Wettelijke Onderzoekstaken Natuur & Milieu

Exploring green agricultural policy scenarios with a spatially explicit agent-based model

WOt-werkdocument 323

M.A.H. Schouten, N.B.P. Polman en E.J.G.M. Westerhof

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Abstract
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This report presents an analysis of the impact of environmental cooperative decision-making for the European Commission's legislative proposals for the EU Common Agricultural Policy (CAP) 2014-2020. The analysis is based on scenarios with a spatially explicit rural agent-based model (SERA) that explicitly models farmers, their socio-economic decision-making, their land use, and the landscape of which they are part. The first part of the analysis focuses on the effects of environmental cooperative collective decision-making for implementation of the 'greening measure' Ecological Focus Areas (EFAs). The second part of the analysis focuses on the interest of collective agri-environment measures. Results show that ways through which EFAs are allocated are crucial for effectiveness of cooperative approaches. Relying on simple market oriented governance structures will not by definition result in a better allocation of EFAs in a region. Results show that when the environmental cooperative is a key player in the designation and allocation of Pillar II agri-environment schemes, farmland biodiversity potentially increases because local expert knowledge on favorable ecological sites can be used for optimal allocation of the schemes.

Keywords: European Common Agricultural Policy, environmental cooperative, collective action, greening, agri-environment scheme, farmer co-operatives, landscape-scale management.

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Preface

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This report does not necessarily reflect the views of participating stakeholders and in no way anticipates on future policy in this area. The authors are solely responsible for the content of this report.

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The Hague, March 2013

Contents

Summary

This working document presents an analysis of the spatial, ecological and economic impact of farmers' cooperative decision-making for the European Commission's legislative proposals for the Common Agricultural Policy (CAP) 2014-2020 on farmers, their land use and their surroundings. The analysis is based on scenarios with a spatially explicit rural agent-based model (SERA) that explicitly models farmers, their socio-economic decision-making, their land use, and the landscape of which they are part.

The analysis is split into two parts. The first part of the analysis focuses on the effects of environmental cooperative decision-making for implementation of the 'greening measure' Ecological Focus Areas (EFAs), in which farmers are obliged to convert 7% of their agricultural land for biodiversity purposes. Two alternative management regimes are simulated, the first one assuming that farmers oblige to the measure by converting 7% of their own land into Ecological Focus Area. The second one assuming that the environmental cooperative facilitates exchange between farmers within the region, through arranging transferable obligations between farmers. The second part of the analysis addresses agri-environmental measures within the second pillar of the CAP. Two alternative management regimes were simulated, the first considering agri-environmental contracting as it is now, with a fixed payment per hectare, irrespective of parcel characteristics. The second one assumes an important role for the environmental cooperative that uses their local knowledge to decide which parcels are contracted with agri-environment schemes given budget constraints and given their contribution to biodiversity.

In order to get a good overview of the spatial, ecological and economic impact of both measures and both management regimes, results were analyzed using indicators with respect to biodiversity, operational farm profit and the number of operating farms in both regions. Results of experimentation with the model in the case study Oost-Groningen (arable farming) and the case study Winterswijk (dairy farming) show that the conversion of high productive land into EFAs leads to a significant decrease in operational profit, as productive land is taken out of production on farm level and regional level. Farms will choose their less productive land to be EFAs. These EFAs will be scattered around the area. Furthermore, it is shown that when exchange of EFA parcels is allowed between farmers in the areas, based on economic value of land only, lower biodiversity is developed in the model than when comparing to a situation in which farmers have to comply to the EFAs measure on their own farm. Less productive land that is not sufficiently located in neighborhood of the farmstead will be under EFAs. This means that coordination of environmental cooperatives cannot rely on simple spot market based mechanisms. Therefore more procedures will be necessary.

When the environmental cooperative is a key player in the designation and allocation of Pillar II agri-environment schemes, farmland biodiversity potentially increases because local expert knowledge on favorable ecological sites can be used for optimal allocation of the schemes. In line with the attributes of the transactions for EFAs and agri-environment schemes it follows that hybrid governance arrangements would be appropriate for environmental cooperatives. Hybrid arrangements consist of elements both of markets and hierarchies. However, other means of co-ordination are used besides prices and hierarchy, such as reciprocity and trust. Implementing these means will require further model development.

We conclude that this approach is novel and holds promise as a way to explore the impact of environmental cooperative decision making on rural areas. The modeling approach used in this study integrates both the natural environment and the socio-economic component at a detailed level. In this

way insight is gained into the complex dynamics of rural areas while imposing different types of policy instruments with different types of management regimes to the system. These insights can be valuable for rural policy makers and managers to evaluate what the impact is of potential policies, and to gain insight into the impact of environmental cooperatives, while aiming at creating sustainable development

Samenvatting

Verkenning van vergroeningsmaatregelen in de landbouw; toepassing van een ruimtelijk expliciete agent-gebaseerde benadering

Inleiding

Collectieven van boeren kunnen mogelijk bijdragen aan vergroening van het Gemeenschappelijk Landbouwbeleid (GLB), zowel in de eerste pijler (met name de ecologische aandachtsgebieden) als de tweede pijler (agrarisch natuur- en landschapsbeheer). De analyse is gebaseerd op experimenten met verschillende scenario's door middel van een ruimtelijk expliciet ruraal agent-gebaseerd model (SERA). Deze nieuwe agent-gebaseerde methode levert inzichten op over de complexiteit van besluitvorming van agrarische ondernemers, de invloed hiervan op het omringende landschap en hoe dit kan worden gestuurd door beleid. Dit kan toegevoegde waarde bieden voor beleidsmakers en gebiedscoördinatoren doordat een globaal inzicht wordt verkregen in potentiële effecten van nieuwe beleidsmaatregelen gericht op biodiversiteit. Om preciezere inzichten te verkrijgen is verdere modelontwikkeling nodig. Het onderzoek laat zien dat collectieve vormen van agrarisch natuurbeheer kunnen bijdragen aan ecologische netwerken op landschapsniveau. De wijze waarop agrarische natuurverenigingen agrarisch natuurbeheer onderling afstemmen in een gebied is hierbij bepalend voor de bijdrage aan biodiversiteit.

Aanleiding

Op 12 oktober 2011 heeft de Europese Commissie wetgevingsvoorstellen gedaan voor het nieuwe Gemeenschappelijk Landbouwbeleid dat op 1 januari 2014 ingaat, en loopt tot en met 2020. Op dit moment zijn de onderhandelingen tussen de Europese Commissie (EC), het Europees Parlement en de Landbouw- en Visserijraad (Ministers) over specifieke invulling van dit nieuwe beleid in volle gang. Een belangrijk element in de voorstellen van de Europese Commissie is het vergroenen van de directe betalingen aan boeren via een verplicht aantal maatregelen. Voor Nederland heeft de maatregel ecologische aandachtsgebieden ('Ecological Focus Areas', EFA) een mogelijk grote impact. In deze maatregel worden boeren verplicht om een deel van hun areaal in te richten voor 'ecologische doeleinden'.

Op dit moment is er een debat gaande in Nederland tussen de overheid en betrokken partijen over hoe deze maatregel ingevuld zou moeten worden. Hoewel nog niet duidelijk is hoe precies de implementatie van de maatregel er uit zal zien, is het wel duidelijk dat de EC voor ogen heeft dat de EFA-maatregel netto meer niet- of minder-productief oppervlak in het agrarisch gebied oplevert, wat een duidelijke meerwaarde oplevert voor klimaat, milieu en/of biodiversiteit. De Nederlandse overheid ondersteunt deze prioritering, en zet daarnaast in op het werken met collectieven om de effectiviteit van agrarisch natuurbeheer te vergroten. De verwachting is dat een collectieve aanpak zal leiden tot een meer samenhangende aanpak van agro-milieubeheer en schaalvoordelen voor individuele ondernemers. Zij kunnen op basis van een regionale visie, zelfsturing en een eigen plan van aanpak een pakket aan maatregelen samenstellen. Dit pakket berust dan op een op het gebied toegesneden plan dat samenhang heeft en past bij de regionale bedrijfsvoering. Binnen een viertal GLB-pilotsstudies is men momenteel aan het experimenteren met gebiedsgericht werken via collectieven van boeren.

Het WOt-project 'Verkenning van vergroeningsmaatregelen met een ruimtelijk expliciete agent-gebaseerde benadering' heeft de potentiële effecten verkend van inzet van collectieven bij de uitvoering van de 1^{e} pijler-maatregel ecologische aandachtsgebieden en 2^{e} pijler-maatregelen voor agrarisch natuur en landschapsbeheer (specifiek gericht op SNL; Subsidiestelsel Natuur en Landschapsbeheer. De regio's Oost-Groningen (overwegend akkerbouw) en Winterswijk (grondgebonden melkveehouderij) worden gebruikt als case study gebieden.

Methode

Het ruimtelijk expliciete ruraal agent-gebaseerde model 'SERA' is toegepast om de potentiële effecten van collectief en individuele uitvoering van beide maatregelen in kaart te brengen. SERA is een model om besluitvorming te bestuderen in een ruraal landschap dat wordt gevormd door boeren, hun bedrijven, en het omringende landschap. Agent-gebaseerde modellen zijn op dit moment een populaire methode om complex gedrag van mensen ('agenten'), natuur en omgeving te bestuderen, omdat dit kan worden gedaan in een experimentele setting waarbij de belangrijkste elementen van de werkelijkheid kunnen worden gevat in een model. Ook voor beleidsevaluaties voor nieuw landbouwbeleid is deze methode in het verleden toegepast. SERA onderscheidt zich van andere agent-gebaseerde benaderingen doordat individuele besluitvorming van boeren, wordt gecombineerd met landgebruik, gewasproductie en biofysische processen (grondwater, bodemgeschiktheid). SERA wordt gevormd door de individuele boeren (agenten), hun percelen en het omringende landschap in Oost-Groningen en Winterswijk.

Figuur 1 geeft een overzicht van de verschillende modules in SERA die iedere boer ieder jaar doorloopt. Het model simuleert een periode van 15 jaar. Voor het model wordt Landbouwtellingdata gebruikt van de individuele boeren in Oost-Groningen en Winterswijk. Er zijn 564 akkerbouwers in Oost-Groningen en 201 melkveehouders in Winterswijk geselecteerd voor het referentiejaar 2010. Samen gebruiken deze boeren ongeveer 60% van de landbouwgronden in beide gebieden. Verder wordt data gebruikt over landgebruik, gewasgroei, bodemkwaliteit, bodemgeschiktheid en grondwater door middel van GIS-kaarten.

De akkerbouwsector in Oost-Groningen in SERA produceert zetmeelaardappelen, suikerbieten en tarwe in een bouwplan. Daarnaast kunnen zij contracten voor agrarisch natuurbeheer afsluiten en kunnen de gevolgen van EFAs worden gesimuleerd. De opbrengst van deze gewassen is afhankelijk van lokale variaties in bodemkwaliteit. Iedere periode maakt de boer keuzes over landgebruik op zijn percelen, en over het eventueel kopen of verkopen van percelen.

De melkveehouderijsector in Winterswijk wordt weergegeven in SERA door melkveehouders. Naast de mogelijkheid voor uitvoering van agrarisch natuurbeheer en EFA's produceren melkveehouders melk, gras en snijmaïs. De boeren verschillen van elkaar in termen van bedrijfsgrootte, aantal koeien, aantal hectares gras en maïs, bodemkwaliteit van de percelen, locatie van het bedrijf in het gebied, leeftijd en aanwezigheid van een opvolger.

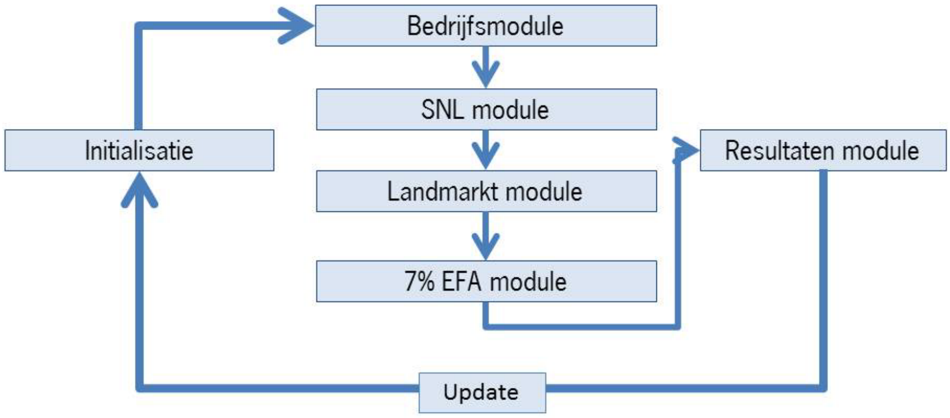
In het model reageert een boer op veranderingen in de omgeving en veranderingen in zijn eigen situatie (bijvoorbeeld door pensionering, bedrijfsopvolging) door het management van zijn bedrijf aan te passen. De boeren zijn in staat om land uit te wisselen op een landmarkt, percelen te contracteren met agrarische natuurbeheerscontracten, of land uit productie te nemen voor de EFA-maatregel. Ieder jaar maakt de boer keuzes op basis van zijn veranderde situatie, of zijn veranderde omgeving.

Voor het model zijn de onderstaande punten van belang:

- Het model start met een initialisatiestap waarbij de basisdata wordt ingelezen.
- In de bedrijfsmodule beschikt iedere boer over een besluitvormingsmodel waarmee de virtuele boer beslissingen neemt, maar die ook interne variabelen meeneemt, zoals leeftijd en de aanwezigheid van een opvolger. Op basis van deze besluitvormingsmodellen reageert de boer in het model op veranderingen in zijn eigen situatie en in zijn omgeving. Het doel van de boeren in SERA is om zoveel mogelijk winst te behalen, gegeven de informatie die de boer heeft.
- In de SNL-module maken boeren de keuze of zij percelen willen contracteren met agrarische natuurbeheerscontracten (SNL = Subsidiestelsel Natuur en Landschapsbeheer).
- In de landmarktmodule kunnen boeren percelen uitwisselen met elkaar.
- In de EFA-module kiezen boeren welk deel van hun bedrijf uit productie wordt genomen voor de 7% EFA regeling.
- In de resultatenmodule worden alle veranderingen in de bedrijfsstructuur en in het landschap geregistreerd. Deze veranderingen dienen als input voor de volgende simulatieronde van een jaar.

- Voor de bijdrage aan het ecologisch netwerk wordt voor ieder perceel een index berekend. Hierdoor is in één oogopslag duidelijk hoe groot de (potentiële) bijdrage is van een perceel aan het ecologische netwerk.

In Figuur 1 wordt SERA schematisch weergegeven. Deze gegeven worden gebruikt bij de start van het model (initialisatie in Figuur 1).



Figuur 1: *Stroomdiagram met stappen die boer in SERA doorloopt*

Scenario's en resultaten

Tabel 1 geeft een overzicht van de scenario's die met behulp van SERA zijn gesimuleerd.

Tabel 1: *Overzicht gesimuleerde scenario's*

Scenario	Naam	Uitvoering in SERA
0	Basis scenario *Geen beleidsimplementaties*	• Geen agrarisch natuurbeheerscontracten • Geen EFA's • Boeren verhandelen grond
1	Huidig Europese Commissie voorstel *7% EFA voor iedere boer verplicht op zijn eigen bedrijf*	• Boeren verplicht om 7% van hun land om te zetten voor ecologische doeleinden op hun eigen bedrijf • Ieder perceel is potentieel geschikt
2	Collectieve implementatie van 7% EFA's *Collectief faciliteert uitruil van vergroeningsrechten tussen boeren*	• Boeren verplicht om 7% van hun land om te zetten voor ecologische doeleinden. Ze mogen dit uitruilen met andere boeren. • Het collectief regelt de uitruil van 'vergroeningsrechten' tussen boeren in het gebied • De uitruil is economisch gedreven, geen criteria gesteld voor biodiversiteit
3	Agrarisch natuurbeheerscontracten volgens huidige SNL beleid *Agrarisch natuurbeheer in door de overheid aangewezen gebieden*	• Een vaste betaling per hectare, ongeacht bijdrage van perceel aan ecologisch netwerk • De provincie wijst gebieden aan
4	Implementatie van agrarisch natuurbeheerscontracten door collectief *Het collectief bepaalt waar percelen worden gecontracteerd, op basis van lokale kennis van het gebied*	• Het collectief bepaalt op basis van bijdrage aan ecologisch netwerk welke percelen worden gecontracteerd, met inachtneming van het beschikbare budget • Er is een flexibele betaling per hectare, op basis van bijdrage van perceel aan ecologisch netwerk en bonus • Het totale budget is niet beperkend.

De boeren in SERA kunnen voldoen aan de verplichtingen voor de EFA-maatregel door 7% van hun areaal in te richten voor ecologische doeleinden. Dit doen ze in eerste instantie op het eigen bedrijf; in tweede instantie is er een optie om 'vergroeningsplichten' uit te ruilen met andere boeren in het gebied. Deze uitruil wordt gefaciliteerd door het collectief. Boeren die vergroeningsplichten uitruilen, betalen een vergoeding aan de boer die de plicht aantrekt. De hoogte van de vergoeding wordt bepaald door vraag en aanbod.

Agrarische natuurbeheerscontracten kunnen worden afgesloten op percelen of akkerranden die zijn gekenmerkt als zoekgebied in de provinciale natuurbeheerplankaart. In eerste instantie bepaalt de overheid waar percelen worden afgesloten, tegen een vaste vergoeding per hectare. In tweede instantie bepaalt – in de modellering – het collectief waar percelen worden afgesloten, op basis van de toegevoegde waarde van het perceel voor ontwikkeling van biodiversiteit. De boeren krijgen een vergoeding die afhangt van deze toegevoegde waarde, op basis van de Reilly index. Het totale budget is onbeperkt. In Oost-Groningen kunnen natuurbeheerscontracten alleen worden afgesloten op akkerranden, die binnen het zoekgebied liggen voor 'bouwland met doortrekkende en overwinterende akkervogels'. De hoogte van de vergoeding verschilt voor klei- en zandgrond. In Winterswijk kunnen potentiële contracten alleen worden afgesloten op percelen die liggen binnen het zoekgebied voor 'botanisch weiland/ botanisch hooiland'. Voor deze contracten geldt een verbod op toedienen van dierlijke mest, gebruik van kunstmest, gebruik van bestrijdingsmiddelen en deze percelen kunnen slechts beperkt worden begraasd.

EFA-maatregel
De resultaten laten zien dat de invoering van de EFA-maatregel in beide case studies zorgt voor een lager inkomen per hectare op bedrijfsniveau, door het uit productie halen van agrarisch land. Als uitruil van vergroeningsrechten wordt toegestaan tussen boeren in het gebied, dan leidt dit tot een iets lagere natuurwaarde dan wanneer iedere boer verplicht wordt om de maatregel op het eigen bedrijf te voldoen. Belangrijkste reden hiervoor is te vinden in de aannames in SERA, die veronderstellen dat boeren de laagproductieve percelen (en niet per definitie die met de hoogste natuurwaarde) zullen gebruiken om aan de eis te voldoen. Deze percelen zijn wijder verspreid in het gebied, en liggen niet per definitie in de buurt van natuurgebieden. Het aantal actieve bedrijven wordt in beide case studie gebieden sterk beïnvloed door demografische factoren als vergrijzing en de beschikbaarheid van een opvolger. Deze factoren zorgen voor een sterke daling in het aantal actieve bedrijven over een simulatieperiode van 15 jaar. Deze demografische factoren blijken een sterkere invloed te hebben op het aantal actieve boeren gedurende de simulatieperiode dan de twee beleidsmaatregelen.

Agrarisch natuurbeheerscontracten
De invoering van agrarische natuurbeheerscontracten zorgt in beide gebieden voor een hoger bedrijfsinkomen dan in een situatie waarin géén agrarisch natuurbeheer wordt uitgevoerd. Belangrijkste reden hiervoor is dat boeren in SERA hun laagproductieve percelen of akkerranden kunnen contracteren voor agrarisch natuurbeheer (SNL), en hierdoor een hogere opbrengst per perceel kunnen behalen dan in het geval van conventionele productie. De bijdrage aan biodiversiteit vertoont een sterke stijging wanneer het collectief leidend is bij het aanwijzen en contracteren van percelen voor agrarisch natuurbeheer.

1 Introduction

1.1 Policy background

On 12 October 2011 the European Commission (EC) presented a set of legislative proposals for the EU Common Agricultural Policy (CAP) 2014-2020 period. The proposals are designed to make the CAP 'a more effective policy for a more competitive and sustainable agriculture and vibrant rural areas' (EC, 2011a; p.5). The main five proposals consist of draft regulations on rules for direct payments; on a single Common Market Organisation (CMO); on support for rural development; on financing, management and monitoring (horizontal rules); and on the Common Strategic Framework (CSF) (see EC, 2011a; EC, 2011b; EC, 2011c; EC, 2011d; EC, 2011e).

In the EC proposals, the present two-pillar structure of the CAP is to be maintained, though they will be modified (Westhoek *et al.*, 2012). The main instruments of Pillar I are direct payments to farmers and market measures. The most prominent change is the introduction of a greening component to Pillar I, giving three measures at farm level:

- Crop diversification;
- Maintenance of permanent grassland;
- 7% Ecological Focus Areas (EFAs) on all eligible land per farm – except permanent grassland and farms with less than three hectares of arable land used for the preservation of ecological reserves and landscapes. This condition may be met by setting aside arable land, left to lie fallow, or by using buffer strips, landscape features, afforested areas and terraces – if part of the eligible area of the farm.

Main aim of the proposed greening measures is to stimulate farmland biodiversity and reduce greenhouse gas emissions. The greening measures in Pillar I have an annual, non-contractual basis and apply to all EU farmers in a generic way. For The Netherlands, the 7% EFA measure will have the largest impact (see Van Doorn *et al.*, 2012 and TK, 2012) on agricultural production, land use and spatial configuration when comparing to the other two. There is an on-going debate in The Netherlands on how to implement EFAs in the most effective and efficient way. Westhoek *et al.* (2012) states that the proposed greening measures will only be effective if they are tailored to region-specific management conditions, giving maximum freedom for optimal implementation at a local level, through i.e. farmers' collectives.

Within Pillar II, proposed changes aim at multi-annual, location specific contracts that are targeted to specific priorities. Six new EU-wide priorities for Pillar II are proposed (EC, 2011b). Restoring, preserving and enhancing ecosystems that depend on agriculture and forestry, is one of these priorities. The special character of each territory should be taken into account and agri-environmental initiatives at national, regional and local level should be encouraged. These proposed changes show a clear reference to the use of farmers' collectives to increase efficiency and effective rural development. The EC proposal for rural development states that '*support for collective approaches to environmental projects and practices should help to provide greater and more consistent environmental and climate benefits than can be delivered by individual operators acting without reference to others (for example, through practices applied on larger unbroken areas of land). Support in these various areas should be provided in various forms'* (EC, 2011b, p.19).

