Transformation towards more sustainable soil management on Dutch arable farms

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Terms of Reference
This report is commissioned by Wageningen Plant Research. The commissioner has given permission for this report to be read by all parties that have been involved with the research. In this report a Sustainable Soil Framework was developed as a solution to the problem that not enough sustainable practices are applied within Dutch arable agriculture. The methods included a literature review and interviews done with farmers, experts, land funds and provinces.

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Executive summary

Currently a debate is ongoing in the Netherlands on how to increase soil sustainable management in general and specifically in short term lease. Sustainable practices may not be adopted by farmers because of an interplay between EU, national and provincial legislation, short-term land lease system, and social and economic aspects. Wageningen Plant Research requested students from Wageningen University to research this topic. The purpose of this project is to develop a Sustainable Soil Management Framework that integrates the legislation, economic and social factors, and Ecosystem Services in order to enable farmers to adopt sustainable soil management practices.

Through a literature study key issues were collected on each of the aspects in the framework. Semi-structured interviews were conducted with farmers, land funds, provinces and experts. The interviewees provided additional key issues as well as input to potential solutions to those issues.

The main key issues concern the absence of an evaluation and rewarding system of sustainable practices within lease agreements, the (short) duration of lease agreements, and insufficient knowledge transfer and exchange on soil sustainable management practices between farmers and other stakeholders. Based on these main key issues we propose a set of solutions for each aspect within the Sustainable Soil Management Framework.

Executive summary (in Dutch)

Momenteel is in Nederland een debat gaande over hoe duurzaam bodembeheer kan worden verhoogd, zowel in het algemeen als met het oog op korte termijn pacht. Duurzame praktijken worden door boeren mogelijk niet aangenomen door een wisselwerking tussen EU, nationale en provinciale wetgeving, korte termijn pacht, sociale en economische aspecten. Wageningen Plant Research heeft studenten van de Wageningen Universiteit gevraagd om dit onderwerp te onderzoeken. Het doel van dit project is het ontwikkelen van een Duurzaam Bodembeheer Kader dat de wetgeving, economische factoren, sociale factoren en ecosysteemdiensten integreert om boeren in staat te stellen praktijken aan te nemen op het gebied van duurzaam bodembeheer.

Door middel van een literatuurstudie werden sleutelkwesties verzameld over ieder aspect in het Kader. Semigestructureerde interviews werden vervolgens uitgevoerd met boeren, landfondsen, provincies en experts. De geïnterviewden benoemden aanvullende sleutelkwesties en gaven input voor mogelijke oplossingen voor die kwesties.

De belangrijkste sleutelkwesties hebben betrekking op het ontbreken van een evaluatie- en beloningssysteem voor duurzame praktijken binnen pachtovereenkomsten, de (korte) duur van pachtovereenkomsten, en onvoldoende kennisoverdracht en uitwisseling over duurzaam bodembeheer tussen boeren en andere belanghebbenden. Op basis van deze kwesties bieden we een reeks oplossingen aan voor elk aspect binnen het Duurzaam Bodembeheer Kader.

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1 Introduction

Soil is a vital source for the sustainment of life on earth and it has a low ability of regeneration (Colombo, 2011). During the last seventy years, soil degradation has increased as a result of human activity. Especially agriculture has played a large part in soil degradation (Colombo). Reduced soil fertility may obstruct the challenge to produce enough amounts and secure a high quality of foods for the growing world population (Schumacher *et al.*, 2012).

Degradation of agricultural soils is the result of agronomic practices that started with the Green Revolution in the late 60's (Basile & Cecchi, 2001). This set the basis for modern agriculture which gave way to the intensification process and specialisation of production (Friedma & McMichael, 1989). Farmers adopted multiple measures to minimise input costs, while their production increased. As a result, traditional practices were abandoned and productivity became more dependent on external inputs such as machinery, artificial fertilisers and pesticides (Altieri, 2009).

Soil degradation means loss of physical, chemical and biological properties of the soil which has a negative impact on the yield and on aspects of the environment and communities. CO_2 emissions and air pollutions are examples of this (Lal, 2011). For instance, heavy and deep tillage contributes to the increase of C mineralisation in the soil (Balesdent *et al.*, 2000). Maintenance and improvement of soil quality is necessary in order to sustain agricultural productivity (Reeves, 1997). The interest for sustainable soil management has increased in the last decades and the main focus is on the rise of soil organic matter levels (Powlson *et al.*, 2011). A definition of sustainable soil management is provided in this project. Sustainable soil management holds practices that have a positive influence on the quality of the soil, without damaging it or depleting it from natural sources. The societal interest is served here through the maintenance and improvement of soil functions. In addition, sustainable soil management provides so-called Ecosystem Services (ES). ES are defined by Boyd and Banzhaf (2007) as components of nature, directly enjoyed, consumed, or used to yield human well-being. Important ES that can be supplied through a responsible soil management are food provisioning, air quality regulation, carbon sequestration, and water purification and provision (van Oudenhoven *et al.*, 2012).

Network collaborations between farmers and research institutes allow for research findings on sustainable agriculture (Le Gal *et al.*, 2011). However, farmers have to make the trade-off between long-term investments and short-term financial benefits. As a result, farmers may not adopt a clearly recognisable strategy regarding sustainable soil management or their priorities shift over time (Darnhofer *et al.*, 2012). Often the trade-offs made by farmers are considered as unwillingness to shift towards more sustainable practices by experts.

The goal of this project stated by the commissioner is to increase the number of Dutch farmers that apply sustainable soil management practices. Multiple factors that hinder the spread of these practices among farmers are identified and researched; *the Dutch land lease system*, *the application of sustainable practices*, *legislation* and *social factors*. Moreover, *ES* (Costanza *et al.*, 1998) are considered as a tool to encourage farmers to apply more sustainable soil management practices.

Problem definition

The main problem stated for the project is that *not enough sustainable soil management is applied to leased land in the Netherlands.* Arable farmers are hindered in the adoption of sustainable soil management practices because of an interplay between current

EU, national and provincial legislation, the short-term land lease system, social and economic aspects.

Several stakeholders are found in this situation. A Stakeholder Matrix can be found in Appendix 1, Table 1. The stakeholders interplay in multiple factors; the current land lease system, the application of sustainable practices, legislation and social factors. These factors are found to be of influence on the main problem. ES are considered to be a possibility to enhance the financial and social position of farmers, which benefits the adoption of sustainable practices (Power, 2010).

Our purpose is derived from the overall goal that all leased arable land in the Netherlands is managed through the application of sustainable soil practices. The purpose is *to develop a Sustainable Soil Framework that includes ES and integrates legislation, practical, economic and social factors in order to enable farmers to adopt sustainable soil management practices.* Three provinces are chosen as the focus of this research; Groningen, Flevoland and Noord-Brabant. The provinces are chosen according to the following criteria: **1)** where both clay and sandy soil is found and a high amount of arable production in in terms of total acreage: Groningen (CBS, 2017), **2)** where the leasing system plays a major role in arable farming: Flevoland (Michielsen, 2017), **3)** both clay and sandy soil and has stated ambitions for sustainable arable farming: Noord-Brabant (Brabant.nl, 2017).

The four main topics below are taken into account. In order to address the purpose, the following research questions are answered per topic;

1a. Land lease system;

- *How can the land lease system be changed in order to support the adoption of sustainable practices by arable farmers?*
- *How can land funds maintain and improve soil sustainability through the leasing system?*

1b. To address sustainable soil management practices;

- *What are the most important indicators of soil quality and how do they affect agricultural production?*
- *Which soil practices are most practical to apply for farmers in terms of farm management and financial outcome?*
- *How do economic factors adhere to the practical application of these practices?*

1c. Policy instruments and social factors;

- *Which barriers in legislation do farmers face when they want to apply sustainable soil practices?*
- *How can social factors influence the decision of farmers to adopt sustainable practices?*
- *How can national and local level policies address the social factors that interplay in the choice of farmers to adopt sustainable practices?*

1d. Ecosystem services;

- *How do non-provisioning ES fit into the new framework?*

2 Methodology

2.1 Literature study

Based on the four main topics a literature study was done. First, keywords were identified for each topic in order to select the most appropriate articles (Table 1). The databases used for the literature search included Google (e.g. company websites), Google Scholar and Scopus. The goal of the literature study was to 1) gain in-depth knowledge about each topic, 2) identify the key issues for each topic, and 3) identify possible solutions to these problems.

Table 1. Keywords used for the literature search, divided by topic

Topic	Keywords
Sustainable management practices	Soil properties (structure, texture, soil biodiversity), soil quality indicators, management practices
Land lease system[1]	Zwarte en grijze pacht (black and grey lease), reguliere pacht (regular lease), liberale pacht (liberal lease), teeltpacht (cultivation lease), pachtprijs (lease price) and Lease law (pachtwet)
Ecosystem Services	Ecosystem services definition, trade-off between agriculture and ecosystem services, conservative management, payment for ecosystem services, benefit of ecosystem services, history of ecosystem services, ecosystem services in the Netherland.
Legislation	EU regulation on soil, soil policies in the Netherlands, sustainable soil management in the Netherlands, dutch manure policy, dutch implementation of Nitrates Directive, soil sustainability in dutch society, farmer perceptions on sustainable soil management

[1] the keywords were used in both Dutch and English language in the databases.

The results of the literature study served as input for the questions in the semi-structured interviews with the stakeholders.

2.2 Semi-structured interviews

In total, 22 semi-structured interviews were taken, of which 15 interviews were taken with farmers, one for each of the three provinces (Groningen, Flevoland and Noord-Brabant), one with Centrum voor Landbouw en Milieu (CLM), one with Nederlandse Akkerbouw Vakbond (NAV), one with land fund A.S.R, and one with land fund Stichting Grondbeheer. The same questions were used for all stakeholders. The interviews for farmers contained additional questions on their soil type, crops cultivated and land leased. Most of the interviews were done by phone, 3 were done face to face.

The goal of the semi-structured interviews was to 1) gain in-depth knowledge on the four topics examined in the literature study, 2) compare the results from the interviews with the results from the literature study, 3) identify the most important issues in practice, 4) compare the opinions of multiple stakeholders on the problem.
The results from the interviews can be found in Chapter 4.2. They have been synthesised with the findings from the literature study in the discussion (Chapter 5.1) in order to propose solutions to the problem.

Respondents

We called 18 farmers from which 15 farmers responded. The number of farmers interviewed for the provinces Flevoland, Groningen and Noord-Brabant were respectively five, five and four. A 15th farmer was interviewed in the province of Gelderland. He is a student at Wageningen University and is considered an expert in soil sustainability as well, therefore it was decided to interview this farmer. The farmers were selected based on their farm type, (e.g. conventional, organic, sustainable or a combination of these). From the group of farmers eight were conventional growers, three were certified organic growers and the remaining three were conventional growers that were certified by 'Stichting Veldleeuwerik'. The soil type differed among farmers, where the majority of farmers grew crops on clay soils (nine farmers), followed by sandy soils (three farmers), clay and sandy soils (one farmer), and clay and peat soils (one farmer). All farmers were contacted by telephone. The interviews consisted of 21 questions for the farmers and 16 questions for the other stakeholders. Since the questionnaire was semi-structured, further questions were asked during the interviews, based on the answers of the interviewees. The interview questions for the farmers and other stakeholders can be found in Appendix 5.

Coding: farmer interviews

They key issues found in the literature study were used to do preliminary coding of the interview results (Appendix 6). Five different main topics were used: land lease system, sustainable soil practices, policy instruments, social factors and ES. After preliminary coding, additional insights from the interviews were included if they were not already taken into account. Preliminary defined labels that were not found in the interviews or that were mentioned less than five times were discarded. Labels that were mentioned by interviewees five times or more were analysed in order to identify sub-labels. Once this was done, sub-labels that were found to include similar issues were regrouped. This resulted in the final list of labels that contained the most relevant information.

Processing: interviews with other stakeholders

The number of interviews that were done with the other stakeholders was too low for separate coding (two experts, two land funds, and three provinces). Therefore, the key information from the interviews with each stakeholder group was identified and summarised. The

province of Groningen was excluded from further analysis. The representative of this province provided too few answers and was found not to be the appropriate person for the topic of this research.

3 Results

This chapter includes the results of the literature review and of the interviews that were done. First, the results of the literature study are discussed based on the four factors of focus; the Dutch land lease system, socio-political factors, sustainable soil practices and ES. Then, the results and conclusions from the interviews are presented. They include the interviews with farmers, land funds and experts and provincial governments. The results of the interviews are divided in key topics.

3.1 Literature review

3.1.1 Land lease system

Currently a debate is ongoing in Dutch government whether or not short-term lease improves sustainable soil management (Van Dam, 2017). Short-term land lease contracts may provide little stimulation to farmers to apply soil sustainable practices, as any long-term investment in the soil will not favour them (Van Dam, 2017). By contrast, farmers that have access to land for a longer period of time may be more inclined to invest in improvement of the soil. According to the Dutch government, the primary responsibility for sustainable soil management lies with the landowner and not with the government (Ministry of VROM *et al.*, 2006). However, specific regulations with regard to soil sustainability have not been implemented in lease agreements until now. In general, hardly any policies are found on sustainable land management within lease agreements of private land funds. However, efforts such as a sustainable soil label and a Soil Passport are put into place by land funds and farmers organizations to relate soil status to land lease (A.S.R., 2016; ZLTO, 2016). Furthermore, nature organisations currently make use of short-term lease agreements in which additional management arrangements are made (Van Dam, 2017). This indicates that landowners can have a large influence on how land is used.

