (Source: Ten farmers' interviews).

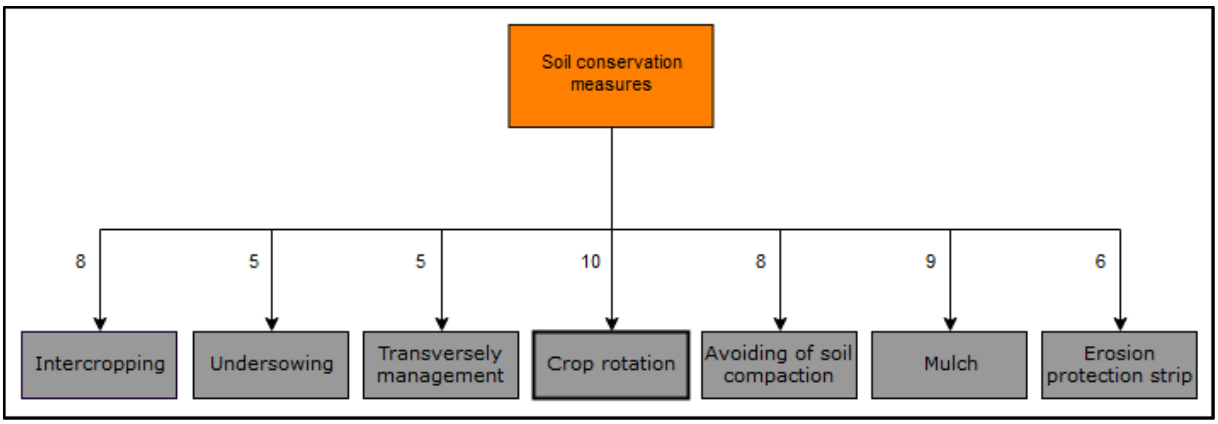


Figure 5: Practiced soil conservation measures by farmers (Source: Ten farmers' interviews).

