Modeling Patterns of Farm Diversification in a Dutch Landscape

Catherine Pfeifer

Thesis committee

Thesis supervisor

Prof.dr.ir. A.J. Oskam
Emeritus Professor of Agricultural Economics and Rural Policy
Wageningen University

Thesis co-supervisors

Dr.ir. J.J. Stoorvogel, Associate Professor, Land Dynamics group, Wageningen University
Dr. M.P.W. Sonneveld, Assistant Professor, Land Dynamics group, Wageningen University
Dr.ir. R.A. Jongeneel, Assistant Professor, Agricultural Economics and Rural Policy group, Wageningen University

Other members

Prof.dr.ir. A.G.J.M. Oude Lansink, Business Economics Group, Wageningen University
Prof.dr.ir. A.K. Bregt, Laboratory of Geo-Information Science and Remote Sensing, Wageningen University
Prof.dr. P.F.M. Opdam, Team Ecological Networks, Wageningen University
Prof.dr. G. Van Huylenbroeck, Agricultural Economics, Ghent University, Belgium

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Abstract

Society values a whole range of landscape services other than food, such as recreation, biodiversity and the maintenance of cultural heritage. These services are the joint result of patterns of bio-physical characteristics and human activities. In agricultural landscapes, farmers' decision making co-defines the quantity and quality of landscape services. Farmers can actively change their contribution to landscape services by adopting new income-generating rural activities, i.e. diversification. There is no guarantee that these activities will emerge coherently within the landscape although, from a landscape perspective, the patterns of adoption are crucial. The objectives of this thesis are to get insights into the spatial patterns of farm diversification and to assess how these patterns may change in the future. The study focuses on the Gelderse Vallei in the centre of the Netherlands. This thesis develops a location specific and consistent micro-economic decision making framework that includes bio-physical characteristics as well as neighbourhood dynamics, to explain farm diversification. Decision making over adopting various rural activities (recreation, agri-environmental schemes and short supply chains) is empirically tested through multivariate probit, zero inflated count and Bayesian spatial autoregressive probit, based on farm household data from the area. A simulation tool is then developed to map farmers' diversification decisions. It is applied to scale-consistent explorative scenarios of rural development to investigate how future policies might influence patterns of farm diversification.

The results show that rural activities have a tendency to emerge at specific locations. Short supply chains emerge in proximity to settlements, and agri-environmental schemes emerge mainly in areas with wet (and less productive) soils. Recreation emerges further away from big cities, in proximity to and within attractive landscapes (national parks and national landscapes). There are also spillover effects, which suggest that various rural activities are complementary, clustering to form "diversified hotspots". Finally, it is argued that farm diversification is most likely to be further enhanced through participatory policies that can make use of the synergies between the various rural activities.

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Vereniging Natuurmonumenten
Eemland
Wolkenberg
Kwetsbaar natuurgebied
Geen toegang

Chapter 1

Introduction

1.1 Trends in Dutch agriculture

Over the last century, Dutch agriculture has intensified significantly resulting in an increase in farm size and labour productivity. Since 1950, 80% of Dutch farms have disappeared, although the amount of agricultural land has remained almost constant and the volume of agricultural production has increased by an average 2.7% per year (Bruchem van *et al.*, 2008). If Dutch agriculture is to remain competitive on world markets, it is expected that this trend will continue (Vereijken and Hermans, 2010).
This intensification has led to increased environmental pollution, a homogenization of the landscape, outbreaks of animal diseases and reduced animal welfare (Stoate *et al.*, 2009). With increased economic growth, wealth and urbanization, society has become more concerned about these tradeoffs and now places different demands on rural areas (Potter and Tilzey, 2005). Environmental concerns have grown in importance and society expects agriculture to be more sustainable (Banks and Marsden, 2000). Society's expectations of rural areas have also changed. Whereas rural areas were, for a long time, seen as a production space (for food fibre, etc.), they are now increasingly becoming a consumption space, where people seek leisure or to enjoy the landscape or cultural heritage (Marsden, 1999; Wilson, 2001). These changing expectations have led to more stringent environmental regulations. The combination of stricter regulations and diminishing prices for agricultural products, increasingly threaten the viability of agricultural production (Baltussen *et al.*, 2010). Yet, at the same time there is growing demand for a whole range of services other than food (Parra-López *et al.*, 2009). This offers new opportunities to farmers who can now generate additional on-farm income by adopting new rural activities (Ilbery, 1991; Andersson *et al.*, 2009; Vereijken and Hermans, 2010). Such activities (farm diversification) can be very diverse and include recreational activities, short supply chains, educational activities, care activities and agri-environmental schemes (payments for nature conservation activities) (Meert *et al.*, 2005).

Policies at both national and European levels have supported the agricultural sector to adjust to these new societal demands by gradually focusing on rural development rather than on agricultural production. The European Common Agricultural Policy (CAP) has shifted from its initial focus on agricultural production (to ensure food security), farm income and price stability towards supporting a more diverse and sustainable form of agriculture. This has occurred through a series of reforms that started in the early nineties with the Mac Sharry reform of 1992 which began to reduce production support via the markets in accordance with the requirements of the GATT/World Trade Organization negotiations (O'Neill, 2002). The main elements of the reform consisted of: (1) price decreases for cereals, beef and sheep; (2) limitation of oil seed production; (3) obligatory set aside for larger farmers; (4) compensation payments per hectare or per animal; (5) introducing agri-environmental measures (Oskam, 2000). The Agenda 2000 reform continued this path (Silvis and Lapperre, 2010). The Midterm or Fischler reform of 2003 established the principle of fully decoupled payments (with a number of exceptions) under cross-compliance conditions (e.g. quality standards with respect to the environment, food and animal welfare). The 2008 Health Check reform removed set-aside and further decoupled still partly coupled income payments. In addition it shifted more funds to rural development, for example to enable farmers to develop new initiatives (Dalgaard *et al.*, 2007; Silvis and Lapperre, 2010). According to Derkzen (2010) voluntary and participative approaches that involve a wider range of stakeholders have become the governance paradigm for rural development. From 2013, when the current EU financial frameworks ends, the CAP and national policies are expected to focus more on payments for public goods, rural development and land management (Lyon, 2010; Meester, 2010).

At the national level, the 1990s saw stricter national environmental regulations implemented for nitrate emissions and animal husbandry (Meerburg *et al.*, 2009). This was followed by new spatial planning policies, such as the creation of National Landscapes, which seek to maintain cultural landscapes (Janssen, 2009). At present new participatory governance structure are being introduced to coordinate voluntary participation of stakeholders (Boonstra, 2006; Meerburg *et al.*, 2009).

1.2 Defining farm diversification

This new societal demand calls for new approaches to assess and regulate rural areas. From an ecological perspective, a rural area can be seen as a landscape, defined as a portion of heterogeneous territory composed of sets of interacting ecosystems (Burel and Baudry, 2003). This definition encompasses all what is non urban, which for the Netherlands mainly refers to peri-urban areas as defined by the OECD topology (OECD, 2010). A rural area can therefore been analysed as a landscape that provides various functions, including agricultural or food production, recreation and nature conservation. These functions are the combined result of bio-physical characteristics and human activities (Willemen *et al.*, 2008; Willemen *et al.*, 2010). Where landscape functions are defined as the capacity to provide goods and services, landscape services are defined as the actual supply. By working on agricultural land, farmers co-produce the landscape (Van der Ploeg, 2003) and thereby influence the quantity and quality of services that the landscape provides. In this thesis, the contribution that farmers make to the supply of landscape services is referred to as rural services. These rural services can be provided intentionally or unintentionally (Figure 1.1). An intentionally provided rural service results from a deliberate decision to allocate inputs to an activity that contributes to the provision of landscape services. In other terms, the rural activity is the decision to provide of rural services. Rural activities are generally new on-farm income-generating activities, resulting from farmers' decision making to diversify. (Ilbery, 1991; Meert *et al.*, 2005; Barbieri and Mahoney, 2009; Maye *et al.*, 2009). Farm diversification refers to the action[1] resulting from the decision to allocate farm inputs to rural activities, other than the traditional agricultural production[2]. Rural activities can be provided by other actors than farmers and therefore are non-joint (or weakly joint) with agricultural production. They contribute towards an increase in the supply of landscape services and can be assessed along two dimensions: intensity and quality. Intensity refers to the number of activities or inputs allocated to their adoption. Quality is location specific and depends on the bio-physical characteristics, as well as the location of other landscape services.

In addition, farmers unintentionally provide many services to society as a by-product of agricultural or food production. This unintentional provision of services is often referred to as the multifunctionality of agriculture (OECD, 2001; Van Huylenbroeck *et al.*, 2007). Examples of such services include water quality, carbon sequestration, and the emission of greenhouse gases.

[1] In this thesis farmer's decision-making to diversify refers to farmer's actions taken to diversify. Hence, actions and decision-making are not distinguished.
[2] Traditional agricultural production consists of food, feed and fibre production.