The following paragraphs elaborate on the history and functions of the land lease system in the Netherlands specifically. Appendix 2 provides an overview of the land lease systems in other European countries.

Lease law and types of lease in the Netherlands

Until the introduction of the Lease Act 1937 on 1st November 1938, lease agreements fell under the rental terms from the Civil Code of 1838 (Federatie Particulier Grondbezit, 2011). The Lease law was revisited in 1958, changed in 1984 and 1995 (e.g. inclusion of one-time lease and cultivation lease) and rewritten in 2007 (Rijksoverheid, 2007). Currently, the Dutch land leasing system distinguishes regular lease, liberal lease, cultivation lease, and leasehold (RVO, 2015). What follows is a description of the different lease forms (RVO, 2015; Federatie Particulier Grondbezit, 2011):

- Regular lease is possible for all lease objects. The legal term is six years for the land and 12 years for a farm. Regular lease is extended automatically every six years (continuation right) and does not end when the tenant becomes 65 years old or dies. It acknowledges that the tenant has the first right to buy the leased land in case it is sold by the tenant (preferential right). The tenant is to be compensated for value added by the end of the agreement (melioration right). A price limit is bound to regular lease;

- Liberal lease is more flexible than regular lease. The term of the lease is not legally determined and continuation right, preferential right and melioration right do not apply to this type of lease. When liberal lease contracts are longer than six years the Land Control Board (Grondkamer) evaluates the lease price according to the lease pricing standards. No evaluation is done for liberal lease contracts shorter than six years. In such case the tenant and the landlord can agree on a lease price without being bound to maximum lease prices.
- Cultivation lease can be used for crops that require crop rotation (e.g. potatoes, bulbs or sugar beets). The legal time duration is one or two years and depends on the crop rotation necessary per specific crop. No evaluation is done by the Land Control Board and continuation right, preferential right and melioration right do not apply to Cultivation lease.

Two illegal lease forms exist (Boerderij, 2012; Federatie Particulier Grondbezit, 2011); grey lease and black lease. Grey lease is a lease agreement that has not approved by the Land Control Board and black lease is solely a verbal agreement.

An alternative to the possibilities that the Lease law provides is leasehold (erfpacht). In contrast to the fact that the tenant has a personal user right within the Lease law, he has (limited) business right in leasehold. The right of leasehold may be alienated to a third party and used as collateral for mortgages (Federatie Particulier Grondbezit, 2011).

History of land lease in the Netherlands

The first sign of a land lease market in the Netherlands originates from the 13th century (Bavel, 2008). Contrary to the eastern part of the Netherlands, the western and central part had no manorial/feudal influence at the time. Communal elements in farming had always been absent or had been disappeared, whereas in the eastern part the peasant structure was relatively strong. It is in the western and central part where the government started to exercise major influence on the organisation of the land market. Short term lease appeared more frequently from the 14th century onwards (Bavel, 2001). By the end of the 16th century the total land leased out could be as high as 90% for the Guelders river area, Frisian sea clay areas, and river clay area of Salland. The average acreage of land leased out was 60%, where Drenthe was among the areas with the lowest amount of land leased (25-35%) (Gelderblom, 2016).

In 1959 almost 52% of the total agricultural land in the Netherlands was leased as opposed to 29% in 2011 (AgriHolland, 2015). The total acreage of leased land in the Netherlands has declined between 1985 and 1999 (Table 2), then rose to some 40% in 2007 (Table 3). After 2007, the number dropped due to legislative barriers. The number has been stable around 30% leased land during recent years (Agriholland, 2015). In 2005, most of the arable land owned was in the province of Groningen and the least in the province of Flevoland (Ministry van LNV, 2009a and 2009d). In the provinces Noord-Brabant, Drenthe, Friesland, Gelderland, Overijssel, Utrecht and Zuid-Holland farmers owned about 60% of land and leased an additional 26% of land (Ministry van LNV, 2009a, 2009b and 2009c). The amount of black lease increased severely between 1995 and 2011, accounting for some 14% of the total agricultural lands (Boerenbusiness, 2012). The largest private land fund is the insurance company A.S.R., the Dutch government together with Staatsbosbeheer is the largest landowner in the Netherlands (AgriHolland, 2015). Investment funds see land as a solid long-term investment with low risks (EUFIN, 2015; AgriHolland, 2015).

Table 2. Development of leased and owned land in the Netherlands

Year	Owned (in ha*)	Leasehold (in ha)	Lease (in ha)	Other (in ha)	Total (in ha)	Owned (%)	Lease (%)
1985	1.220.275	55.355	726.727	16.667	2.019.024	60,4	36,0
1987	1.231.960	63.526	699.610	19.168	2.014.264	61,2	34,7
1990	1.274.891	67.518	629.961	33.238	2.005.608	63,6	31,4
1993	1.278.208	75.445	606.404	27.266	1.987.323	64,3	30,5
1995	1.287.208	74.445	561.558	41.536	1.964.747	65,5	28,6
1997	1.287.277	111.830	538.488	27.526	1.965.121	65,5	27,4
1998	1.289.848	105.583	547.149	30.177	1.972.757	65,4	27,7
1999	1.278.591	96.016	558.981	33.360	1.966.948	65,0	28,4

*ha = hectare.

Adopted from Kloet et al. (2000)

Table 3. Distribution of EU states according to the share of leased land in 2007

Share of leased land	State of the EU
15–30%	Ireland (16.5%); Poland (27.5%); Denmark (28.3%)
30–45%	Austria (31%); Slovenia (31.8%); Portugal (31.8%); Spain (33.6%); Finland (34.8%); Italy (38.8%); Netherlands (40.3%); Romania (41.5%); Great Britain (42.6%); Greece (43%); Latvia (44.6%)
45–60%	Luxembourg (50.7%); EU (52.5%); Sweden (53.4%); Estonia (59.8%);
60–75%	Lithuania (60.1%); Cyprus (64%); Hungary (67.2%); Germany (70.5%); Belgium (74.1%)
75–90%	Malta (81.2%); France (84.5%); Czech Republic (87.9%); Bulgaria (89%)
above 90%	Slovakia (96.3%)

Adopted from Střeleček et al. (2011).

Lease functions

Land lease fulfils an economic function. Landowners who do not want to manage their farmland themselves connect with farmers who want to farm more than they own. Such a commitment will only be achieved when both parties can take advantage from it (Kloet et al, 2000). Advantages of leasing land are that no start-up capital is required and it provides a certain degree of flexibility to agricultural companies (e.g. crop rotation) (Bruil, 2014).

Lease law

The current land lease system in the Netherlands is called ambivalent (Bruil, 2014). A summary of critique was reported by Bruil (2014):

The legislator has undermined the legitimacy of regular lease with liberal lease;

- Inequality exists between tenants and starting or expanding agricultural entrepreneurs;
- Inequality between tenants and owners;
- A strong increase in gray lease;
- A difference in the freedom in lease terms. As contracts until six years are free, contracts between six and 26 years are strictly regulated, while contracts longer than 26 years (leasehold) are quite freely regulated;
- Different lease prices in regular lease agreements made before and after 2007.

Lease price
In the Netherlands, the prices of regular lease are controlled by the government. However, such control does not exist for the price of land, maximum leasehold prices or for short term liberal lease. Advantages of lease price control would be that farmers do not pay too much for lease land, as the prices in the land lease market have already increased from 600 to 1.500 euros per hectare (Bruil, 2014). Within the EU large differences exist as well. In 2007 the average lease price was 813 euros per hectare in the Netherlands compared to the EU average of 150 euros (Střeleček et al., 2011). In 2014 almost 12% of all the farmers in the Netherlands leased at least 50% of their cultivation land through regular lease. These farmers are likely to have problems when lease prices are liberalised.

In case of excessive short-term lease contracts, farmers can become more vulnerable to price increases and loss of area. This can affect a financial equity of a farmer and result in fewer investments made on sustainable soil management (Bruil, 2014). An unequal playing field is noticeable between private landlords and institutional and governmental landlords.

3.1.2 Socio-political factors

Legislation
EU level
A European soil policy was introduced with the sixth EU Environmental Action Programme (2002- 2012). Soil, contrary to air or water, had not been systematically addressed on EU level before this Action Programme was implemented. The Soil Thematic Strategy was published by the EU in 2006 together with a proposal for a Soil Framework Directive (SFD). This SFD, however, was released in 2014 because member states could not reach a consensus. The Netherlands was one of the member states that opposed to the measures on grounds of proportionality, subsidiarity and costs associated with the implementation of the Framework (Withana et al., 2010). The seventh EU Environmental Action Programme (2014-2020) was introduced in 2014 with the goal that by 2020 land will be managed sustainably, soil will be protected adequately and contaminated sites will be remediated. This ongoing programme commits member states to increase their efforts to reduce soil erosion and increase soil organic matter, as well as rehabilitate contaminated areas.

Although currently no legislation exists at the EU level that focuses on soil specifically, several other European Regulations and Directives do impact important soil functions in agricultural ecosystems (e.g. the Nitrates Directive, industrial emissions, water framework, GAEC measures in CAP). However, the impact of most of these policies on soil function, positive or negative, usually is not established. It depends on how the policy is implemented by local authorities and the farmers (Vrebos *et al*, 2017). Especially through the European Agricultural Fund for Rural Development (EAFRD), regions have a wide range of management options to choose from that can have an effect on soil functions. As a result, it can be expected that Rural Development Policies (RDPs) have significant effects on soil functions, dependent on the interests of the region in question. How much money of the EAFRD is spent on the designated priorities related to soil functions and which measures are funded, is decided by national and/or regional authorities (Vrebos *et al.*, 2017).

National policy
In the Netherlands, the Soil Protection Act was the first national initiative for soil preservation in Europe. However, this Act holds a limited number of mandatory requirements relevant to farming, whereas incentives rely on side effects of practices on soil. In addition, most of the environmental stakes considered are EU-driven. Agricultural soils seem to receive low priority after water quality, biodiversity, and climate change. No clear policy towards sustainable soil management is stated (Turpin et al., 2015). Does the government

want arable farmers to intensify and produce to compete on the world market or to preserve nature and enhance sustainable food security (Sanders et al., 2015)?

The provincial governments differ in their ambitions and regulations for future development. What is clear is that all three provinces (Groningen, Flevoland and Noord-Brabant) adopt the common EU policy for sustainable development in the period 2014-2020, but the local implementation of this sustainable development differs.

The Dutch manure policy is derived from the EU Nitrates Directive (Europese Nitraatrichtlijn) in an effort to address the manure problem which has been on the political agenda for many years due to the conflicting objectives within society. This directive holds agreements on the amount of nitrate and phosphorus allowed in groundwater and surface water (RVO, 2017). In order to achieve the objective of the EU Nitrates Directive, measures have been taken with regard to fertilisation (RVO, 2017). Among other things, the period in which fertiliser (N and P) and manure can be applied, as well as the method and amount of application, has been specified. For arable land 170 kg N per ha is allowed. Slurry must be injected into the soil. Tractor spraying is popular for foliar application of fertilisers (except N and P). A minimum soil cover must be maintained. Based on the size (>30 ha) of the farm, a minimum of three different crops are required to maintain diversification. Management practices such as crop rotation and shallow tillage have been encouraged which is beneficial for soil health and reduce the input cost.

Possible impacts on socioeconomic strength and viability of the agricultural sector need to be considered to allow for gradual adaptation by the farmers (CSD-16/17 National Report, UN). Recent research by Lauwere *et al.* (2016) indicates that arable, dairy and pig farmers think it is good that a manure policy exists and that they have the intention to accurately follow the policy, even when it is further tightened. However, many find that the practical implementation of the manure policy has not been thought through by policymakers. Solutions put forward by these farmers include simpler and more flexible manure legislation (Lauwere *et al.*, 2016). A possible direction of policies for sustainable soil management is to reward sustainability efforts that farmers make instead of applying regulations and financial penalties. An example of such rewards is to use a bonus point system. This mechanism allows farmers to earn bonus points upon efforts made in terms of sustainability on their soils. Such a system has been put into use in Germany, where the quality of the soil is connected to bonus points, upon which (among other things) the price of land is determined (Boerenbusiness, 2017).

Social aspects

Even though people in their effort to manage natural resources have engaged in forms of collective action for a long time already, development assistance has paid too little attention to how social and human capital affects environmental outcomes (Pretty & Ward, 2001). When farmers consider to adopt sustainable practices on their farm, multiple factors interplay. Governmental policies, financial capital, entrepreneurial risk and farmer characteristics (*e.g.* age, education level, management skills) are of influence (De Buck *et al.*, 2001). Apart from economic drivers, the social capital includes heritage, family factors, social cohesion, relationships with change agents and cultural image such as appreciation from rural communities. The term “social capital” captures the idea that social bonds and social norms are an important part of the basis for sustainable livelihoods (Pretty & Ward, 2001).