Currently, the Dutch government evaluates the potential of applying more collective instead of individual agreements concerning agri-environment schemes (AESs). The basic logic is that agri-environment programs are not applied on isolated parcels, but are integrated into the regional farming system. Both the provinces and the central government encourage such a regional approach, where environmental cooperatives receive a budget linked to a given biodiversity target, which they may organize in their own way within the existing governmental regulations. The Ministry of Economic Affairs states that one wants to examine the possibility to increase the role of environmental cooperatives for executing CAP measures (TK, 2011). The execution of CAP measures is expected to be more effective and efficient when using environmental cooperatives. The concept of collective agreements is applicable to both Pillar I measures (especially the EFAs) and Pillar II measures (mainly AESs).

For this study, a first analysis is made of the potential impact of using environmental cooperatives for the EFAs proposed in Pillar I and AESs in Pillar II. A spatially explicit rural agent-based model (SERA) is used to experiment with different implementation scenarios for the 7% EFA measures. Furthermore, the model assists in evaluating the possibilities for applying collective instead of individual agreements concerning AESs.

1.2 Objective

The objective of this study is to provide insight into the spatial, ecological and economic impact of applying collective approaches for both Pillar I greening measures and Pillar II agri-environment measures through experimentation with different scenarios using a spatially explicit agent-based model. The first part of the analysis focuses on the EFAs greening measure. The second part of the analysis focuses on the interest in collective AESs.

1.3 Overview of the working document

This working document proceeds as follows. In Chapter 2 an overview is given of the European Agricultural Policy post 2013. Chapter 3 discusses the agent-based method used in this study. Chapter 4 discusses the two case studies. In Chapter 5 the scenarios used for model simulation are discussed as well as the way we implemented the EU proposals in SERA. Chapter 6 discusses the results. The working report concludes with a conclusion and discussion in Chapter 7.

Table 1.1: *Overview of the working document*

Chapter	Content
Chapter 1: Introduction	Policy background and research objective
Chapter 2: European Common Agricultural Policy post 2013: State of the Art	Extensive policy background
Chapter 3: Methodology	Why using an agent-based modelling approach?
Chapter 4: Case studies from Oost-Groningen and Winterswijk	Case studies
Chapter 5: Scenarios	Modeling scenarios for Ecological Focus Areas and agri-environment schemes in SERA: Discussion of model scenarios
Chapter 6: Results	Main results
Chapter 7: Reflection	

2 European Common Agricultural Policy post 2013: State of the Art

2.1 Pillar I: Ecological Focus Areas

2.1.1 Initial legislative proposals of the European Commission

In the legal proposals for the CAP after 2013 (EC, 12 October 2011), its present two-pillar structure is to be maintained: Pillar I for market measures as well as direct payments, and Pillar II covering rural development. According to the proposals, both Pillars will be modified. These modifications have several objectives, including increasing the contribution of the CAP to a more sustainable management of natural resources and climate actions (Westhoek *et al.*, 2012). The direct payments in Pillar I are mainly aiming at providing 'basic annual income support to EU farmers' (EC, 2011a). Proposed changes to the CAP concern a reform of cross-compliance requirements and a new design for direct payments. The most prominent change is the introduction of a greening component to Pillar I, with three measures at farm level:

- Crop diversification by growing at least three different crops, each covering an area of between 5% and 70% per farm holding. The legislative proposal does not promote crop rotation or a specific combination of crops, as the latter could be perceived as production support and hence distort trade.
- Maintaining permanent grassland. This applies to grassland that has not been reseeded for at least five years. Individual farmers are obliged to preserve at least 95% of this reference area.
- 7% EFAs on all eligible arable land per farm – except permanent grassland and farms with less than three hectares of arable land. This condition may be met by setting aside arable land, left to lie fallow or by using buffer strips, landscape features, afforested areas and terraces – if part of the eligible area of the farm. The conditions for payment are annual and non-contractual, therefore EFAs are not fixed in space or time.

Organic farms do not have to comply with these conditions to be eligible for payment. Agricultural areas that have been designated as nature areas under the Bird and Habitats Directives have to comply, unless the measures interferes with Natura 2000 targets.

In the legislative proposals, EFAs are defined as (EC, 2011a):

> *Article 32: Ecological focus area*
>
> *1. Farmers shall ensure that at least 7 % of their eligible hectares as defined in Article 25(2), excluding areas under permanent grassland, is ecological focus area such as land left fallow, terraces, landscape features, buffer strips and afforested areas as referred to in article 25(2)(b)(ii).*
>
> *2. The Commission shall be empowered to adopt delegated acts in accordance with Article 55 to further define the types of ecological focus areas referred to in paragraph 1 of this Article and to add and define other types of ecological focus areas that can be taken into account for the respect of the percentage referred to in that paragraph.*

It can be concluded that EFAs can be described as parts of the eligible hectares that are not used for conventional agricultural production, but are used for ecological purposes (Van Doorn *et al.*, 2012).

EFA measure is still under development

The legislative proposals of the Commission are still described in general terms and the implementation of EFAs is still subject to European and national debates. The proposals state that only area currently used for agricultural production can be designated for EFAs. During a debate in November 2011, Commissioner Ciolos proposed to add existing landscape elements (e.g. field margins, hedges, trees, fallow land, landscape features, biotopes, buffer strips and afforested areas) to the eligible area that can be designated as EFA. In May 2012 the debate was taken one step further, as a concept paper on Greening was presented (EC, 2012) in which the EC states that also AESs should be fulfilling for the EFA greening measure. From a Dutch standpoint, the former Dutch State Secretary Bleker stated that not only arable land should be fulfilling for EFAs, but also grassland (see Van Doorn *et al.*, 2012). These debates show that the 'rules of the game' for EFAs are maturing, still there is a lot of unclarity about the management conditions.

Though, for this study we have to make assumptions with respect to the EFA management conditions and there is a high probability that the actual decisions made by policy makers with respect to the EFA measure will be different. Still, this study can be a valuable contribution to the on-going process as it provides insights into different ways of implementing EFAs.

Despite of the fact that the EFA measure is still under development, the main idea behind the measure is that more eligible hectares should be taken out of production, and used for ecological purposes. In Chapter 5 it is described how we deal with these ambiguities using several assumptions.

2.1.2 Foreseen impacts of EFAs

Effects on farming practices

According to the EC Impact Assessment (EC, 2011f) an ecological set-aside requirement of 7% would lead to a set-aside of between 2.3% and 4.6% in actual practice. This percentage is lower than the requirement, as currently fallow land is already considered ecological set-aside. In The Netherlands, approximately 0.5% of agricultural land eligible for direct payments, is suitable for the EFA measure. Less than 3% of the area is contracted with AESs. The total area of landscape elements is unknown, estimations range from 3.2% to over 10% (Van Doorn *et al.*, 2012). It seems most meaningful to implement the measure in these areas where the obtained ecological value could be the highest.

Hence, there are certain loopholes, as a farmer with little EFA could rent parcels from farmers in other regions with plenty of low-productive areas, or even rent parcels of land from non-farmers (Westhoek *et al.*, 2012; Zijlstra *et al.*, 2011). In Chapter 5, we elaborate on how we prevent these possible loopholes from occurring by making model assumptions.

Effects on farmland biodiversity

The actual impact on biodiversity very much depends on the local conditions, details of regulations, and practical implementation. Westhoek *et al.* (2012) states that the introduction of EFAs may result in about one per cent more species richness on EU farmland by 2020. This one per cent increase is not absolute, but relative to a baseline scenario that does not foresee greening of the CAP (adaptation of PBL results from Van Zeijts *et al.*, 2011). Species richness is very much related to land-use type and land-use intensity. Changes in land use and intensity are therefore a rough indicator of changes in biodiversity in farmland areas. Westhoek *et al.* (2012) conclude from their study that biodiversity could improve substantially if EFAs would be implemented in such a way that they create a region-specific natural habitat for species under threat, organized on landscape level through multi-annual green infrastructure. Relevant boundary conditions concern shape and size of the areas (sufficiently large or broad), vegetation type (e.g. herbs or grains without chemicals), duration (multi-annual) and location. Preferably, EFAs would be connected through a multi-annual green infrastructure, yielding associated positive effects on biodiversity through species migration from ecological stepping stones and by establishing keystone structures, such as hedgerows and woodlands. This could be reached by combining the Pillar I greening measure and compensating additional costs and stimulating regional cooperation with Pillar II. In Section 3.2.3 is explained how an indicator for farmland biodiversity is integrated in this study.

2.2 Pillar II: Agri-environment schemes and collectives

2.2.1 Proposed changes European Commission Pillar II

Within the proposed changes for Pillar II, the EC states that rural development aims at promoting competitiveness, the sustainable management of natural resources, and the balanced development of rural areas by more specific and targeted measures. Pillar II would remain the support tool for community objectives giving the Member States sufficient flexibility to respond to their specificities on a multi-annual, programming and contractual basis. Member States is given sufficient flexibility to respond to their specificities on a multi-annual, programming and contractual basis (EC, 2011b). For AESs, the proposals state that they should continue to play a prominent role in supporting the sustainable development of rural areas and in responding to society's increasing demands for environmental services. The latest communication (May 2012) of the EC on simplification of the proposals (see EC, 2012; p.3) stated that:

> *'With a view to simplification and recognizing the environmental contributions farmers may make by taking up Pillar II agri-environment climate commitments or in the context of an environmental certification scheme, it is proposed:*
> - *To foresee, under certain conditions, that a beneficiary of a Pillar II agri-environmental climate measure can be considered as fulfilling one (or several) of the greening measures;*
> - *To foresee, under certain conditions, that a farmer, subject to an environmental certification scheme, can be considered as fulfilling one or several of the greening measures.*
>
> *The conditions which the agri-environment commitments or the environmental certification scheme would have to comply with concern:*
> - *Coverage of whole farm (in line with the greening objective that almost all agricultural area is subject to greening requirements)*
> - *Environmental ambition level that goes beyond the ambition level of greening*
> - *Type of agri-environmental scheme requirement that corresponds to the nature of the greening measures (e.g. crop rotation requirements corresponding to the greening requirement of crop diversification).*
>
> *These adjustments could bring simplification to those farmers who already generate significant benefits for the environment and the climate. It would also encourage other farmers to join the schemes and programs in question thus increasing overall environmental and climate benefit of the CAP.*

Apparently, the discussion after adoption of the proposals on greening and simplification resulted in extension of the greening measure EFA. It can be concluded that parcels under AESs also contribute to the 7% EFA greening component.

With respect to the use of environmental cooperatives, the proposals state that commitments undertaken jointly by a group of farmers (environmental cooperative) multiply the environmental and climate benefit and therefore should be promoted. However, joint action brings additional transaction costs which should be compensated adequately.

2.2.2 A collective approach to farmland conservation: the Dutch example

As stated in the introduction, in The Netherlands a decentralization process from government to provinces is going on, especially concerning nature policy. With respect to biodiversity and landscape elements on agricultural land, one aims for more responsibility for environmental cooperatives. Also within the proposed changes of Pillar II of the CAP, the importance of environmental cooperatives is mentioned (EC, 2011b). According to the CAP 2014-2020 website of the Ministry of EZ[1] *'farmers' delivery of public goods play an important role in the continuation of the CAP towards 2020. A collective approach will be conductive to a coherent agri-environment approach and will benefit the delivery of public goods. The effect of the agri-environment schemes will benefit the approach to climate change, renewable energy, water management and biodiversity in the rural area and is expected to lead to greater participation in agri-environment schemes'*.

Within the Netherlands there are about 150[2] environmental cooperatives. Around 25%[3] of the agricultural land is covered by these cooperatives. Their organizational form and activities are gradually changing from organizations focusing on the administrative process concerning AESs towards organizations who manage on-farm nature and landscape objectives within a region. Instead of simply implementing measures, one more and more develops and manages measures in a region-specific way, given the overall objectives outlined by the national authorities.

According to Jongeneel *et al.* (2008) the hypothesis is that collective agri-environmental contracts will lead to more effective and efficient policies when comparing to individual contracts. Slangen & Polman (2002) and Jongeneel *et al.* (2008) define several reasons for justifying the use of environmental cooperatives. The four most important are:

1. Reduction of the transaction costs because of economies of scale and common expertise in on-farm nature management. Also transaction costs for the government are lower because negotiations have to take place with one central organisation, instead of individual farmers.
2. Individual farmers need an institutional mechanism to countervail opportunistic behaviour: main problem here is that each contracting party worries about being forced to accept disadvantageous terms after making an investment, or worries that its investment will be devalued by actions of others. The collective body can prevent this by setting rules.
3. Compartmentalization in on-farm nature and landscape management is reduced, because of the regional or landscape scale approach.
4. Quality is monitored throughout the process, potential land users are screened and mechanisms of self-selection occur.

There is a difference between collective contracts which are pre-determined, or so-called 'take-it-or-leave-it-contracts, and a collective contract in which parties are able to negotiate on the preconditions (negotiable contracts). In the first case, the government settles the contract terms, and the land users have no specific input in the formulation of the contract terms. The negotiable contract is characterized by negotiation, in which each party can represent their arguments (tailor made contracts) (Jongeneel *et al.*, 2008). More information on the type of contracts, and contract terms used for this study can be found in Chapter 5.

Currently one is experimenting with self-management by environmental cooperatives in four pilot projects. On 14 October 2010 the Minister of Economic Affairs presented four pilot studies in which the role and possibilities of environmental cooperatives in delivering public goods (i.e. landscape,

[1] www.toekomstglb.nl

[2] Personal communication with Paul Terwan research & consultancy.

[3] According to 'A collective approach to farmland conservation – the Dutch example' by Paul Terwan research & consultancy for the ENRD Coordination Committee, 14 June 2012.

biodiversity) is further explored (TK, 2010). The four pilot areas get the opportunity to show that they are able to contribute to biodiversity or landscape objectives on agricultural land in their region, given a certain budget. The four environmental cooperatives 'Water, Land en Dijken' (province Noord-Holland), 'Stichting Waardevol Cultuurlandschap Winterswijk' (province Gelderland), 'Noorderlijk Friese Wouden' (province Friesland) and 'Agrarische Natuurvereniging Oost Groningen' (province Groningen) were assigned to investigate whether environmental cooperatives can be beneficial in the new CAP reforms 2014-2020 (TK, 2011).

On 14 June 2012, the four pilot studies presented their views to the ENRD (European Network for Rural Development) in Brussels[4]. The following advantages of a collective approach were presented:

1. Increased environmental benefits
   a. more effective for species and habitats that go beyond farm level, interlinking of elements and fields, reducing negative externalities (e. g. water quality);
   b. improved regional tailoring: apply measures on suitable locations and motivated farms, room for local ideas and environmental innovation;
   c. high participation and scheme coverage because of organisation close to farmers;
   d. high flexibility: adjust measures during the season;
   e. professional support to farmers, sharing knowledge, improved skills.
2. To the farmer: better tailored measures, less paperwork, shared acquisition of specialist equipment.
3. More efficient scheme control, saving budget (using regional knowledge, creating positive social norm).
4. Simplification of execution of policies. According to the pilot studies, the government only has to negotiate with the collective, and not with individual farmers. Except from that, also more local knowledge is available, through which policies can be fine-tuned.

[4] see http://www.toekomstglb.nl/upload/files/presentationbrussels14062012.pdf

3 Methodology

In Chapter 2, an overview is given of the proposed changes in the CAP post 2013, and the potential of collective agreements in both Pillar I (EFAs) and Pillar II (AESs) is discussed. In this chapter we continue with a description of the model SERA[5] that will assist in evaluating the potential effects of collective instead of individual measures, taking into account the previously discussed policy measures: AESs and the 7% EFAs measure. Section 3.1 gives a description of the main elements of the SERA model.

3.1 Background Agent Based Model SERA

For this study we use the model of Schouten *et al.* (2012) to analyze human decisions in coupled human and natural systems, which builds on Happe *et al.* (2006) and Lobianco & Esposti (2010) and extend it with an arable farm module and the possibility for collective measures. We apply the model to the case of 7% EFAs within Pillar I, and AESs in Pillar II.

Modeling human decisions in coupled human and natural systems by means of an agent-based modeling (ABM) approach has become a popular bottom-up tool that has been extensively employed over the past decades to understand system complexity and non-linear behavior (see e.g. Heckbert *et al.*, 2010; An, 2012; Rounsevell *et al.*, 2012). Also many studies exist that focus on ABMs to investigate land use changes and consequences of land-use policies at landscape level (see e.g. Parker *et al.*, 2003; Bakker & Van Doorn, 2009; Le *et al.*, 2010;). With respect to spatial ABMs applied to agricultural policy analysis Balmann (1997), Berger (2001), Happe *et al.* (2009), Lobianco & Esposti (2010), Schreinemachers & Berger (2011) and Schouten *et al.* (2012) focus on the impact assessment of agricultural policy support measures that are part of the EU Common Agricultural Policy, taking into account both microeconomic farm management theory and modules for simulating biophysical dynamics. Advantage of these policy assessment models is that the effects of policy changes on different farm types can be shown, taking into account both structural and spatial heterogeneity of the farms in a spatial explicit way.

This type of models is gaining importance as tools for managing tomorrow's agriculture, as they allow to study a wide range of price and trade policy options. Traditionally, predicting the behavior of individual farmers is typically based on mathematical programming methods. These models usually aggregate individual decision-making at the regional or sector level to evaluate policy options. They do not capture the interactions between actors (i.e. individual farm households) assuming that there are no transactions and information costs. Furthermore, these models do not fully capture the spatial dimension of agricultural activities and their effects on surrounding (nature) areas (Berger, 2001). ABMs focused on agricultural policy assessment are able to capture these farmers' interactions, as well as the spatial dimension of their activities while being subject to policy interventions. Farmers in ABMs are called agents or in our case *farm agents*.

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[5] The software code of SERA is written in the object-orientated programming language Java using the open-source agent based modelling framework *Recursive Porous Agent Simulation Toolkit Symphony 2.0* (Repast S 2.0). Repast offers libraries designed for the needs of agent based modelers which include scheduling mechanisms, spatial classes, visualizations and basic statistic output features. The model is a middle ranged model and in accordance to other ABMs in the field, the designed ABM inherits features from the fields of ACE and MAS/LUCC. Namely, the interaction of economic agents in a realistic GIS-based landscape.

3.2 Farm agents

For the purpose of SERA, an agent is defined as *'an entity that acts individually, senses parts of its environment and acts upon it'* (Tesfatsion, 2002). In the context of regional agricultural systems, the main group of agents we define in the model are the farm agents or in other words farmers.

In the context of SERA, one farm agent corresponds to one farm or agricultural holding. In accordance with the above definition, a farm agent is an 'independently acting entity that decides autonomously on its organization and production to pursue a defined goal (e.g. to gain the highest profit)'. A farm agent reacts to changes in its environment and its own state by adjusting its farm organization through for instance selling or buying land. By 'own state' we mean the available factor endowments like the total amount of land, land use or the number of cows. Farmers can adjust their farm organization for instance by extending their farm through buying land. We will discuss the farm agent en environment in the next sections in more detail.

3.2.1 Model overview

Figure 3.1 summarizes the different modules and course of events per year of the model for this study which are run for every farm agent separately.

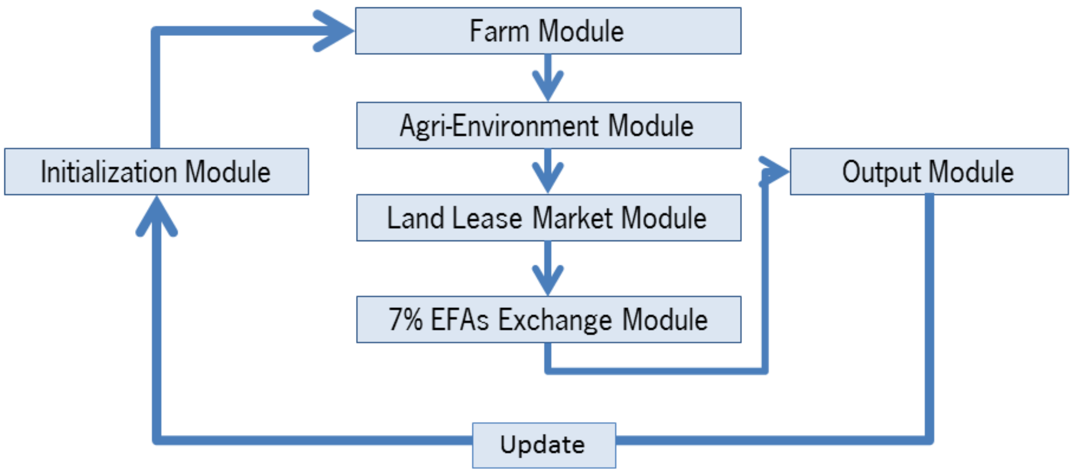

Figure 3.1: *Course of events during one simulation period*

Figure 3.1 shows that the model consists of an *initialization module,* a *farm module*, an *agri-environment module*, a *land lease market module*, a *7% EFAs exchange module* and an *output module*. We will discuss the different modules in more detail below.

- For the *initialization module,* 201 individual dairy farms (case study Winterswijk) and 564 individual arable farms (case study Oost-Groningen) are distinguished, each of which are taken from the Agricultural Census (reference year 2010). For both areas, these farm types are the main farm types in the areas, and together they cover approximately 60% of the main agricultural production area in the regions. Both areas are selected because they both participate in the CAP-pilot of the Ministry of Economic Affairs (EZ), and because of their different character (arable farming vs. dairy farming). Furthermore they are selected because of their importance for agri-environmental management (see e.g. Arisz, 2007 for an example of agri-environmental management in Oost-Groningen and Korevaar *et al.*, 2006 for an example in Winterswijk). One of the advantages of

ABMs is that they can accommodate different behavioral model types, and this model distinguishes two farm agent's behavioral models, namely a behavioral model for arable farmers (starch potato producers) and dairy farming (specialized dairy farmers). Agricultural Census data serves as input for the individual farm characteristics. The attributes on farm level are the farm structure, given in age of the farmer, type of farm, size and number of total owned and rented parcels. At parcel level, attributes are crops grown, soil quality, crop suitability, information on ground water tables and land use which were used to integrate the production characteristics of individual parcels in the model. These characteristics are derived from Cadastral GIS-maps. At landscape level, attributes are number of farms in the region, spatial land characteristics (nearby National Eological Network nature areas), size and distance from the parcel to the agent's farmstead.

- In the *farm module* each farm agent is equipped with a behavioral model that guides decisions and keeps track of the agent's internal state described by attributes such as age, location and size. According to their behavioral models the individual farm agents evolve subject to their current state of attributes and to changes in their environment.

- In the *agri-environment module* farmers make choices on whether to contract parcels for agri-environment schemes, keep conventional farming, or offer their parcels to other farmers.