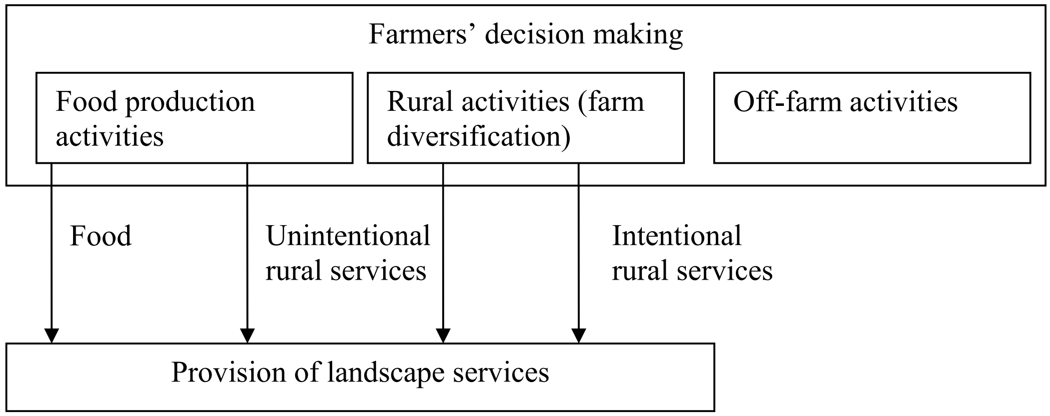

Figure 1.1: Conceptual representation of farmers' contribution to the provision of landscape services

Finally, farmers can also decide to allocate inputs, usually labour, to off-farm income generating activities. This is usually referred to as pluriactivity (Fuller, 1990; Bateman and Ray, 1994).

While farm diversification has gained some attention in the literature (Drake *et al.*, 1999; Vanslembrouck *et al.*, 2002; Meert *et al.*, 2005; Jongeneel *et al.*, 2008), its spatial dimension has not yet been investigated. Only few studies have investigated the roles of bio-physical characteristics and the behaviour of neighbouring farms (Van Huylenbroeck *et al.*, 2007). One reason why the spatial dimension of farm diversification remains unaddressed is the lack of appropriate spatially specific methodologies. Traditional micro-economic models largely ignore the role of location, more particularly bio-physical characteristics, in individual decision making – and in farming this is potentially critical as agriculture is a highly location specific activity (Wilson, 2009) and traditional models of landscape change ignore the extent to which such changes result from human decision making (Irwin and Geoghegan, 2001). Therefore, there is also a need to develop approaches to investigate farmers' decision making and the subsequent patterns of farm diversification by mapping the adoption of rural activities at a landscape scale.

1.3 Objectives

The overall objective of this thesis is to get insights into the spatial patterns of farm diversification. By assessing the spatial patterns of where rural activities are being adopted one can gain insights into the contribution that farmers make to the provision of landscape services. This is useful information for policy makers seeking to optimize the incentives they provide to farmers. This thesis does not seek to quantify the rural services resulting from the rural activities, although some of the results could be used as a foundation for such an investigation.

The factors that influence spatial patterns of farm diversification are empirically assessed by combining econometric and geostatistical techniques. Through this combination farm and landscape level effects can be linked, enabling the following sub-objectives to be addressed:

1. to identify the role of location, bio-physical characteristics and neighbourhood dynamics on farmers' decisions to diversify,
2. to identify patterns of farm diversification, and
3. to assess how patterns of farm diversification might change under different explorative rural development scenarios.

The model was applied to the Gelderse Vallei, in the centre of the Netherlands to assess the spatial patterns of farm diversification. It is a very diverse area, in term of land use as well as farmers' strategies. Four separate scientific papers have been compiled in order to address the sub-objectives mentioned above.

Chapter 2 investigates the role of location in influencing farmers' decision making about diversification. The location characteristics are introduced into a farm household utility maximization framework that can explain farmers' decision making about providing different goods and services. Econometric techniques are used to measure the empirical drivers of farm diversification, including the relevant location characteristics.

Chapter 3 presents a tool to represent the adoption of rural activities in a spatially explicit way. A simulation tool is developed that makes use of the identified drivers of farmer's decision making about diversification (*Chapter 2)* to predict the adoption of rural activities in a spatially explicit way.

Chapter 4 applies the tool developed in *Chapter 3* to investigate how the spatial distribution of farm diversification might change by 2015. The various simulated scenarios are based on storylines developed by local stakeholders.

Chapter 2 and *Chapter 3* both suggest that one important driver might have been missing from this analysis, namely the spillover effect: the influence that a diversifying farmer has on his neighbours. *Chapter 5* proves empirically the existence of this spillover effect.

Finally, *Chapter 6* synthesizes the results of all the chapters, discusses their implications for future policies and research and provides conclusions


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Chapter 2

Landscape properties as drivers for farm diversification: a Dutch case study[3]

Abstract

Farm diversification is stimulated by the societal demand to transform production countryside into consumption countryside. In most empirical studies on farmers' decision making for diversification, geographical information is either omitted or reduced to a variable that links the farm to an administrative unit. Therefore, the influence of the exact farm location on farmers' decision making is often lacking. This chapter addresses the role of location, in terms of site specific natural conditions as well as neighboring dynamics, in influencing farmers' decision making to diversify. In addition, it investigates to what extend low returns from primary production stimulate farmers to find new strategies, and therefore explains diversification. The Gelderse Vallei area, a region in the centre of the Netherlands, is used as a case-study. For this area an extensive farm survey data could be combined with topographic data and soil maps (GIS). Both the numbers of activities as well as the kind of activities that are adopted are analyzed. Landscape attractiveness turns out to be a driver of diversification. Daily recreation most frequently occurs close to national parks, agri-environmental schemes are more likely to be adopted on relatively wet soils. Activities resulting from diversification might produce positive externalities: new activities have the tendency to emerge next to already existing ones, therewith explaining the formation of "hotspots" in the landscape. Finally, diversification was found to be sensitive to returns from primary agriculture production.

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[3] Adapted from Pfeifer C., Jongeneel R.A., Sonneveld M.P.W, Stoorvogel J.J. (2009) *Land Use Policy* :26 pp 1106-1115

2.1 Introduction

The current European Common Agricultural Policy (CAP) has been moving from production support subsidies to direct decoupled income support (European Union, 2003; European Union, 2006). Recent policy proposals for further CAP reforms confirm this trend. The emergence of the concept of multifunctional agriculture in policy making (OECD, 2001) is connected with the recognition that farmers produce more than food, feed and fiber. They produce both commodity and non-commodity goods (green services such as landscape, biodiversity and wildlife habitat maintenance). New forms of governance, such as individual or collective contracts between farmers and government, have been developed to encourage the provision of these non-commodity goods. This stimulates the transformation of production countryside into consumption countryside (Marsden, 1999). Multifunctional landscapes are an expression of the societal demands for non-commodity goods. At farm level, farm diversification, *i.e.* the allocation of inputs to on-farm activities (*e.g.* to provide recreational activities) apart from traditional agricultural production or taking up additional off-farm employment (Schmitt, 1988) can be observed. As such farm diversification contributes to multifunctional landscapes.

The driving forces behind farm diversification have been studied widely. Bateman and Ray (1994) showed that farm diversification is driven by farm size, farm type and education. Benjamin (1994) showed the role of farmers' age as a driving force, and more recently Vanslembrouck *et al*. (2002) showed that the participation in agri-environmental schemes that stimulate the production of green services not only depends on farmers' age and education but also on their attitude, such as the personal values that they place upon nature or their vision of farming. Similar results have been reported by Dupraz *et al*. (2003). Other studies have shown that diversification also correlates positively with trust in government (Vandermeulen *et al.*, 2006; Jongeneel *et al.*, 2008). The influence of location in farmers' decision making has been mentioned by a number of authors (Vanslembrouck *et al.*, 2002; Vandermeulen *et al.*, 2006; Dalgaard *et al.*, 2007; Jongeneel *et al.*, 2008), but most often geographical information is either omitted in empirical studies or reduced to a variable that links the farm to an administrative unit, such as a municipality or a province. Few studies on the factors affecting farm diversification have used a more detailed level of precision in measuring location when making empirical estimations (Van

Huylenbroeck *et al.*, 2007). This chapter uses a dataset for the Gelderse Vallei region in the Netherlands where farms are geo-referenced on the basis of their postal code. By using Geographic Information System (GIS) techniques it was possible to measure site specific conditions and local neighborhood effects and link these to individual farms.

The objective of this chapter is two-fold. Firstly, it seeks to address the role of location, in terms of site specific natural conditions as well as neighboring dynamics, in influencing farmers' decision making to diversify. Attention is paid to the number of activities farmers start as well as the specific types of activities, notably agri-environmental schemes, recreation activities and other farm-linked services (on farm shop, care farms etc.). Secondly, it investigates to what extend low returns from primary agriculture production might stimulate farmers to find new strategies, and therefore contribute to explain diversification.

The chapter starts with a description of the study area and the data used. It then describes the modeling approach used to link landscape scale to the individual farm level. This is followed by the construction of the variables used for the econometric estimations that allow for testing the importance of location and return from agriculture for farm diversification. Finally we present and discuss the econometric estimations and draw conclusions.