Farmers’ decisions on land management are certainly affected by nature conservation and environmental programs and schemes. in addition, other factors range from municipality

regulations to general norms in the society (Ahnström *et al.*, 2009). Since the public sector is not the only actor that shapes farmers' decision-making, environmental governance seems to be the answer to the growing concern about degrading environmental quality, depletion of resources, biodiversity loss and climate change. such environmental governance adheres to an interaction between actors on state level, the market and civil society (Driessen *et al.*, 2012).

With shortcomings of the present visions on agriculture and farming systems, it is a social, ecological and economic challenge to develop a multifunctional agriculture that does not only focus on maximum production. According to Vereijken, multifunctional agriculture implies the integration of plant and animal production with environmental care (management of water, soil and air, notably control of emissions), conservation of nature and agro-historical landscape, control of climate and the effects of global warming (CO2 -storage, biomass for energy, water retention) and care of health and well-being (including tourism and recreation) (Vereijken, P. H. ,2003). However, farmers' methods of production should and can match the demands of society in terms of sustainability for both, farming systems that are used in a monofunctional way (production only) and multifunctional farming systems (Meerburg *et al.*, 2009).

Network collaborations between farmers and research institutes allow for research findings on sustainable agriculture to be transmitted to farmers in the Netherlands. For instance, the advisory services of Agricultural Knowledge and Information System (AKIS) support collaboration and network enhancement. In this system farmers are involved in research through trial plots and observation that facilitates knowledge sharing. Some of the main reasons for this success is the high literacy rate of farmers and their consent to pay for advisory services (Caggiano, 2014). In such manner farmers gain influence on research planning and better acceptance of research is ensured. DLV (Dienst LandbouwVoorlichting) offers such services, although the privatisation of this formerly state-owned service provider has brought down the number of farmers that appeal on their services. Farmers' associations such as LTO and NAV and product boards play important roles in technology adaptation as well.

3.1.3 Sustainable soil practices

Application of practices

Conservation practices and organic practices in agriculture require reduced to no chemical and tillage inputs. Therefore such practices can be more energy efficient and have less impact on the environment (e.g. minimum soil disturbance because of minimum tillage, Integrated Crop Management (ICM), Integrated Pest Management (IPM)). However, in terms of cost-benefit ratio these practices do not ensure rapid turnover. Therefore, sustainable soil management should be considered as an investment for future productivity (Gruhn et al., 2000). Despite the usefulness of the technology, an adoption gap in sustainable agricultural practices is evident (De Buck et al., 2001; Farooq & Siddique, 2015). Dutch farmers have to abide by EU, state and provincial policies. Moreover, conservation practices do not produce immediate effects such as cash crops (Rodriguez et al., 2009). Incompatibility with ongoing field operations impose further money and labour investment. In addition, they encounter economic barriers. However, although economic barriers are considered to be one of the main constraints, they provide a strong incentive for technology adoption as well. Finally, geographical location and physical characteristics of the farm affect adoption of technology (Carlisle, 2016).

Soil quality

Six components of soil quality management exist (Appendix 3, Table 1); enhancement of organic matter, avoid excessive tillage, management of pest and nutrient efficiency, prevention of soil compaction, grow cover crops and diversify cropping systems. In addition to these categories, management of the groundwater is crucial for a healthy soil. The adequate management of water depends per situation.

In general, soil quality encompasses *fitness for use* and the *capacity of a soil to function*. Soil quality is the ability of the soil to retain and to release nutrients and water in order to support both biological activities and root growth without degradation (Acton & Gregorich, 1995; Larson & Pierce, 1994). Soils should have the ability to sustain human and animal life along with their habitats through the maintenance of air and water quality (Karlen *et al.*, 1997).

Doran and Parkin (1994) propose the following specific criteria for soil quality indicators: they should 1) include ecosystem processes and models related to those processes, 2) encompass soil properties (physical, chemical, biological) and processes, 3) be easily accessible and applicable, 4) respond to climate and management variations, and 5) be chosen from already available data bases if possible.

Gregorich et al. (1994) emphasise ease and reproducibility of indicator measurements. In addition, the sensitivity of the indicators should be enough to respond to any changes due to anthropogenic activities (Arshad & Coen, 1992). An overview of the key soil indicators is provided in Appendix 3, Table 2. Some soil indicators can affect the value of other indicators (Table 4).

Table 4**.** Interrelationship of soil indicators

Selected indicator	**Other soil quality indicators in the multidimensional scaling (MDS) affecting the selected indicator**
Aggregation	Organic matter, microbial (especially, fungal) activity, texture
Infiltration	Organic matter, aggregation, electrical conductivity, exchangeable sodium percentage (ESP)
Bulk density	Organic matter, aggregation, topsoil-depth, ESP, biological activity
Microbial biomass and/or respiration	Organic matter, aggregation, bulk density, pH, texture, ESP
Available nutrients	Organic matter, pH, topsoil-depth, texture, microbial parameters (mineralisation and immobilisation rates)

Source: Arshad & Martin (2002)

Economic factors

Farmers are struggling to keep up a viable turnover against the demand of cheap food inflicted by consumers, retail and policy makers. Three principal investments or costs that hinder the adoption are identified; *opportunity costs* for changing cash crops, *fundamental investments* for machinery or infrastructure *continuous investment* for materials, labour and management (Snapp *et al.*, 2005). Opportunity costs are considered the main barrier for adoption of sustainable practices. Furthermore, uncertainty of profit margin and labour supply, changing the farm policies and setup for new management practices and perception of reduced yield make farmers reluctant to adopt new practices. Many sustainable practices take a few years to have visible environmental improvements. Farmers are inclined to adopt management practices that have direct and rapid impact regarding crop production and market demand (Wauters *et al.*, 2010). Large farmers with higher capital and capacity are more likely to adopt sustainable practices as they have the financial ability for initial investments and resilient to potential losses or slow turnover (Carlisle, 2016).

3.1.4 Ecosystem Services

Agricultural practices influence the level of food production to be achieved, as well as the environment on a whole. Unsustainable intensive practices can cause loss of the natural ecosystem (Figure 1). Although agriculture is considered to be responsible for many environmental issues such as loss of biodiversity, loss of soil organic matter and fertility, the sector can provide benefits for the environment and the community in the form of ES (Costanza *et al.*, 1998). The ES as defined by Boyd and Banzhaf (2007) are components of nature, directly enjoyed, consumed, or used to yield human well-being. In the TEEBAg framework (2015) to assess ES value, three different categories are defined; *Provisioning services*, (e.g. food production) *Regulating and maintenance services* (on how the entire ecosystem mediates and moderates the environment that affects human performance) and *Cultural services* (the cultural heritage provided by food production and consumption). Agroecosystems are considered the main source of provisioning services (MEA, 2005). The capacity of agricultural lands to provide ES is largely influenced by human management and the management is influenced by the balance between short and long-term benefits. However, almost no marketing tools have been applied to translate the effect of ES on the outcome of food and goods (Dale & Polasky, 2007).

According to Wesem (2013) the role of the ES in the Netherlands is associated with the landscape management; the ES concept is seen as a tool for enhancing biodiversity, creating more sustainable regional development plans, and, most importantly, for getting the involvement of much broader stakeholder groups. He also claims that the Netherlands not only have a high demand for various ES and a desire for multifunctional land use, it also has a long tradition of consensus-seeking. Moreover, ES concept in the Netherlands gains a central role in developments of Ecological Risk Assessment methods (Faber & Van Wensem, 2012).

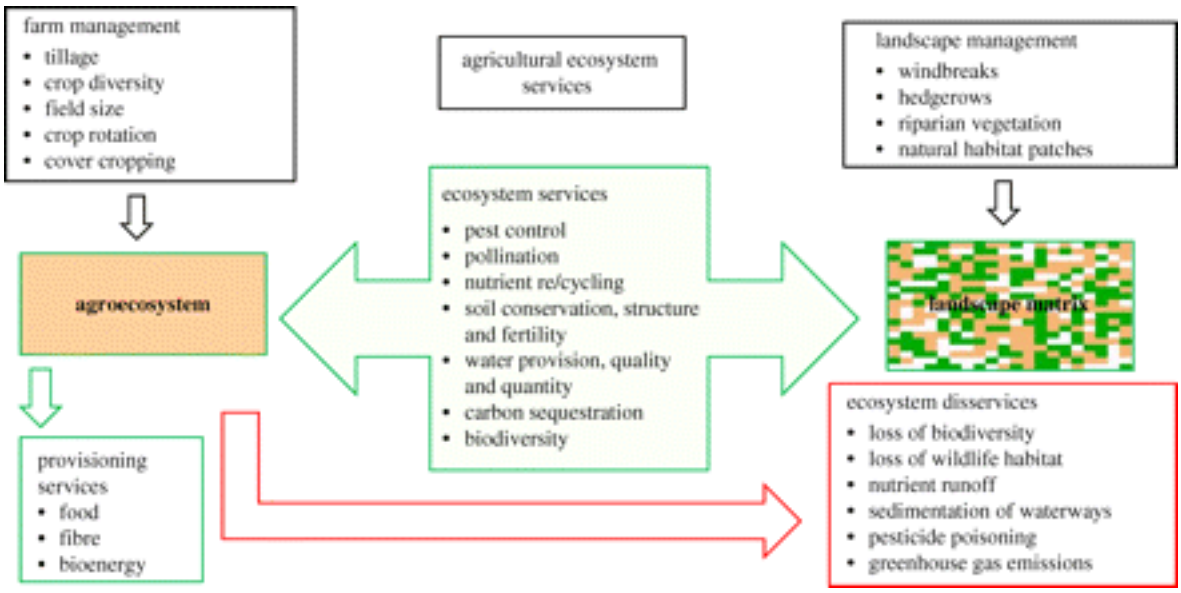

Figure 1: Ecosystem Services
Source: Power (2010)

Effects of agriculture on ES
Management practices greatly influence the probability of ES as well as disservices from agriculture (Dale & Polasky; Zhang *et al.*, 2007). An overview of specific management practices related to ES can be found in Appendix 4, Table 1. According to the MEA (2005) most of the ES related to agriculture have decreased. Possible effects are habitat loss which influences biodiversity, nutrient runoff, sedimentation of waterways, and poisoning of humans as well as non-target species because of pesticide poisoning (Zhang *et al.*, 2007).

Nitrogen and Phosphorus are the two nutrients that are heavily applied on agricultural lands and are known to limit most biological productions (Vitousek *et al.*, 1997). Nitrogen runoff from agricultural lands into aquatic systems is an acknowledged problem (Galloway *et al.*, 2004). To maintain ES is important to manage nutrient pools for crop supply. Sustainable practices such as diversified cover cropping, diversifying nutrient sources, legume intensification can be applied in order to secure ES (Drinkwater & Snapp, 2007).

The availability of water in agricultural lands depends not only on infiltration and flow. Rainfall, plant cover, the content of organic matter in soils as well as the population of living organisms in the soil have a major influence on water storage in the soil (Molden, 2007). A decrease in the quality as well as the quantity of water can be traced to intensive agriculture in terms of water used by farmers for irrigation purposes, low quality of water due to the presence of nutrients in it as well as salts that have been dissolved from agricultural lands (MEA, 2005). Management practices that help conserve water stored in the soil can help reduce water shortages on farms (Rost *et al.*, 2009).

The fertility and structure of soils provide important ES to agricultural Lands (Edwards, 2004; Zhang *et al.*, 2007). For crops to access nutrients in soils, a good aeration system coupled with high levels of organic matter as well as a good water retentive capacity is

important. microorganisms in the soil play a major role in soil structure, aggregation and the rate of decomposition of organic matter. Bacteria, fungi and actinomycetes are of importance here since they serve as mediators for nutrient cycling to occur (Vitousek *et al.*, 2002). Practices such as mechanical ploughing deteriorate the structure as well as the microbial population in the soil. Conservation tillage can help reduce this effect by retaining nutrients for crop use.

Financial outputs of ES

Nowadays the focus of research lies with methods to estimate the economic value of ES (Costanza et al., 1997). In addition to food, fibre, fuel and materials for shelter, they provide a wide range of benefits that are difficult to quantify and have not been priced (Figure 1). Often, Agro-ES are left out in the costs of the farmer and thus in the price of the final product (Gómez-Baggethun et al., 2010). They are lost as a result of incorrect agricultural practices and a lack of incentives is evident (Pagiola and Platais, 2017). Prominent ES that can be achieved through sustainable soil management practices are yield increase, air quality regulation (fine dust capture, carbon sequestration), protection from pest insects, research and education (van Oudenhoven et al., 2012).

A possible instrument to stimulate practices on the farm that benefit ES is an incentive-based mechanism of Payment for Ecosystem Services (PES) (Engel et al., 2008). This mechanism is market-based and focuses on four ES categories: biodiversity conservation, carbon sequestration, watershed protection, landscape beauty and recreation (Landell-Mills and Porras 2002). In addition, there are four types of ES buyers (Scherr et al. 2004): the public sector, the private sector that is obligated to compensate its environmental impact, the private sector that acts voluntarily in order to support their business operation and consumers that pay additional costs for the products. Under certain conditions PES can create markets to trade environmental externalities. Some authors believe that this is more effective than policy alternatives such as government regulation, voluntary community payments or educational approaches (Ferraro, 2001; Wunder, 2005). However, pitfalls of PES have been highlighted. Muradian et al. (2010), Van Hecken and Bastiaensen (2010) and Vatn (2010) state how many PES initiatives ignore the institutional setting and that they over-rely on the potential of markets to overcome problems that require broader collective action approaches.