- In the *land lease market module* parcels of land are reallocated by means of an auction which matches bids and asks based on creation of the largest buyer/seller surplus (for extensive elaboration see Appendix III).

- Then, the results of the land lease market module, the agri-environment module and the farm module serve as input for the *7% EFAs exchange module.* In the 7% EFAs exchange module farm agents either are obliged to assign 7% EFAs on their own land, or there is a possibility to shift these obligations between farmers in the area. The environmental cooperative then has a facilitating role in shifts of 7% EFAs obligations between farmers.

- Finally the function of the *output module* is keeping track of the changes in the region with respect to farming structure and AESs and to conditioning of the model results for the next simulation period. Results on farm level as well as on the regional level are used to update farm attributes and regional attributes in the next period.

3.2.2 The regional environment

The farm agents' external environment consists of a spatial environment and an economic-policy environment in the region. The first build block is space where land is an essential input for most kinds of agricultural production activities, be it for crop or fodder production, or as manure disposal area. Hence, space is a factor that cannot be neglected where agriculture is concerned. One way of considering the spatial environment of a farm in the context of an ABM is to use Geographic Information Systems (GIS) as a representation of landscape. GIS provide a way for organising spatial data and assigning certain properties to space. A common way to organise space in a GIS is to define a grid of cells. A grid categorises land with respect to attributes of the cells (see i.e. Berger, 2001; Parker, *et al.*, 2003). SERA differs from currently existing models by mapping the exact location of farms and their farm parcels within a region.

Furthermore, we introduce spatially explicit mapping between farm production and landscape through integrating ecological quality of the parcels using an index for biodiversity. In this manner, the model can be used for environmental impact assessments. The basic approach is to incorporate environmental impacts within the assigned parcels with agri-environment schemes within the production economic choices farm agents make in SERA. We derive an indicator, namely the *spatial cohesion Reilly index*, to characterise biodiversity in terms of spatial cohesion of the parcel with AESs within the regional ecological species habitat network. See Section 3.2.3 for an extensive elaboration on this point.

The economic-policy environment represents the second block of a farm agent's external environment. Agricultural (and environmental) policies affect the farm at different instances such as prices, CAP payments, and payments for AESs. Also when the environmental cooperative comes into force, this is part of the policy environment.

3.2.3 Biodiversity and habitat network

To assess the ecological impact of parcels with AESs or 7% EFA, we look at the contribution of the parcel to the spatial cohesion of habitat networks in the landscape. This assumption is based on the idea that natural ecosystems with viable populations of species need a low degree of fragmentation (Saunders *et al.*, 1991; Kinnaird *et al.*, 2002; Myers, 2003). Opdam *et al.* (2003) applied metapopulation ecological theory to infer spatial characteristics for configurations of landscape elements that can be used in landscape management for sustainable biodiversity. They introduced the concept of spatial cohesion of habitat networks in the landscape. The degree of cohesion of the habitat network determines whether or not local extinction and recolonization rates are in equilibrium, and whether the network allows the population to persist under stochastic demographic processes and environmental perturbation (Hanski, 1999). The spatial cohesion concept implies that the number of species finding sustainable conditions in the regional landscape increases with the size and environmental quality of the network elements and the degree of connectivity in their pattern. These characteristics can be used as proxies for the number of species that potentially occurs in a landscape (Opdam *et al.*, 2008). For our purpose, we use the change of connectivity brought about by adding a piece of land to the conservation network as a proxy for the change in the spatial conditions for biodiversity. The simplification of this approach is that we neglect the time required for redeveloping the piece of land from a conventional farmers grassland into a conservation grassland. This transition normally requires a period of at least 5-10 years.

To be able to assess the potential of a specific landscape pattern to conserve biodiversity we introduce a landscape cohesion method based on spatial data. For this study, we assess the parcels contracted with AESs on their potential to conserve biodiversity thereby taking into account their spatial configuration in the surrounding landscape. Whittingham (2011) demonstrates that at landscape scale, the effect of parcels with AESs on farmland biodiversity has been shown to be positively related to the extent of nature conservation area and land under AESs in the surrounding landscape. Spatial econometric literature provides an appropriate tool for this problem: The Reilly index. The Reilly index derives from Newton's law of gravitation, where gravity is stronger for larger 'bodies' and gravitational strength is inversely related to the distance between 'bodies'. It was originally applied to the study of retail markets (Reilly, 1931), to reflect the attractiveness of different retail areas (cities) relating consumers' travel costs with the size of alternative retail areas. We modify the Reilly index to calculate the impact of surrounding nature conservation areas (within the area, and within a radius of 20 km around the case study area) on the potential for biodiversity conservation by parcels with AESs. Rather than distance to urban centres, we employ distance to nature conservation areas. Instead of population, we use the size of the nature conservation areas (measured in square meters).

Equation (1) gives the formula for the calculation of the spatial cohesion Reilly-index. The calculation of the spatial cohesion Reilly-index starts at the point where the site is located. After that, the size of the nature conservation areas (abbreviation NCA) within a certain radius (i.e. 5 km) is determined, as well as the size of the AES site. Based on the sum of all the distances of the site to the nature conservation areas located within the chosen radius, and on the size of the nature conservation areas and AES sites, the spatial cohesion Reilly-index can be calculated:

$$R_i = \sum_{j=1}^{J} \frac{A_i + C_j}{d_{ij}^2} \qquad (1)$$

where R_i represent the Reilly-index of parcel i, A_i the surface area of parcel i, J the number of conservation areas within range, C_j the surface area of the j^{th} nature conservation area, and d_{ij} the distances from the parcel to the centres of the conservation areas. The index captures, in one number, the size of the nature conservation areas in proximity to the AES or 7% EFA site, and the distance from the site to the nature conservation areas (Cotteleer, 2008). We calculate the (potential) spatial cohesion Reilly-index for each individual parcel with AES or 7% EFAs, R_i, hereinafter referred to as ecopoints. Strong aspects of the spatial cohesion Reilly-index are the combination of distance with size, and the fact that nature conservation areas located further away or that are smaller in size are weighted less. As such, the spatial cohesion Reilly-index is a measure for the share of land used for a certain land-use function in the surroundings of a specific location.

We illustrate the calculation of the spatial cohesion Reilly-index in Table 3.1 and Figure 3.2 for the location of two parcels with AESs: A and B at the beginning of the simulation period. The two parcels (A and B) are heterogeneous in size and are situated in the proximity of four different nature conservation areas (NCAs). The size of the four NCAs is also given. Figure 3.2 shows the two parcels, and their location in relation to the four NCAs. The arrows in Figure 3.2 give the distance to the four nature conservation areas. The size and distance correspond with Table 3.1.

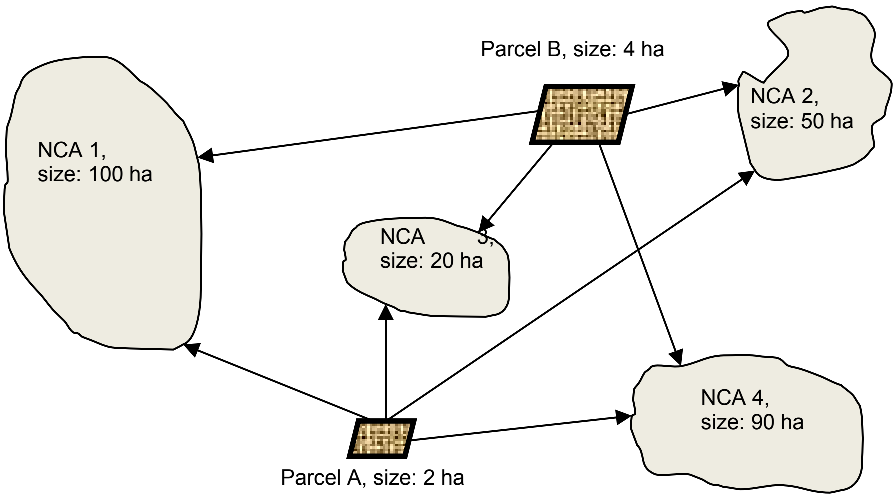

Figure 3.2: *Graphically presentation of the spatial cohesion Reilly-index at the beginning of the simulation period*

From Table 3.1 and Figure 3.2, it is apparent that for parcel B, the spatial cohesion Reilly-index is larger than for parcel A, because parcel B is located closer to one of the nature conservation areas and has a larger size. Although NCA 2 is not the largest area, the shorter distance from parcel B to this area is largely responsible for the larger number of ecopoints for this parcel. From this theoretical example, it can be seen that a parcel with AESs located near or in a NCA, have higher number of ecopoints than a parcel that is located further away. Also larger parcels result in higher number of ecopoints when compared to smaller parcels.

Table 3.1: Spatial cohesion Reilly-index for two parcels with agri-environment schemes at the beginning of the simulation period given the size of parcels and NCA and the distance to the NCA

NCA	NCA size (m^2)	Size parcel A (m^2)	Distance to parcel A (m)	Size / $(Distance)^2$	Size of parcel B (m^2)	Distance to parcel B (m)	Size / $(Distance)^2$
1	1,000,000	20,000	1,000	1.02	40,000	1,400	0.53061
2	500,000		2,100	0.11791		400	3.375
3	200,000		600	0.61111		700	0.4898
4	900,000		1,200	0.63888		2,000	0.235
Spatial cohesion Reilly-index				2.38791			4.6304

Source: Adapted from Cotteleer (2008: p. 101) and adjusted.

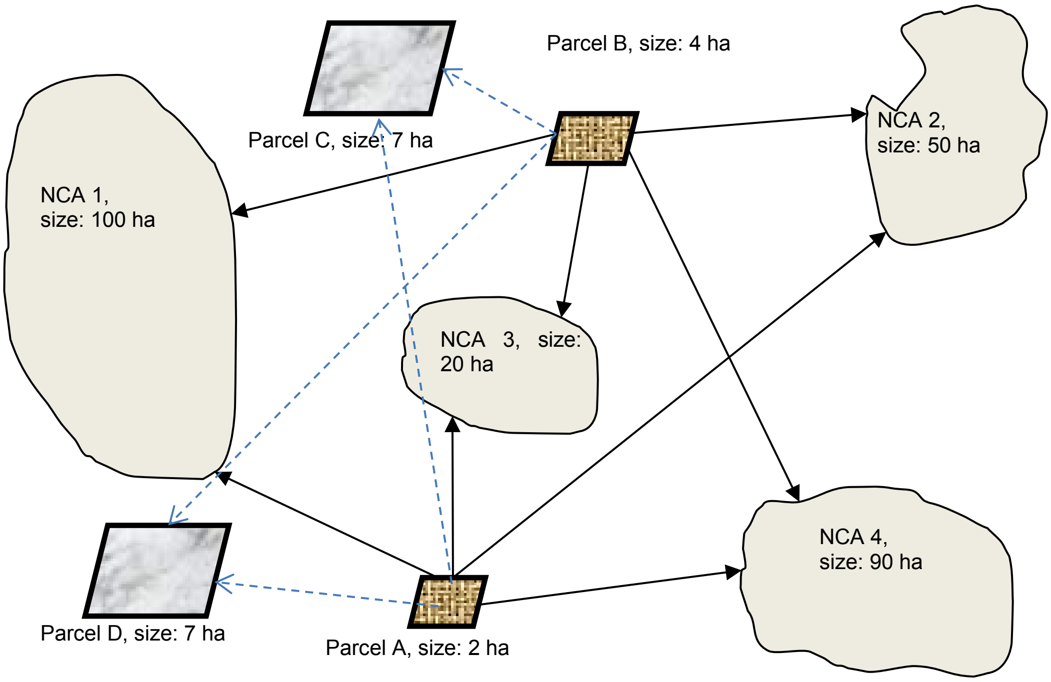

Figure 3.3: Graphically presentation of the spatial cohesion Reilly-index during the simulation, with two parcels contracted with AESs in previous periods

In Table 3.2 and Figure 3.3 we again illustrate the calculation of the spatial cohesion Reilly-index for two parcels with AESs: A and B during the simulation period, but now we assume that during previous periods two other parcels were contracted with AESs (parcel C &D).

From Table 3.2 and Figure 3.3 it is apparent that for parcel B, the number of ecopoints is larger than for parcel A, because parcel B has a larger size, is located closer to one of the NCAs, and is closer to one of the AES parcels contracted in a previous period.

Table 3.2: Spatial cohesion Reilly-index for two parcels with AESs during the simulation period given two other parcels contracted with AESs in previous periods

NCA or other AES site	**NCA size (m^2)**	**Size parcel A (m^2)**	**Distance to parcel A (m)**	**Size / (Distance)^2**	**Size of parcel B (m^2)**	**Distance to parcel B (m)**	**Size / (Distance)^2**
1	1,000,000	20,000	1,000	1.02	40,000	1,400	0.53061
2	500,000		2,100	0.11791		400	3.375
3	200,000		600	0.61111		700	0.4898
4	900,000		1,200	0.63888		2,000	0.235
C	70,000		2,000	0.0225		200	2.75
D	70,000		400	0.5625		1,800	0.034
Spatial cohesion Reilly-index				2.9756			7.4144

Source: Adapted from Cotteleer (2008: p.101) and adjusted.

4 Case studies from Oost-Groningen and Winterswijk

This chapter shows how the two case study areas Oost-Groningen and Winterswijk are parameterized in the model. Furthermore, this chapter discusses how the 7% EFAs measure and the AESs were modelled for the two case studies Oost-Groningen and Winterswijk, including the possibilities for environmental cooperatives within Pillar I and Pillar II.

4.1 Arable farming in Oost-Groningen

4.1.1 Description of the study area

The first case study is carried out in the agricultural region Oost-Groningen. The area is dominated by arable farming (starch potatoes, sugar beets, cereals). The main soil type is sea clay, and sandy soil. The northern-most part of Oost Groningen is characterized by sea clay and dike landscapes. The eastern part is also characterized by sea clay and dike landscapes, alternating with forested areas, and sandy ridges. In the south-west of the area, peat lands are situated. In the most southern part of Oost-Groningen densely forested areas are situated. The cultivation of potatoes takes place on the sand grounds in the southern part of the region, the cultivation of cereals mainly takes place on the clay grounds in the northern part of the region. Figure 4.1 gives an overview of the case study region.

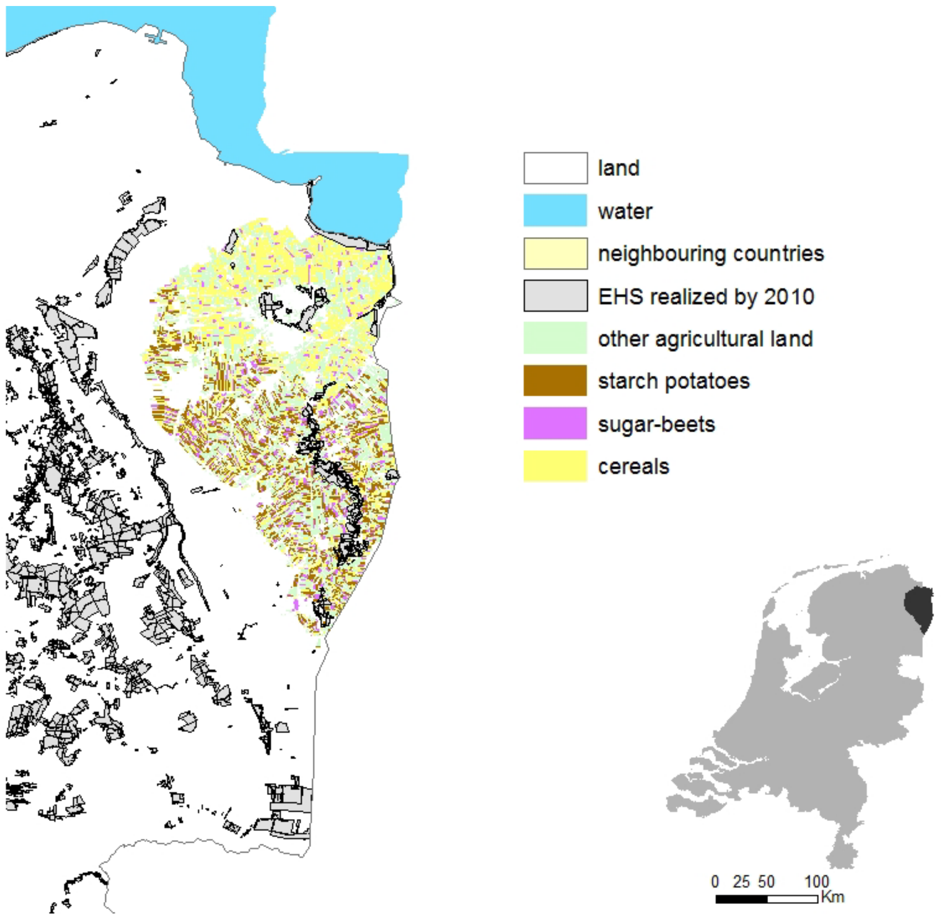

Figure 4.1: *Dominant land use in case study region Oost-Groningen and the realized Natural Ecological Network (or EHS in Dutch) (reference year 2010)*

Table 4.1 gives an overview of the main characteristics of the region, and gives information on the farm population selected for this study.

Table 4.1: General information on Oost-Groningen

General information Oost-Groningen (Corop region), reference year 2010	
Municipalities	Oldambt, Menterwolde, Bellingwedde, Vlagtwedde, Pekela, Veendam
Total number of farms in the area in 2010	992 farms
Total size area	Appr. 85.000 ha
Total number of arable farms	564 farms
Most common group: Starch potato farmers (NEG type 1410)	234 farms
Land used by arable farmers	38386 ha (incl. stables, homestead, farms with land outside the area)
Main soil types	Sea clay, Pleistocene sand, peat, loamy soil,
Most common crops	Starch potatoes, sugar beets, cereals

For the case study Oost-Groningen in SERA, the landscape was stylised by limiting to only two soil types: Pleistocene sand and sea clay soil. For the case study the cultivation of three types of crops is taken into account: starch potatoes, cereals and sugar beets. These three crops are chosen because they represent the major production options available to arable farmers in Oost-Groningen (own Agricultural Census analysis). It should be noted that maize, which is also an important crop for arable farmers in Oost-Groningen is not taken into account in the model for reasons of simplicity. This means that five types of land use are applied for the case study Oost-Groningen: starch potato production (either sand or clay soil), sugar beet production (either sand or clay soil), cereals production (either sand or clay soil), arable land with AESs or 7% EFAs, and nature conservation areas (National Ecological Network, Natura 2000 areas).

4.1.2 The arable farm agent in SERA

To characterize the arable farm agent in SERA, it is useful to first describe why arable farm agents do what they do and based on what. For this study, 564 arable farms were selected from Agricultural Census data (reference year 2010). Together, these farms use approximately 60% of all agricultural land present in the area. Main soil types of the land used by the population of farmers selected for the case study is sea clay and sand, and these two types of soil are selected for analysis in SERA. Later on, we will see that a distinction is made in maximum allowed manure supply for both soil types, as well as for compensatory payments from AESs (see Section 5.3.2 and Appendix I).

Arable farm agents can produce a selection of goods (crops or on-farm nature). They can also engage in land rental activities. In the model, we simulate the actions and interactions of autonomous agents (both individual and collective entities) with a view to assessing their effects on the system as a whole. Arable farm agents are assumed to attain the highest possible operational farm profit. The decision making of the modeled farms is highly simplified compared to that of real farmers in Oost-Groningen, and only serves the purpose of this study. For example, strategic aspects such as speculation on land between farmers is not included in the model, as well as fluctuation of input and output prices, future expectations about an uncertain political environment etc. With respect to expectations of farm agents, they anticipate to price changes in the same period, taking into account the prices from the previous periods.

An arable farm agent is handed over to the next generation after a given number of periods (≥ 65 years), unless there is no successor. Finally, arable farm agents differ with respect to their farm size in terms of parcels, number of crops grown, soil quality, spatial location, as well as age. In this way the identity of the arable farm agent is constituted.

As stated before, the arable farm agent's objective is to attain the highest possible operational farm profit, given the information the farm agent has. Although no explicit linear optimization problem is used in SERA because of heterogeneous parcels used, the farm agents' objective function can be expressed in the following way: Operational arable farm profit is based on the sum of the contribution of each individual parcel (i) and all crops grown (j) on land controlled by the farm agent, based on the following function (2)

$$Y_{farm}^{arable} = \sum_{i=1}^{n} Y_{ij} \quad (2)$$

For each parcel the profit (Y_{ij}) is calculated based on the following function

$$Y_{ij}\ (PY_{ij}, S_i^{sand}, S_i^{clay}, TRC_{ij}, MAR_i, FC_i, CC_{ij}, p_j, p_{manureapply}, p_{fertilizer}) \quad (3)$$

With

$$Y_{ij} = PY_{ij} + S_i^{sand} + S_i^{clay} + MAR_i - TRC_{ij} - FC_i - CC_{ij} \quad (4)$$

Crop production revenue PY_{ij} for starch potato production, sugar beet production and cereals are determined by local variations (i.e. low crop yields because of low soil quality) at parcel level. Crop prices p_j are determined exogenously for each individual crop (starch potatoes, sugar beets, cereals), and is treated as exogenous in the model. Local variation in prices due to for instance quality differences among farmers is not permitted in this model, meaning that all producers receive the same exogenous product price. Farm agents start their crop rotation scheme with the crop they grow on the respective parcel in 2010 based on initial GIS land use maps, distributed by the Ministry of EZ. This means each parcel follows its own crop rotation sequence. Table 4.2 gives an overview of the main parameters in the arable farm model

Table 4.2 Main model parameters arable farm agent

Description	Unit of analysis	Parameter
Production yields for the three crops j	Ton/ha	PY_{ij}
Yield losses for the parcel and three crops j	% point	$yieldloss_{ij}$
Production per hectare for three crops j	Ton/ha	$yield_j$
Fertilizer costs on the parcel for crop j	Euro/parcel	FC_{ij}
Fertilizer application for three crops j	Ton/ha	FU_j
Product sell price for three crops j	Euro/ton	p_j
Manure application revenue depending on crop j	Euro/kg N	MA_j
Cultivation costs for three crops j	Euro/ton	CC_{ij}
Transport costs depending on parcel and crop j	Euro/parcel	TRC_{ij}
SNL subsidy sand	Euro/ha	S_i^{sand}
SNL subsidy clay	Euro/ha	S_i^{clay}
SNL contract length	Years	6
SNL fertilizer allowance	Kg N/ha	0
SNL nitrogen allowance	Kg N/ha	0
Cultivation costs for SNL parcel	Euro	CC_{ij}^{nature}
Transport costs for SNL parcel	Euro	TRC_{ij}^{nature}
Discount rate for lowering transport costs for SNL parcels	% point	$discount_{nature}$
Expectation price for greening permit	Euro/permit	$p_{expectation}^{permit}$
Reserve price for greening permit	Euro/permit	$p_{reserve}^{permit}$

Based on the relative production hectares of the three primary field crops, all farms in the simulation are assumed to determine their annual crop mix based on the sequence 1:2 (year 1: starch potatoes; year 2: sugar beets; year 3: starch potatoes; year 4: cereals). The 'Vroegrooiregeling Noord-NL'[6] makes it possible to cultivate potatoes in such an intensive way. When potatoes are harvested before 10th July, the chance for contamination with cyst nematodes is minimized. One should note that we distinguish only one type of crop rotation scheme for simplicity reasons. In reality, more types of crop rotation (i.e. only cereals and sugar beets on sea clay soil) are observed.