2.2 Methods

2.2.1 Study area

The Gelderse Vallei study area measures approximately 1100 km^2 and is located in the center of the Netherlands straddling the two provinces of Utrecht and Gelderland (see Figure 2.1). Soil formation has resulted in considerable soil heterogeneity (Stiboka, 1997). The southern and most of the northern parts consist of sandy soils whereas the north-western part is characterized by poorly drained peat soils. Soil variability has led to varied land-use in the area, which alongside dairy farming, arable farming and intensive livestock production includes forested hills, national parks, historical villages and cities. The eastern part is dominated by intensive livestock production. With a junction of highways and railroads, the western part of the study area has become a central position in the Netherlands. There is an increasing number of claims on the land for various functions, such as housing, recreation and flood protection (Province of Gelderland, 2005).

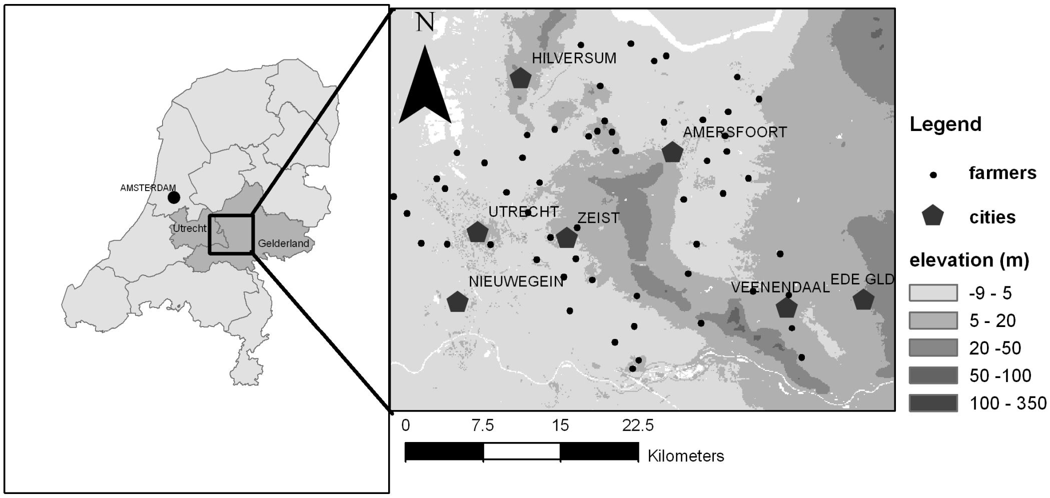

Figure 2.1: Location of the study area in the Netherlands and location of the farmers with respect to elevation

2.2.2 Data description

In 2005, the Dutch Agricultural Research Institute (LEI) sent a survey to all 1821 farmers in the region, of which 258 (14.2%) were returned. The structured survey covered different topics such as general farm characteristics, farm type and location, land-use together with the activities that have been adopted by farmers and their attitudes towards diversification. The last part of the survey covered management issues and future perspectives, including trust in the government and membership of stakeholder groups or other voluntary associations. Of all respondents, 241 farmers indicated their postal code (at least 4 digits, with most indicating at least the first of the 2 letters that indicate the street). These farms could be geo-referenced to postal code areas with an average size of 0.8 km^2. They were located in 57 postal code areas and represented as points by the centroïd of the postal code area. Figure 2.1 indicates these locations. The survey indicated the importance of farm diversification in the region: 34% of the farmers had taken up at least one activity apart from agricultural production (Table 2.1). The most popular activity was the adoption of agri-environmental schemes, followed by renting out storage space, off-farm work and activities linked to horses.

The survey information was compared to data from the Geographical Information System for Agricultural Businesses (GIAB) dataset (Naeff, 2006). This dataset is based on an annual survey of all farmers in the Netherlands. It includes location and farm production characteristics, but does not include any attitudinal information. In 1999, 2003 and 2005 the survey contained questions about diversification, investigating the adoption of agri-environmental schemes, care services, on-farm shops, home delivery, on-farm processing of farm products and renting out space for storing goods or animals.

Table 2.1: Diversification of the respondents in the sample compared with the GIAB dataset

	sample	GIAB
A. diversification	83 (34%)	28%
B. agri-environmental schemes	76 (32%)	16%
C. recreation including horse-riding	28 (12%)	*
Of which daily recreation	22 (9%)	*
D. other services (e.g. on farm shop, direct selling, renting out space)	62 (25%)	**
B+C agri-environmental schemes and recreation	10 (4%)	
B+D agri-environmental schemes and other services	26 (11%)	
B+C+D agri-environmental schemes, recreation and other services	21 (9%)	

* The GIAB does not include horse riding in recreation. Recreational activities excluding horse-riding among farmers in the survey is 4%, the same as in the GIAB, the daily recreational activities excluding horse riding among sample without horse riding is 2.5%, while in the GIAB it is 2%.

** renting out space is measured differently in the GIAB than in the survey and therefore the datasets cannot be compared. Two percent of farmers in the survey 2% have a shop compared to 1% in the GIAB, and 7% directly sell farm products, compared to 6% in the GIAB.

For the purpose of this chapter, activities resulting from diversification have been categorized into three groups: i) adoption of at least one agri-environmental scheme offered by the Dutch government or other payments aiming at landscape management, nature conservation and wildlife habitat creation, ii) recreation and iii) a miscellaneous group of other activities that include care services, home delivery, on-farm shops, on-farm processing and renting out storage space. Recreation is further sub-divided into daily and overnight recreation. Daily recreation is seen as mainly attracting people from the surrounding area to spend their leisure time in the area, whereas overnight recreation includes people coming from outside the region. Because the study area is small and it is easy to move around within the region, it is expected that, for tourists staying several days in the region, the exact location of their overnight stay is not important. By contrast, location is expected to be important for daily recreation.

2.2.3 Conceptual framework and modeling

Landscape scale and farm scale

Analyzing the role of landscape properties in farmers' decision making implies connecting a biophysical and hierarchically organized complex system with a micro-economic unit. This requires giving consideration to the problem of scaling: since the dynamics occurring at the landscape scale differs from those at the farm scale and at each scale different driving factors play a role. As this chapter investigates those changes that are dependent on the farmers' decision making, the level of interest is the farm. Hence, it translates spatially explicit landscape properties into location assets at the farm level.

Certain landscape patterns are relatively static and relate to the intrinsic characteristics of a landscape including topography, geology, and soils. Farmers have to deal with the natural variation of these static properties. Other landscape patterns are the result of societal and governmental decisions in terms of planning (*e.g.,* nature reserves) and investments in infrastructure. Although the latter are more dynamic, farmers usually cannot directly influence them. Finally, there are landscape patterns, such as land use, that are largely the result of land users like farmers. These patterns are of particular interest as they can both influence decision making, while at the same time the decisions made by farmers feed back into land-use patterns. These interactions between farmer and their biophysical environment is sometimes referred to as co-production (Ploeg, 2003; Van der Ploeg, 2003).

Dynamic land use patterns in the landscape emerge as a result of *collective behavior.* They are driven by interactions between hierarchically organized eco- and human systems (Turner *et al.*, 1989). Farmer's decision making is an *individual action* that occurs on a farm scale, where inputs and outputs are optimized in accordance with the farmer's objectives. Farmers are inclined to consider many things as given, including location assets, because the landscape patterns that define these assets result from a higher level of organization on which he, as an individual, has negligible influence. Nevertheless, at the same time, farmers contribute to the collective behavior that leads to a given landscape and creating positive or negative externalities for other actors. For example, a farmer needs an attractive landscape in order to offer recreational activities. He cannot create one by himself, but can contribute to it by adopting agri-environmental schemes with other actors in the landscape. These synergies between activities generate positive externalities that might encourage new activities alongside the existing ones.

Figure 2.2 shows a graphical representation of the conceptual framework that we used to link landscape patterns to farmer's decision making. The central part represents the farm scale, which is driven by a household decision making unit that is assumed to maximize its utility subject to a multiple input – multiple output farm technology and a time constraint. The upper part of Figure 2.2 represents the landscape scale as well as the redefinition or 'translation' of landscape patterns into location assets at farm level. This framework provides the basis of an estimable farm household model, where the theoretically identified drivers have been transformed into empirically measurable variables. This procedure allows for testing the impact and significance of location factors together with other drivers. The following subsections explain the various parts of the framework and the construction of the derived empirical model.