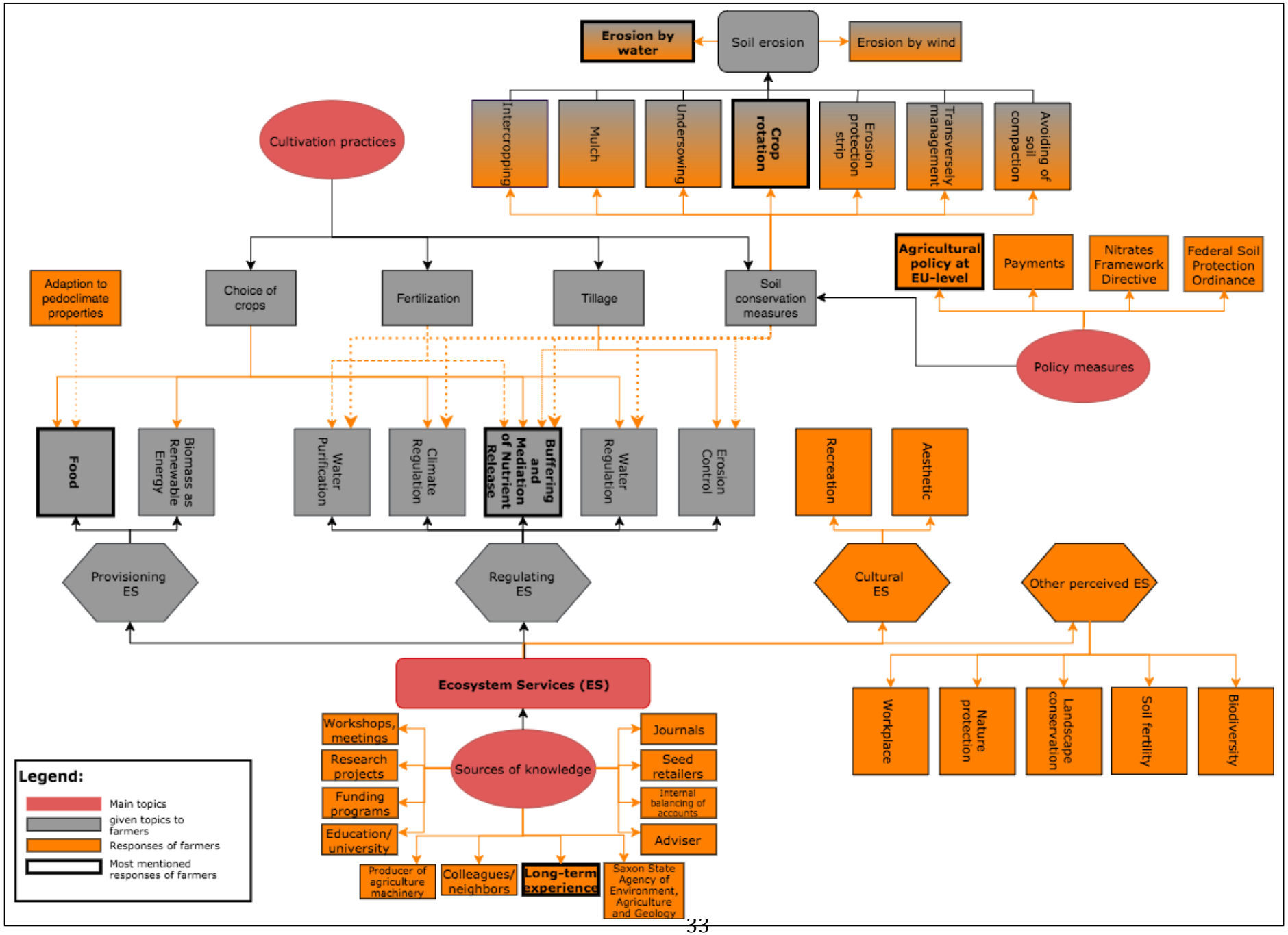
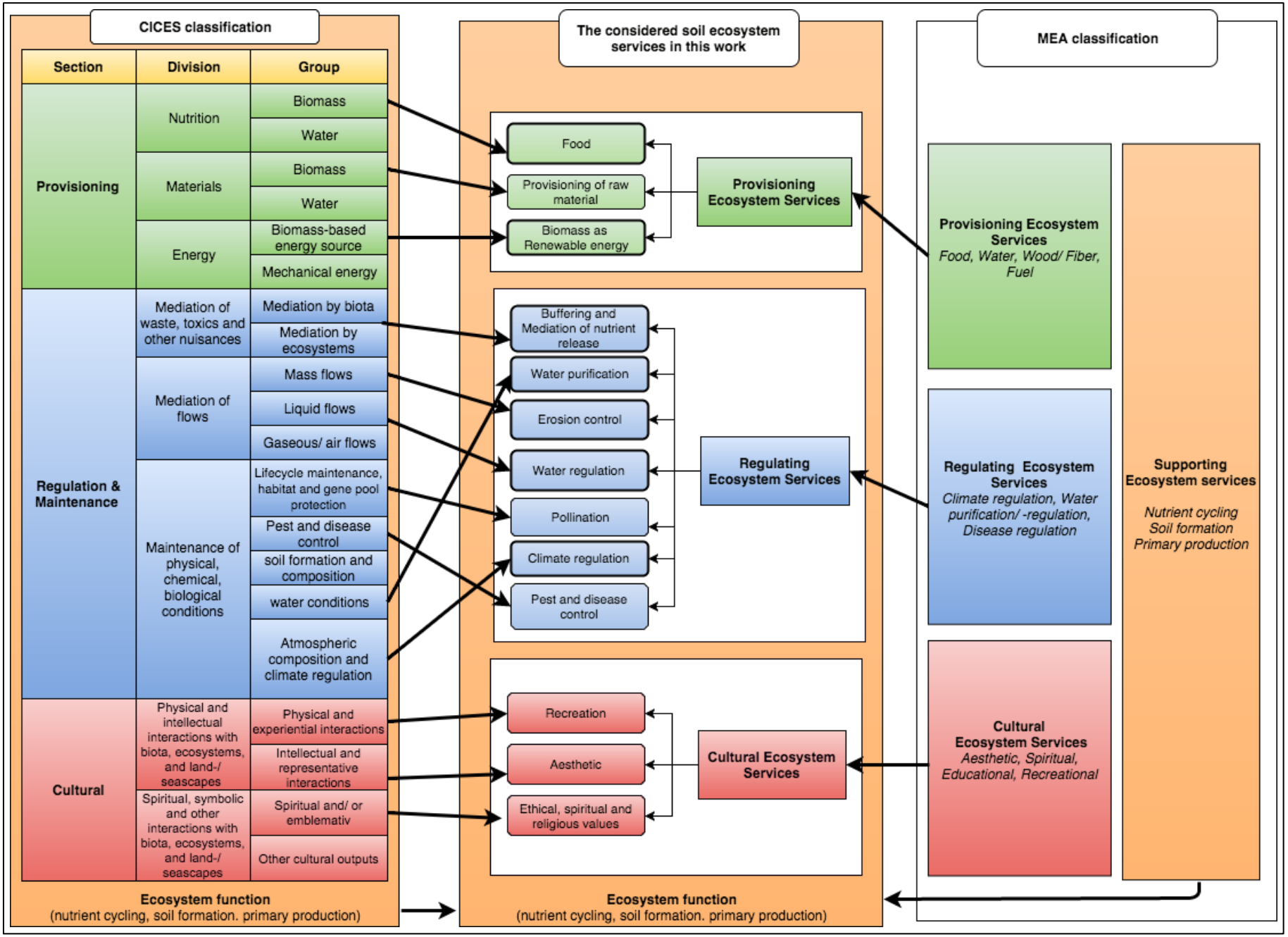


Figure 6: Modified conceptual framework (Source: Our own compilation).