The key point is to identify whether external influences have positive or negative outcomes (Van Hecken & Bastiaensen, 2010). Young et al. (2003) elaborate on the concept of duty-of-care, where land users have the obligation to take all reasonable steps to prevent environmental degradation or disservices for the community through their activities. The concept of duty-of-care is based on the internalisation of external influences. Land users should be punished by society if their management falls below the societally desired level and they should be rewarded if their management produces benefits above the minimum duty of care (Bromley & Hodge, 1990). In regard to payments for efforts done, global services (e.g. biodiversity protection and carbon sequestration) should be globally funded, while local benefits such as watershed services or landscape beauty should be financed locally (Engel *et al.*, 2008; Pagiola *et al.*, 2007; Wunder *et al.*, 2008).

3.2 Interviews

3.2.1 Farmer interviews

Farmers selection was on soil type and farming practices and the selection of the provinces was on soil type, leasing system and stated ambitious for sustainable farming. Combined, four axes were obtained to make some descriptive analysis of our results from the coding: the soil type, the farming practices, the leasing contract type and the comparison between province.

However, analyses based on the soil types and the leasing contracts were not possible. The repartition between the two main soil textures was too uneven (twice as much for clay compared to sand) and some farms had soil of multiple types. In relation to lease contract types, too many different sub-labels were identified in order to be combined. Therefore, the results were not considered relevant to analyse. Since the number of interviewed farmers was unevenly divided between organic and conventional farmers and the sample number was small, organic farmers and Veldleeuwerik certified farmers were merged to one category, called *certified farmers*. This comparison showed interesting results (Figure 2).

Moreover, all farmers in all provinces faced legislative barriers, mainly at national level (four occurrences for Groningen and Noord-Brabant and six for Flevoland). The occurrences of answer from farmers in Noord-Brabant were in between the answer of the two other provinces, except for the leased land where they presented the highest number of occurrences (four for "Price of land" and two for "Agreement on duration") (Figure 3).

In Flevoland, the short term of the leasing system has been identified as a brake to sustainable soil practices applications with five occurrences "Agree".

Leasing system

Most of the farmers (11) leased part of their cultivated land. Only two farmers leased the entire cultivated area and three of them owned all their land. Half of the farmers leased land for a longer time span (long term lease and leasehold), whereas the rest leased land for a shorter period (loose lease, regular and liberal lease). Only one farmer had both short-term and long-term contract lengths. The landowners, apart from farmers, were equally divided among retired farmers, civilians, government, land funds and banks.

The question on short-term versus long-term lease contracts resulted in clear responses. Ten out of 14 farmers agreed with the idea that in short term lease farmers are less inclined to invest in soil management compared to long term lease. One farmer said:

> *"If the lease period is short and you are not certain whether you can keep on leasing the same field, you cultivate crops more intensively and focus on yield whilst reducing costs".*

Five farmers declared that they experienced difficulties with the high prices of land lease. Three of them attributed the guilt to the governmental influence in setting land prices. Three farmers found problems in lack of clarity regarding the length of their contract. None of the farmers had formal, and hardly any informal, requirements included in their lease contracts. Informal requirements that were opted, included keeping the field free of weeds, maintaining a good crop rotation and avoiding nematicides in the soil.

Soil quality

In response to payment for higher quality soils, 12 out of 14 were willing to pay more for higher quality soils:

> *"A good soil always pays back financially in the long term".*

Related to this point were the responses on the question about bonus points. 11 farmers expressed their opinion on such a system. An interesting finding was that most farmers drew the topic broader. The conception of a system that would *reward* sustainability efforts made by farmers rather than a punishment in regulatory/financial form appealed to them. Seven farmers were enthusiastic about the bonus point system specifically, whereas four of them had mixed feelings. Reasons for this were fear of additional regulations or possible fraud with the system.

Manure policy

Six out of 14 farmers declared they experienced soil degradation. The main causes were ascribed to the manure policy. The heavy machinery required because of the manure regulations lead to soil compaction according to the farmers. Moreover, farmers in both sandy and clay soils claimed that they had difficulties keeping up organic matter levels and macronutrient levels in the soil. According to them this was due to the restrictions imposed on the application of manure at national level.Nine farmers in fact stated that most of the constraints are experienced in legislation at national level. Apart from the manure policy, four farmers were dissatisfied with the national crop rotation regulation:

> *"An extensive crop rotation is not always economically sustainable. On the one hand they stimulate to sow catch crops after wheats. However, it doesn't work out well. And it takes a lot of machinery work, energy and petrol to do it. and often it does not deliver any nutrients to the soil."*

Contrary to the conventional farmers, all the organic farmers interviewed did not experience problems with the manure policy yet. However, they did notice that the phosphorus content in the soil has started to decrease. At European level some farmers complained about the Greening. Complains arose from incompatibility of the green manure recommendation on EU level and National manure policy:

> *"They want us to use organic manure. But in order to grow that stuff needs Nitrogen. But we are not allowed to apply it. Sometimes the crop just needs more than is allowed."*

In addition, farmers find difficulties in matching green manure growing season with cash crop growing season and Dutch weather.

Sustainable practices

The interviews elicited specific soil practices that farmers considered to be sustainable. The following seven sustainable soil practices were identified: reduced use of machinery, reduced use of chemicals, time-reducement practices, extensive crop rotation, green manure cultivation and animal manure and compost application. On average, farmers adopted between three and four sustainable soil management practices per farm. Surprisingly, most conventional farmers stated opinions about sustainable practices. The main barriers that were mentioned in relation to the application of sustainable soil practices were economic and practical/technical difficulties (i.e. incompatibility with current practices). All the conventional farmers from Groningen identified practical barriers.

Subsidies

Overall, the farmers had neutral opinions about subsidies that could be used to induce sustainable practices. None of the farmers said to be in favour of subsidies, where three of them answered that they are against subsidies. Three conventional farmers said to be in favour of subsidies (Figure 2). The remaining number neither agreed nor disagreed. The province of Groningen recorded the highest number of farmers in favour of subsidies (four

occurrences) with none against subsidies. In the province of Flevoland, farmers were the least favourable to subsidies with three occurrences and one occurrence who neither agreed or disagreed (Figure 3). The reasons for opinions against subsidies were the additional regulation that this would entail and a possible incorrect allocation of money. Moreover, subsidies were found to be a short-term solution:

> *"They (government) stimulate things with subsidies but when the money has run out the development stops as well."*

Social aspects

Three categories of interest were derived from the interviews: to increase the knowledge transfer among farmers, between farmers and society and how to improve farmer position in the food chain. The majority of the farmers claimed that more knowledge transfer is needed among farmers. It was recognized in all province as a problem (Figure 3). It is followed by the opinions that knowledge transfer should preferably happen between farmers and consumers and farmers and government:

> *"Knowledge. That's what this is all about. It's growing a lot already, that's the good thing. Has to do with education, young farmers educate themselves.*
> *Decisions need to come from the farmer himself. Too much involvement from the government gets in the way of entrepreneurship. It's a mix of letting the market run things, regulations, governmental support and knowledge. And better communication with LTO."*

In regard to the position of farmers within the chain, seven farmers believed that it is the responsibility of farmers to seek creative solutions in order to enhance their situation. The other seven held that it should be accounted for by the government, mainly through regulative interventions. In addition, they believed the market should pay more money for higher quality products.

Ecosystem services

The main remark found on this point was that only four farmers were familiar with the term ES. The farmers in the province of Groningen were not familiar to the term ES, where respectively three and four farmers in Flevoland and Noord-Brabant were familiar with the term. Different opinions arose regarding who had the responsibility to reward efforts that benefit ES made by the agricultural sector. The results showed an equal distribution of the responsibility attributed to farmers, the community or the government. Seven farmers found it their own responsibility to provide ES because they, in turn, would benefit from it. Seven farmers believed that their efforts should be recognised by the community and rewards should be provided by the government. The type of reward desired by farmers was in the form of incentives (11 farmers), compensation through increased food price (five farmers), or both. Only two farmers favoured regulatory or financial penalties.

On account of this topic, the unfamiliarity of farmers with ES and the terminology caused problems during the interviews. Therefore the results were found insufficient to give possible explanations and conclusions on this topic.

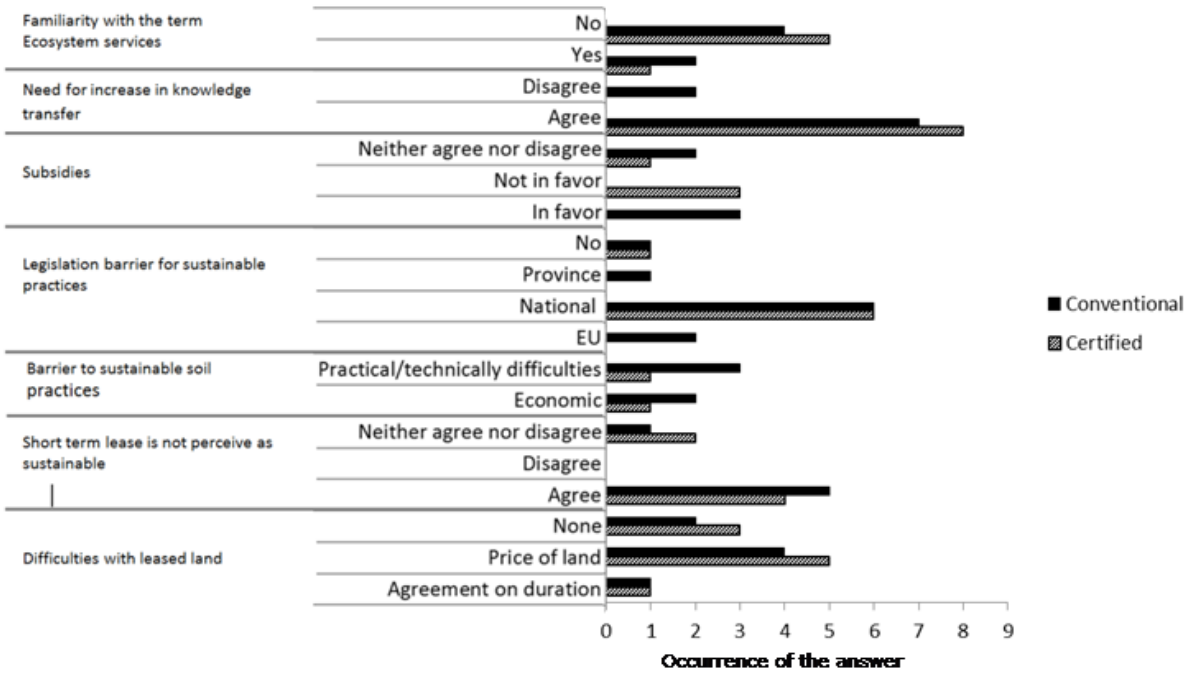

Figure 2 Comparison of results between conventional farmers and certified farmers

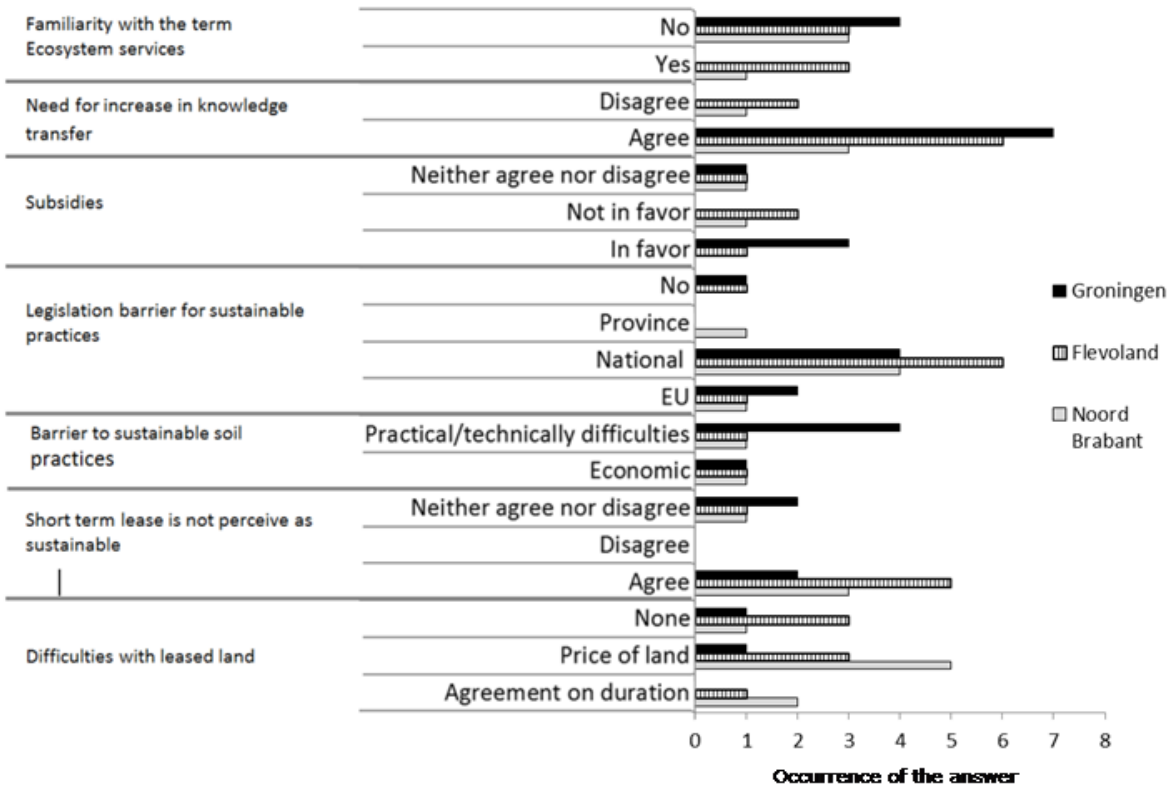

Figure 3 Comparison of the main results between provinces

3.2.2 Expert interviews and land funds

Sustainable soil management

Among land funds, the perception of sustainable soil management was expressed in economic terms. Either through a linkage of the lease price to specific farm type, (e.g. organic farmers, farmers with a sustainable certificate), or through requirements on practices adopted. Soil experts, on the other hand, approached sustainable soil management in more scientific terms. They referred to the physical, biological and chemical domains of soil and highlighted the dynamic character of soil quality.