Crop production revenues for the three selected crops are based on the average yields for the reference year 2010 (CBS & LEI, 2011). Each arable farm agent keeps track of its nitrogen balance on farm and parcel level. For each crop grown on a parcel, a fixed amount of nitrogen/ha is assumed to be used in accordance to the Dutch legal manure regulations (CBS, 2010). In the SERA model, for each individual crop per soil type, specific norms are applied. These norms are used in SERA (see Appendix I). Arable farm agents earn revenue from applying animal manure on their parcels. We assume that all farmers apply the maximum legal norm on their parcels, given the soil type (either sea clay or sand). The price that arable farm agents receive for manure application is based on the average manure disposal price, which we based on the average price paid for manure disposal in 2010 (CBS, 2010). In reality, a distinction can be made between different types of animal manure, stemming either from cows, poultry or pigs. For reasons of simplicity we take the average disposal price, which was also used in the 'Koeien en Kansen' LEI-ASG project. The price for chemical fertilizer in the model is fixed (Verloop *et al.*, 2009). Furthermore, we assume a fixed cultivation costs per hectare, thereby taking into account the costs for sowing, harvesting etc. Also transport costs are distinguished, which depend on the distance from the parcel to the farmstead (in kilometers) and depend on the type of crop.

For detailed information on the parameters used, we refer to Appendix I. Parameters with respect to 7% EFAs and AESs will be explained in Section 5.3 and Section 5.4.

4.2 Dairy farming in Winterswijk

4.2.1 Description of the study area

The second case study is carried out in the agricultural region Winterswijk which is located in the eastern part of the Netherlands. From a landscape perspective, the area represents a highly valued cultural-historic landscape where small-scale agriculture and nature areas are closely related providing particular cultural, recreational, ecological and economic value to the region (Provincie Gelderland, 2005). The spatial structure of the landscape attributes are characterized as small fields surrounded by hedges or wooded banks (Mastboom, 1996). The size of the area is approximately 22000 ha, in which 634 farms are present (reference year 2010). The most important agricultural sector in the region is dairy farming. 60% of the main production area in the region is used for specialized dairy farming, with an average production intensity of approximately 12.000 kg milk per ha^{-1} (Korevaar *et al.*, 2006).

Figure 4.2 gives an overview of the case study region.

[6] See information on website of Dutch Arable Product Board
http://www.productschapakkerbouw.nl/files/Toelichting_aanvraag_controle_vroegrooi_2009.pdf

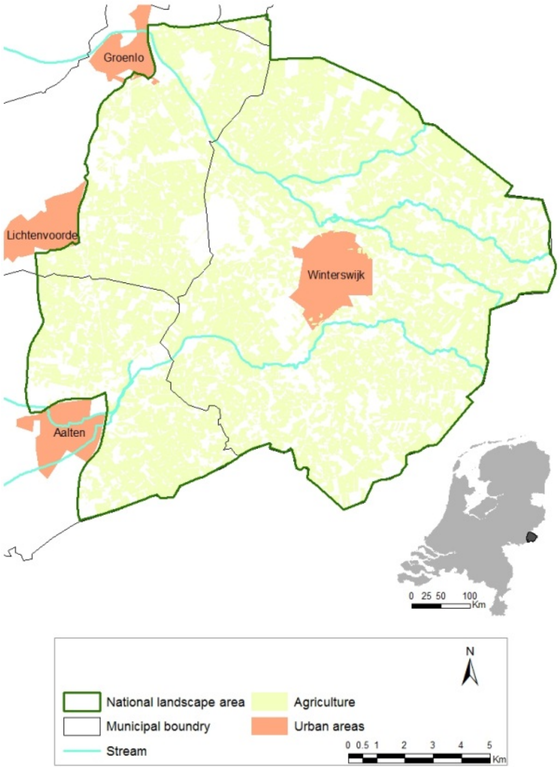

Figure 4.2: *The study region Winterswijk*

Table 4.3 gives an overview of the main characteristics of the region, and gives information on the sample selected for this study.

Table 4.3: *General information on Winterswijk*

General information Winterswijk, reference year 2010	
Municipalities	Winterswijk, Aalten, Oost Gelre, Berkelland
Total number of farms in the area in 2010	634 farms
Total size area	Appr. 22.000 ha
Most common group: Dairy farms (NEG type 4110)	201 farms
Land used by dairy farmers (only grassland and maizeland)	6286 ha
Main soil type	Sand, Peat
Most common crops	Grass, maize, cereals

4.2.2 The dairy farm agent in SERA

For this study, 201 specialized dairy farms were selected from Agricultural Census data (reference year 2010). Together, these farms use approximately 60% of all agricultural land present in the area. Main soil type present on land used by the sample of farmers is sand, and only this soil type is selected for analysis in SERA. Dairy farm agents can produce milk, grass, maize or biodiversity. They can also engage in land rental activities. Like in Oost-Groningen, the decision making of the modeled farms is highly simplified compared to that of real farmers in Winterswijk, and only serves the purpose of this study. Also for dairy farm agents it holds that the farm is handed over to the next generation after a given number of periods (≥ 65 years), unless there is no successor. Dairy farms differ with respect to their farm size in terms of parcels, number of cows, hectares of maize grown, soil quality, spatial location as well as age (yes/no successor). In this way the identity of the dairy farm agent is constituted.

Same as for the arable farm agents, dairy farm agents' objective is to attain the highest possible operational farm profit, given the information the dairy farm agent has. Although no explicit linear optimization problem is used in SERA because of heterogeneous parcels used, the farm agents' objective function can be expressed in the following way: Operational dairy farm profit is based on the sum of the contribution of each individual parcel (i) and crops grown (j) (either grass or maize) on land controlled by the farm agent, based on the following function (5):

$$Y_{farm}^{dairy} = \sum_{i=1}^{n} Y_{ij} \tag{5}$$

For each parcel the profit (Y_{ij}) is calculated based on the following function

$$Y_{ij}\ (DI_{ij}, S_i, TRC_i, MAR_i, FC_i, FB_i, p_{milk} p_j, p_{manureapply/dispose}, p_{fertilizer}) \tag{6}$$

With

$$Y_{ij} = DI_{ij} + S_i + MAR_i - TRC_i - FC_i - FB_i \tag{7}$$

Revenue from dairy production DI_{ij} is calculated as the sum of the number of cows per hectares, set at the initial farm level, times the size of the parcel in hectares, times the average milk production per cow, which is set in accordance to the average milk production of dairy cows in The Netherlands in 2010 (CBS & LEI, 2011). The milk price is given in the model at the average rate in 2010 (CBS & LEI, 2011). Local variation in prices due to for instance quality differences among farmers is not permitted in the model, meaning that all producers receive the same exogenous product price.
Table 4.4 gives an overview of the main parameters in the dairy farm model.

Table 4.4: *Main model parameters dairy farm agent*

Description	**Unit of Analysis**	**Parameter**
Fertilizer costs on parcel *i*	Euro/ kg N	FC_i
Manure application revenue (or costs) for parcel *i*	Euro/kg N	MA_i
Transport costs depending on parcel *i*	Euro/ha	TRC_i
Transport costs for SNL parcel	Euro/ha	TRC_i^{nature}
Milk production per cow	Kg/cow	$qmilk$
Nitrogen production per cow	N kg/cow	NP
Fertilizer application for two crops (grass or maize) *j*	N kg/ha	FU_j
Mineralisation grassland	N kg/ha	M_i
Yield losses for the parcel *i*	% point	$yieldloss_i$
Milkprice	Euro/kg	p_{milk}
Workability coefficient grassland	%	$work_{grass}$
Leaching coefficient grassland	%	$leach_{grass}$
NEL (feed) requirements per dairy cow	NEL/cow	NEL
SNL subsidy for parcel *i*	Euro/ha	S_i
SNL contract length	year	6
Nitrogen application crop *j* (maize)	N kg/ha	NA_j
Feed production crop *j* (maize)	NEL	$yield_j$
Fertilizer application crop *j* (maize)	N kg/ha	FA_j
Maximum number of cows per hectare	Cows/ha	r_{cow}
Expectation price for greening permit	Euro/permit	$p_{expectation}^{permit}$
Reserve price for greening permit	Euro/permit	$p_{reserve}^{permit}$

Each dairy farm agent is restricted to production of two major crops: grass and maize. These two crops are chosen because they represent the major production options available to dairy farmers in Winterswijk (own Agricultural Census analysis). It should be noted that this study focuses on dairy farmers in Winterswijk, and that other important sectors such as arable farming are not taken into account in the model for simplicity reasons. Each farm agent keeps track of its own nitrogen balance on parcel and farm level. Nitrogen production for all dairy cows held on the farm is known, as well as nitrogen production on parcel level (based on the number of cows/ha, taken from Agricultural Census data). At farm level, nitrogen is disposed on grassland and maizeland. Fertilizer use is fixed on grassland. The total grass production (dry matter yield) per parcel is calculated based on the available nitrogen (given the legal norms) and soil type based on studies of Aarts & Middelkoop (1990), Aarts (1996), Middelkoop (2007) and Peerlings & Polman (2008).

Each dairy cow has a fixed feed requirement, based on key numbers of the Ministry of EZ. Costs for manure disposal (in case of a surplus at farm level) are fixed and an average price (based on CBS & LEI, 2011) is used. At farm level farm agents also keep track of a feed balance. When more feed is produced on farm level (stemming from relation nitrogen balance and grass production functions) the farm agent is able to sell feed. When there is a lack of feed at farm level, the farm agent is able to buy external feed. Transport costs represent the costs for machinery, manure and cattle transport to the parcels. For parcels where maize is grown, also manure can be disposed, and transport costs are needed too. For both the feed- and manure balance different prices for shortages and surpluses are used, assuming a 10% lower price when manure is attracted externally, and a 10% lower price when feed is sold externally.

For detailed information on the parameters used, we refer to Appendix II. Parameters with respect to 7% EFAs and AESs will be explained in Section 5.3 and Section 5.4.

5 Scenarios

5.1 Introduction

This chapter discusses the scenarios that have been simulated using the 7% EFA measure and AESs measure. Furthermore, we discuss how we bring the 7% EFA measure and the AESs into the model.

Table 5.1 summarizes the scenarios taking into account both measures. For each measure, two different types of implementation will be simulated: collective decision-making vs. individual decision-making.

Table 5.1: *Scenarios simulated with SERA taking into account both measures, experimenting with collective and individual decision-making.*

Scenario	Name	Explanation
0	**Base** *No policies*	- No AESs - No EFAs - Farm agents interact on the land market
1 (Section 5.2)	**Scenario based on current EC proposal:** *7% Ecological Focus Areas measure obligation for each individual farmer*	- farmers are obliged to transform 7% of their land into ecological focus area - Free to choose whatever parcel - EFAs parcels result in no yield and no room for manure disposal
2 (Section 5.3)	**Collective implementation of 7% ecological focus area measure:** *Environmental cooperative facilitates exchange of 'greening permits' between farmers within the region*	- farmers are obliged to assign 7% ecological focus area - Environmental cooperative facilitates exchange between farmers within the region, reflected in SERA as tradable 'greening permits' (transferable obligations). - In this way we try to grasp the social processes between farmers and collective: Farmers are allowed to trade their 7% obligation within the region - Allocation basis: profit maximization, irrespective of ecological quality
3 (Section 5.4)	**Scenario based on agri-environmental contracting following the current situation in Pillar II:** *Agri-environmental contracting on field margins (for Oost-Groningen) and on parcel level (Winterswijk), in areas designated by the government*	- Fixed payment/ha, irrespective of parcel characteristics - Province assigns parcels
4 (Section 5.5)	**Collective implementation of Pillar II agri-environmental contracting:** *Selection of contracted parcels by environmental cooperative based on 'ecopoints-score' for each parcel*	- Collective decides based on 'ecopoint-score' for each parcel which parcels should be contracted given budget constraints - Spatial cohesion Reilly index is calculated in each subsequent period, updating for nature areas and contracted agri-environment parcels in the surrounding areas - Flexible payment/ha based on ecopoints, including a bonus to reflect the power of cooperatives with regard to ecological knowledge, and encouraging and persuasive behavior

In this study we compare the scenarios with a base scenario (scenario 0) in which no 7% EFAs measure is applicable and no possibilities exist for agri-environmental contracting. In the base scenario, farm agents only interact on the land market by offering and attracting parcels based on their age, the availability of a successor and the opportunity costs. In the remaining chapter we will discuss the four policy scenarios and their implementation in the model in detail.

5.2 7% EFA scenario based on current EC proposals (scenario 1)

According to the EC proposals with respect to direct payments (EC, 2011a), farmers are obliged to use 7% of their land as Ecological Focus Areas by turning those areas into fallow land, landscape features, buffer strips or afforested areas. Given the European and national debates that are still going on with respect to the actual implementation and management conditions for EFAs, as indicated in Chapter 2, assumptions on EFAs are needed. In this study we assume that EFAs are applicable to both arable land and grassland. This assumption diverges from the EU proposals, as they state that EFAs are only applicable to arable land and temporary grassland. We motivate this choice by the fact that the former State Secretary Bleker expressed the wish that not only arable land should be fulfilling for EFAs, but also grassland (see Van Doorn *et al.*, 2012). Furthermore, we assume that EFAs are only applicable to complete parcels, and not to parts of arable land such as buffer strips, for reasons of model simplicity. This results in two separate definitions of 7% EFAs, applicable to the case study areas Oost-Groningen and Winterswijk:

For the case study Oost-Groningen
7% EFAs are parcels of arable land that are eligible for direct payments and that are not used for agricultural production, but are managed for ecological purposes.

For the case study Winterswijk
7% EFAs are parcels of grassland that are eligible for direct payments and that are not used for agricultural production, but are managed for ecological purposes.

To implement the obligatory conversion of 7% agricultural land into on-farm nature in the model, the following assumptions are made:

- Each farm agent is willing to participate in the 7% EFAs measure, and tries to satisfy the obligatory measure. No fines are modeled in SERA.
- Greening permits take place on whole parcels for both Winterswijk and Oost-Groningen.
- Yield losses because of 7% EFA measures are 100%.
- No compensatory payments are given for conversion of land to satisfy the 7% EFAs measure.
- Total number of 7% EFA obligations on the farm is equal to 7% of the size of the farm (in hectares).

When assuming that each farm has to assign 7% of its own parcels for biodiversity purposes, the following steps are taken by the farm agent in each period to determine the total number of 7% EFA obligations at farm level:

1. Take the sum of the present parcels with AESs.
2. When this is <7% of the farm size, the farm agent ranks all owned parcels from lowest to highest yield.
3. The parcels with lowest yield are selected subsequently until 7% EFA is reached.

5.3 Collective implementation of 7% ecological focus area measure (scenario 2)

As indicated in Chapter 2, the Dutch government wants to investigate the role of environmental cooperatives in executing the greening measures and their potential effectiveness. In this study we therefore investigate the impact of a potential role for environmental cooperatives in the implementation of 7% EFAs.

The current proposal, in which each farm is obliged to turn 7% of its production area into on-farm nature is compared to an alternative in which the environmental cooperative facilitates exchange between farmers. We simulate this facilitating role by introducing a market for so called ‘greening permits’. A greening permit is the right/obligation for conversion of 1 hectare of land into on-farm nature which makes a permit a homogenous product. The exchange of greening permits is represented by a market in which multiple demanders and suppliers act at the same time. Some arable farms will assign more land than the obligatory 7% for biodiversity purposes, attract ‘greening permits’ from the exchange market and receive a compensatory payment in return. Farmers can fulfil the 7% EFAs obligation with ‘greening permits’ only, both greening permits and own land, or they can fulfil their obligation on their own land only. Parcels with AES are also included in the 7% EFAs measure. This means that:

7% EFA requirement on farm level = AESs + greening permits + EFAs on own land

In the model, to fulfil the 7% EFAs obligation, farm agents will first try to contract parcels under AESs. If that does not fulfil the obligation, the farm agent tries to offer his ‘greening permits’ for exchange. Then, if the obligation is not fulfilled yet, the farm agent will assign 7% of his own land for 7% EFAs. Whether all the before mentioned steps will be taken depends on the expectation price on the exchange market, and depends on the characteristics of the individual parcels. Permits collected from the exchange market are valid for one year. We assume that the permits offered by a farm agent is transferred as a complete set, and cannot be divided; for example, when a farm agent offers 3.8 ha on the exchange market, this amount can only be transferred to another farm agent in total, and cannot be divided.

If a farm agent offers the permit on a virtual market (bids), other farm agents can apply for the permits (asks). Bids are collected by the environmental cooperative and are matched with the asks based on the highest price. The farm agent with the ‘winning’ bid receives a payment for applying conservation for the extra converted parcel. The buyer and seller surplus is equally divided in the default setting of the model:

- BIDS: Bids are constituted by farmers that want to trade permits because they can acquire a higher revenue from conventional production on the parcel when comparing with switching to on-farm nature management. They will pay a compensatory payment to the farmers that will convert extra land for ecological purposes. The size of the compensatory payment is equal to the difference between the revenue from conventional production (see Section 4.1 for arable farming and Section 4.2 for dairy farming) and the revenue from production when switching to assigning land for 7% EFA ecological purposes.

  $$bidprice = revenue\ conventional\ farming - revenue\ conservation\ farmin$$

  Permits are only traded when the expected price is larger than the reserve price. The expected price is equal to the average price paid for permits on the market in the past two periods.

  $$p_{expectation}^{permit} = \frac{p_{t-1}^{permit} + p_{t-2}^{permit}}{2} \quad (8)$$

The reserve price is equal to the revenue that would be generated from conventional production. The revenue from the last four years is taken into account (given the crop rotation scheme 1:2 for arable farmers in Oost-Groningen, see Section 4.1).

$$p^{permit}_{reserve} = \pi_i = \frac{Y^{crop}_{i\,t+1} + Y^{crop}_{i\,t+2} Y^{crop}_{i\,t+3} + Y^{crop}_{i\,t+4}}{4} \quad (9)$$

- ASKS: Asks are generated by farmers that want to attract additional permits for on-farm nature management because conventional production on their land results in smaller revenue than the revenue generated from the permits. The price they ask for executing permits on their land is equal to the minimum of the expected price and their reserve price.

$$askprice = \min(expected\ price, reserve\ price) \quad (10)$$

Here, it holds that first the total of 7% EFAs permits must be fulfilled on the farm, before trade in permits is possible. As stated before, AESs are part of this 7%.

In the model the environmental cooperative collects all bids and asks and matches the highest bid with the highest ask. When a match is made, the exchange of permits lasts for one year. This means the farm agents must meet the 7% EFAs obligations each year. Table 5.2 shows the decisions that farmers make with respect to the permit market.

Table 5.2: *Farm agent's decisions for greening permits*

Parcel is conventional and possibility for greening permit			
Profit conventional parcel	*Price collected for greening permit*	*Expectation price*	*Decision*
Y_{ij} <	$p^{permit}_{reserve}$	$p^{permit}_{reserve} < p^{permit}_{expectation}$	Offer permit
Y_{ij} <	$p^{permit}_{reserve}$	$p^{permit}_{reserve} > p^{permit}_{expectation}$	Buy permit

The type of auction mechanism which is used to clear the exchange market is essential for the way the greening permits are allocated. Clearing means the bids and asks are confronted and actual trades take place. The exchange market in SERA is a double auction in which multiple demanders and suppliers act on the market at one time, given a homogeneous product. In SERA we make use of the 4-heap algorithm proposed by Wurman *et al.*(1998) which generates efficient and stable matches of bids and offers. The key idea of the 4-heap algorithm is to make matches between the best prices. To make matches between prices, we make use of the *Mth* and *(M+1)st* price rules, which are well known in the double auction theory and applications. They define the range of equilibrium prices, which balance the market demand and supply. Wurman *et al.* (1998, p.19) uses the following example to explain the importance of the *Mth* price algorithm: '*Consider a simple case where there is one buyer willing to pay no more than $ x, and one seller willing to accept no less than $ y, with x>y. The Mth price is $ x, and the (M+1)st price is $ y. If we set the price for the good above $ x, then one agent would be willing to sell it, but no agent would be willing to buy it. At a price below $ y, there is demand for one unit but no supply. Only if the price is between $ y and $ x is the excess demand zero.'* . This mechanism has been chosen because it simulates a competitive market for homogenous goods. This resembles the current policy proposals.

5.4 Scenario based on agri-environmental contracting following the current situation in Pillar II (scenario 3)

5.4.1 Agri-environment schemes in Winterswijk

For the case study Winterswijk, farm agents make a choice in each period for each individual parcel between continuing conventional dairy farming (and producing grass), executing AESs, or offering the parcel to the land market. Also for new parcels offered on the land market, these choices are made. Executing AESs, and receiving a compensatory payment is weighed against the price which could be received at the land market (due to high opportunity costs), which is based on the average price on the market in the previous two periods, or revenue from conventional production. This mechanism is repeated each period for all farmers that have parcels within the search areas for agri-environmental contracting, designated by the public authorities. Figure 5.1 gives on overview of these search areas, as well as the nature areas present in Winterswijk (Realized NEN 2010).