Annex a: Classification of the soil ES in this work (Source: Our own compilation based on Haines-Young & Potschin, 2013; MEA, 2005).



Annex b: Classification of policy instruments

Most of the soil-related and agricultural policy instruments are "**Mandatory Instruments**" (Table A). They define norms and acceptable behavior or limit activities in society (Lemaire, 2003). Mandatory instruments can be classified into legal binding and legal non-binding instruments (Vedung, 2003). Legal binding rules such as laws and regulations have the aim of restricting behavior that has a negative impact on the environment (Albert et al., 2014). The actors are threatened with sanctions if the laws have been broken (Kutter et al., 2011). The criticisms of these instruments are that they are inflexible and they do not take regional conditions into consideration (Henke, 2007). The CAP, Nitrates Framework Directive and Water Framework Directive (WFD) are the most important instruments for protecting soil and ES at the EU-level (Turpin et al., 2017). In Germany the "[…] Federal Soil Protection Act is the only policy measure that directly targets soil conservation" (Prager et al., 2011: 217).

Incentive-based Instruments are voluntary based instruments that offer financial incentives for the implementation of environmental protection measures (Trommler et al., 2013). Direct payments (Prager et al., 2011), payments for compensation, subsidies or environment taxes are examples of financial incentives (Möckel et al., 2014). Direct Payments are the most important funding program in Germany (BMEL, 2015b). Each state in Germany implements a Rural Development Program (RDP) based on EU-Regulation. Each RDP varies in its specific design. It contains general objectives and measures to maintain soil quality. Together with AECM they are part of the second pillar of the CAP. These instruments are very popular amongst farmers (Prager et al., 2011) because they are particularly efficient and cost-effective (Trommler et al., 2013). But AECM underlies the criticism that they are lacking in the provision of additional ES because of their design and implementation at the local level (Meyer et al., 2016).

The aim of **informational Instruments** is to provide stakeholders with information about the consequences of their actions (Henke, 2007) and to counsel them about the adaption of soil conservation measures. Awareness and understanding of stakeholders should be increased thereby (Prager et al., 2011). Informational instruments are necessary for the successful implementation of mandatory and incentive-based instruments because they distribute information between local stakeholders (Prager et al., 2011).

Annex c: Soil-related and agricultural policy instruments at the European, national (Germany) and regional (Saxony) level (Our own compilation based on Frelih-Larsen et al., 2016; Prager et al., 2011; Möckel, 2015; Glaesner et al., 2014; Oppermann et al., 2013; Schröter-Schlaack & Blumentrath, 2011; Pfaff, 2010; Henke, 2007; Turpin et al., 2017).

level	Policy Instruments			
	Mandatory Instruments		Incentive-based Instruments	Informational Instruments
	Legal binding	*Legal non-binding*		
EU-level	• Nitrates Framework Directive • Placing of Plant Protection Products on the EU Market • Framework for Community Action to Achieve the Sustainable Use of Pesticides • European Eco-Regulation • GMO Directive • Pesticide Framework Directive • Common Agriculture Policy ➢ European Agricultural Fund for Rural Development ➢ European Financing, Management and Monitoring of the Common Agriculture Policy ➢ Common Rules for Direct Support Schemes ➢ European Common Organization of the Markets in Agricultural Products • Environmental Impact Assessment Directive • Habitat Directive • National Emission Ceilings for Certain Pollutants • Environmental Liability Directive • Air Quality Framework Directive • Conservation of Wild Birds Directive • Sewage Sludge Directive • Water Framework Directive	• EU-Thematic Strategy for Soil Protection • Biodiversity Strategy 2020 • Environmental Action Program • EU Strategy on Adaptation to Climate Change	• Greening Direct Payments • Natura-2000 Payment for Compensation • Cohesion Fund • European Regional Development Fund • European Social Fund • Horizon 2020 • LIFE Program • Certification systems	• Eco Labels • Environmental Report • IPBES reports • Soil Atlas of Europe