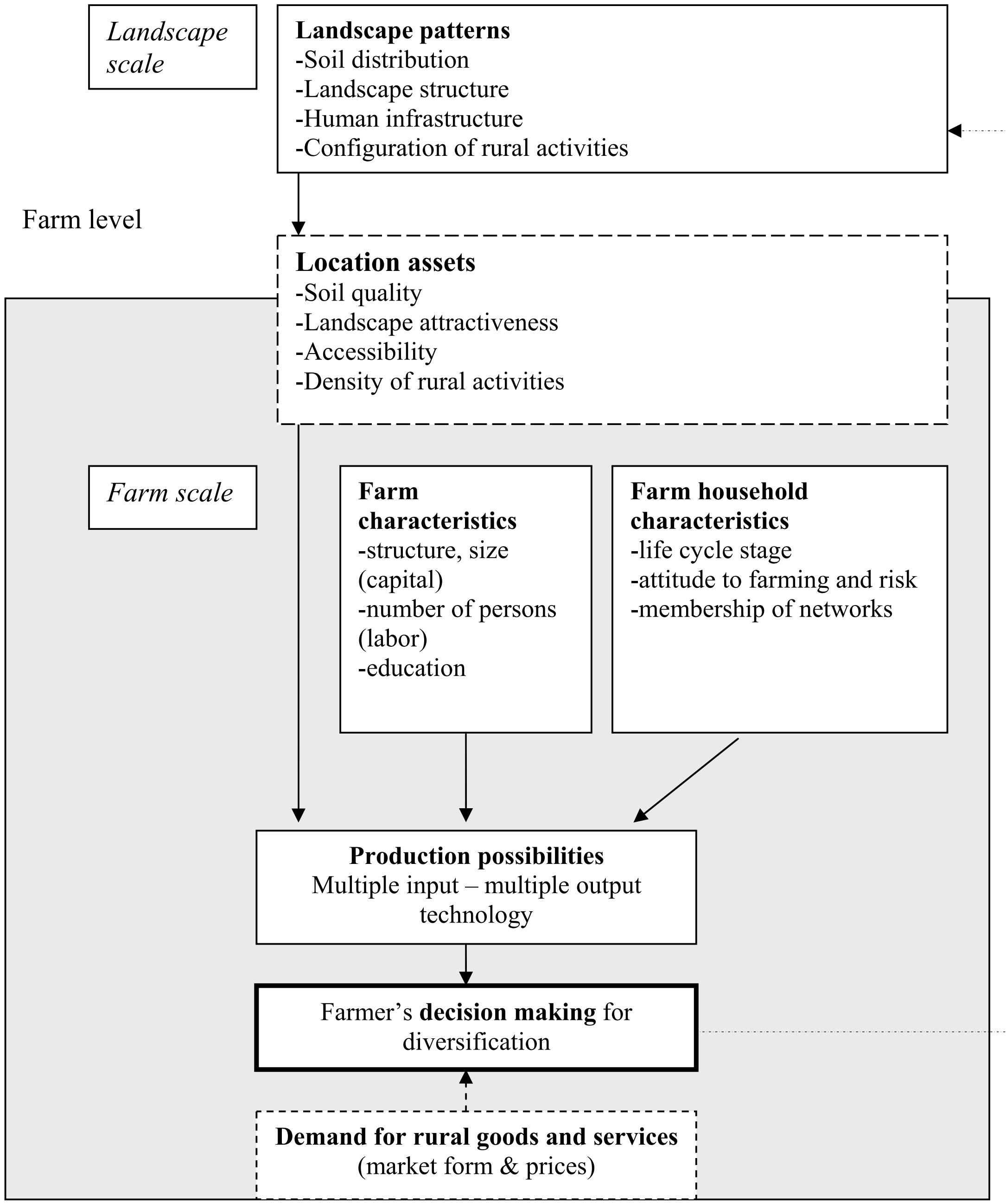

Figure 2.2: Graphical representation of the conceptual framework to link landscape patterns to farmer's decision making

Modeling at farm level: the farm household model

A farm household approach is followed to identify those factors that explain farmers' decision making (e.g. Ellis, 1993). According to this approach, a farm household makes his activity- and consumption choices in such a way as to maximize its expected utility subject to a set of constraints. It includes a budget constraint (also comprising farm profits), a time constraint, and constraints representing the production technologies for commodity and non-commodity outputs (Jongeneel *et al.*, 2008).

Assuming that the household utility and production technologies satisfy the normal properties of regularity (*i.e.* increasing and concave), the solution to the farmer's or farm household's utility maximization problem yields a set of input demand (including the allocation of labor) and output supply functions, which are a function of input and output prices, payment functions for green services, quasi-fixed factors (farm characteristics, such as land characteristics and the size and type of herd) and household characteristics (Jongeneel *et al*., 2008). One of the implications of this model is that changes in relative prices (or factor remunerations) lead to adjustments in the factor input-activity output mix (substitution and income effects). Thus a relative decline in commodity prices might lead to a reduction in primary agricultural production and increase diversification.

Farm household utility characteristics are relevant as they are likely to affect the preference structure (*i.e*. the utility function). As such, the life cycle stage is expected to influence the preferences of a household, as needs differ greatly between households at different life cycle stages (*e.g.* with or without children). The idea of a farming style is used to describe a coherent set of strategic notions that guide practical actions and informs farmers' judgments, which also takes a farmer's attitude towards risk into account (Ploeg, 2003). Finally, the social networks (*e.g.,* participation in farmer cooperatives, sports associations or churches) in which farmers participate may also influence their preferences (social attitudes) for different farming activities. Social networks can be seen as a proxy of the social capital of a farmer. They provide information about the reference group with which farmers will compare themselves, as well as the ease of acquiring new types of knowledge.

Construction of selected variables at farm scale

At farm scale, three groups of variables are distinguished on the basis of the available data, capturing farm characteristics, farm household characteristics, and market conditions respectively (see Appendix 2.I for further details).

The group of variables for farm characteristics includes farm size and farm type (dairy farm or non-dairy). Farm size is measured by the number of hectares a farmer uses. Farm type is represented by a dummy variable indicating the presence and active use of milk quota at the farm. In addition to this, the presence of an off-farm job (part-time farming) is treated as a farm characteristic in the form of a dummy variable "off-farm job" which considers whether one or more family members work outside the farm. It is used to indicate that part of the labor not allocated to on-farm activities but instead to generating external income.

The group of variables for farm household characteristics includes indicators for age, education, participation in networks, together with attitudinal variables. In the recent literature a debate on how to best approximate the life cycle of the family farm suggests that the average age of all the family members should be used as an explanatory variable (Burton, 2006). The dataset that we used contained the age of the person(s) officially owning the farm, also referred to as head(s) of the farm. The average age has been used. We also introduced the square of this average age in order to take into account potential non-linearities with respect to the life cycle. The level of education of the farm household is taken from the highest available educational qualification possessed by any farm household member, on the assumption that acquired knowledge can be shared by all household members and that the household as a whole can profit from it. The social network of a farmer is described by a dummy variable that takes into account the farmer's participation in associations such as agriculture related cooperatives, church life, or sports clubs. In the study area the government offered the possibility to apply for individual as well as collective agri-environmental schemes. In the latter case a farmer could only participate if (s)he became a member of a cooperative, which might introduce an endogeneity issue. This explains why "participation in voluntary associations" appeared to be highly correlated with agri-environmental schemes and diversification. Therefore it was decided to not use this variable as an explanatory variable in the regression analyses of this chapter.

Farmers' attitude was captured by closely analyzing their responses to a set of attitudinal questions contained within the survey. A factor (principal component) analysis was done on these questions to identify and extract a few common factors that explain most of the variability in the answers to these questions (Kaiser, 1958). The identified factors were then used as explanatory variables within the model. This factor analysis was separately applied to two subsets of questions measuring farming style and trust. Farming styles could be summarized into 5 dimensions: 'responsible production' showed a preoccupation with sustainable development, 'independence' showed a preoccupation with the control farmers wish to have over their own businesses, 'ownership' showed a preoccupation with the importance farmers attached to owning their own land, 'cooperation' showed a preoccupation with cooperation between farmers and the government, and finally 'investment' showed a preoccupation with the importance of land as a form of investment. 'Trust' was summarized into one factor (trust in the government) capturing the trust expressed in a range of governmental institutions, including the European Commission and the national provincial and municipal governments.

The third category of variables representing market conditions consists of one indicator, which measures the hourly return from primary agriculture. This variable has been computed with the return from (traditional) farming activities, divided by the time (hours) spent on these activities by the farm household. Although this variable reflects product prices it should be noted that in a cross-sectional analysis covering a relatively small region, as in this case-study, one might expect that all farmers receive roughly the same product prices (except for quality differentials). Farmers, however produce different products that vary in quality as well as quantity. In this sense the hourly return from agriculture also depends on the chosen product mix and is likely also reflect differences in farmers' entrepreneurial skills[4].

Assessing landscape patterns and redefinition as location assets

Landscape patterns are the spatial arrangements of the elements within a landscape. They can be analyzed in terms of the spatial layers of geology, topography, hydrology, soils, (natural) vegetation and human activity. Because of the high inter-correlations between the various phenomena within a landscape, selecting appropriate indicators to analyze landscape patterns usually depends on the objectives of the analysis, the spatial characteristics of the system, and the processes under examination (Bailey *et al.*, 2007).

Here, four spatial layers were selected: soil distribution, landscape structure, human infrastructure and the composition of rural activities in space. In order to connect the landscape and farm scale levels, site specific information about farms was derived from landscape patterns. From the perspective of an economic decision maker or farmer, landscape patterns provide location assets, which may lead to an advantage or

[4] Sixty-nine of the farms did not indicate their total income form agriculture. In order to not loose these observations, the missing values were replaced by the predictions based on a stepwise regression approach in which income was explained as a function of crop and animal conditions.

disadvantage and can be seen as a (quasi-) fixed input to a production function (see Figure 2.3).