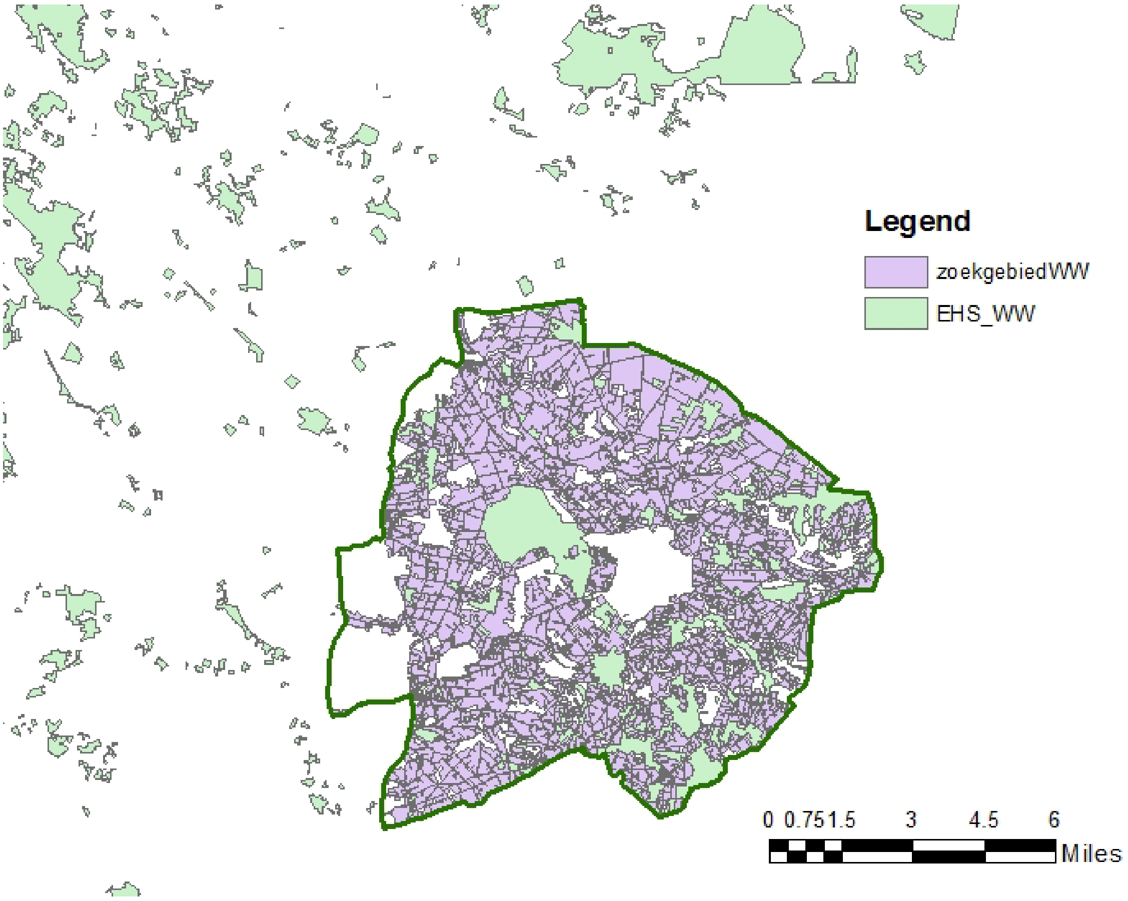

Figure 5.1: *Nature areas and search areas designated for agri-environmental contracting in Winterswijk*

Table 5.3 summarizes the options of farm agents for each parcel in each simulation period, given the scenario based on agri-environmental contracting.

Table 5.3: *Farm agents' options for new and owned parcels*

Parcel within search area but currently without contract, or contract expires next period					*Decision*
if	$Y_{ij} < Y_{nature}$	and if	$Y_{nature} < P_{\exp}$	then	offer to land market.
if	$Y_{ij} < Y_{nature}$	and if	$Y_{nature} > P_{\exp}$	then	sign an AES contract and try to attract more parcels eligible for AESs.
if	$Y_{ij} > Y_{nature}$	and if	$Y_{ij} < P_{\exp}$	then	offer to land market.
if	$Y_{ij} > Y_{nature}$	and if	$Y_{ij} \geq P_{\exp}$	then	keep parcel conventional and try to attract more parcels.
Parcel lies outside the search area, no possibility for contract					*Decision*
		If	$Y_{ij} < P_{\exp}$	then	offer to land market.
		if	$Y_{ij} > P_{\exp}$	then	keep parcel conventional and try to attract more parcels.
Parcel has contract					*Decision*
		if	$Y_{nature} < P_{\exp}$	then	offer to land market.
		If	$Y_{nature} > P_{\exp}$	then	sign an AES contract and try to attract more parcels eligible for AESs.

Y_{ij} =operational profit of conventional parcel

Y_{nature} =operational profit of parcel with agri-environment scheme

$P_{\exp}$ = expected price of parcel on land market

In the model we assume that AESs can only be applied to grassland parcels. Maize land parcels are only used for feed production and manure disposal. When a contract expires, the farm again has the opportunity to choose whether conventional or conservation farming is applied to the parcel. When a contract is signed, the farmer cannot choose anymore to explore conventional farming on the parcel, so only offering the parcel to the land market or continue contracting is possible. No application of nitrogen is allowed on the assigned parcels for the contract period of six years. In this study we focus on so-called 'take-it-or-leave-it-contracts', in which we assume that land owners do not negotiate on the conditions. Furthermore, transport costs (in euros/km) are assumed to be lower than for conventionally managed parcels as less manure disposal and mowing is needed.

For Winterswijk we focus on AESs that take place on parcel level, focusing on grassland management and therefore the following restrictions are valid:

Beheerpakket A.02.01.01Botanisch weideland A.02.01.02 Beheerpakket Botanisch hooiland	- Manure application prohibited - Chemical and mechanic weed control is prohibited. - Restricted grazing (between 1 August – 1 March, or max. 1.6 dairy cows per hectare, equal to 2 Dsu[7]) - Payment up to € 1.065,- per ha (botanisch hooiland) or € 1.020,- per ha (botanisch weideland). In SERA we assume one level only, namely € 1.065,- per ha.

Farmers are able to trade parcels with AESs because of high opportunity costs, or because of retirement (>65 years). In the first period, each farmer makes a choice between the parcels with AESs and the conventional grassland parcels. In the following periods, when a contract is chosen, the farmer keeps the AESs until the period of 6 years is over. Almost-retired farmers are also able to

[7] Dsu (Dutch size unit) is a measure to indicate the economic size of agricultural activities (see also http://www3.lei.wur.nl/neg/)

sign an AES contract, when they do not have a successor these parcels will be supplied to the land market (see Appendix III). This means that after the first period of the model run there are three options that can be chosen by the farmer:

1. Owner of parcel with contract, but contract is expired. Choose whether to extend the contract.
2. Parcel with contract which is offered to the land market. The bidprice is subject to restrictions for nitrogen application, and lower yields.
3. Parcel is not yet contracted, but there is a possibility, and is offered to the land market. The farmer makes a choice between conventional farming and conservation farming

Options 1 and 3 have the same strategy: the farmer makes a choice between conventional farming and conservation farming. For option 2 there is an extra restriction on the parcel, which reduces the manure and fertilizer application to zero.

5.4.2 Agri-environment schemes in Oost-Groningen

For Oost-Groningen we focus on an AES aiming at the conservation of field edges for breeding and wintering farmland birds. We chose this scheme because two tariffs are used, for clay and sandy soil. We take the Nature Management Plan (in Dutch; zoekgebieden weide- en akkervogels), which is delineated at Provincial level (in cooperation with the environmental cooperative) as a reference point: farmers are able to contract field edges on the assigned parcels. When this is the case, farmers have a lower yield from the parcel, as well as manure restrictions.

For Oost-Groningen the following restrictions apply:

Beheerpakket A01.02.02 Bouwland met doortrekkende en overwinterende akkervogels	- Edges with a width of at least 9 meter, sown with grass, wheat, herbs or a mix of herbs. - Chemical and mechanic weed control is prohibited. - Manure application and grazing are prohibited. - Payment up to € 2.028,- per ha for clay and € 1.745,- for sandy soil.

A good example of an arable bird that benefits from this type of AESs is the Montagu's Harrier. In Textbox 1, an overview is given of the characteristics of this bird species.

Textbox : The Montagu's Harrier

The Montagu's Harrier (*Circus pygargus*) is a migratory bird of prey of the harrier family. The Montagu's Harrier is a deceptively small raptor, though it appears larger because of its large wing surface compared to small body weight, which gives it a typically buoyant flight. The female is larger than the male, however this is not apparent in the field. The diet consists mainly of small ground-living animals in areas of low or sparse vegetation. An important part is taken by small rodents, small birds and large insects. The goal of ANOG is to improve the bird population on arable land in their working area. They focus on certain species: skylark, Montagu's harrier and partridge. They aim to improve the density of the skylark from for instance 5 – 10 birds per 100 ha to 10 – 15 birds per 100 ha. For the Montagu's harrier they try to maintain the density of 35 – 40 couples and increase it by enhancing field margins, increase the area of fields margins under management, and improve 'forgotten' landscape structures like margins along dikes. Improvements for partridge habitat the group plans are increasing insect-rich habitats, leaving arable land fallow, or sowing the land with special grasses and grains as fodder for the birds.

Source: www.grauwekiekendief.nl; www.anog.nl

We assume that field margins with a minimum width of 9 meters are contracted. We furthermore assume that when field margins are contracted, they apply to the entire contour of the parcel with a width of 9 meter. We compute the surface that is covered with field margins for each parcel individually. Contracted field margins lead to a decrease in production yields (minus 100% is assumed), and lower possibilities for manure application. Payment per hectare for sandy soil is € 1745 euro per ha; for clay soil 2028 euro/ha. With respect to cultivation costs, we assume that they are 20% higher when comparing to conventional farming. Lower costs because of smaller sizes of the parcel due to field margin management are discounted in this value. Cultivation costs still depend on the type of crop, but are now raised with 20% because of conservation of the field margin, sowing botanic mixes on the field margins etc. Furthermore, we assume that transport costs for parcels with AESs are lower because of smaller yields resulting in lower transportation. This percentage is set at 60% of the original transportation parameter values. Figure 5.2 gives an overview of the nature areas (NEN realized in 2010) and the search areas for AESs.

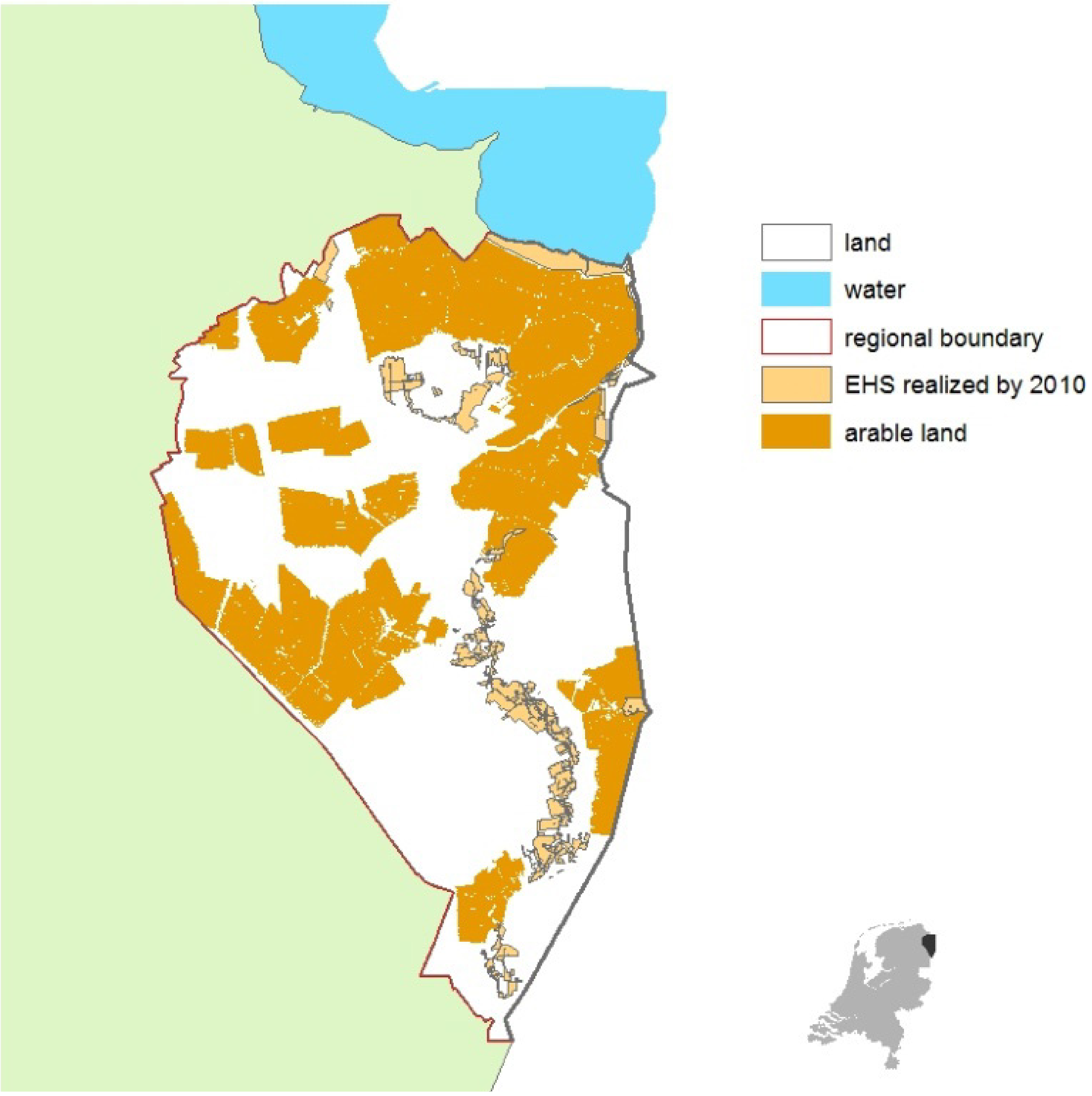

Figure 5.2: *Nature areas and search areas designated for agri-environmental contracting in Oost-Groningen*

Figure 5.2 shows that nature areas are scarce in the case study area Oost-Groningen. Given the spatial cohesion Reilly-index that is used by the environmental cooperative to distribute the AESs in the area, we want to stress that for Oost-Groningen the cohesion of the habitat network is mainly caused by contracted agri-environmental areas, and not so much by the existing nature areas. In the first period a farmer makes a choice between conventional arable farming or contracting an AES leading to lower yields, but receiving a compensatory payment or offering the parcel to the land market due to high opportunity costs. The same rules hold as is explained in Table 5.3. Difference with the options of dairy farm agents is that now the crop rotation scheme is taken into account when calculating the yield per parcel. Because the revenues from starch potatoes, sugar beets and cereals differ, we take the average revenue of the crops grown in the coming four years when calculating the operational profit per parcel. This means that the model keeps track of the crops grown on each parcel for the future three periods (see eq. 11). This is done to prevent that bid prices are too low, because cereals was produced on the parcel in the current year. The farm agent also has the possibility to attract parcels, by comparing operational profits for the offered parcels and has the opportunity to bid on offered parcels when their bid price is higher than the expectation price.

$$Bidprice\ parcel_i\ or\ Y_{ij} = \frac{Y_{i\,t+1}^{crop} + Y_{i\,t+2}^{crop} Y_{i\,t+3}^{crop} + Y_{i\,t+4}^{crop}}{4} \qquad (11)$$

In the first period, each farmer makes a choice between the parcels with AESs and the conventional arable parcels. In the following periods, when a contract is chosen, the farmer keeps the AESs until the period of six years is over. Almost-retired farmers are also able to sign a protection contract, when they do not have a successor these parcels will be supplied to the land market. This means that after the first period of the model run, the same three options are applicable as is discussed within the case study Winterswijk.

5.5 Collective implementation of Pillar II agri-environmental contracting (scenario 4)

Within SERA, a possibility is included to experiment with collective decision-making with respect to contracting AESs. We implemented this opportunity into SERA by giving the environmental cooperative a prominent role in the designation and actual contracting of parcels with AES. It is expected that an environmental cooperative has more local expertise on where parcels with high ecological value and high potential biodiversity are situated. Therefore, in the model complete knowledge on ecopoints of individual parcels (see Section 3.2.3) is assumed. Based on these ecopoints the environmental cooperative maps within each simulation period where the arable or grassland parcels with the highest added value to biodiversity are situated. It is assumed that the environmental cooperative receives a fixed budget from Provincial authorities, which can be spend according to the own strategy of the cooperative. The only requirement is that the highest possible amount of biodiversity must be achieved, given the fixed budget. Then, the environmental cooperative virtually consults the particular farm agent and offers a flexible compensatory payment based on ecopoints for conversion of the parcel into on-farm nature (see also Schouten *et al.*, 2013a). The farm agent on its turn makes a choice, which we discussed in detail in Section 5.4.1, between continuing conventional farming, contracting an AES and thereby facing decreased yields, or offering the parcel to the land market because of high opportunity costs.

With respect to the environmental cooperatives, we assume that the success of delivering AESs in a cost-effective way is not entirely linked to the compensatory payment, but also that they raise the willingness among farmers to deliver benefits for biodiversity, and resulting landscape amenities. In practice, by increasing ecological knowledge among members by providing training courses, they may increase the effectiveness of AESs by encouraging farmers to allocate schemes to parcels where they are likely to be most effective (see e.g. Verhulst, Kleijn, & Berendse, 2007, Mills *et al.*, 2011). To include this success factor for contracting AESs in the model, we assume that the environmental cooperative pays an extra bonus, on top of the compensatory payment (see eq. 12).

$$bonus = \Delta\ (compensatory\ payment, Y_{ij}) \qquad (12)$$

This bonus reflects the persuasive power of the collective body. Figure 5.3 shows a graphical explanation of the bonus distributed by the environmental cooperative. On top of the AES payment per hectare, a flexible bonus is given which is based on the difference between the conventional production revenue from the parcel and the AES payment per hectare.

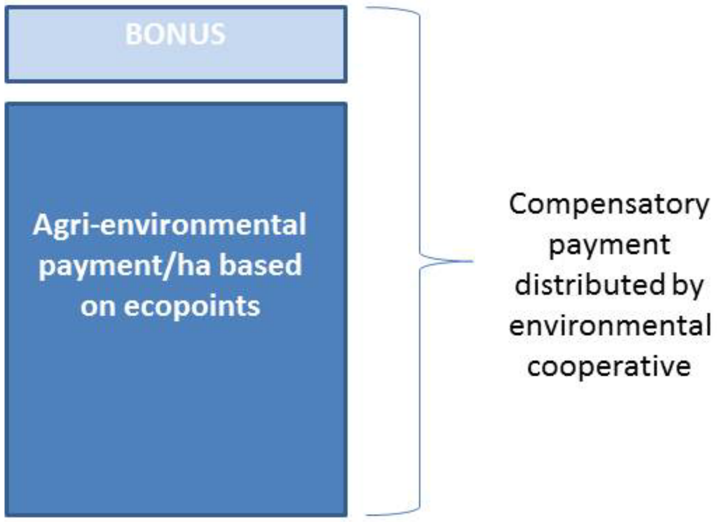

Figure 5.3: *Graphical explanation of the bonus given by the environmental cooperative on top of the AES payment/ha*

In Section 3.2.3 the ecopoints method is discussed which is used by the environmental cooperative to designate the parcels with the highest ecological value. To prevent that the environmental cooperative contracts parcels purely on the highest number of ecopoints that can be generated on the parcel, we correct the bonus that is given on top of the compensatory payment (see equation 13). For each eligible parcel, the environmental cooperative corrects the bonus based on the highest number of ecopoints that can be generated on the parcels. Equation (13) shows how for each parcel the bonus is computed (denoted as 'delta price') by dividing the number of ecopoints that could be generated on the parcel by the conventional production value of the parcel. This ratio is then used in the matching process.

$$delta\ price = f\left(\frac{number\ of\ ecopoints\ generated\ on\ parcel_i}{conventional\ production\ value\ of\ parcel_i}\right) \qquad (13)$$

Now matching of bids and offers is aiming at parcels with the highest ecopoints for the smallest possible budget.

6 Results

6.1 Introduction

In this chapter, an answer is given to the research questions stated in the introduction of this study focusing on getting insight into the spatial, ecological, economic impact of applying collective vs. individual approaches for both Pillar I 7% EFAs measures and Pillar II AESs. To get a good overview of the spatial, ecological and economic impact of both measures, we will analyse the model results using the following indicators:

- *Biodiversity*
  - Development of ecopoints of AESs or 7% EFAs area (see Chapter 3);
  - Area contracted with AESs.

- *Socio-economic impact*
  - Development of operational farm profits (see Chapter 4) of the farm agents in the population during the simulation period;
  - Number of continuing farms during the simulation period.

The results of the four scenarios discussed in Section 5.4 will be shown in this chapter. Each scenario is compared with the base scenario, in which no policies are applied. The model is simulated for 15 time periods, corresponding to 15 years, starting in the reference year 2010.

6.2 7% Ecological focus area measure (scenario 1 and 2)

6.2.1 General

In this section, the results of scenario 1 and 2 will be discussed. First, we will shortly repeat what is simulated in both scenarios. In scenario 1, the arable farm agents and dairy farm agents are obliged to convert 7% of their agricultural land for ecological purposes. In scenario 2, arable farm agents and dairy farm agents have the opportunity to exchange the obligatory 7% EFAs measure, by offering greening permits on an exchange market facilitated by the environmental cooperative.

Table 6.1 summarizes the results for the base scenario and the two alternative 7% EFAs scenarios for the case study areas Oost-Groningen and Winterswijk. Results will be discussed in more detail in Sections 6.2.2, 6.2.3 and 6.2.4.

Table 6.1: Model results for scenario 1 (current EC proposal) and 2 (collective implementation of 7% EFAs) for Oost-Groningen and Winterswijk, average after a 15-year simulation period[8]

Indicator	Description	Unit of analysis	Scenarios		
			0 Base No policies	1 Current EC proposal	2 Collective implementation of 7% EFAs
Oost-Groningen					
Biodiversity[8,9]	Contracted ecopoints (% of total eligible ecopoints)	%	0	32.4	31.7
Operational farm profit	Index average operational farm profit (base scenario = 100)	%	100	92.8	93.2
Operating farms	Number of operating farms (% of initial number of operating farms)	%	24	24	24
Winterswijk					
Biodiversity	Contracted ecopoints (% of total eligible ecopoints)	%	0	53	52
Operational farm profit	Index average operational farm profit (base scenario = 100)	%	100	98.2	98.4
Operating farms	Number of operating farms (% of initial number of operating farms)	%	23	23	23

6.2.2 Biodiversity

Figure 6.1 illustrates the dynamics of the total number of ecopoints generated on parcels taken out of production to comply to the 7% EFAs measure for scenario 1 (current EC proposal) and scenario 2 (collective implementation of 7% EFAs) in both case study areas (OG means Oost-Groningen; WW means Winterswijk), during a simulation period of 15 years.

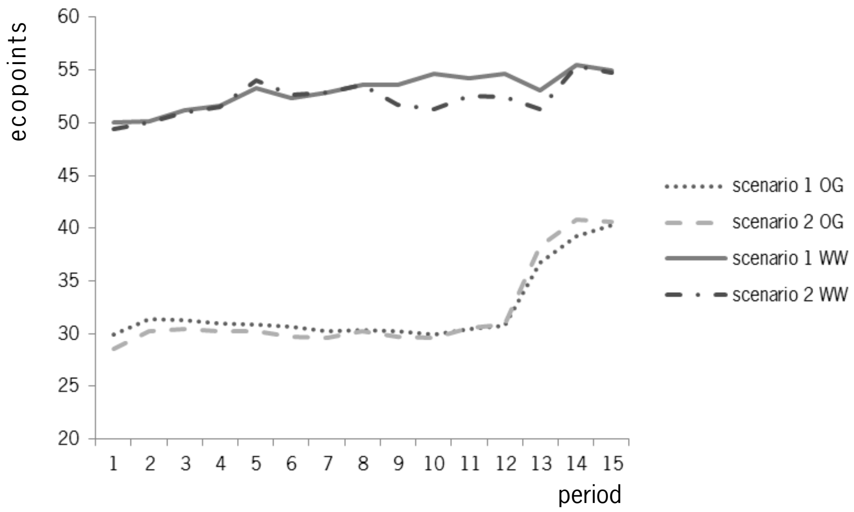

***Figure 6.1** Total number of ecopoints achieved for scenario 1 (current EC proposal) and 2 (collective implementation of 7% EFAs), for Oost-Groningen.*

[8] One digit is shown for the operational farm profit and biodiversity indicators, to illustrate differences between scenarios. Differences between scenarios are relatively small.
[9] The location of the parcels differs over the scenarios.