The experts and land funds agreed that soil monitoring is more important in short term lease than it is in long term lease. Experts stated that soil sampling is the way to monitor sustainable soil management, while land funds considered crop rotation as a monitoring rule. Both experts and land funds stated that the transfer of knowledge on sustainable soil management of advisory services to farmers is very important, but it depends partly on the interests and visions of the former. Soil sustainability was also considered insufficiently integrated in policies:

> *Expert: "Soil sustainability is weakly addressed by current policies. Some policies affect soil sustainable management, but these lack proper integration, like e.g. the Manure policy, which is driven by one single element."*

Knowledge

Apart from what sustainable soil management means for each of the stakeholders, awareness is another major issue to look into. Awareness about sustainable soil management is considered to be growing both among farmers and among citizens. According to land funds, farmers show this increase in awareness through their preference for longer lease contracts even though there are still some cases where farmers deplete their soils independently of the lease duration, a phenomenon which they attribute to a possible knowledge gap between experts and what farmers think it is right. As far as the consumers are concerned, land funds consider them to have little knowledge about soil although it is gradually growing.

Experts mostly based their views about the awareness of farmers regarding sustainable soil management on the kind of farmer and the type of soil. They considered arable farmers to be more concerned by nature, since soil quality affects their yields and activities much more than animal farmers.

Ecosystem Services

The land funds seemed not to be too familiar with the term. They also indicated that they think that farmers do not know the term and are not really aware of good soil management in general. Experts specified that farmers, even though ES is a rather vague concept to them, are not only aware of most of the individual services, they also consider them as very important.

Many different views were given on whether or not ES are the responsibility of farmers. One land fund considered ES to be completely the responsibility of landowners as they saw no incentives for farmers to apply them. The other land fund highlighted the need for an external regulator for lease prices when efforts are put into place that influence ES. They expect society may not be be willing to pay for these efforts. Experts, on the other hand, fully considered ES as a farmer's responsibility since those ES related to the soil directly benefit their own produce.

Views among stakeholders differ much when a bonus system is put forward as a possible solution. Some think that rewarding sustainable soil management is indeed a solution while others believe that taxing unsustainable soil management is the best pathway, even though such an approach would cause a political dilemma.

With regard to measures that can serves as incentives for maintenance of ES, land funds referred to setting requirements in the leasing contracts which promote organic agriculture as the main incentive while they considered rewarding through subsidies or discounts on lease potentially helpful. However, trade-offs exist between the number of requirements and the level of support from farmers:

> *Land fund: "We could prescribe what farmers should do, but we also have a reputation to maintain. We cannot prescribe too much."*

Experts mentioned several incentives that can be given to farmers in order to maintain ES. The connection of soil to water, biodiversity and climate change, factors tangible and easy to observe by farmers were stated. In addition, they talked about securing access to land use, implying the need for alterations in the current leasing system. And finally, some changes in regulations were also deemed as necessary, but not yet limiting:

> *Expert: "For now most of them (farmers) can still manage with the regulations."*

Position of farmers

Land funds stress it is difficult to unite farmers in order to convey their efforts on, among other things, sustainable soil management to government and society. Experts proposed to focus more on structural characteristics, such as improving access to land or introducing fiscal policies which would give farmers more incentives to do (long term) investments. They also refer to knowledge exchange between private actors and farmers as an integral part of improving farmers' position.

3.2.3 Provinces

Practical application

The province of Flevoland and Noord-Brabant both refer to sustainable soil management as the maintenance of fundamental soil properties and maintenance of the soil as a system in the long term. According to the provinces a large part of community has no idea what soil sustainability is, but they think farmers have their own ideas on soil sustainability:

> *"Farmers give their own specific meaning to sustainable soil management, which is satisfactory."*

The province of Noord-Brabant referred to soil sampling as the main way for farmers to monitor their soils. In the province of Noord-Brabant there is a 'Sustainability score' present that is based on scoring a farm on the certificates it has related to sustainability. This then is linked to a certain priority for lease lands and its subsequent price. As an addition to this system, points for the ones that participate in the Soil Passport program were also included. Moreover, Noord-Brabant province considers it as a responsibility of the national government as well to take some action on the matter. The province of Flevoland acknowledges that there are no specific measurements for soil quality. The province of Noord-Brabant adds:

"From our perspective, it appeared to be very difficult to determine parameters for soil quality for one-year liberal lease contracts."

Regarding now the contribution of advisory services to sustainable soil management by the farmers, both the provinces of Noord-Brabant and Flevoland talk about the commercial nature of some of them and therefore the possibility of this advice to be biased. The Noord-Brabant province in particular referred to these commercial consultancies as mainly thinking in terms of traditional production and that independent advisories are important. The province of Flevoland talks more about the willingness of these parties to cooperate if they are asked to, with some being more active and with others showing some interest but not actively participate. Flevoland province also raised the issue of knowledge transfer from universities to the farmers as something that needs to be strengthened.

Legislation

With regard to the current legislation and the extent to which it addresses sustainable soil management, all three provinces state that soil sustainability is not really mentioned in current policies. These were more the result of debates concerning the environment:

"I think sustainability to be a by-product of these current policies."

When looking at the EU, national and provincial level in terms of power dynamics, the provinces of Noord-Brabant and Flevoland stated that they have almost no power and that national government and then individual municipalities have the most power. By contrast, the provinces have to comply to national regulation and therefore to put targets in their policies. Current EU and national policies (such as the Manure Policy, Water Directive, and N-Directive) were drafted with regard to the environment. Soil sustainability was not a goal in these policies, but rather appeared to be a by-product of this legislation.

Both provinces of Noord-Brabant and Flevoland also see their role between the government and the farmers rather limited since the government sets the rules and their involvement is mostly through lobbying or projects.

Regarding the effect of the current manure policy on the choices that farmers will make to apply sustainable soil management practices, some different views were presented. According to Noord-Brabant province, the current manure policy functions mostly as deterrent for the farmers to cultivate their soil sustainably while for the province of Flevoland it indeed affects their choices but not to such a big extent as farmers say. The province of Flevoland also stresses that there is a big difference in the soil types and the type of farming in the way that the manure policy affects farmers' choices towards sustainability

As far as farmer unions are concerned, the representatives of the two provinces stressed that the activities of LTO in Flevoland and Noord-Brabant are mainly with concern to soil state, manure and local opposition.

Lease system

As far as the leasing system is concerned, all three provinces indicate that short term land lease does not trigger long term investments, or inversely, encourages over cropping. Where long term lease is considered beneficial to some extent as it may decrease soil mobility. The province of Flevoland indicated that current land lease prices are found to be hardly different among soils of different quality. Provinces indicate that the Central Government Real Estate Agency, RvB (Rijksvastgoedbedrijf) should also take its responsibility in the transition

towards sustainable soil management. All landowners should then include requirements on soil management in their lease agreements. Where the reasoning could be that:

> *"Say, I am a landowner, then I would want the soil I am leasing at least has the same quality it had when the lease started. Then what will be the price? Well, it implies that, as a consequence, high lease prices will not be possible anymore due to investments that need to be done in the soils".*

ES

Regarding ES, two provinces confirmed that the term is unknown among farmers. Two provinces indicated that the landowner is responsible for the soil, but all of them added that there could be more governmental influence.

The provinces of Noord-Brabant and Flevoland indicated that they actively approach farmers through projects. Through those projects, which are topic-specific, they try to influence the thinking process of farmers and other stakeholders. However, they observed that initiatives from society are more useful than those of the government. A bonus point system could potentially work, but no further reasoning was provided. The province of Noord-Brabant only suggested that such a bonus system could be linked to the soil passport. All three provinces indicated that the government could try to accommodate the farmer to manage soils more sustainably. Where, the provinces indicated they mainly want to mediate the thinking process, provide certain exemptions from (or induce extra) regulations to farmers, or grant subsidies.

3.3 Overview of key issues

The literature study and interviews led to the identification of key issues for each aspect (Table 5). The main issues concern the absence of an evaluation and rewarding system of sustainable practices within lease agreements, the (short) duration of lease agreements, and insufficient knowledge transfer and exchange on soil sustainable management practices between farmers and other stakeholders.

Table 5. Overview of the main issues to soil sustainable practices applications encountered during the literature review and the interviews.

Key issues		
	From literature review	**From interviews**
Leasing systems	● Short-term lease ● High price ● Lease requirements ● Relationship between lessor and lessee by law	· No requirements · Duration · Price · Government influence on lease pricing
Legislation	● Manure policy ● Nitrate directive ● Phosphate directive	· Manure policy · Greening · Crop rotation (National legislation) · Contrasting regulation

Sustainable soil practices	● Adoption gap ● Economic barriers ● Soil structure ● Nutrient loss ● Biodiversity loss ● Water scarcity	· Soil compaction · Investment on short- or long-term · Incompatibility with current practices (economic/technical)
Social factors	● Financial and social capital ● Entrepreneurship risk ● Farmer's characteristics	· Network collaboration · Forcing regulations · Consumer awareness
Ecosystems services	· Compensation	· Awareness of farmers · Appreciation from society

4 Discussion and conclusion

4.1 Regarding the land lease system

- *How can the land lease system be changed in order to support the adoption of sustainable practices by arable farmers?*

As explained by Van Dam (2017), short term leased land does not motivate farmers to invest in more sustainable soil practices. The same point was raised during the interviews where the provinces and most of the farmers identified a short-term lease contract as an obstacle for investments in soil. As investments in the field (drainage e.g.) are costly for the farmers, they do not want to invest in this if they have no certainty of beneficial outcomes on them. The problem perceived by farmers is the lack of long-term vision of the landowner. Especially project developers and the government are mentioned, who used to lease out their lands for one year and renew the contract several years in a row. Therefore, it occurred that farmers would use the same plot during several years while they had not invested in sustainable practices. A solution is to obligate landowners to plan project developments in the long term before leasing out the land. This allows farmers to invest in the soil, provided that the length of the contract is long enough. Drawing from this idea, we propose that all contracts are extended to a minimum of six years between landowners and farmers. A time frame of six years corresponds to the opinion of farmers of the minimum duration for which they are willing to invest in sustainable practices on the fields they lease. Apart from that, we propose the creation of a bonus system (Box 1).

Proposed solutions: Increase duration of lease contracts &
Bonus system

Box. 1 Outside the box solution
Bonus point and soil passport to improve sustainable soil management

A proposed solution is to link ES rewards to the leasing system through the application of a bonus system. What emerged from the interviews is that most farmers would appreciate the introduction of bonus points as rewards for sustainable (soil) practices. Such a bonus system can be used twofold. Points could be assigned per unit of land (1 hectare) or per farmer. When points are assigned to the land in terms of quality, the value of the land can be linked to the number of points. In order to determine the quality of the soil, the Soil Passport can be used (ZLTO, 2016). If the quality of the soil is assessed in such manner, the landlord is likely to feel more responsible to ensure that tenants apply sustainable soil management practices. When points are assigned to a farmer based on his efforts made on the adoption of sustainable soil practices, farmers can gain rewards in terms of farm management.

How can land funds maintain and improve soil sustainability through the leasing system?

Both the literature study and interviews from farmers and others stakeholders showed that no requirements are stated for land lease apart from few informal points between the landowner and the tenant (e.g. keeping the field free of weeds). Farmers responded that they find it useless to invest in sustainable practices if they do not know who would take their succession and how the soil will be worked. The Soil Passport can play an important role to solve this

problem (Box 1). The provinces considered it as the responsibility of the landlords to include requirements for soil management in the lease contracts. How to valorise soil sustainable practices remains uncertain as some lands funds considered the reward through discount as a solution, whereas others believed in a tax approach to reprehend unsustainable practices.