	• Groundwater Directive • Surface Water Directive • Floods Directive • Water Quality Standards Directive • European Renewable Energy Directive • Carbon Storage Directive			
National level - Germany	• Federal Soil Protection Act • Federal Soil Protection Ordinance • Groundwater Ordinance • Surface Water Ordinance • Federal Water Act • Regional Planning Act • Town and Country Planning Code • Federal Nature Conservation Act • Federal Emission Control Act • Federal Emission Control Ordinance • Farmland Consolidation Act • Federal Nitrates Law • Plant Protection Law • Direct Payment Implementation Law	• National Sustainable Strategy 2020 • National Strategy for Biological Diversity • National Action Program for Plant Protection • National Action Program for Biomass • Energy Strategy	• Direct Payments • Joint Task for the Improvement of Agricultural Structures and Coastal Protection • Environmental taxes • Payments for Compensation	• Eco Labels • Environment Report • Information about Environmental Law
Regional level - Saxony	• Saxon Water Resource Law • Saxon Nature Conservation Act • Federal level spatial plan • Land use plan		• LEADER • ILE • Development program for rural areas	• Extension services • Field trials and information by State Federal Office for Agriculture, Environment and Geology • Information about Environmental Law

Annex d: Questionnaire1

1. Since when does this farm exist?
2. What is the total area of this farm?
    a. How high is the share of arable land?
    b. How high is the share of grassland?
3. What kind of farm is it?

    o_1 family farms o_2 cooperatives o_3 others_____

4. What are you practicing on the farm?

    o_1 pure agriculture o_2 livestock and arable farming o_3 others_____

5. What kind of cultivation is it?

    o_1 conventional o_2 organic o_3 others_____

6. To what extent have you heard anything about the concept of Ecosystem Services?
7. Where did you hear about this concept?

If they do not hear anything about the concept of Ecosystem Services, I will give a short explanation and ask them again, if they hear in this context anything about the concept of Ecosystem Services.

8. Which Ecosystem Services related to soil are known to you?

    o_1 Food
    o_2 Biomass as Renewable Energy
    o_3 Climate Regulation
    o_4 Water Regulation
    o_5 Water Purification
    o_6 Erosion Control
    o_7 Buffering and Mediation of Nutrient Release

9. Are there further Ecosystem Services that are known to you?
10. Please order the Ecosystem Services according to their significance to you?

	very important	important	unimportant
Food	o_1	o_2	o_3
Biomass as Renewable Energy	o_1	o_2	o_3
Climate Regulation	o_1	o_2	o_3
Water Regulation	o_1	o_2	o_3
Water Purification	o_1	o_2	o_3
Erosion Control	o_1	o_2	o_3
Buffering and Mediation	o_1	o_2	o_3

[1] A shortened version of the questionnaire. Only the questions that were analyzed in this paper, were listed.

of Nutrient Release

11. Why are these Ecosystem Services highly relevant to you?
12. How do you take these Ecosystem Services into consideration for your farm management?
13. What are the sources of knowledge regarding which method of tillage is the best for you?
14. What kind of fertilizer do you use?

    o_1 mineral fertilizer o_2 organic fertilizer o_3 others_____

15. Do you have problems with erosion on your land?

    o_1 Water erosion o_2 Wind erosion

    o_3 no problems with erosion o_4 others_____

16. Which conservation measures are you implementing to protect against soil erosion?

    o_1 Mulch o_2 Crop rotation

    o_3 Intercropping o_4 Undersowing

    o_5 Transversal Management o_6 Avoiding of soil compaction

    o_7 Erosion protection strips o_8 others_____

17. What kind of political instruments have an influence on your decision to apply technical measures for soil conservation?
18. Which policy instruments that are responsible for the implementation of soil conservation measures do you seen as sensible?
19. In your opinion, which incentives would have to be introduced for you to more readily take the Ecosystem Services into consideration for your farming practices?

Annex e: Selected central questions of the interview.

Topic	Central questions
Concept of ecosystem services	• To what extent have you heard anything about the concept of Ecosystem Services? • Which Ecosystem Services related to soil are known to you? • Are there further Ecosystem Services that are known to you?
Sources of knowledge	• Where did you hear about this concept? • What are the sources of knowledge for deciding which crop you should choose? • What are your sources of knowledge, for deciding, which method of tillage is the best for you?
Relevance and consideration of ecosystem services	• Please order the Ecosystem Services according to their significance to you? • Why are these Ecosystem Services highly relevant to you? • How do you take these Ecosystem Services into consideration for your farm management? • Which conservation measures are you implementing to protect against soil erosion?
Policy measures	• What kind of political instruments have an influence on your decision to apply technical measures for soil conservation? • Which policy instruments that are responsible for the implementation of soil conservation measures do you seen as sensible? • In your opinion, which incentives would have to be introduced for you to more readily take the Ecosystem Services into consideration for your farming practices?