Figure 6.1 shows that the number of ecopoints achieved on the 7% EFAs parcels is slightly lower (1.34% lower for scenario 2 in Winterswijk when taking the sum of the number of ecopoints in both scenarios, see also Table 6.1) when exchange of greening permits is allowed (scenario 2), compared to a situation with no exchange (scenario 1). The difference between the two scenarios in the case study area Oost-Groningen is negligible (Figure 6.1 and Table 6.1). The lower number of achieved ecopoints can be explained by the assumption that farm agents that exchange greening permits search for the parcels with the lowest productivity, irrespective of its contribution to biodiversity (see Section 5.3). For simplicity reasons, we chose to simulate an exchange of greening permits purely driven by economic reasons. The large increase in ecopoints after period 12 can be explained by the large number of farm agents that retire during that year. More land is available on the land market and the remaining operating farms increase in size, which leads to more dynamics in the exchange of greening permits. The retired farm agents without a successor, that did not manage to supply all of their land to the landmarket are still able to attract greening permits in SERA. Given that they do not apply agricultural production on their land, they are able to conduct the permits at low cost. Given that many retired farm agents apply permits on their land, it is not always the case that these parcels are highly valued for biodiversity resulting in a higher number of achieved ecopoints.

Overall, the higher level of achieved ecopoints in Winterswijk compared to Oost-Groningen can be explained by the small-scaled characteristics of the landscape. In Winterswijk, the National Ecological Network (NEN) of nature areas is larger, and more scattered. Therefore higher ecopoints can be achieved in this case study area. Besides the characteristics of the farm population (because of retired farm agents applying greening permits), also the characteristics of both case study areas cause the small differences between scenario 1 and 2. Clustering of parcels together when exchange of greening permits is allowed does also not occur because of the small differences in ecopoints between the parcels in both case study areas. The value added for biodiversity of the parcels in both case study areas is rather homogeneous, leading to small differences whenever exchange of greening permits occurs. In Appendix IV, an example is given on how the number of ecopoints differs when comparing both scenarios, resulting in lower number of ecopoints for scenario 2. For simplicity reasons, we use the set-up of Figure 3.2, used to explain the spatial cohesion Reilly index, as a starting point.

6.2.3 Operational farm profit

Figure 6.2 shows the development of the average operational profit per farm as an index for both case study areas. The first year of the base scenario of both case studies serves as the reference year (first simulation year=100%). The other lines represent the percentage change in average operational farm profit compared to this reference year.

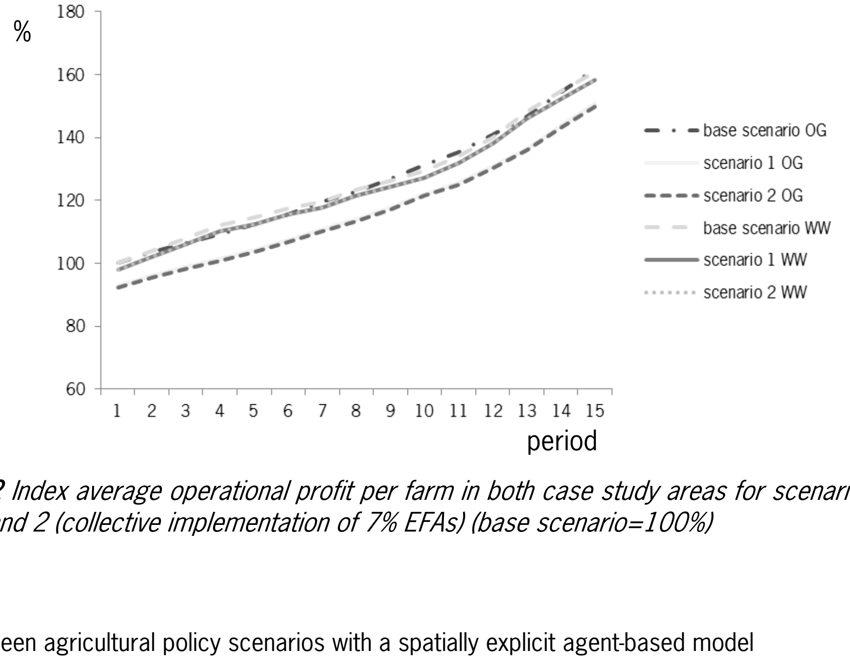

Figure 6.2 *Index average operational profit per farm in both case study areas for scenario 1 (current EC proposal) and 2 (collective implementation of 7% EFAs) (base scenario=100%)*

Figure 6.2 shows for all four scenarios that the implementation of the EFAs measure results in a decreasing average operational profit per farm up to a maximum of 7% because agricultural land is taken out of production which leads to a loss of revenue from production. Table 6.1 shows that the loss of operational farm profit due to implementation of this measure is lower in Winterswijk, comparing to Oost-Groningen. This can be explained by the characteristics of the case study area. In Winterswijk, nature areas are scattered throughout the case study area, with comparatively more low production quality parcels. In Oost-Groningen, parcels are more homogeneous with respect to soil quality, with higher production quality parcels. We will illustrate that the 7% EFAs measure can result in less than 7% operational farm profit decrease with the following example (Textbox 2):

Textbox 2: Illustrating change in operational farm profit after implementation of 7% EFAs measure
Imagine a farm with a farm size of 100 hectares. The farmer owns 3 parcels; one parcel of 50 ha, 30 ha and 20 ha. Table T2.1 shows the revenue from production for the three parcels.

Table T2.1: Example of farm with 100 hectares, using three parcels for agricultural production

Parcel	Size (ha)	Revenue/ha (€)	Total revenue (€)
A	50	200	10,000
B	30	100	3,000
C	20	10	200
		Total revenue	13,200

Now the 7% EFAs measure obliges farmers to convert 7% of their agricultural land for biodiversity purposes. Assuming that the farmer converts the parcel with the lowest quality (or revenue), this means that 7 hectares will be converted for biodiversity purposes, stemming from parcel C. The following revenue from production is generated on the farm (Table T2.2).

Table T2.2: Implementation of 7% EFAs measure

Parcel	Size (ha)	Revenue/ha (€)	Total revenue (€)
A	50	200	10,000
B	30	100	3,000
C	*13*	10	130
		Total revenue	13,130

Because of the 7% EFAs measure, the revenue from production is decreased with 0.53%. This example illustrates that the 7% EFAs measure can result in a decreasing operational farm profit which is lower than 7%.

Figure 6.2 shows that during the simulation period, an increasing curve is detected for all scenarios. The shape of the operational farm profit curves can be motivated by the assumptions made in the model in which farm agents try to attain the highest possible operational farm profit while making decisions. Given a rapidly decreasing number of active farm agents in the simulation (see Figure 6.3 for further explanation of the demographic patterns in Oost-Groningen and Winterswijk), and increasing scale (in hectares) of the average farm business, the average operational profit per farm increases.

As is shown in section 6.2.2, changes in total operational farm profit in the area are relatively small when comparing scenario 1 with the collective implementation in scenario 2, in which exchange of greening permits is allowed. These results rely heavily on the assumptions made with respect to the small differences in initial operational farm profit in the area between farms, and the small number of exchanged greening permits when compared to the total number of present parcels, and the total number of traded parcels on the landmarket in both case studies. Further, in the model we assume that the farm agent that offers a greening permit transfers the complete surplus between revenue from conventional production and revenue whenever 7% EFA would be applied to the farm agent that attracts the greening permit and performs the extra EFA hectares on his land. In practice, the division of this surplus depends on the market power (ratio between number of offering and attracting farm agents). For reasons of simplicity we assume that market power is in favor of the attracting farm agents. Further research is needed in order to make this assumption more realistic including more differentiation in parcel characteristics, so that more differences are shown between the two scenarios.

6.2.4 Operating farms

When looking at the number of remaining farm agents in the region, we note that demographic imbalances threaten the farm populations in Oost-Groningen and Winterswijk. In the Agricultural Census of 2010, farmers in both regions were asked for their age, and whether they had a successor for their farm. From this data we conclude that the average age of the 564 farmers in Oost-Groningen was approximately 55 years old in 2010. With respect to the presence of a successor, 24% of the farmers indicated that they had a successor for their farm (Agricultural Census 2010, Ministry of Economic Affairs). For Winterswijk, we conclude that the average age of the 201 farmers was approximately 51 years old in 2010. With respect to the presence of a successor, 24% of the farmers indicated that they had a successor for their farm (Agricultural Census 2010, Ministry of Economic Affairs).

When calculating both the EFAs and AESs policy scenarios with the model, we detect no differences in the demographic pattern for the simulation period when comparing to the two base scenarios. Figure 6.3 shows the annual percentage decrease in the number of operating farm agents in both case study areas, as modeled in SERA.

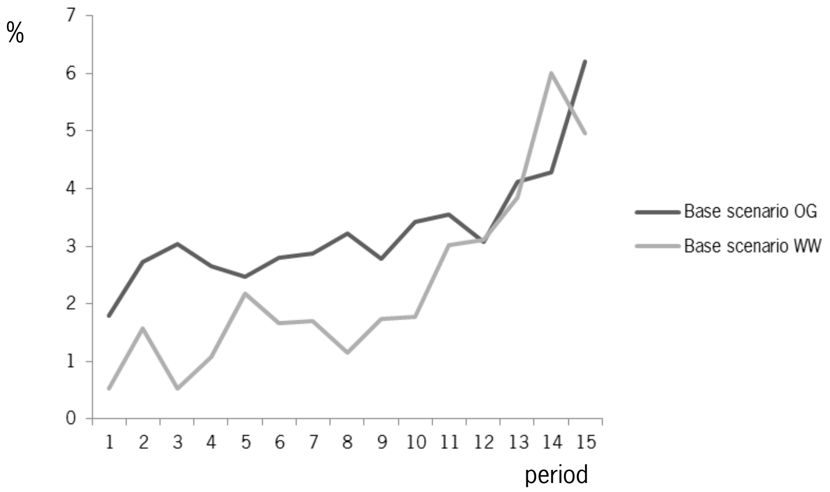

Figure 6.3 *Percentage decrease in operating farm agents in the base scenario (Reference year 0 = 564 and respectively 201 farms)*

Figure 6.3 shows that the number of operating farms decreases during the simulation period. Model results show that given the Agricultural Census data, a minor group has a successor (24%), these farm agents retire during the simulation period, and they will offer their land to the land market at an age of 65.

6.3 Agri-environmental measures (scenario 3 and 4)

6.3.1 General

In this section we discuss the model results for scenario 3 and 4, simulating the current policy situation with respect to AESs and a collective implementation of the AESs. The potential area in Oost-Groningen for applying AESs is 2379 hectares (based on the 'Natuurbeheerplankaart' of the province Groningen). Given the restricted budget of € 300,000 we conclude that only 147 hectares of clay soil or 171 hectares of sandy soil can be contracted with AESs (given the compensatory payment of € 2028/ha for clay soil, and € 1745/ha for sandy soil; see Section 5.4). This means that approximately 6% (for clay soil) and 7% (for sandy soil) can be contracted. When looking at the development of the average operational farm profit given the current budget of € 300.000, results show that there are only minor changes in the average operational farm profit when analyzed on the regional level. For Winterswijk, also a restricted budget of € 300,000 is available, which results in a minority of the eligible AES-area that can be contracted. Given the compensatory payment of € 1065/ha for grassland, only 282 hectares, or 4%, can be contracted of the eligible AES-area of 6314 hectares (based on the 'Natuurbeheerplankaart' of the province Gelderland for the case study area). When looking at the development of the average operational farm profit given the budget of € 300.000, results for Winterswijk also show that there are minor changes in the average operational farm profit when analyzed on the regional level. In order to show more pronounced differences in operational farm profit development, number of hectares contracted and number of achieved ecopoints in the two scenarios for the two case studies, we have used a larger maximum budget amounting the *potential* area for AESs times the compensatory payment per hectare.

Textbox 3: AESs budget assumptions scenario 3 and 4

As is stated in this section, budget assumptions are made in the model in order to show more pronounced differences in operational farm profit development, number of hectares contracted and number of achieved ecopoints in the two scenarios for the two case studies. We now assumed that the maximum available budget is equal to the potential hectares available for AESs (based on the eligigible AES-area shown in the 'Natuurbeheerplankaart' of both regions) times the compensatory payment per hectare. However, this modelling assumptions influences the results to a large extend. Because in scenario an extra bonus is given on top of the compensatory payment, a larger budget is spend in scenario 4, comparing to scenario 3. Intuitively, if this assumption would not have been made, fewer hectares would have been contracted in scenario 4 because relatively more budget is spend per hectare than in scenario 3. More research is needed in order to improve this modelling assumption.

Table 6.2 summarizes the results for the base scenario and the two alternative AESs scenarios for the case study areas Oost-Groningen and Winterswijk.

Table 6.2: *Model results for scenario 3 (implementation following current legislation) and 4 (collective implementation) for Oost-Groningen, average after a 15-year simulation period*

Indicator	**Description**	**Unit of analysis**	**Scenarios**		
			0 Base No policies	3 Implementation following current legislation	4 Collective implementation
Oost-Groningen					
Biodiversity	Contracted ecopoints (% of total eligible ecopoints)	%	0	26	83
	Percentage eligible AES-area contracted	%	0	52	93
Operational farm profit	Index average operational farm profit (base scenario = 100)	%	100	101	102
Winterswijk					
Biodiversity	Contracted ecopoints (% of total eligible ecopoints)	%	0	6	46
	Percentage eligible AES-area contracted	%	0	21	48
Operational farm profit	Index average operational farm profit (base scenario = 100)	%	100	115	111

6.3.2 Biodiversity

Table 6.2 shows the percentage hectares contracted with AESs, given the potential hectares contracted with AESs (=100%). As stated earlier, the budget is determined by the potential area for AESs (=100%) times the compensatory payment per hectare. Table 6.2 also shows the average achieved ecopoints on contracted AES area for both scenarios after a simulation period of 15 years.

Table 6.2 shows that scenario 4 results in a larger number of hectares contracted with AESs for both case study areas, and also results in higher numbers of achieved ecopoints on these contracted AESs parcels. The extra bonus that is given to reflect the persuasive power of the collective body convinces farm agents to contract extra AESs when comparing to scenario 3. Consequence of the persuasive power is that a larger budget is needed in scenario 4 to pay the bonus on top of the flexible compensatory payment (see Section 5.4.2). The increase in ecopoints can be explained by this larger budget.

6.3.3 Operational farm profit

Figure 6.4 shows the development of the average operational profit per farm as an index for both case study areas, given the available budgets in scenario 3 and 4. The first year of the base scenario of both case studies serves as the reference year (first simulation year=100%). The other lines represent the percentage change in average operational farm profit compared to this reference year.

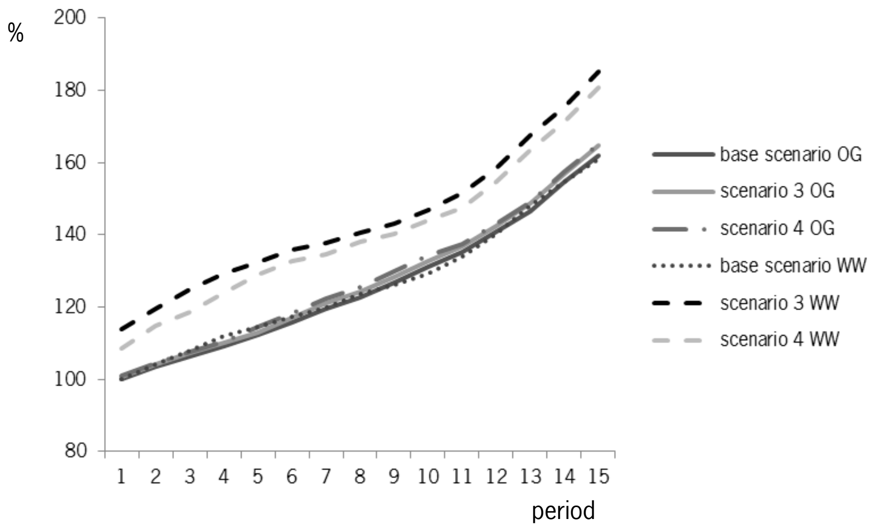

Figure 6.4 *Index average operational profit per farm in both case study areas for scenario 3 (implementation following current legislation) and 4 (collective implementation), given the base scenario with no applied policies.*

Figure 6.4 shows that during the simulation period, an increasing curve is detected for all scenarios. The shape of the operational farm profit curves can be motivated with the same reasoning as used in Section 6.2.3. Given the assumptions made in the model with respect to farm agents trying to attain the highest possible operational farm profit, and given the decreasing number of operating farms in the simulation (see Figure 6.3).

Figure 6.4 shows that during the simulation period, an increasing curve is detected for all scenarios. The shape of the operational farm profit curves can be motivated by the assumptions made in the model in which farm agents try to attain the highest possible operational farm profit while making decisions. Given a rapidly decreasing number of active farm agents in the simulation (see Figure 6.3) the scale of the average farm business increases (in hectares) and the average operational farm profit increases. Figure 6.4 and Table 6.2 show for Winterswijk that the average operational profit per farm is higher in scenario 3, given the fixed AES payments per hectare. This can be explained by the fact that more farm agents can increase their income in scenario 3, because no selections take place by the environmental cooperative on parcels with the highest contribution to biodiversity. Figure 6.4 and Table 6.2 show that the average operational profit per farm is slightly higher in scenario 4 for Oost-Groningen, where the environmental cooperative has a dominant role in assigning the AESs. The difference between these two results can be explained by the case study characteristics. When comparing both case studies, Winterswijk is characterized by more heterogeneous parcels (heterogeneous in size and quality). In Oost-Groningen parcels are larger, and more homogeneous with respect to size and quality. Therefore, scenario 4 will result in higher operational farm profit in Oost-Groningen because more budget is allocated in the area. However, in Winterswijk the opposite occurs, because the environmental cooperative is determined to contract the parcels with the highest value added to biodiversity. Therefore, the budget (including the bonus) will be spend on less parcels, but with achieving higher ecopoints.

7 Reflection

This report explores the spatial, ecological and economic impact of environmental cooperative decision-making for the European Commission's legislative proposals for the Common Agricultural Policy (CAP) 2014-2020 on farmers, their land use and their surroundings. The analysis is based on scenarios with a spatially explicit rural agent-based model (SERA) that explicitly models farmers, their socio-economic decision-making, their land use, and the landscape of which their farms are part. We illustrate the approach by comparing two rural policies aiming at biodiversity conservation while experimenting with two alternative management regimes: one based on centrally governed rules, and the other on rules of cooperative decision-making. We applied the model to two case study areas: Oost-Groningen and Winterswijk. These areas were chosen because of their differing characteristics: Oost-Groningen is dominated by large-scale arable farming with nature areas outside the region. while Winterswijk is dominated by small-scale dairy farms with small fields nearby nature areas. The very different character of the two case studies makes them interesting to compare from a policy perspective. Furthermore, both areas are engaged in regional pilot projects with self-management by environmental cooperatives.

The first part of the scenario analysis focused on the 'greening measure' Ecological Focus Areas, in which farmers are obliged to convert 7% of their agricultural production land for biodiversity purposes. Two alternative scenarios were simulated were simulated, the first one assuming that farmers oblige to the measure by converting 7% of their own land into Ecological Focus Area. The second one assuming that the environmental cooperative facilitates exchange between farmers within the region, through arranging transferable obligations between farmers. Given that the precise design of the 7% EFAs measure is still under development, it is expected that actual decisions made by policy makers with respect to the EFAs measure will be different from our assumptions. Still, this study provides insights into possible ways of implementing EFAs, and illustrates what possible impacts might occur.

The second part of the analysis addresses agri-environment measures (AESs) within the second pillar of the CAP. Within the proposed changes for Pillar II, the European Commission aims at promoting more specific and targeted measures through environmental cooperatives. Therefore also two alternative scenarios were simulated, the first considering agri-environmental contracting as it is now, with a fixed payment/ha, irrespective of the parcel characteristics. The second one assumes an important role for the environmental cooperative that uses their local knowledge to decide which parcels are contracted with agri-environment schemes given budget constraints and given their contribution to biodiversity.

For the 7% EFAs measure, the indicators showed to be influenced by the assumptions in the model, the characteristics of both case study areas, and by the characteristics of the farm population. In scenario 2, the behavior of the biodiversity indicator was influenced by the fact that parcels can be converted for biodiversity purposes irrespective of their spatial configuration in the surrounding landscape. We conclude that the contribution of cooperative arrangements to biodiversity can improve substantially if eligible parcels for 7% EFAs were to be dependent on their contribution to the ecological network at landscape level. This means that coordination of environmental cooperatives cannot rely on simple spot market based mechanisms. Therefore more procedures will be necessary. This confirms the conclusion of Polman (2002) where it is argued that solutions that work well for transactions on spot markets will not work for wildlife and landscape management contracting by farmers and further model development is needed. The potential biodiversity results of the AESs measure showed to be largely influenced by the characteristics of the case study areas, mainly caused in Winterswijk by nature areas that are scattered throughout the case study area with more heterogeneous parcel qualities than were found in Oost-Groningen. Furthermore, case study characteristics also influenced the number of operating farms. Ageing of the farm population, together with the small number of available successors dominated the decreasing trend of operating farms in both regions. Also the way we modeled the farm agent played a large role here, as we did not include the opportunity for new farm agents to start a farm practice, or the possibility to find a successor during the simulation. Furthermore, also the size of the assumed income transfers from one farm agent to another in scenario 1 and 2, and the assumptions made with respect to the available budget influenced the results to a large extend. Further research to improve these assumptions is needed. Given that the assumptions built into the model strongly influenced the behavior of the indicators, we conducted a sensitivity analysis for those parameters (see Schouten *et al.*, 2013b). Unfortunately, a sensitivity analysis for the 7% EFAs measure has not yet been carried out and requires an extensive discussion which is out of the scope of this study. In line with New Institutional Economics theory and the attributes of the transaction it follows that hybrid arrangements are appropriate for environmental cooperatives. Hybrid governance arrangements consist of elements both of markets and hierarchies. However, other means of co-ordination are used besides prices and hierarchy, such as reciprocity and trust (see Polman, 2002).