Proposed solution: Land lease requirements

More than one third of the farmers interviewed considered the high lease prices a constraint as they have ample financial space left to invest in leased fields. In all stakeholder interviews it was mentioned that the Dutch government leases out land in liberal lease to the highest bidder, without including requirements for sustainable soil management. Moreover, farmers said that the high lease price was considered a reason to invest in the most profitable crops (bulbs, sugar beet and potatoes), that are quite intensive in terms of soil depletion (Appendix 3). A proposed solution therefore is to establish maximum prices for liberal lease in the Netherlands.

Proposed solution: Maximum price for liberal lease

4.2 Sustainable management soil practices;

- *Which soil practices are most practical to apply for farmers in terms of farm management and financial outcome?*

Soil is the principal and most diverse source of biodiversity and soil structure is the key indicator of its functionality (Arshad & Martin, 2002). Soil structure can be improved with use of sustainable soil practices. It is a approach that saves on resources and it increases nutrient- and water use efficiency through minimum soil disturbance. Mechanised conventional agriculture may be helpful to achieve production target for a short duration but at the same time it is responsible for rapid soil degradation (physical and chemical) as well as over-exploitation of natural resources (Farooq & Siddique, 2015). Soils benefit from effective use of mechanisation and chemicals in terms of ecological balance. The opinions of stakeholders in the interviews were in line with what was found in the literature. The Dutch arable farm system is highly mechanised. Due to frequent use of heavy machinery soil compaction is perceived by farmers as a common problem. As a result, soil structure has hampered and nutrient and water use efficiency has decreased. Therefore we propose to adopt a more extensive cropping system. This will reduce the stress of intensive agriculture on soils and the surrounding environment.

Proposed solution: Extensive cropping system

- *How do economic factors adhere to the practical application of these practices?*

Although various sustainable practices have been proven effective, an adoption gap has been identified (De Buck *et al.*, 2001; Farooq & Siddique, 2015). Snapp *et al.* (2005) indicate that economic barriers as the most important barrier to adopt sustainable practices. The uncertainty of profit margin for a long-term investment plays an important role in deciding adoption of sustainable practices. This notion was reflected in the interviews with farmers and experts. Farmers that had short-term lease contracts did not feel encouraged to apply sustainable practices. Long-term investments, according to them, need longer periods of time to show in the profit margin. Moreover, farmers found some sustainable practices to be unsuitable for their farm system or crop type. The proposed solution to this problem is to facilitate farmers with long-term investments so that they can apply sustainable practices.

Investments can be facilitated through a long-term lease system, the use of a bonus system (Box 1) and compensation from government and society for efforts made in terms of ES.

Proposed solution: Facilitate long-term investments

4.3 Policy instruments and social factors

- *Which barriers of legislation do farmers face when they want to apply sustainable soil practices?*

As Lauwere *et al.* (2016) indicated, farmers struggle with current national legislation, especially the current manure legislation. They call for more simple and flexible legislation. The interviews with farmers showed exactly this. Most farmers were aware that the boundaries on P are needed in legislation, but that the current legislation lacks local flexibility. This comes in agreement with what the province of Flevoland stressed in the interview about the fact that there is a big difference in the soil types and the type of farming in the way that the manure policy affects farmers' choices towards sustainability and thus it should be taken into account. A proposed solution in terms of legislation therefore is to allow space in national legislation for local adjustments. These adjustments can be based on soil samples that show how much manure the soil and crop need in terms of N and P.

Proposed solution: Local flexibility in national legislation

- *How can social factors influence the decision of farmers to adopt sustainable practices?*

As Pretty & Ward (2001) show, the social capital is important for farmers to adopt sustainable practices. Strong social bonds and norms help to share and exchange information among farmers. The responses from the farmers in the interviews reflect this information. The farmers that are certified by Veldleeuwerik said they very much appreciate the regular meetings that are organised. They gain knowledge during these meetings, both from expert presentation and exchanging practical knowledge with colleagues. In addition, the interviews with land funds and experts showed that these parties perceive a knowledge gap between experts and farmers about sustainable soil management. They believed a lack of unity between farmers adds to the issue. The province of Flevoland also raised the issue of knowledge transfer from universities to the farmers as something that needs to be strengthened as well. Therefore, it is important that regular meetings are organised that provide chances for knowledge exchange between farmers, experts and landlords.

Proposed solution: Knowledge exchange among farmers, experts and landlords

An important point raised by the farmers in the interviews was the awareness and appreciation from citizens and consumers for their products and sustainability efforts. The awareness was specifically mentioned in relation to the effects of sustainable practices on soil quality, because they believe citizens do not see how much effort they put into maintenance of the quality of the soil. In terms of appreciation, both social appreciation and a higher price for their products was mentioned. Farmers called for a better PR approach throughout the sector in order to raise awareness about what farmers do with their soil and what that means for the quality of the final product. They hope that more effective marketing will help to ask higher prices for their products as well.

Proposed solution: Effective marketing

- *How can national and local level policies address the social factors that interplay in the choice of farmers to adopt sustainable practices?*

Caggiano (2014) and Le Gal (2011) state the importance of network collaborations between farmers in order to enhance the shared knowledge between farmers and other stakeholders in the chain. In relation to the interviews it was found that farmers would like to have the space to connect to other farmers in the region. Connections between crop farmers allow for the use each other's land in order to create wider crop rotation plans. Connections between crop farmers and animal farmers can result in shorter manure transports and grass land that is high in nutrients could be used as cropland. However, the current manure legislation and the legislation on permanent grassland is a barrier to such collaborations. Therefore, the national and local level policies should look into how regional connections can be stimulated in order to facilitate sustainable soil management.

Proposed solution: Stimulate regional connection

As Ahnström et al. (2009) show, in the adoption of sustainable practices farmers are affected by many factors that range from their municipality to more general norms. In relation to this, Driessen et al. (2012) indicate that interaction is needed between state level, the market and society in order to successfully implement changes in agricultural management. It became clear from the interviews that farmers detect a gap between the practices of farming and the current decisions that are made in policies and legislation. Business organisations could play an important part in fulfilling that role, although it was generally perceived that these authorities do not have enough power to influence governmental decisions. It is important that efforts will be made to facilitate adequate knowledge transfer from farmers to the government. This can help to raise the awareness about practical outcomes from legislation and policies.

Proposed solution: Knowledge transfer from farmers to government

4.4 Ecosystem Services

- *How do non-provisioning ES fit into the new framework?*

The literature review revealed that the main issue regarding ES is on how benefits are provided by agriculture and how efforts can be compensated. The key element lies in the failure of the market to include efforts done with regard to soil sustainability (Van Hecken and Bastiaensen, 2010). The interviews showed that farmers have little to no understanding of the term. This highlights the gap between scientific literature and the awareness of farmers. Moreover, farmers and other stakeholders did not share the same opinion on who should take the responsibility for ES and consequently the ES compensation. We propose three solutions to face the key issues related with ES.

Firstly, we offer a solution in line with the duty-of-care theory described by Young et al. (2003). Farmers can positively influence ES and thereby benefit themselves as well as the community. The concept of duty-of-care implies that landowners are obliged to take all steps deemed reasonable to positively influence ES or prevent negative influences. A threshold level could be defined to correct or reward landowners for their practices (Young et al., 2003; Bromley and Hodge, 1990). A reward could be monetary, but through the interviews with farmers indicated that they would appreciate it when their efforts were more valued by society.

Proposed solutions: Requirements for compensation (thresholds) &
Communicate Sustainable Soil Management Practices (SSMP) with ES to farmers and consumers

To raise the awareness of consumers about sustainable soil management practices and how they provide ES, appears to be a valid strategy to reward farmers. Consumer awareness can be reached through e.g. advertising or labels. To increase the food price directly relates to what was found both in the literature study (TEEB framework (2015) for evaluation of ES and the internalisation of the externalities) and in the findings obtained from the interviews. Even though farmers were not familiar with the term ES, some of them suggest that ES provisioning should be paid by the consumer directly in the food price.

Proposed solution: Link ES to lease system

4.5 Conclusion: Sustainable Soil Management Framework

The purpose of this research was to provide a Sustainable Soil Framework to Wageningen Plant Research. This framework proposes a set of solutions based on key issues identified concerning the adoption of soil sustainable practices for several aspects. All solutions described in this chapter are part of the main solutions. From that perspective, these solutions should not be considered independently from one another. The main solutions concern the proposition of an evaluation and rewarding system of sustainable practices within lease agreements, to extend the duration of lease agreements, to increase knowledge transfer and to exchange knowledge on soil sustainable management practices between farmers and other stakeholders.

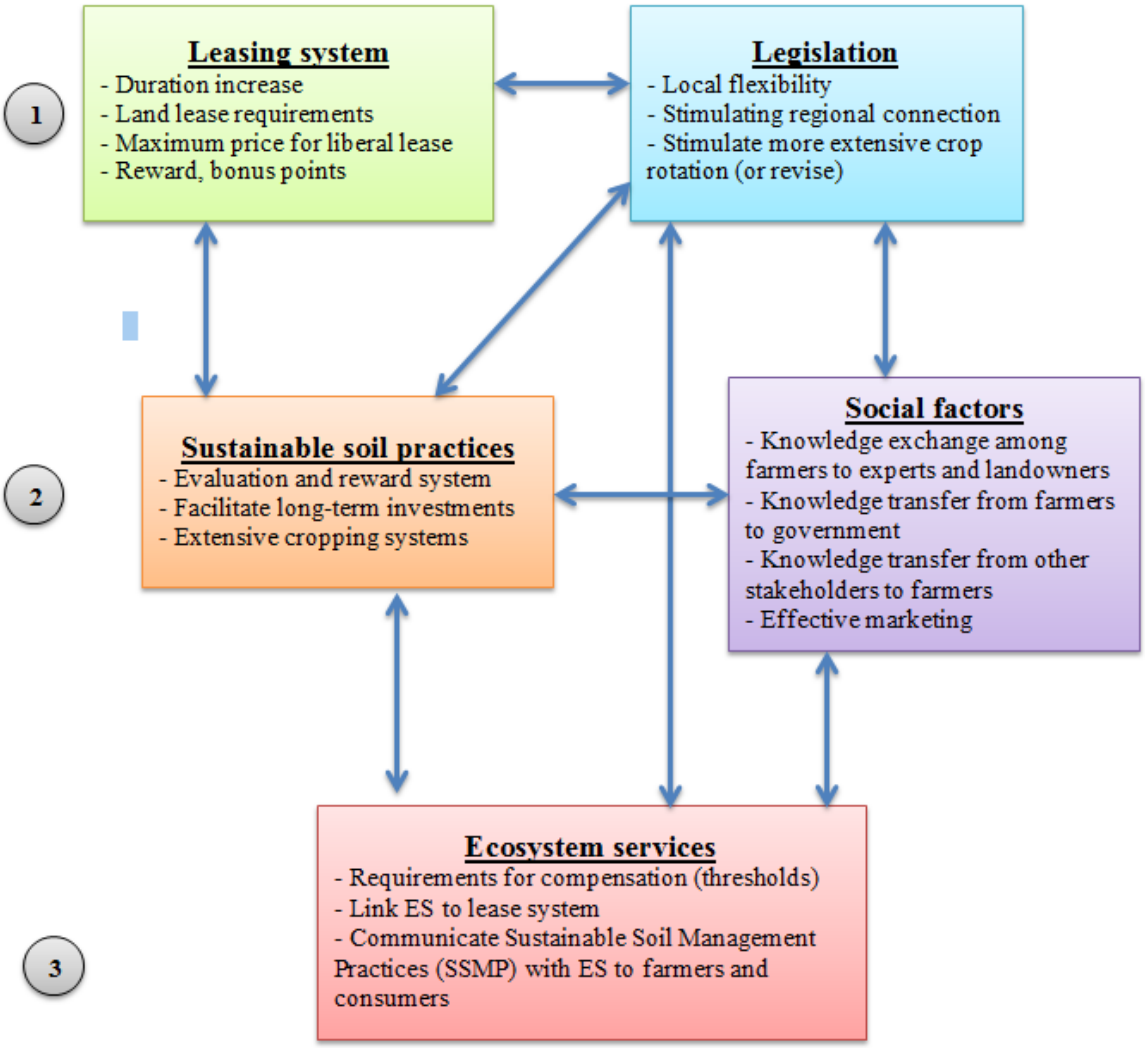

Figure 4 Sustainable Soil Management Framework (SSM)

5 Recommendations

Some aspects need further investigation. Three aspects emerged from the interviews with farmers that require additional attention. First, all the conventional farmers from Groningen experienced practical barriers to apply sustainable soil management. This opens space for a research into the possible obstacles encountered by these farmers.

Second, almost no farmers were familiar with the term ES. This indicates a possible gap between the scientific community and farmers. Further research will have to point out whether the gap lies within the terminology only or that underlying problems are at hand.

Third, most farmers said that they receive advice from supply companies (e.g. fertiliser and pesticide companies). As these parties have particular interests, they may have a subjective influence on the sustainable practices performed by farmers. A deeper analysis will have to be done in order to find out how these companies influence the decisions of farmers in relation to sustainable soil practices.

The interviews with land funds raised an additional point for further investigation. A price policy on soil was proposed by land funds as the simplest solution for the government to provide support for sustainable soil management. Research will need to show to what extent this can be effective and how it could be integrated into current policies.