Soil distribution is the landscape pattern that describes variations in soil quality that influence suitability for production. Soil quality is a broad concept that measures how well soils fulfill their functions, of which production is one (Doran and Parkin, 1994). Soil properties are often strongly inter-related with other landscape features. In the study area the low-lying areas often have high groundwater tables and the soils are peaty which limits their agricultural potential. Farmers in the survey referred to the wetness of soil as a main variable for explaining the soil quality of their fields. To describe soil quality, buffers were created around the approximated farm location – in relation to the farm size (farm size - buffer radius : < 10 ha - 1 km; 10-50 ha - 2.5 km; >50ha - 3.5 km). Within the buffer, the percentage of land with very high ground water tables (classes I and II in the Dutch classification system) were computed. These classes correspond to very wet soils, where trafficability is low.

Landscape structure refers to the spatial distribution of elements in the landscape. It influences human perception of the aesthetic value of the landscape. For example, small agricultural fields with hedgerows are generally often more appreciated than large homogeneous fields. The forest areas in the region have been well designed for daily recreation activities, and are generally perceived as attractive. Therefore, the landscape structure is expected to influence the emergence of recreational activities.

Landscape attractiveness indicates how people with an interest in spending their leisure time in the countryside perceive the landscape. In this chapter landscape attractiveness was measured as the proximity to national parks. National parks in the Netherlands aim to conserve and even sometimes re-create the former natural vegetation and biodiversity. These areas are made accessible through well-planned walking, biking and horse-riding paths. For this reason, the proximity to national parks was assumed to be a good indicator for measuring landscape attractiveness. We also assumed that proximity to national parks is only relevant from within a biking distance of 5-10 minutes. To take this into account we used a binary variable that indicates whether a farm is located within 1.5 km of the border of a national park, an indicator that was adopted since cycling is such a popular leisure activity in the Netherlands and most landscapes contain biking routes.

Infrastructure includes roads or railways and is an indication of accessibility. It indicates how easy or difficult it is to reach a market. This can be measured in terms of the real or the opportunity costs of getting from one point to the other. For services in rural areas, such as direct selling of farm products, it was assumed that city dwellers choose the nearest option to their home. Accessibility is therefore only relevant within a few kilometers from the city. To take this into account, accessibility was measured with a binary variable indicating the proximity to the closest city. This binary indicates whether a farm is located within a buffer of 2 km from a city border. This distance corresponds to 10-20 minutes cycling distance from the city to the farmer. Since only the approximate locations of the farms were known, more sophisticated indicators were not considered.

The spatial configuration of rural activities (Figure 2.2) creates a landscape pattern of human activities that is spatially explicit. Past configurations of rural activities may be used to explain current activities resulting in dynamic descriptions of rural development. Land use changes are usually path dependent, implying a dependency on past events or past land use on the current landscape. When the time dimension is taken into account "neighborhood effects" may be observed that suggest a higher probability that farmers whose neighbors provide a given activity, will also start providing the same (or a complementary) activity (Nyblom *et al.*, 2003). These synergies can be seen as positive externalities and might lead to clustering of activities around multifunctional "hotspots" in the landscape.

It was possible to take this spatial and temporal aspect into account by deriving the configuration of past activities from the GIAB dataset of 2003 and creating a buffer of 2 km around each farm. Density of agri-environmental schemes has been approximated by the share of farmers adopting agri-environmental schemes within the buffer, excluding the information about the observed farmer. Density of activities has been computed as the average number of activities per farmer adopted within the buffer, applying a similar correction for the observed farmer as in case of agri-environmental schemes.

2.2.4 Statistical methods: choice of econometric techniques

The variables discussed in the previous section were introduced into two different econometric models in order to test whether these characteristics are relevant to the farmers' decision making. The first model analyses the number of activities adopted. Since this variable is a positive integer with no, *a priori*, upper bound, a count model was employed (Model 1). Diversification is often constrained by legislative restrictions such as building permits and zoning restrictions which restrict the type of agri-environmental schemes that can be adopted on a given parcel of land. It can also be affected by financial constraints, such as availability of own capital for new investment or access to credit. Another factor might be that some farmers have better off-farm employment opportunities than others, therefore preferring to refrain from diversification. Unfortunately it was not possible to capture all these issues (financial/legislative constraints and employment opportunities) through the survey data, even though they could play a role in influencing choices about diversification. In order to address this issue, a zero inflated count model has been fitted. This is a modified count model that assumes that an observation of zero can result from two different processes: an unobserved state of nature, *viz*. the farmer faces restrictions or off-farm employment advantages, or an unconstrained choice, *viz*. the farmer does not face any restrictions or employment advantages but decides to not diversify. The estimation procedure fits simultaneously a logit model for defining the state of nature for each farm (restricted *vs.* non restricted farm) and a count model for the numbers of activities based on a negative binomial distribution for the unrestricted farms (see Cameron (1998, pp.125-127) for a more detailed explanation and discussion of this technique).

The second model (Model 2) investigates the adoption of specific activities: agri-environmental schemes, daily recreation and other services in a simultaneous framework. It estimates the choices for these activities while taking into account the potential correlations between them. The simultaneous framework can be estimated with a multivariate probit estimation. This approach calls for a maximization of a trivariate normal distribution, which can only be estimated with simulation techniques (Train, 2003). Further technical details about this estimation procedure can be found in Appendix 2.II.

The hourly return from agriculture, which is used as one of the explanatory variables, could be endogenous (*i.e.* influenced by the farmer's choice of product mix), implying that low returns from (traditional) agriculture might be influenced by the choice for diversification. The approach of Rivers and Vuong (1988) was used to test for the endogeneity of hourly income from agriculture. In its basic form this test is based on probit estimation with one potential continuous endogenous variable using a two-step instrumental variable approach. This test can be extended in order to test endogeneity within a count data framework (Wooldridge, 2002, pp. 663-666). For all types of activities adopted, and the number of activities taken up, the hypothesis of exogeneity could not be rejected. This permitted us to use the hourly return from agriculture as an explanatory variable. More details about these tests can be found in Appendix 2.III. Furthermore, note that in order to avoid potential heteroskedasticity, all estimations were corrected with a White-correction (White, 1980).

2.3 Results and discussion

Firstly, the GIAB dataset, which covers the whole farm population, was used to test whether the 2005 LEI survey was representative (see Table 2.1). It shows that most activities such as on-farm shops, food processing, and recreation are quite well represented in the sample, the only exception being the adoption of agri-environmental schemes. With a 32% uptake in the sample as compared to 16% in the GIAB dataset, agri-environmental schemes are clearly overrepresented in the sample. Potentially, this might introduce some bias in favor of the adoption of the adoption of agri-environmental schemes.

Figure 2.3 presents the data on new activities and agri-environmental schemes in relation to various location assets. Figure 2.3A shows the average number of activities adopted by postal code. It shows that farms in the western part of the area are highly diversified, with up to 3.5 activities per farm. Agri-environmental schemes are found in areas with predominantly wet soils, mostly in the north-west of the region (Figure 2.3B). Recreation seems to be more important within the proximity of national parks (Figure 2.3C). Other activities have mostly emerged in the proximity of cities (Figure 2.3D).