We conclude that this novel approach holds promise as a way to explore the impact of environmental cooperative decision making on rural areas. The modelling approach used in this report integrates both the natural environment and the socio-economic component at a detailed level. Farm agents can be included in the model with heterogeneous characteristics, and can participate in social networks through the environmental cooperative. In this way insight is gained into the complex dynamics of rural areas while imposing different types of policy instruments with different types of management regimes to the system. These insights can be valuable for rural policy makers and managers to evaluate what the impact is of potential policies, and to gain insight into the impact of environmental cooperatives, while aiming at creating sustainable rural development. For policy relevance, a next step would be to experiment with different rules for exchanging EFAs.

Future developments of the model are important to improve the practical use of the results to support more detailed policy development. Now we focus on one agricultural sector for each case study (arable farming for Oost-Groningen and dairy farming for Winterswijk). It would be interesting to take into account both arable and dairy farming sectors in both case studies. By mixing the sectors the influence of diversity can be investigated and its effects on exchanging EFAs. Furthermore, it would be interesting to take into account more crop rotation schemes, depending on different soil types. We now assume one crop rotation scheme in Oost-Groningen, taking place on both sandy and clay soils. In reality, this is more sophisticated (i.e. 1:2 scheme with cereals and sugar beets on clay soil). With regard to the farm agent's behavior, we currently focus on limitedly rational behavior. It would be interesting to experiment with different farm behavioral models, representing different types of farms and taking into account more elements relevant for allocating EFA and agri-environmental schemes. With respect to the biodiversity indicator and governance mechanism of the collective, used in this study we conclude that they are pretty rough and should be developed further i.e. through the role of habitat quality of particular species or on specific locations and the way in which collectives operate. Future developments of more sophisticated biodiversity indicators could add to the informative use of the model for studying ecological dynamics while different policy measures are implemented.

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Appendix I: Detailed description behavioural rules arable farm agent

To characterize the arable farm agent, it is useful to first describe why arable farm agents do what they do and based on what. That is, this Appendix will first describe an arable farm agent's behavior and the goal of its actions before describing the arable farm agent's actions themselves. Arable farm agents can produce a selection of goods. They can also engage in land rental activities. Arable farm agents are assumed to act autonomously and their objective is to attain the highest possible operational farm profit, given the information the farm agent has. Although no explicit linear optimization problem is used in SERA because of heterogeneous parcels used, the farm agents' objective function can be expressed in the following way: Operational arable farm profit is based on the sum of the contribution of each individual parcel (i) and all crops grown (j) on land controlled by the farm agent, based on the following function (1)

$$Y_{farm}^{arable} = \sum_{i=1}^{n} Y_{ij} \tag{1}$$

For each parcel the profit (Y_{ij}) is calculated based on the following function

$$Y_{ij}\,(PY_{ij}, S_i^{sand}, S_i^{clay}, TRC_{ij}, MAR_i, FC_i, CC_{ij}, p_j, p_{manureapply}, p_{fertilizer}) \tag{2}$$

With

$$Y_{ij} = PY_{ij} + S_i^{sand} + S_i^{clay} + MAR_i - TRC_{ij} - FC_i - CC_{ij} \tag{3}$$

s.t.

Table I-1 gives an overview of the main parameters in the arable farm model

Table I-1: *Main model parameters arable farm agent*

Description	**Unit of analysis**	**Parameter**
Production yields for the three crops j	Ton/ha	PY_{ij}
Yield losses for the parcel and three crops j	% point	$yieldloss_{ij}$
Production per hectare for three crops j	Ton/ha	$yield_j$
Fertilizer costs on the parcel for crop j	Euro/parcel	FC_{ij}
Fertilizer application for three crops j	Ton/ha	FU_j
Product sell price for three crops j	Euro/ton	p_j
Manure application revenue depending on crop j	Euro/kg N	MAR_j
Cultivation costs for three crops j	Euro/ton	CC_{ij}
Transport costs depending on parcel and crop j	Euro/parcel	TRC_{ij}
SNL subsidy sand	Euro/ha	S_i^{sand}
SNL subsidy clay	Euro/ha	S_i^{clay}
SNL contract length	Years	6
SNL fertilizer allowance	Kg N/ha	0
SNL nitrogen allowance	Kg N/ha	0
Cultivation costs for SNL parcel	Euro	CC_{ij}^{nature}
Transport costs for SNL parcel	Euro	TRC_{ij}^{nature}
Discount rate for lowering transport costs for SNL parcels	% point	$discount_{nature}$
Expectation price for greening permit	Euro/permit	$p_{expectation}^{permit}$
Reserve price for greening permit	Euro/permit	$p_{reserve}^{permit}$

Yield losses related to soil quality

For each parcel the yield losses due to low soil quality is known based on GIS-maps of watertables, soil quality and soil suitability provided by Alterra. For each parcel a percentage yield loss is known for the three crops grown. These yield losses influence the crop production revenue on each individual parcel (see (4)).

$$yieldloss_{ij} = f(yieldloss_{starch}, yieldloss_{sugar}, yieldloss_{cereal}) \quad (4)$$

Crop production revenue starch potatoes

Crop production revenue from starch potatoes is calculated based on the average yield of starch potatoes (in kg/ha) in (CBS & LEI). For the area 'Veenkolonien and Oldambt', we see that the average yield in kg per hectare is equal to 39863 kg/ha. The price per 100 kg is equal to the price/100 kg off-farm given the in water weight of 400 gram, which is 5.05 per 100 kg (0.051 euro/kg).

$$p_j = f(p_{starch}, p_{sugar}, p_{cereal}) \quad (5)$$

$$p_{starch} = 0.051$$

$$PY_j = f(PY_{starch}, PY_{sugar}, PY_{cereal}) \quad (6)$$

$$PY_{starch} = (parcel_{ij} \cdot yield_{starch} \cdot yieldloss_{starch}) \cdot p_{starch} \quad (7)$$

$$yield_{starch} = 39863$$

Crop production revenue sugar beets

For sugar beets, the average yield in kg/ha is equal to 69000 kg/ha in 2010. The price per 1000kg is equal to 43 euro per ton (0.043 euro/kg)(CBS & LEI, 2011).

$$PY_{sugar} = (parcel_{ij} \cdot yield_{sugar} \cdot yieldloss_{sugar}) \cdot p_{sugar} \quad (8)$$

$$p_{sugar} = 0.043$$

$$yield_{sugar} = 69000$$

Crop production revenue cereals

For cereals, we take into account the production of winter barley, spring barley, rye, oats, spring wheat and winter wheat, as well as triticale and a group of 'other cereals'. We treat these types of cereals as equal in the model under the name 'cereals'. For computing the average yield of cereals from a crop, we use the average yield of winter wheat in reference year 2010 as a starting point (see (CBS & LEI, 2011). The same type of treatment is used to conduct the crop price for cereals (0.1135 euro/kg)(CBS & LEI, 2011). The following function is used in the model.

$$PY_{cereal} = (parcel_{ij} \cdot yield_{cereal} \cdot yieldloss_{cereal}) \cdot p_{cereal} \quad (9)$$

$$p_{cereal} = 0.1135$$

$$yield_{cereal} = 8849$$

Nitrogen balance on parcel level: Manure supply revenue and fertilizer costs

For each crop grown on a $parcel_i$ a fixed amount of nitrogen/ha is assumed to be used. According to the Dutch legal manure regulations, the legal norm for nitrogen stemming from animal manure is 170 kg/ha. For individual crops and soil qualities, Dutch authorities have declared special norms. These norms are given in Table I-2.

Table I-2: Legal norms manure disposal (source: (EL&I, 2010), Agricultural Census data 2010)

Crop	Maximum N kg/ha stemming from manure on sandy soil	Maximum N kg/ha stemming from manure on sea-clay soil	Average use of fertilizer in kg N/ha
Starch potatoes	240	230	45
Sugar beets	145	150	90
Cereals	245*	160*	60

*Using winter wheat as reference

Arable farmers earn revenue from applying animal manure on their parcels. We assume that all farmers apply the maximum legal norm (according to (EL&I, 2010) on their parcels, given the soil type (either sea-clay or sand). The manure application revenue for farmers is equal to the legal manure application norms, depending on the soil type times the average price for manure disposal.

$$MAR_{ij} = MA_j \cdot p_{manure} \quad (10)$$
$$MA_j = f(MA_{starch}, MA_{sugar}, MA_{cereal}) \quad (11)$$

The average price that arable farmers receive for manure application depends on the type of manure, which could stem from pigs, poultry or cows. We assume an average manure disposal price which we base on the average price paid for manure disposal in 2010 (CBS, 2010) which is 14 euro/ton, with 4.4 kg N/ton, gives an average manure disposal price per kg N of 0.06 euro/kg N. (source: (Verloop, Hilhorst, Teenstra, & Meerkerk, 2009). In practice, a distinction can be made between different types of animal manure, stemming from cows, poultry or pigs. For this project we take the average disposal price, as is used in the 'Koeien en Kansen' LEI-ASG project by *(Verloop et al.,* 2009).

$$p_{manure} = 0.06$$

The price of fertilizer per kg N is 0.80 euro/kg N (reference pure nitrogen calcium ammonium nitrate 27% KAS stemming from (Verloop *et al.*, 2009))

$$p_{fertilizer} = 0.80$$
$$FC_{ij} = FU_j \cdot p_{fertilizer} \cdot parcel_{ij} \quad (12)$$
$$FU_j = f(FU_{starch}, FU_{sugar}, FU_{cereal}) \quad (13)$$
$$FU_{starch} = 45$$
$$FU_{sugar} = 90$$
$$FU_{cereal} = 60$$

Cultivation costs

We assume a fixed cultivation costs per hectare thereby taking into account costs for sowing, harvesting etc. The average cultivation costs per hectare can be distinguished for the three different crops. Furthermore, the function includes a part which is depending on the average production in kg per crop, assuming that for example starch potatoes asks for higher cultivation costs because of more costs for weed control.

$$CC_{ij} = f(CC_{starch}, CC_{sugar}, CC_{cereal}, parcel_{ij}) \quad (14)$$
$$CC_{starch} = 1406 \cdot parcel_{ij} \quad (15)$$
$$CC_{sugar} = 1014 \cdot parcel_{ij} \quad (16)$$
$$CC_{cereal} = 725 \cdot parcel_{ij} \quad (17)$$

Source: (Van Reeuwijk *et al.*, 2010)

Transport costs

Transport costs (TRC_i) depend on the distance from the parcel to the farmstead (km_i) and depends on the type of crop. As sugar beets have the highest kg/ha production, we assume that more effort is needed to transport the harvest to the farmstead. For each parcel the distance to the farmstead is known. A fixed average per kilometer is used, to represent the costs of machinery and transport to the parcels.

$$TRC_{ij} = f(TRC_{starch}, TRC_{sugar}, TRC_{cereal}, km_i) \quad (18)$$
$$TRC_{starch} = 40 \cdot km_i \quad (19)$$
$$TRC_{sugar} = 60 \cdot km_i \quad (20)$$
$$TRC_{cereal} = 20 \cdot km_i \quad (21)$$

Farmers' choice: Contracting agri-environmental schemes

For arable farm agents in Oost-Groningen, we focus on one type of contract aiming at the conservation of field edges for breeding and wintering farmland birds. We take the nature management plan as a reference point: farmers are able to contract field edges on the assigned parcels. The following restrictions are present, given the agri-environment scheme. For Oost-Groningen we assume that field margins with a minimum with of 9 meters are contracted. We furthermore assume that when field margins are contracted, they apply to the entire contour of the parcel. We compute the surface that is covered with field margins for each parcel individually. Contracted field margins lead to a decrease in production yields, and lower possibilities for manure application. Payment per hectare for sandy soil is 1745 euro/ha; for clay soil 2028 euro/ha.

$$S_i^{sand} = 1745 \cdot parcel_{ij} \quad (22)$$
$$S_i^{clay} = 2028 \cdot parcel_{ij} \quad (23)$$

With respect to cultivation costs, we assume that they are 20% higher when comparing to conventional farming. Lower costs because of smaller sizes of the parcel due to field margin management are discounted in this value. Cultivation costs still depend on the type of crop, but are now raised with 20% because of conservation of the field margin, sowing botanic mixes on the field margins etc.

$$CC_{ij}^{nature} = f(CC_{starch}^{nature}, CC_{sugar}^{nature}, CC_{cereal}^{nature}) \quad (24)$$
$$CC_{starch}^{nature} = 1687 \cdot parcel_{ij}^{nature} \quad (25)$$
$$CC_{sugar}^{nature} = 1217 \cdot parcel_{ij}^{nature} \quad (26)$$
$$CC_{cereal}^{nature} = 870 \cdot parcel_{ij}^{nature} \quad (27)$$

Transport costs (TRC_{ij}^{nature}) depend on the distance from the parcel to the farmstead (km_i). For each parcel the distance to the farmstead is known. Depending on the type of crop grown on the parcel, the transport costs are determined. A fixed average per kilometer is used, to represent the costs of machinery and transport to the parcel. For parcels with agri-environment schemes, we assume a percentage discount because smaller yields result in lower transportation. This percentage is set at 60% of the original transportation parameter values.

$$TRC_{ij}^{nature} = f(TRC_{starch}^{nature}, TRC_{sugar}^{nature}, TRC_{cereal}^{nature}) \quad (28)$$
$$TRC_{starch}^{nature} = 40 \cdot km_i \cdot discount_{nature} \quad (29)$$
$$TRC_{sugar}^{nature} = 60 \cdot km_i \cdot discount_{nature} \quad (30)$$
$$TRC_{cereal}^{nature} = 20 \cdot km_i \cdot discount_{nature} \quad (31)$$
$$discount_{nature} = 0.6$$

Appendix II: Detailed description behavioural rules dairy farm agent

This Appendix describes the dairy farm agent's behavior and the dairy farm agent's actions. For this study 201 specialized dairy farms were selected from Agricultural Census data (reference year 2010). Together, these farms use approximately 60% of all agricultural land present in the area. Dairy farm agents can produce milk, grass, maize or farmland biodiversity. They can also engage in land rental activities. Like in Oost-Groningen, they also are assumed to act autonomously and to attain the highest possible operational farm profit. The decision making of the modeled farms is highly simplified compared to that of real farmers in Winterswijk, and only serves the purpose of this study.

Same as for the arable farm agents, dairy farm agents' objective is to attain the highest possible operational farm profit, given the information the dairy farm agent has. Although no explicit linear optimization problem is used in SERA because of heterogeneous parcels used, the farm agents' objective function can be expressed in the following way: Operational dairy farm profit is based on the sum of the contribution of each individual parcel (i) and crops grown (j) (either grass or maize) on land controlled by the farm agent, based on the following function (1):

$$Y_{farm}^{dairy} = \sum_{i=1}^{n} Y_{ij} \tag{1}$$

For each parcel the profit (Y_{ij}) is calculated based on the following function

$$Y_{ij}\ (DI_i, S_i\ , TRC_i, MAR_i, FC_i, FB_i, p_{milk} p_j, p_{manureapply/dispose}, p_{fertilizer}) \tag{2}$$

With

$$Y_{ij} = DI_i + S_i\ + MAR_i - TRC_i - FC_i - FB_i \tag{3}$$

s.t.

Table II-1 gives an overview of the main parameters in the dairy farm model

Table II-1: *Main model parameters dairy farm agent*

Description	**Unit of Analysis**	**Parameter**
Dairy income on parcel *i*	Kg/parcel	DI_i
Fertilizer costs on parcel *i*	Euro/ kg N	FC_i
Manure application revenue (or costs) for parcel *i*	Euro/kg N	MAR_i
Legal nitrogen application norm	N kg/ha	N_{legal}
Nitrogen supply according to legal norms	N kg/ha	NS_{ij}
Nitrogen supply realized	N kg/ha	NS_{ij}^{real}
Nitrogen deposition due to grazing	N kg/ha	D_i
Nitrogen leaching	N kg/ha	L_{ij}
Transport costs depending on parcel *i*	Euro/ha	TRC_i
Transport costs for SNL parcel	Euro/ha	TRC_i^{nature}
Milk production per cow	Kg/cow	$qmilk$

Description	Unit of Analysis	Parameter
Nitrogen production per cow	N kg/cow	NP
Nitrogen production per parcel *i*	N kg/parcel	NP_{ij}
Fertilizer application for two crops (grass or maize) *j*	N kg/ha	FU_j
Mineralisation grassland	N kg/ha	M_i
Yield losses for the parcel *i*	% point	$yieldloss_i$
Milkprice	Euro/kg	p_{milk}
Workability coefficient grassland	%	$work_{grass}$
Leaching coefficient grassland	%	$leach_{grass}$
NEL (feed) requirements per dairy cow	NEL/cow	NEL
SNL subsidy for parcel *i*	Euro/ha	S_i
SNL contract length	year	6
Nitrogen availability for parcel *i* with crop *j*	N kg/ha	NA_{ij}
Nitrogen uptake for parcel *i* with crop *j*	N kg/ha	NU_{ij}
Dry matter production grassland	DM/ha	DM_{ij}
Nett energy for lactation	NEL kJ/kg	NEL
Dry matter production per parcel *i*, expressed in NEL	NEL kJ/year	$DMNEL_{ij}$
Feed requirements grazing cows on parcel *i*	NEL kJ/kg	TFR_{ij}
Fertilizer costs on parcel *i* with crop *j*	Euro/ kg N	FC_{ij}
Fertilizer price	Euro/kg N	p_{fert}
Total feed bought/sold	NEL kJ	TFB_{ij}
Feed production crop *j* (maize)	NEL	$yield_j$
Fertilizer application crop *j* (maize)	N kg/ha	FA_j
Maximum number of cows per hectare	Cows/ha	r_{cow}
Expectation price for greening permit	Euro/permit	$p^{permit}_{expectation}$
Reserve price for greening permit	Euro/permit	$p^{permit}_{reserve}$

Parcels revenue from dairy production activities

The parcels income from dairy production (DI_i) is calculated as the sum of number of cows per hectare, known as the cow-ratio (r_{cow}), which is set at the initial level, times the size of the parcel in hectares ($parcel_{ij}$), times the average milk production per cow ($qmilk$) which is set at 7875 liter/cow/year (see (CBS & LEI, 2011)), times the milk price (p_{milk}). The milk price is given in the model at a rate of 0.31 euro/liter milk. In the model is a possibility to fluctuate this level.

$$DI_i = \sum (r_{cow} \cdot parcel_{ij} \cdot qmilk \cdot p_{milk}) \quad (4)$$

Nitrogen production

The nitrogen produced by dairy cows on the parcel (NP_{ij}) is calculated as the sum of nitrogen production per cow (NP) (115 kg N/cow/year, see (CBS & LEI, 2011)) times the cow-ratio (r_{cow}), times the size of the parcel in hectares ($parcel_{ij}$).

$$NP_{ij} = \sum NP \cdot r_{cow} \cdot parcel_{ij} \quad (5)$$

At the farmlevel a nitrogen availability for grassland is calculated, where the nitrogen application of maize is subtracted. In this way a nitrogen balance is created at farm level. Fertilizer use is assumed to be only on grassland which is not subject to agri-environmental schemes. Several studies, such as (Aarts, 1995, 1996, 2000) on nitrogen application and feed requirements in "De Marke" show that the average use of fertilizer, F, in the Winterswijk region can be set at 35 kg N/ha . A future model extension could be the estimation of a function for fertilizer use, related to the size of the farm, the number of dairy cows, using FADN data.

The relation between N-application and NEL production per ha per year is adapted from {Middelkoop, 1991 #42}; {van de Ven, 1992 #47}; {Groeneveld, 1998 #38}; {Groeneveld, 2001 #39}; and Peerlings & Polman (2008) and the following nitrogen supply, leach, nitrogen availability, uptake and dry matter yield per parcel were calculated. The legal limits of the Ministry of EL&I prescribe that nitrogen can be applied to the parcel up to a maximum of 250 kg N/ha (N_{legal}) for manure from livestock. Here derogation applies; farm agents are allowed to apply 250 kg N/ha on their parcels when >70% of their farm is grassland. When this changes, the legal norm is decreased to 170 kg N/ha[10]. The nitrogen supply (NS_{ij}) which has to fulfill the legal norms is calculated as *legal supply=manure.* Only transportable manure is assumed to be produced by the livestock.

But, the amount of N available for the grass is higher, NS_{ij}^{real} due to mineralization and deposition. The nitrogen supply (NS_{ij}^{real}) is calculated as *supply=manure+fertilizer+deposition+mineralisation.* We assume mineralization (M_i; process in which N is released from organic matter and becomes available for uptake by plants) is 250 kg N/ha, we assume deposition (D_i; N deposited by cattle during grazing) is 50 kg N/ha. A workability coefficient of 100% is assumed for the use of fertilizer FU_j, which is now set at 35.

The nitrogen supply (NS_{p_i}) which is used for the legal limits norm, set by the Ministry is:

$$NS_{ij} = parcel_{ij} \cdot NP_{ij} \leq N_{legal} \qquad (6)$$

The nitrogen supply which is used to calculate the availability for grass later on (NS_{ij}^{real}), is calculated as

$$NS_{ij}^{real} = parcel_{ij}(FU_j + M_i + D_i) + NP_{ij} \qquad (7)$$

Not all supplied N will be available for grass because of N leaching (L_{ij}). The fraction of nitrogen supply that is leached is calculated using the following function:

$$L_{ij} = 15 + 0.32(NS_{ij}^{real} - 300) \qquad (8)$$

Available N (NA_{ij}) at the parcel level can then be derived as follows:

$$NA_{ij} = NS_{ij}^{real} - L_{ij} \qquad (9)$$

[10] See further explanation on derogation at
http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:2005D0880:20100206:EN:PDF

Only part of the N from available N is taken up by the sward. Uptake N/ha (NU_{ij}) is calculated as

$$NU_{ij} = \frac{(-(\alpha_b + NA_{ij}) + ((\alpha_b + NA_{ij})^2 - 4\alpha_a \alpha_c NA_{ij})^{0.5}}{-2\alpha_a} \tag{10}$$

Where α_a is a constant (1.14), α_b is the ratio α_b / α_c $(= 1.176 \cdot \alpha_c)$, α_c is the horizontal asymptote that is 11.85 per cent above the maximum N uptake per parcel.

Feed production

The dry matter yield of grass per parcel is expressed in tons of DM. The DM production depends on the N uptake of grass:

$$DM_{ij} = \frac{(-(\beta_b + NU_{ij)}) + ((\beta_b + NU_{ij})^2 - 4\beta_a \beta_c NU_{ij})^{0.5}}{-2\beta_a} \tag{11}$$

Where dm is DM yield per parcel, β_a is a constant (19.88), β_b is 21.6 x β_c, β_c is 1.078 x maximum DM production. Maximum DM production is derived from the questionnaire by (Peerlings & Polman, 2008) and is based on the subjective judgments of individual farmers.