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Appendix 1: Stakeholder analysis

Table 1: Stakeholder analysis of the adoption of sustainable soil management practices by arable farmers

	Primary	Secondary
In favour	Farmers	European Union
	Local government	Science WUR Louis Bolk Institute RIKILT
	National government Ministry of Economic Affairs State Forestry Management Planbureau voor de Leefomgeving NVWA	
	NGOs/Farmer associations LTO akkerbouw NAV ASR Fortis Stichting Grondbeheer Stichting Milieukeur Stichting Veldleeuwerik WNF	Landscape agencies/Advisors CLM
	Citizens in rural areas	
	Land funds	
Dual interest	Banks and investors Rabobank	Consumers
	Input actors Fertiliser suppliers Pesticide companies Contractors	Supply chain members Food processors Wholesales
	Retailers	

Primary stakeholders are those considered to be most important as they have a direct influence on the choice of farmers to adopt sustainable practices and/or are directly affected by this choice. The farmers themselves, of course, are the primary actors. Governments and NGOs can have a direct influence through regulations, subsidies and support. Citizens in rural areas see the outcome of intensive agricultural production methods and their concern for the decline of biodiversity can lead to initiatives in order to push farmers and governments to take measures (Kening fan ‘e Greide, 2016). Land funds can have a large influence when they rent out land and set out boundaries for sustainable cultivation of the land.

Primary dual interest stakeholders are found in banks and investors can support or restrict the economic opportunities for farmers and they are influenced by the economic outcome of farmers production management. Input actors supply chemicals for conventional practices and are directly influenced if the use of chemicals would decrease. The contractors that apply the chemicals would be influenced in their manner of work if the regulations for chemical use change. Finally, retailers can pressure farmers to supply sustainable products when there is a market for it, but they want to keep prices low as well in order to compete with other retailers.

Secondary stakeholders have an influence on the adoption and application of sustainable practices but are not directly affected by this. The EU sets out general goals for its members. Science finds and supplies adequate information. Landscape agencies play a role to fit sustainable practices in the local area where farmers are located in terms of infrastructure, nature conservation etc.

Consumers and supply chain members are secondary stakeholders that have a dual interest. Consumer studies show that consumers state they want to buy sustainable products but practice shows they are not prepared to pay a higher price for it (Meijers & van Dam, 2012). Supply chain members are involved with the process but they have a stake in keeping prices low as well.

Appendix 2: Land lease systems in European Countries

History of land leasing in Europe

Bavel (2008) argued that differences in the rise of land and lease markets across regions in Europe were related to socio-political structures and their development. What follows is a concise overview of the history of land lease in several European countries. Table 3 provides an overview of the amount of land leased in European countries in 2007.

England

More than 85% of the English agricultural land was leased in 1880 (Swinnen, 2002). At the time, feudal influence was still prominent. At the beginning of the 20th century the share of leased land decreased rapidly and stabilised at around 1927 to 64%. A combination of increased tenure security, high land taxes, improved investment climate, and a strong increase in farm income further decreased the share of land leased. The Agricultural Tenancies Act of 1995 (ATA) allowed for much more flexibility for landowners and tenants to draw up lease agreements that fit their specific circumstances. The proportion of leased land - after the introduction of the ATA - remained relatively stable from 2000 on (36%) and even increased to 43% in 2007 (Table 3).

France

The in 1804 introduced Napoleonic Code resulted in the compulsory equal division of land with inheritance as well as strong property rights and freedom of landowners in contracting with tenants (Swinnen, 2002). A large part of the land was first nationalised and then sold. Small farmers however, could not afford the land as it was sold in large parcels. The amount of area leased in France was 70% in 2015 and ranges between 50-88% (Sulonen & Kotilainen, 2015). Lease price ranges are controlled and determined annually by the government. The legal minimum term is nine years and can be longer and applies for both written and oral agreements (Sulonen & Kotilainen, 2015). The lease is automatically renewed with 9 years. France (together with Belgium) has the highest minimum length (nine years) of lease agreements (Ciaian et al., 2010).

Germany

In order to stimulate the lease market, the German government introduced a liberalised tenancy law in 1952. The law gave both freedom and some protection to the tenant (Federatie Particulier Grondbezit, 2011). The main dilemma's German lawmakers were confronted with were the trade-off between business security and soil mobility and the legal protection of both landlord and tenant. The solution for these problems was sought in long-term non-renewable lease agreements (sometimes lifelong leasing). It would secure both the business of the tenant and the returns for the landlord. For large parcels the lease period commonly ranges between four and nine years. The lease period for small parcels are extended yearly (until cancelled) and often they are agreed orally. The average lease price in Germany was 300-400 euro per hectare in 2014, where the lease price in the north-west amounts 600 euro per hectare (Sulonen & Kotilainen, 2015).

Ireland

Land lease in Ireland decreased from 97% in 1879 to 6% in 1933. Main drivers for this change were decreased farm income and multiple Rent Acts that were introduced through time. In 2007 leased land accounted for 16% of the total agricultural land of Ireland (Table 3)

Appendix 3: Practices to enhance soil quality and indicators associated

Table 1. Types of practices increasing the sustainability of soil management

1. Enhancement organic matter Incorporation of crop residues (e.g. plowing) Crop residues not incorporated into the soil Apply organic matter (composition, solid manure) and reducing OM degradation Fertiliser replaced by natural manures Apply manure differently (reduction of slurry application)
2. Avoiding of excessive tillage Incidental deep soil tillage (plowing) Reduced tillage/no-tillage
3. Management of pests and nutrients efficiently Adjusting timing of operation Chemical crop protection Stimulating functional agro-biodiversity (FAB) Adjust crop and cultivar choice Fertilise less Optimse soil acidity (e.g. liming) Improve inorganic soil composition (less metals; toxicity) Mechanical weed control
4. Prevention of soil compaction Measures to reduce pressures on soils Adjust operation for less soil compaction
5. Keeping the ground covered Cover crop/ catch crop

6. Diversify cropping systems Intensive crop rotation Extensive crop rotation Diversifying crop rotation (grains, grasses/herbs, fallow) GBDA (hedges, perennial flowers/buffer strips)
7. Groundwater management Better drainage Decrease water level Increase water level Rinse against silting Irrigation

(after Soil Quality for environmental health, 2011; Ann Lewandowski (2001); United States Department of Agriculture (n.d).)

Table 2. Key soil indicators for soil quality assessment

Selected indicator	**Rationale for selection**
Organic matter	Defines soil fertility and soil structure, pesticide and water
Topsoil-depth	Estimate rooting volume for crop production and erosion
Aggregation	Soil structure, erosion resistance, crop emergence and early indicator of soil management effect
Texture	Retention and transport of water and chemicals, modeling use
Bulk density	Plant root penetration, porosity, adjust analyses to volumetric basis
Infiltration	Runoff, leaching and erosion potential
pH	Nutrient availability, pesticide absorption and mobility, process models
Electrical conductivity	Defines crop growth, soil structure, water infiltration; presently lacking in most process models

Suspected pollutants	Plant quality, and human and animal health
Soil respiration	Soil respiration Biological activity, process modeling; estimate of biomass activity, early warning of management effect on organic matter
Forms of N	Availability to crops, leaching potential, mineralisation/ immobilisation rates, process modeling
Extractable N, P and K	Capacity to support plant growth, environmental quality indicator

(after Arshad and Coen, 1992; Doran and Parkin, 1994; Gregorich et al., 1994; Larson and Pierce, 1994; Carter et al., 1997; Karlen et al., 1997; Martin et al., 1998).

Appendix 4: Practices related to Ecosystem Services

Table 1. Overview of the practices and their ES associated to answer the mains problems faced by farmers.

Problem	Indicators	Possible causes	To improve soil quality	Ecosystem services associated	Beneficiaries
Soil fertility decline	Total soil carbon, Soil organic matter (SOM), Soil biodiversity Soil Total Nitrogen Soil Total Phosphorus	Excess tillage low organic matter inputs, Use of slurry instead of farmyard manure Nitrate Leaching	Reduce tillage, Long crop rotation, Increase SOM input, Soil cover Use of catch crops	Crop Yield Carbon and nutrient cycling Water retention and nutrient availability Soil structure and aggregation Soil biodiversity Greenhouse effect mitigation Pesticide and water retention nutrients conservation	Farmers, Citizens
Soil Compaction	Bulk density, Soil infiltration rate,penetration resistance, Porosity, Root growth pattern Soil strength Texture	Working on wet soil, Heavy machinery, Repeated tillage at the same depth, Excess animal traffic, Poor aggregation	-Controlled traffic- use of reduced contact pressure systems, reduce animal traffic and change traffic pattern pressure systems -Crop rotation -Organic matter amendments -Adjust tillage- mechanical loosening such as deep ripping -Use non-compacting tillage	Crop yield, Water flow and retention Soil structure, Decrease CO_2,	Farmers Citizens
Soil crusting	Aggregate stability, Soil crust, Slaking	Low SOM, Excess of sodium	Increase SOM input, Soil cover, Reduced tillage (hoeing)	Crop yield, Water flow and retention, Soil structure	Farmers
Plant diseases	Crop resistance, Plant health Plant yield Soil pH	Pathogens, Nutrient deficiency - soil structure poor drainage and compaction texture, -Low organic matter -Low biological biodiversity -Monoculture	-Increase SOM input -Application of compost and proper placement in soil -Diversify crop rotation -Cover cropping, -Optimise soil acidity -application of lime,	-Crop yield -Soil health (Reduction in soil toxicity) -Carbon and nutrient cycling, -Food safety	Farmers, Citizens

		-Short crop rotation -Low pH -Excessive manure application	Adjust operation time, Improve drainage		
Poor drainage capacity of soil	Infiltration rate, Hydraulic conductivity Soil structure	Tillage pan, High water table, Poor soil structure	-Improve drainage – -construct French drains -Deep tillage (chisel) -Change tillage depth -Amend the soil with organic matter -Cover cropping -Regulate irrigation systems	-Crop yield -Water flow and retention -Soil health Low CH_4 emission from the soil -Nitrogen uptake -Soil biodiversity -Nutrient bioavailability	Farmers, Citizens
Decline in soil biodiversity	Soil biodiversity, Pitfall trapping	Low soil organic matter, Low residues, Excess chemical input, Excess tillage, Poor aeration	Increase SOM input, Increase crop diversity, Conservation/reduced tillage, Cover crops	Crop yield Increase soil biodiversity, Increase biodiversity Carbon and nutrient cycling Food safety, Soil structure Water stability	Farmers, Citizens
Soil salinity	Electrical conductivity, White crust	Shallow water table, excessive use of irrigation water Saline water intrusion, Poor drainage	Leach excess salt, Plant deep rooted crop , Manage irrigation, Improve drainage	Increase soil biodiversity Soil detoxification Soil structure Water infiltration crop growth	Farmers, Citizens
Soil Acidity	Soil solution pH P Ca Mg Mo Si	Use of ammonium fertiliser, Lack of liming Build-up in organic matter	Correct pH level -Timing and application of lime Improve drainage	Crop yield, Soil life biodiversity, Carbon and nutrient cycling, pesticides (Bennett *et al*., 2010) absorption and mobility, nutrient availability Water quality	Farmer, Citizens

(after Soane, 1990; Gardner *et al.*, 1992; Janzen *et al*., 1992; Olson & Janzen, 1992; Berry & Karlen, 1993; Hamblin & Karlen *et al.*, 1994; Lavelle *et al.*, 1997; Reeves, 1997; Haynes & Naidu, 1998; Chaer, 2010;Davies, 1997; Bolin & Sukumar; 2000; Hamza & Anderson, 2001; 2003; Franzluebbers, 2002; Hamza & Anderson, 2002a, 2003; Fujita *et al.*, 2006; Kogel-Knabner, 2002; Reichert *et al.*, 2007; Verzanni & Mielniezuk, 2009)

Appendix 5: Semi-structured Interviews

Farmers:
Which crops do you cultivate on your farm?
Which soil type do you have?
On how many hectares do you cultivate?
Do you lease land? If yes, how many hectares?

Sustainable soil practices:

- What is sustainable soil management according to you?
- Do you experience soil degradation? If yes, what type? In how far does that affect your farm management?
- Do you take soil samples on regular basis? Why?
- Which indicators of soil quality do you consider to be most important?

The definition of sustainable soil management that we include in our research is the practices that have a positive influence on the quality of the soil, without damaging it or depleting it from natural sources. The societal interest here is served by the maintenance and improvement of soil functions. Sustainable practices that apply to this are *reduced tillage, crop rotation, use of natural manure.*

- What would be the reasons for you to apply or not to apply these practices?
- Where do you gain advice on sustainable soil management? (for example DLV or free advice from fertiliser suppliers, magazines, farmer meetings)

Law/policy

- According to you, which sustainable soil practices are stimulated on EU, national or provincial level?
- Which barriers do you find on EU, national or provincial level regarding the application of sustainable soil management practices?
- To which extent does the current manure policy influence your choices on sustainable soil management?
- How do you perceive the transfer of knowledge from authorities to farmers? How do authorities such as LTO and NAV look after your interests within this picture?