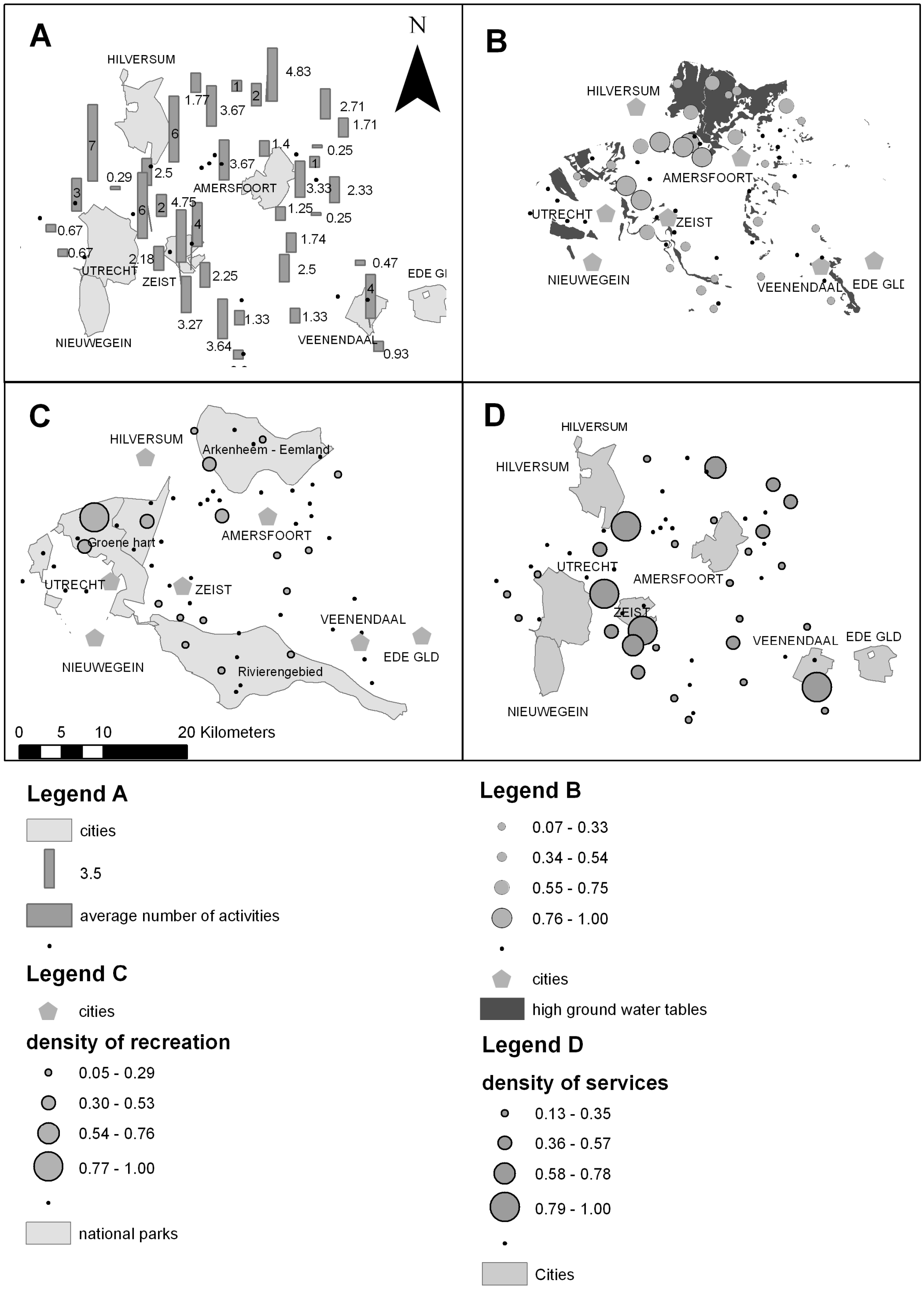

Figure 2.3: activities shown in Table 2.2 per postal code, A = average number of activities adopted, B = percentage of agri-environmental scheme adopted, C = percentage of recreation adopted, D = percentage of other services adopted

2.3.1 Diversification (Model 1)

Table 2.2 shows the estimation results for Model 1 explaining the number of activities adopted. The model indicates that farm characteristics, specifically a high hourly return from agriculture as well as having an off-farm job increases the probability of observing a zero outcome, (*i.e.* no diversification). The significance of having an off-farm job can be interpreted in two different ways. Firstly, by having one or more members of the farm household working outside the farm, less labor is available to initiate new activities, which are generally quite labor intensive. This influence of labor allocation is also highlighted by Benjamin and Kimhi (2006). Secondly, having an off-farm job brings in a supplementary income to the household. As a result the household may be less interested in seeking new opportunities at the farm to generate additional income. In addition a high hourly return from agriculture also decreases the probability to further diversify activities. This finding suggests that diversification might be a survival strategy for farms for which returns from primary agriculture are low.

Table 2.2: Zero inflated negative binomial model for diversification (Model 1)

Estimations for Number of activities (count)		
Farm characteristic	Size	-0.012 (2.61)**
Farm household characteristics	Mean age of head of farm	0.294 (3.39)**
	Mean age of head of farm squared	-0.003 (3.65)**
	Non-monetary motivation	0.190 (2.62)*
Location asset	Location within 1.5 km from a national park	0.571 (2.96)**
	Density of activities in 2003	0.630 (2.12)*
	Constant	-7.243 (3.32)**
Estimations for State of nature (probability for no diversification)		
Farm characteristic	Hourly income from agriculture	0.064 (2.14)*
	Off-farm job	16.43 (2.91)**
	Constant	-17.57 (2.89)**

Robust z statistics in parentheses
** significant at 5%; ** significant at 1%*

Size has a significant negative impact on the number of activities adopted (count estimation), suggesting that diversification might be a survival strategy of small farms that do not have the opportunity to increase in size. The household life cycle (mean age of head of farm) also appears to be significant. Non-monetary motivation was also found as a significant driver, indicating that intrinsic valuation of diversification might explain the number of activities taken up. Other variables such as the attitudinal variables and farm specialization did not turn out to be significant and are therefore not shown in Table 2.2.

Location plays a role in explaining the number of activities adopted. Proximity to national parks is one of the drivers for diversification. National parks attract people, and therefore it is relatively worthwhile to provide goods and services in areas surrounding the national parks. The density of activities in 2003 was a highly significant factor, which suggests that activities resulting from diversification create positive externalities that motivate other farmers to follow in their footsteps. Often these activities are complementary, especially when they lead to a wider range of services being offered together in the same location. If this holds more generally, this dynamic may lead to the emergence of ‘diversified hotspots’ in rural landscapes. The mirror side of this argument could be that other areas might develop into, or remain as ‘diversified coldspots’. Generalizing our other findings would imply that areas with less suitable soils that are next to urban centers are the most likely to diversify. Their historic disadvantages turn out now to become an asset: preserved landscapes are better equipped to fulfill the societal demand for consumption countryside.

2.3.2 Probabilities of taking up specific activities (Model 2)

In seeking to explain the probabilities for the adoption of specific activities one needs to take into account that these choices could be correlated with each other. The results from the multivariate probit estimation for daily recreation, adoption of agri-environmental schemes and other services (Model 2) are given in Table 2.3. The hourly return from agriculture turns out to be significant for all the activities and for the number of activities adopted, implying that diversification is sensitive to returns from agriculture just like in the previous model. As such the switch from price support to direct payments, which has been ongoing since the MacSharry reform of the early 1990s, (which have lowered the relative prices for agricultural products and influences income from agriculture) and the expansion of the second pillar of the CAP (which emphasizes rural rather than solely agricultural policies) both contribute to the increasing popularity of diversification. The notable increase in modulation within the EU's 2008 Health Check reform will further strengthen this tendency. At the same time, price increases for agricultural products (e.g. the recent price rise resulting from increased world-wide demand for agricultural products due to oil price increases, increased demand for bio-fuels and increased demand for animal products in Asia and drought in Oceania (OECD-FAO, 2007) might induce a reverse trend and make farm diversification relatively less attractive.

Table 2.3: Multivariate probit estimation for daily recreation, agri-environmental schemes and other services (Model 2)

		Daily recreation	**Other services**	**Agri-environmental schemes**
Farm characteristic	Hourly return from agriculture	-0.041 (3.72)*	-0.049 (3.08)*	-0.020 (2.60)*
Farm household characteristic	Mean age of head of farm	0.400 (3.70)**	0.222 (2.48)*	
	Mean age of head of farm squared	-0.004 (3.67)**	-0.009 (2.61)*	
	Highest level of education in the household			0.138 (2.32)*
	Factor for independency			-0.216 (2.56)*
	Factor for trust in governmental institution			-0.165 (1.82)
Location assets	Location within 1.5 km from a national park	0.490 (2.04)*		
	Location within 2 km from a city		0.294 (1.55)	
	Density of adopted agri-environmental schemes and multifunctional activities in 2003	2.379 (2.58)*		
	Percentage of bad quality soils with a buffer related to the farm size			0.009 (2.31)*
	Constant	-12.43 (4.19)**	-5.24 (1.55)	-1.228 (4.39)**
Correlation daily recreation- other services		0.865 (17.04)**		
Correlation daily recreation– agri-environmental schemes		-0.207 (1.41)		
Correlation other services– agri-environmental schemes		0.222 (1.86)		
Pseudo R square		0.14		

Robust z statistics in parentheses
*Significance level: * significant at 5%; ** significant at 1%*
Number of draws (see Appendix 2.II): 500

Location assets turn out to be significant, but in a different way for each activity. Daily recreation emerges next to attractive landscapes (measured through the proximity of national parks), and adoption of agri-environmental schemes is more likely to occur on less productive and wet soils. The density of the adoption of agri-environmental schemes in 2003 proved significant in driving daily recreation in 2005 suggesting synergies between these two activities. Proximity to cities was not found to be a significant driver for other services within the multivariate framework. This is probably due to the high diversity of services included with this category.

With respect to farm and farm household characteristics two different dynamics can be identified. Marketable goods, including daily recreation and other service, show a different dynamic than agri-environmental schemes, which aims at the provision of a public good. Life cycle appears to be significant in all the case except for the adoption of agri-environmental schemes. In addition to this, higher education levels increase the probability of the adoption of agri-environmental schemes. This may partly reflect the need for specific knowledge and training in order to be able to fulfill the governmental requirements associated with these services, as well as the knowledge needed to sign a contract with the government and understand the administrative process. In addition, the adoption of agri-environmental schemes tends to increase with increasing size of the farm.

The factor for independence presents a negative sign, implying that the more farmers want to stay independent the less likely they are to adopt agri-environmental schemes. Indeed, an agri-environmental scheme implies a contract with the government for a minimum duration of 6 years, and is linked to various conditions such as field management or training courses. Jongeneel *et al*. (2008) suggest that trust in the contracting party is an important factor for adopting agri-environmental schemes. In this regard Table 2.3 shows a somewhat puzzling result. The trust variable is not significant in the multivariate framework. While not significant this factor even shows a negative relationship with the adoption of agri-environmental schemes. There are several possible explanations to this result. Firstly a drastic change in payments for agri-environmental schemes took place just before the survey was run. Because agri-environmental schemes contracts last 6 years, farmers that lost trust were not yet able to step out of the agreements. This could explain that farmers participating in this activity and affected by the ‘contract-breach’ by the government were the ones who responded negatively on the trust-variable. Equally, the lack of trust could be linked to poor governmental performance during outbreaks of animal disease in the study area in 2001, 2002 and 2003 (Van der Ziel, 2003, pp. 96-98). Contrary to our expectations, farm specialization and other attitudinal factors, did not turn out to be significant for any of the models and are therefore not shown.