The nett energy for lactation (NEL) is the energy value of forage expressed in NEL kJ/kg DM is based on grazing, according to

$$NEL = (\gamma_0 + \gamma_1 NU_{ij} + \gamma_2 NU_{ij})^2 \tag{12}$$

Where γ_0 is 5947.932, γ_1 is 15.0628 and γ_2 is -0.020439 (based on (Peerlings & Polman, 2008)).

$$DMNEL_{ij} = \frac{NEL \cdot DM_{ij}}{\delta} \tag{13}$$

The DM ($DMNEL_{ij}$) produced per parcel, expressed in NEL kJ, per year is calculated by multiplying the NEL in kJ per kg DM by DM production per parcel divided by a production coefficient (δ =6.9). This coefficient is set at DM production to be medium quality grassland, given the questionnaire of Peerlings and Polman (2008).

Feed requirements grazing dairy cows

To calculate the feed requirements of the grazing dairy cows on the parcel the total net energy requirements for lactation (TFR_{ij}) of the herd should be calculated.

$$TFR_{ij} = TF_{cow} \cdot r_{cow} \tag{14}$$

It is written as the NEL requirements per dairy cow (TF_{cow}) times the cow-ratio (r_{cow}) (see statement below).

The NEL requirements per dairy cow are calculated following the guidelines by the Dutch Ministry of EL&I (see (Tamminga *et al.*, 2004)). The energy requirements of calves and heifers is not taken into account in this model. This can be a valuable model extension.

$$TF_{cow} = 1.02 \cdot (\overline{NEL}_{milkprod} + \overline{NEL}_{maintenance} + \overline{NEL}_{premium}) = 6374.8 kJNEL / cow / year \tag{15}$$

$$\overline{NEL}_{milkprod} = 3747.56 kJ / cow / year$$

$$\overline{NEL}_{maintenance} = 1900.24 kJ / cow / year$$

$$\overline{NEL}_{premium} = 602 kJ / cow / year \qquad (16)\text{ - }(18)$$

Given the NEL requirements and the feed production for grassland, the amount of feed bought can be calculated as follows

Feed costs

It is assumed that the costs for buying feed are higher than for selling feed. We assume a 10% variation around the feed price of 0.19 euro/NEL. The feedshortage/surplus on parcel level (TFB_{ij}) is calculated using the following equation:

$$TFB_{ij} = TFR_{ij} - DMNEL_{ij} \tag{19}$$

The total feed bought can be calculated as the total feed required by the dairy cattle (TFR_{ij}) minus the yield of energy production value from grass ($DMNEL_{ij}$).

Manure disposal costs

When the nitrogen production (from dairy cows grazing on the parcel) exceeds the legal limits of 250 kg N/ha the farmer needs to dispose of the manure from the parcel. Costs are involved to do so. Average cost of manure disposal is taken as 2 euro/kg N based on (CBS/LEI, 2007) and is calculated from the manure disposal cost or manure application revenue per m^3 manure (Middelkoop, 2007).

when $NP_{ij} > 250$

The nitrogen surplus (MAR_{ij}) is a cost when the total nitrogen production (NP_{ij}) exceeds the legal limits of 250 kg N/ha. When there is a shortage, the farmer is assumed to apply nitrogen on the parcel until a maximum of 250kg.

When $NP_{ij} < 260$ then $MAR_{ij} < 0$

Fertilizer costs

On grassland a fixed amount of 35 kg N/ha is assumed to be used. Later on, the fertilizer use will be calculated as depending on size of the parcel and number of dairy cows within a regression analysis using FADN-data. For now, we stick to the 35 kg N/ha.

$$FC_{ij} = p_{fert} \cdot 35 \cdot parcel_{grass} \tag{20}$$

This results in fertilizer costs (FC_{ij}) which are calculated by the price of fertilizer, which is set at 0.70 euro/ kg N (p_{fert}) (source:(CBS/LEI, 2007) times 35, times the hectares of grassland ($parcel_{ij}$).

Transport costs

Total transport costs (TRC_i)depend on the distance from the parcel to the farmstead (km_i). For each parcel this distance is known. A fixed average of $TRC_{fixed} = 50$ euro costs per kilometer is used, to represent the costs of machinery, manure and cattle transport to the parcels. Furthermore, a constant ($const$) is used to represent the costs of mowing and other machinery on the parcel, multiplied by the size of the parcel. This constant is now set at 50 euro.

$$TRC_i = TRC_{fixed} \cdot km_i + const \cdot parcel_{ij} \tag{21}$$

Maizeland parcels

Maizeland is included in the model but is not taken into account for the agri-environmental schemes which a farmer could choose. It is assumed that grassland parcels cannot be switched into maizeland parcels and vice versa for reasons of simplicity. Maizeland is used for the production of fodder for the dairy cattle in the model. In the model, two types of revenue can be distinguished for the maizeland parcels: manure disposal revenue (150 kg N/ha) and feed revenue (14973 NEL kJ/ha).

Manure disposal revenue

On maizeland parcels, no nitrogen is produced as grazing is not allowed. The fixed maximum manure application for maizeland is set by the Ministry of Agriculture at 150 kg N/ha. Average revenue from manure application is set at 2 euro/kg N based on (CBS/LEI, 2007) and is calculated from the manure disposal costs per m3 (Middelkoop, 2007). When the farmer has a negative nitrogen balance, the farmer is able to attract external manure on the farm and a revenue could be gained. Transportcosts are calculated in the same way as done for grassland parcels.

Agri-environment schemes

Farmers receive a subsidy of 1065 euro per hectare for plant species protection contracts

$$(S_i) = S \cdot parcel_{ij}$$
$$S = 1065 \tag{22}$$

Transport costs

Transportation cost for parcels with AESs is assumed to be lower than for conventionally managed parcels. A fixed average of TRC_{fixed}^{nature} =20 euro costs per kilometer is used. This is lower than the transport costs for conventional farming, because it is assumed that less transport for i.e. manure disposal is needed. The transport costs (TRC_{ij}^{nature})depend on the distance from the parcel to the farmstead (km_i) and the constant parameter ($const$) which is equal to the constant used in the conventional grassland functions.

$$TRC_{ij}^{nature} = TRC_{fixed}^{nature} \cdot km_i + const \cdot parcel_{ij} \tag{23}$$

Appendix III: Explanation of the land market mechanism

This Appendix informs about the land market mechanism used in SERA. Agents in SERA interact indirectly by competing on a land market which is facilitated by an *Auctioneer*. Agents in SERA interact indirectly by competing on a land market. The land market is the central interaction institution between agents in SERA and is fully endogenous in the model. There is a broad range of applications of land market mechanisms within agent-based models available for social sciences (see Parker *et al.*, 2003; Parker & Filatova, 2008; Filatova *et al.,* 2011; Kellermann *et al.,* 2008; Magliocca *et al.*, 2011). Our approach has in common with other approaches that land allocation is modeled through an auction mechanism in which competition for land is based on a defined bidding process and a set of rules for price determination and 'matching' of asks and bids. However, it differs from existing approaches in that farm agents are informed in advance when multiple parcels are offered simultaneously. They are informed on several attributes of the parcel: soil quality, size, current land use and distance to the homestead. In SERA, farm agents extend their hectare base exclusively so called perpetual lease contracts. This implies that the farm agent is free to offer the parcel again to the land market or remain farming after each simulation period. When SERA is run, available perpetual lease parcels stem from two sources: one is that farms offer their land to the market due to high opportunity costs, the second one is retirement of farmers when they reach the age of 65 and do not have a successor.

Figure III-1 presents the sequence of events in the informed single auction market mechanism of SERA. At the start of each auction, the auctioneer informs the traders that the auction is open. Based on the outcome of the farm agent decision making (does the agent wants to offer or attract parcels?), traders can respond by expressing interest in the auction. Next, the auctioneer requests all interested agents to provide the parcels they would like to offer with a related reserve price for these parcels. This reserve price is determined by the valuation strategy the agent is applying. Once all asks have been identified, the auctioneer requests the interested agents to provide bids for the parcels on offer. An interested farm agent evaluates all available parcels and is allowed to create one bid, for the asks that he or she values the most. Again, this is decided by the farm agent's decision making strategy.

After all bids have been collected, the informed single auction mechanism matches bids and asks based on creation of the largest surplus (difference between bid price and reserve price). The auctioneer will inform the traders involved in a transaction, who then complete the transaction and are asked to provide new asks, or can update or retract their asks in the auction, based on their valuation and decision making rules. If there are still unaccepted asks left after the matching process, a new cycle of iteration of the auction is started, in which remaining participating agents are again asked to provide a bid for one of the remaining asks. The process continues until there are no asks left, or no more bids are made. The auctioneer will then inform all interested traders that the auction is closed. In order to calculate the transaction prices for all matched bids in the auction, the auctioneer uses a pricing policy in which the surplus is equally shared (k=0.5).

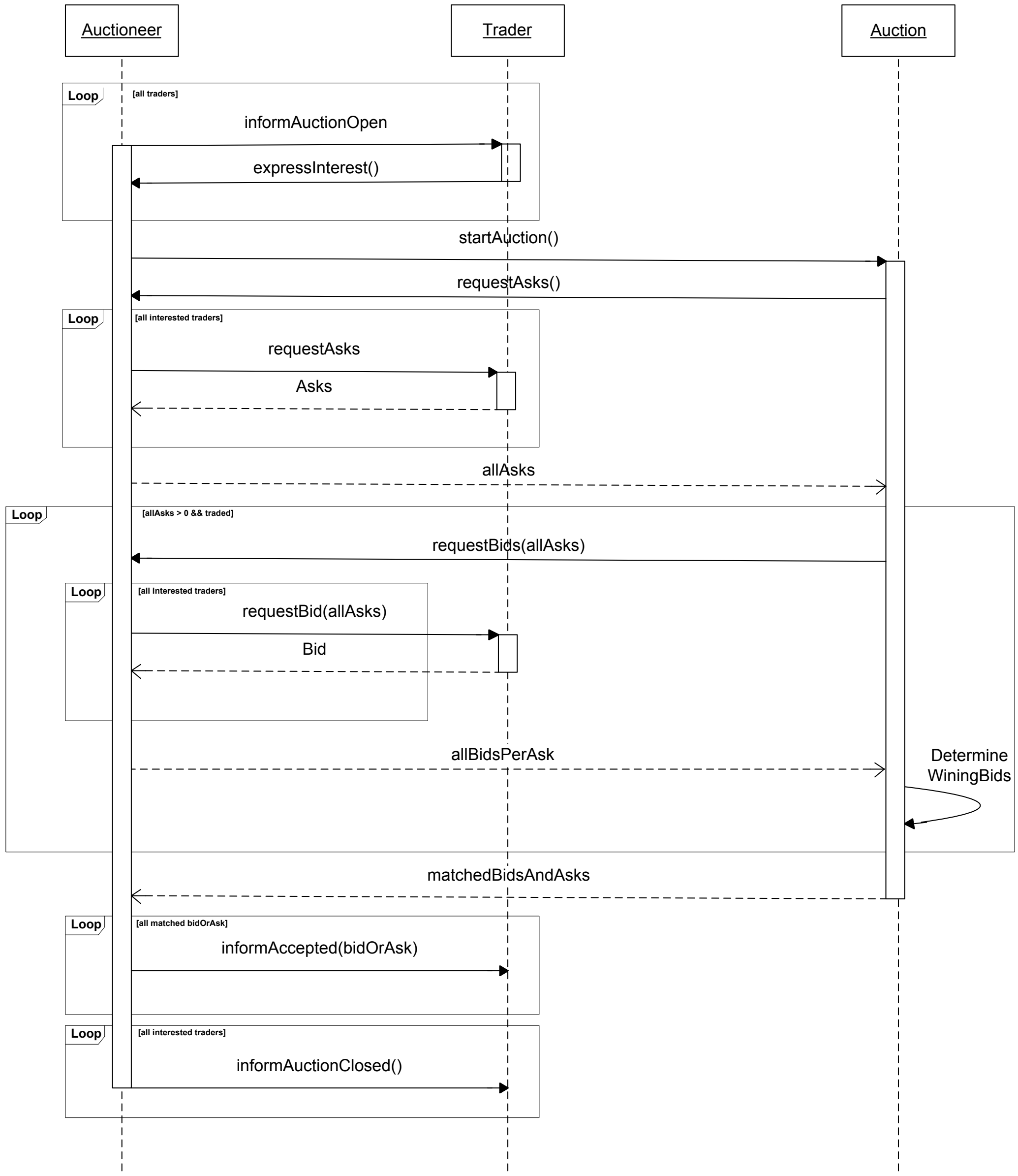

Figure III-1: *Sequence diagram*

Appendix IV: Exchanging green permits

During the WOT N&M stakeholder workshop on 17 September 2012, stakeholders from the two case study areas found the results counterintuitive. They agreed on the fact that when exchange of greening permits is allowed, these greening permits would be applied to parcels with low productivity. However, they assumed that these parcels would cluster together, resulting in higher number of ecopoints for scenario 2 (collective implementation of 7% EFAs). Therefore, we further explain the results by giving an example on how the number of ecopoints differs when comparing both scenarios, given the assumptions made in the model. For simplicity reasons, we use the set-up of Figure 3.2, used to explain the spatial cohesion Reilly-index, as a starting point.

Figure IV-1 illustrates a hypothetical situation with four farms in the area, all having to take 7% of their agricultural land out of production. We assume that all farm agents have a farm size of 100 hectares. This means that they take 7 hectares out of production for ecological purposes. We assume that the 7% EFA measure is applied on complete parcels, meaning that they are indivisible. The four farms take four parcels (parcel A, B, C and D) out of production: parcel A is owned by farm agent 1, parcel B by farm agent 2, parcel C by farm agent 3 and parcel D by farm agent 4.

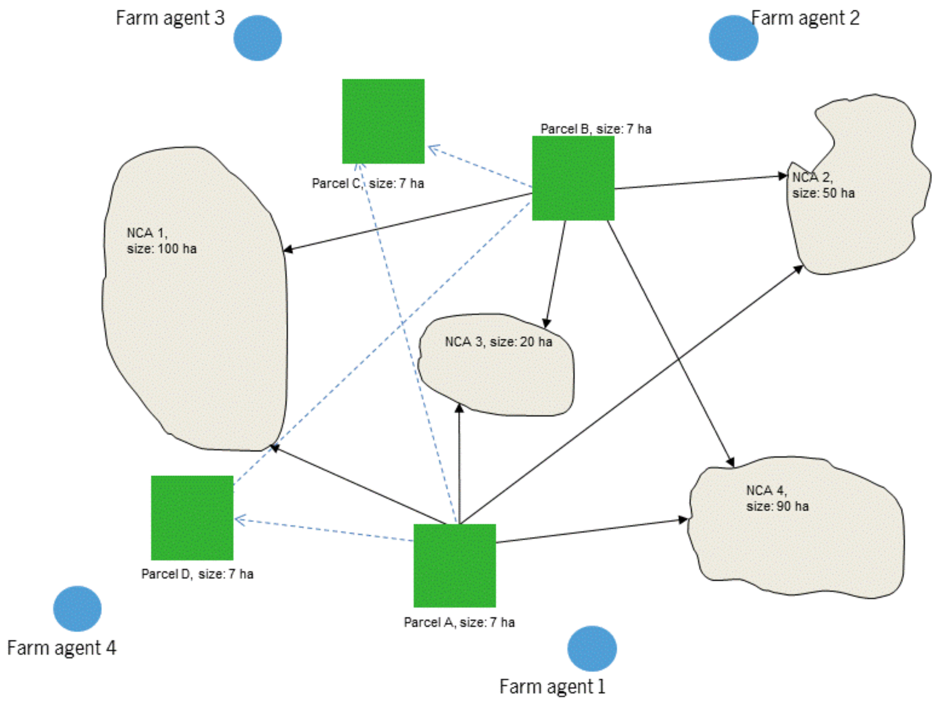

Figure IV-1: *Example of calculation of the spatial cohesion Reilly-index for scenario 1 (current EC proposal), given four farm agents that comply to the 7% EFAs measure by taking out of production 7% of their own agricultural land.*

Table IV-1 illustrates the calculation of the spatial cohesion Reilly-index for the two parcels A and B, that are both taken out of production to comply to the 7% EFAs measure. Parcel A and B both have a size of 7 hectares, and are situated in the proximity of four different nature areas (NCAs), and two other parcels that are taken out of production to oblige to the 7% EFAs measure (parcel C owned by farm agent 3 and parcel D owned by farm agent 4).

Table IV-1: Spatial cohesion Reilly-index for two parcels (A and B) in scenario 1 (current EC proposal) given surrounding four nature areas and two other parcels that are taken out of production for the 7% EFAs measure

NCA or other AES site	NCA size (m^2)	Size parcel A (m^2)	Distance to parcel A (m)	Size / (Distance)^2	Size of parcel B (m^2)	Distance to parcel B (m)	Size / (Distance)^2	Sum Reilly index parcel A & B
1	1,000,000	70,000	1,000	1.07	70,000	1,400	0.5459	
2	500,000		2,100	0.1293		400	3.5625	
3	200,000		600	0.75		700	0.551	
4	900,000		1,200	0.6736		2,000	0.2425	
C	70,000		2,000	0.35		200	1.925	
D	70,000		400	0.875		1,800	0.0432	
Spatial cohesion Reilly-index				3.848			6.8701	10.7181

Table IV-1 shows that the spatial cohesion Reilly-index is larger for parcel B, as it is situated closer to one of the nature areas, and is situated close to one of the other parcels that is taken out of production to oblige to the 7% EFAs measure (parcel C).

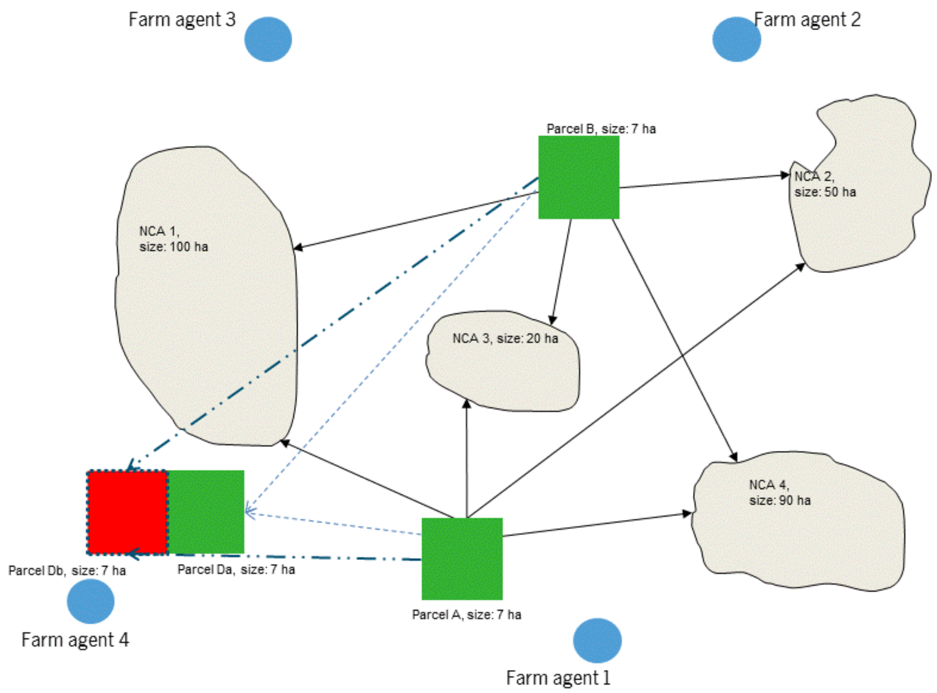

Figure IV-2: Example of calculation of the spatial cohesion Reilly-index for scenario 2 (collective implementation of 7% EFAs), given exchange of greening permits to the size of 7 hectares from farm agent 3 to farm agent 4.

Figure IV-2 illustrates what happens in the area when farm agents are allowed to exchange greening permits with each other. We assume that farm agent 3 transfers greening permits with a size of 7 hectares to farm agent 4, who will take 7 extra hectares out of production to comply to the 7% EFAs measure. In return, farm agent 4 receives a compensatory payment from farm agent 3.

Figure IV-2 shows that farm agent 4 takes an extra 7 hectares out of production. Parcel C is not anymore shown in the figure, as farm agent 3 now uses this parcel for conventional agricultural production. Table IV-2 illustrates the calculation of the spatial cohesion Reilly-index for the two parcels A and B, taking into account the exchange of greening permits from farm agent 3 to farm agent 4.

Table IV-2: *Spatial cohesion Reilly-index for two parcels (A and B) in scenario 2 (collective implementation 7% EFAs) given exchanged greening permits and surrounding four nature areas*

NCA or other AES site	**NCA size (m^2)**	**Size parcel A (m^2)**	**Distance to parcel A (m)**	**Size / (Distance)^2**	**Size of parcel B (m^2)**	**Distance to parcel B (m)**	**Size / (Distance)^2**	**Sum Reilly index parcel A & B**
1	1,000,000	70,000	1,000	1.07	70,000	1,400	0.5459	
2	500,000		2,100	0.1293		400	3.5625	
3	200,000		600	0.75		700	0.551	
4	900,000		1,200	0.6736		2,000	0.2425	
D_a	70,000		400	0.875		1,800	0.0432	
D_b	70,000		500	0.56		1,900	0.0388	
Spatial cohesion Reilly-index				4.058			4.9839	9.0419

Table IV-2 shows that the total number of achieved ecopoints in the region decreased from approximately 10.72 to 9.04. This is due to a transfer of greening permits (of 7 hectares) from farm agent 3 to farm agent 4, leading to a decrease in the number of ecopoints for parcel B, as the nearby situated parcel C changed to conventional production. The number of ecopoints for parcel A increased, because more 7% EFAs land is situated nearby.

From this theoretical example, it is shown that when exchange of greening permits is allowed given a perfect market situation, the number of ecopoints decreases given the assumptions made for this study.

Verschenen documenten in de reeks Werkdocumenten van de Wettelijke Onderzoekstaken Natuur & Milieu vanaf 2010

Werkdocumenten zijn verkrijgbaar bij het secretariaat van Unit Wettelijke Onderzoekstaken Natuur & Milieu, te Wageningen. T 0317 – 48 54 71; E info.wnm@wur.nl
De werkdocumenten zijn ook te downloaden via de WOt-website www.wageningenUR.nl/wotnatuurenmilieu

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174 *Boer de, S., M.J. Bogaardt, P.H. Kersten, F.H. Kistenkas, M.G.G. Neven & M. van der Zouwen.* Zoektocht naar nationale beleidsruimte in de EU-richtlijnen voor het milieu- en natuurbeleid. Een vergelijking van de implementatie van de Vogel- en Habitatrichtlijn, de Kaderrichtlijn Water en de Nitraatrichtlijn in Nederland, Engeland en Noordrijn-Westfalen
175 *Jaarrapportage 2009.* WOT-04-001 – Koepel
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