Land lease system

- What are the lease requirements in your contract with regard to sustainable soil management?
- To what extent do short-term/long-term contracts influence your choices on sustainable soil management?
- Would you be prepared to pay extra for lease land that has high soil quality?

- Do you think the land lease system can be used to stimulate sustainable soil management? (for instance by means of the bonus point system)

First: explain what ES are. Think of carbon balance, disease and pest control , water regulation, food provisioning on short-term and long-term, biodiversity, nutrient supply.

Ecosystem services

- Which ES do you find most important? Top three.
- Do you consider the application of ES as your own responsibility or do you believe you should be compensated for it?
- How could the position of farmers in the chain be improved in order to stimulate sustainable soil management?

Experts, land funds and provinces

Practical application

- What do you consider to be sustainable soil management?
- How is sustainable soil management perceived by the farmers and the community?
- How is sustainable soil management monitored?
- How do you think advisory services (DLV, free advice from fertiliser suppliers) contribute to sustainable soil management by farmers?

Legislation

- How primary do you consider sustainability as an objective of current policies ?
- How do you think that soil sustainability is addressed by current policy and legislation on EU, national and provincial level? Which barriers can you identify? Who has the most power?
- What is your role between government and farmers?
- What can be the effect of the current manure policy (N and P related legislation) on the choices that farmers will make to apply sustainable soil management practices?
- How do you think LTO and NAV take their role in knowledge transfer and protecting the interests of the farmers?

Leasing system

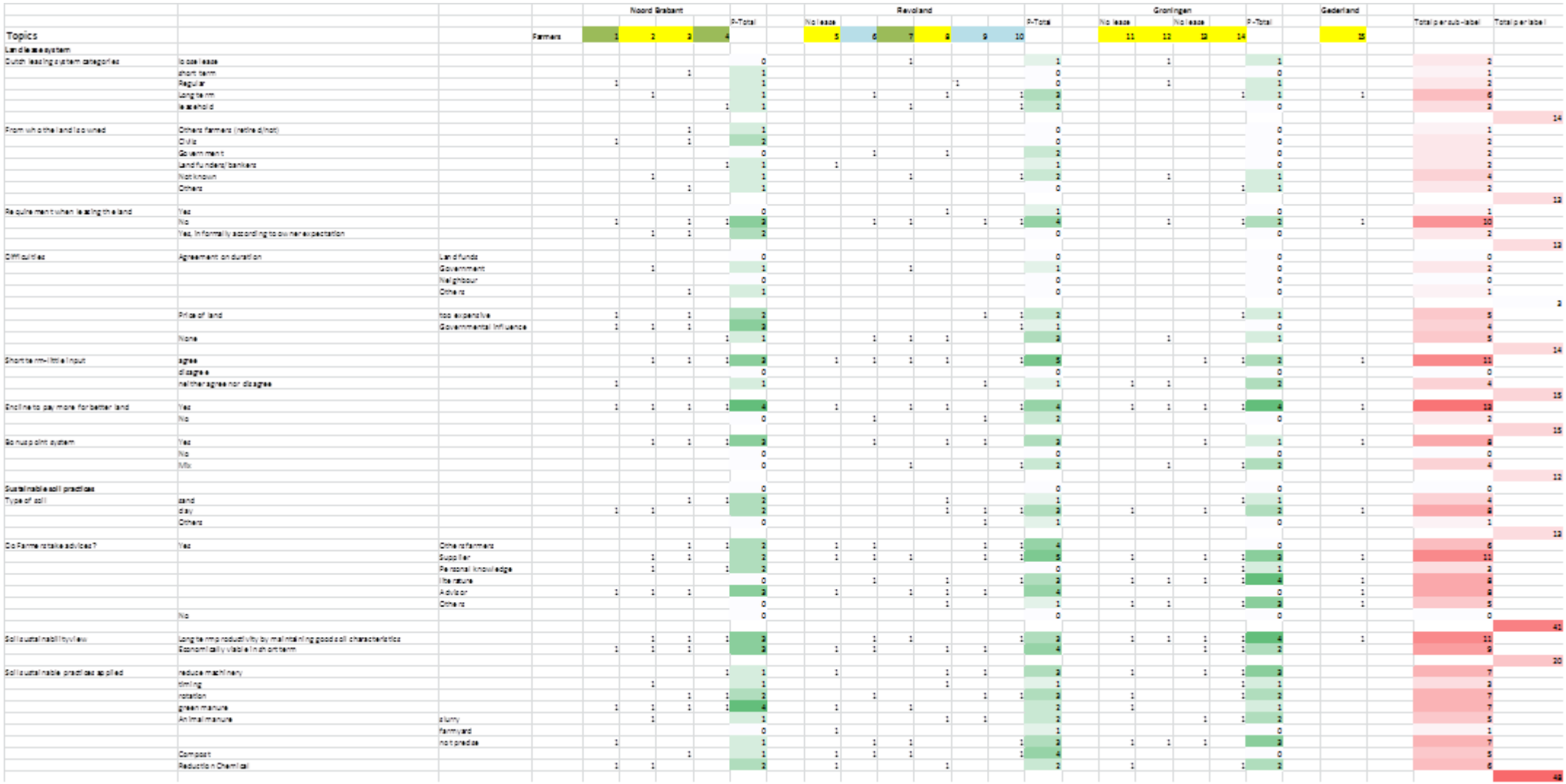
- How do you think the short-term/long-term leasing system influences sustainable soil management?
- How do you think the land leasing system can support sustainable soil management practices?

Ecosystem services

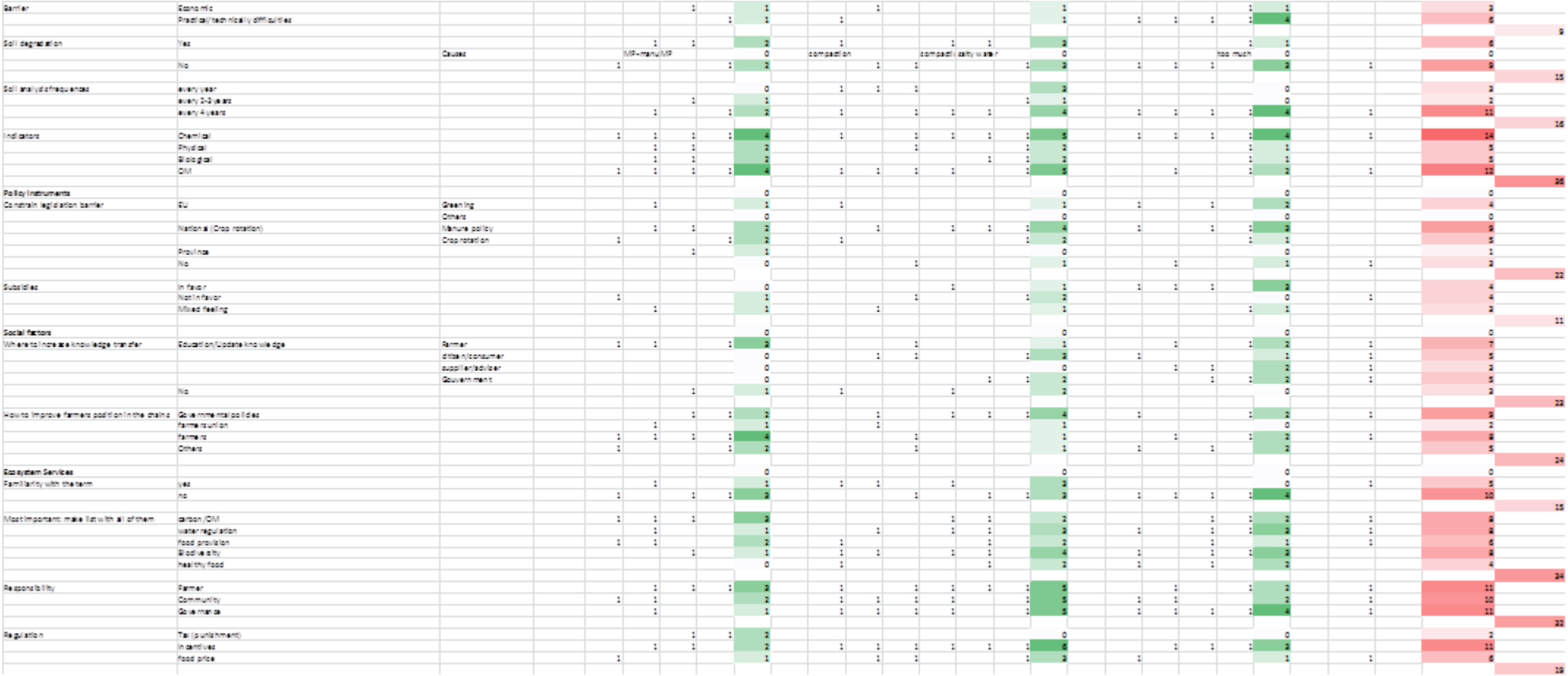
- How do you think farmers perceive the term ES?

- To what extent do you consider ES the responsibility of farmers?
- How do you incentivise maintenance of ES?
- Can bonus points serve as a solution?
- How could the position of farmers be improved in order to stimulate sustainable soil management?

Appendix 6: Coding of the interviews



				Noord Brabant					Revoland							Groningen					Gederland		
								P-Total							P-Total					P-Total		Total per sub-label	Total per label
Topics			Farmers	1	2	3	4		5	6	7	8	9	10		11	12	13	14		15		
Land lease system																							
Dutch leasing system categories	loose lease							0			1				1		1			1		2	
	short term					1		1							0					0		1	
	Regular			1				1				1			0		1			1		2	
	Long term				1			1		1			1		2				1	1	1	6	
	leasehold						1	1			1			1	2					0		3	
																							14
From which the land is owned	Others farmers (retire d/not)					1		1							0					0		1	
	Civils			1		1		2							0					0		2	
	Government							0		1		1			2					0		2	
	Land funders/bankers						1	1	1						1					0		2	
	Not known				1			1			1			1	2		1			1		4	
	Others					1		1							0				1	1		2	
																							12
Requirement when leasing the land	Yes							0			1				1					0		1	
	No			1		1	1	3		1	1		1	1	4		1		1	1	1	10	
	Yes, informally according to owner expectation				1	1		2							0					0		2	
																							13
Difficulties	Agreement on duration	Land funds						0							0					0		0	
		Government			1			1			1				1					0		2	
		Neighbour						0							0					0		0	
		Others				1		1							0					0		1	
																							3
	Price of land	too expensive		1		1		2					1	1	2					1	1	5	
		Governmental influence		1	1	1		3						1	1					0		4	
	None						1	1		1	1	1			3		1			1		5	
																							14
Short term- little input	agree				1	1	1	3	1	1	1	1		1	5				1	1	1	11	
	disagree							0							0					0		0	
	neither agree nor disagree			1				1					1		1	1	1			2		4	
																							15
Incline to pay more for better land	Yes			1	1	1	1	4	1		1	1		1	4		1	1	1	1	1	10	
	No							0		1			1		2					0		2	
																							15
Bonus point system	Yes				1	1	1	3		1		1	1		3				1	1	1	9	
	No							0							0					0		0	
	Mix							0			1			1	2		1		1	2		4	
																							13
Sustainable soil practices								0							0					0		0	
Type of soil	sand					1	1	2				1			1				1	1		4	
	clay			1	1			2				1	1	1	3	1		1		2	1	8	
	Others							0					1		1					0		1	
																							13
Do Farms take advices?	Yes	Other farmers				1	1	2	1	1			1	1	4					0		6	
		Supplier			1	1		2	1	1	1		1	1	5	1			1	2	1	11	
		Personal knowledge			1		1	2							0				1	1		3	
		The nature						0		1		1		1	3	1	1	1	1	4	1	8	
		Advisor		1	1	1		3	1		1	1	1		4					0	1	8	
		Others						0				1			1	1	1		1	3	1	5	
	No							0							0					0		0	
																							42
Soil sustainability view	Long term productivity by maintaining good soil characteristics				1	1	1	3		1	1			1	3	1	1	1	1	4	1	11	
	Economically viable in short term			1	1	1		3	1	1		1	1		4				1	2		9	
																							20
Soil sustainable practices applied	reduce machinery						1	1	1			1	1		3	1			1	2		7	
	timing				1			1				1			1				1	1		3	
	rotation					1	1	2		1			1	1	3	1			1	2		7	
	green manure			1	1	1	1	4	1		1				2	1				1		7	
	Animal manure	slurry			1			1				1	1		2				1	2		5	
		farmyard						0	1						1					0		1	
		not precise		1				1		1	1			1	3	1	1	1		3		7	
	Compost					1		1	1	1	1			1	4					0		5	
	Reduction Chemical			1	1			2	1			1			2	1			1	2		6	
																							48



The figure below is a copy from the excel file used to analyse the interviews from the farmers. The labels and sub-labels are gathered per topics in column and the farms are regrouped per provinces. For all of them a color code is attributed, the green color correspond to the organic farms, the blue is for the conventional growers that were 'Stichting Veldleeuwerik' certified and the yellow ones are the conventional ones. In order to quantitatively analyse our results, each time a label or a sub-label was identified in an interview the number one "1" was attributed in the corresponding cell. The results are calculated per province (P-Total), per sub-label and per label.