2.4 Conclusions

This chapter shows that landscape patterns and their derived location assets are relevant for farmer's decision making to diversify. Firstly, it turns out in our study area that the adoption of agri-environmental schemes is more likely to occur on relatively wet soils which are relatively less suitable for agricultural production. Secondly, attractiveness of landscapes plays a significant role in explaining diversification. More in particular daily recreation most frequently occurs close to national parks and at locations where agri-environmental schemes have already been adopted. This suggests that there might be positive synergies between these activities. Furthermore, activities resulting from diversification were found to have the tendency to emerge next to already existing ones, therewith forming "hotspots" in the landscape. These hotspots are mainly located near to attractive landscape as well as on soils that are less suitable for agriculture. Finally, this chapter has shown that diversification is sensitive to changes in income from agriculture suggesting that the adoption of agri-environmental schemes and other activities might depend on the evolution of world prices for food and fiber as well as on the (future) balance between the first and second pillars of the CAP.

Appendix 2.I: Overview of the used variables

Table A2.1: Overview of the explanatory variables

Farm characteristics	Construction	Units
Farm size	Direct survey information	Hectare
Dairy farm	Availability of milk quota & number of dairy cows > quota/10,000 The second condition makes sure that farms that lease all their quotas are not considered as a dairy farm. 10,000 kg is the maximum amount of milk that a dairy cow can produce in one year	Binary
Off farm job	Indicates if at least one member of the household is working outside the farm.	Binary
Farm household characteristics		
Average age of head of farm	Average age of the individual(s) indicated in the survey as head(s) of the farm	Years
Highest level of education	The highest education level among all individuals on the farm. Education is an integer increasing with each level education achieved.	integer
Participation in voluntary association	Survey information	Binary
Responsible production	A factor analysis was prepared for each section of questions concerning attitudes towards: multifunctionality, farming style and trust. The variables used are the dimensions identified through the factor analysis	Factor
Independency		Factor
Ownership		Factor
Cooperation		Factor
Investment		Factor
Trust in government		Factor
Market conditions		
Hourly return from agriculture	Income of the farm-income from traditional agricultural activities divided by the time spent in food and fiber production	Euros/hour

Location assets		
Location with 1.5 km of a national park	Based on the national parks maps	Binary
Location with 2km of a city	Based on the topographic map	Binary
Density of activities in 2003 (within 2 km)	Average number of activities per farmer taken up within the buffer of 2 km, excluding the information about the observed farmer	number of activities/farmer
Density of adopted agri-environmental schemes in 2003 (within 2 km)	Share of farmers adopting agri-environmental schemes within the buffer, excluding the information about the observed farmer	Percent of farmers adopting agri-environmental schemes
Percentage of wet soils with a farm size dependent buffer	Based on soil map	Percent

Appendix 2.II : multivariate probit

In order to estimate the different activities resulting from diversification, a multivariate probit was fitted. Different on-farm activities such as agri-environmental schemes, recreational and other services cannot be considered as independent choices. Therefore, the take up of these activities must be estimated simultaneously, which allows correlations between the choices to be taken into account. Formally the estimated model is as follows:

$$\begin{cases} y*_{recreation} = \beta_r X_r + \varepsilon_r \\ y*_{green\_services} = \beta_g X_g + \varepsilon_g \\ y*_{other\_services} = \beta_o X_o + \varepsilon_o \end{cases} \qquad \text{with} \qquad \varepsilon_i \approx \mathrm{N}(0,\Omega)$$

$$y_i = 1[y*_i \geq 0]$$

$$\text{and } \Omega = \begin{bmatrix} 1 & \sigma_{r,g} & \sigma_{r,o} \\ \sigma_{r,g} & 1 & \sigma_{g,o} \\ \sigma_{r,o} & \sigma_{g,o} & 1 \end{bmatrix}.$$

The coefficient β_i and the correlation of the residuals between the choices $\varepsilon_{i,j}$ are estimated with the same estimation procedure. To avoid an identification problem, the variance-covariance matrix was restricted to ones on the diagonal axis, implying that only the correlation between the activities chosen by a farmer can be estimated.

In mathematical terms, log likelihood includes the probability for each possible combination of 3 choices. This calls for a triple integration over a trivariate normal distribution, which has no closed form solution. Therefore, the usual maximization of the log likelihood function is not possible, and must be evaluated numerically through simulations (Train, 2003, p. 102). There are various methods to perform this simulation. For this chapter the Geweke-Hajivassiliou-Keane (GHK) simulator, which is the most widely used and the most accurate probit simulator, was used. Per individual 500 draws were performed. The full GHK procedure for a three-alternative case can be found in Train (2003, pp. 126-130).

Appendix 2.III: Endogeneity tests

In order to test for exogeneity of the hourly return from agriculture in Model 2, a River and Vuong approach (as described in Wooldridge (2002: pp. 472-477) was applied to each equation (daily recreation, agri-environmental schemes, other services) separately as well as on a binary basis so as to measure diversification. This test is based on probit estimation with one potential continuous endogenous variable using a two-step instrumental variable approach.

The instrument corrects for bias due to endogeneity: it must be correlated with the potentially endogenous variable (hourly return from agriculture) but not correlated with the explained variable (activities). If the instrument is significant at a 5% significance level it can be concluded that the potentially endogenous variable cannot be considered as exogenous and therefore cannot be used as an explanatory variable. As instruments the number of milk cows, the production of corn and grain production in terms of ton per hectare were used. For recreation the hypothesis of exogenetity could not be rejected with a p-value of 0.23, for other services with a p-value of 0.87 and for agri-environmental schemes with a p-value of 0.20.

Wooldridge (2002, pp. 663-666) proposes an extension of the Rivers and Vuong test, that allows, within a quasi-maximum likelihood approach, the performance of the same two step procedure as described above on count data. This approach was used for testing for the endogeneity of hourly income from agriculture in Model 1, using the same instruments as mentioned before. This procedure led to the non-rejection of exogeneity at a p-value of 0.15.

In all the cases the hypothesis of endogeneity were rejected, allowing us to use the variable income from agriculture as exogenous variable.

38 NIEUWBOUW KOOPWONINGEN
PLAN NOORDWEST - DEELPLAN 9A - FASE 1
2 X TYPE DAVOS
12 X TYPE LUZERN
24 X TYPE ZURICH
Architectuur: ir. J.M. Braamhaar, Architect Roosdom Tijhuis Bedrijven
Ontwikkeling en realisatie
Participatie
Verkoop
Roosdom Tijhuis
Rabobank
Rabo Vastgoed
BREUNISSEN
MAKELAARS
0317 - 425 600
Hypotheken
Klantgericht Bouwen
Rabobank
Vallei en Rijn
0318 - 660 617
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INFRASTRUCTUUR
Ontwerp en Realisatie
ROELOFS
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Chapter 3

A spatially explicit simulation tool for farm diversification[5]

Abstract

In Europe, agricultural and rural policies increasingly aim at addressing the new societal demand for alternative functions of the rural landscape like recreation, cultural heritage, habitat for fauna and flora, biodiversity maintenance and water storage. By diversifying and adopting rural activities, farmers contribute to these various functions of a landscape. Supporting the adoption of rural activities does not necessarily increase the landscape functions as these activities might not emerge coherently in the landscape. Therefore, there is a need to visualize the patterns of rural activities at the landscape scale under different policy interventions. This chapter presents a spatially explicit simulation tool for farm diversification that visualizes adoption patterns of rural activities, like agri-environmental schemes, or recreational activities. It is based on a micro-economic model describing the decision making process of farmers to select theoretical driving factors behind the adoption process of various rural activities. The relation with the relevant farm-level driving factors is subsequently empirically identified with a probit model using farm-level data in combination with a GIS database. The resulting probit model can subsequently be used to simulate the adoption of a particular rural activity for the region resulting in patterns of potential adoption. In order to acknowledge individual farm variability, as well as taking potential spatial correlation into account, the probit residual is modeled explicitly. By changing input parameters of the model we can evaluate alternative scenarios representing site specific changes in the region. This tool is illustrated with an application to the Gelderse Vallei in the center of the Netherlands. Visualization of adoption patterns of short supply chains, agri-environmental schemes, and recreational activities under different scenarios are presented.

Acknowledgments

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[5] Pfeifer C. Stoorvogel J.J, Jongeneel R.A. Submitted to *Agricultural Systems*

3.1 Introduction

The European Common Agricultural Policy shifts funds away from price and production support (Marsden, 1999; Dalgaard *et al.*, 2007; Fischler, 2008). In this process, the policies address the new societal demand for alternative functions of the rural landscape like recreation, cultural heritage, habitat for fauna and flora, biodiversity maintenance and water storage (Willemen *et al.*, 2008). In agricultural landscapes, the landscape functions are the combined result of biophysical characteristics and decisions taken at the farm level. Next to their traditional agricultural activities, famers can diversify and adopt on-farm rural activities such as bed and breakfasts, on-farm shops and educational programs for children (Meerburg *et al.*, 2009). In addition, agri-environmental schemes are offered to farmers in which they are compensated for the extensification of field management to provide green-services (Peerlings and Polman, 2004).

By diversifying and adopting rural activities, farmers contribute to landscape functions. The total landscape function is more than a simple aggregation of farm level activities and depends on the coherence of the spatial distribution. As a result, policies supporting the adoption of on-farm activities do not necessarily increase landscape functions as these activities might not emerge coherently in the landscape (Termorshuizen and Opdam, 2009). Therefore, there is a need to visualize the patterns of rural activities in the landscape under different scenarios.

Various spatially explicit simulation tools based on farm information have been developed for the rural area. They use different approaches such as agent based modeling (Happe *et al.*, 2006), spatial micro simulations (Ballas *et al.*, 2006; Hynes *et al.*, 2009), or trade-off analysis (Stoorvogel *et al.*, 2004). None of these models has addressed patterns of rural activities as a result of individual and rational economic decision making in relation to farm diversification. The objective of this chapter is to present a spatially explicit simulation tool that assesses the adoption patterns of rural activities. To illustrate the tool, it is applied to the Gelderse Vallei in the center of the Netherlands to simulate and visualize adoption patterns of short supply chains (*e.g.*, on-farm shops, home delivery), agri-environmental schemes, and recreational activities under different scenarios. However, these scenarios are meant as illustration the tool and developing consistent scenarios goes beyond the scope of this chapter.

3.2 The simulation tool

3.2.1 Overview

Conceptually, the simulation tool is based on a micro-economic model describing the decision making process of farmers to select theoretical driving factors behind the adoption process of various rural activities. The relation with the relevant farm-level driving factors is subsequently empirically identified with a probit model using farm-level data in combination with a GIS database. The resulting probit model is used to simulate the adoption of a particular rural activity for the region resulting in patterns of adoption. The simulation tool can be roughly sub-divided in 4 modules dealing with data collection, the assessment of the probit model, the actual simulation, and finally the visualization of the adoption patterns (Figure 3.1).

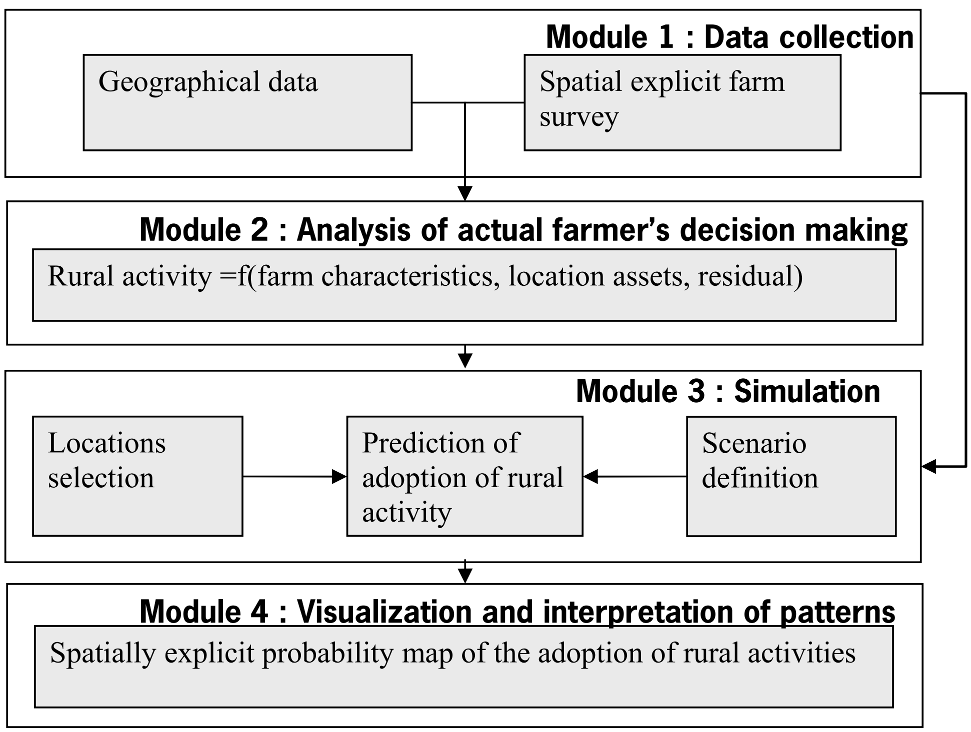

Figure 3.1: overview of the simulation tool with its four modules

3.2.2 Data collection (Module 1)

The analysis starts with the identification of numerous potential factors that may play role in the decisions of farmers to adopt alternative rural activities. Possible explanatory variables for farm diversification can be derived from existing theoretical models. From a micro-economic perspective, a farm household utility maximization (Ellis, 1993; Sadoulet and de Janvry, 1995) suggests that the adoption of rural activities depends on input and output prices, labor input, and other variable inputs. In addition, empirical studies suggest that farm household characteristics such as life cycle, education and site characteristics are important drivers of farm diversification (Ilbery, 1991; Bateman and Ray, 1994; Vanslembrouck *et al.*, 2002; Jongeneel *et al.*, 2008; Pfeifer *et al.*, 2009). Information on the explanatory variables and the adoption of alternative rural activities needs to be derived from a geo-referenced farm survey. A geographic database is used to determine the spatial variation in site characteristics that may be important (*e.g.*, soil type, distance to city).

Although ideally we select driving factors at the beginning of the research process based on a conceptual model, many studies make use of available survey data and geographic information.

3.2.3 Analysis of actual farmers' decision making (Module 2)

Actual farm decision making is analyzed in module 2 using a probit model. The analysis aims at identifying empirically which factors drive the farmers' decision to adopt a particular rural activity. To do so a matrix of farm household and production characteristic X and a matrix of site characteristics S are established using the farm survey data and the geographic database. A probit model for each rural activity is estimated. The probit specification is given by $y = \begin{cases} 1\,if\ y^* > 0 \\ 0\,if\ y^* \le 0 \end{cases}$ and $y^* = X\beta + S\gamma + u$

The adoption of the rural activity is indicated by a binary variable y, y* is the latent model of the adoption of rural activities, β is a vector of coefficients of the farm household and production characteristics, γ is a vector of coefficients of the site characteristics, and *u* is the residual. The probit model ignores a potential spatial correlation between its residuals. Spatial correlation can be addressed by spatial econometrics and geo-statistics. Spatial econometrics introduce a spatial correlation by imposing a spatial structure to the error term (weighting matrix), which introduces simultaneity into the estimation (Anselin, 2006, p. 952). On the contrary, geostatistics is a data driven approach in which spatial correlation is introduced into the model based on the observed distribution of the residual (Cressie, 1986; Cressie, 1990; Anselin, 2006). For the purpose of this chapter, the geo-statistical approach offers a range of advantages over the spatial econometrics. It avoids complications connected to the estimation of a simultaneous problem, and, because simultaneity is avoided, it allows to predict probabilities of adoption of a rural activity for random locations without requiring an initialization of the simultaneous equations. As a result, it is most appropriate for the simulation tool to use an approach based on geostatistics and model explicitly the residual into the prediction of independent probit estimation.

For each rural activity the probit estimation results in a vector of significant coefficients ($\hat{\beta}, \hat{\gamma}$). The predicted probability of adoption $\hat{y} = \Phi(X\hat{\beta} + S\hat{\gamma})$ can be computed for each farm in the survey and for each rural activity. Several residuals can be calculated due to the non-linear nature of probit estimation (Cameron, 1998). The raw residual $\hat{u}^r$ refers to the difference between the observed outcome and the predicted probability: $\hat{u}^r = y - \Phi(X\hat{\beta} + S\hat{\gamma})$. Raw residuals cannot be used to perform diagnostic tests known from linear regressions in a non linear setting such as probit (Gourieroux *et al.*, 1987). Therefore, the raw residuals are transformed into generalized residuals given by $\hat{u}^g = \dfrac{\phi\left(X\hat{\beta} + S\hat{\gamma}\right)}{\Phi\left(X\hat{\beta} + S\hat{\gamma}\right)\left[1 - \Phi(X\hat{\beta} + S\hat{\gamma})\right]} u^r$ (Gourieroux *et al.*, 1987).

The importance of residuals in the whole model is assessed by the McFadden R^2. The McFadden R^2 indicates (similar to the R^2 in a linear model) the explanatory power of the model (Cameron and Windmeijer, 1997). Independent probit estimations on cross sections usually have a rather low explanatory power. Comparisons with similar studies (Vanslembrouck *et al.*, 2002; Jongeneel *et al.*, 2008; Pfeifer *et al.*, 2009) lead to the conclusion that a McFadden R^2 between 0.1-0.5 is acceptable. This implies that the major part of variation remains unexplained and is absorbed by the residual of the model. In order to take this unexplained variation into account, the residual can be modeled with the predictions.

The generalized residual of the probit models can be used for diagnostic purposes. Generalized residuals can be interpolated with a local sample mean (Maguire, 1991, p. 370). The resulting map is a measure of the accuracy of the probit model: it indicates where the model over- and under-estimates the adoption of a rural service showing patterns of unexplained variation. Alternatively one can use a map of the local sample standard deviation to reflect the variability of the residual as a measure of spatial correlation. Indeed, in locations where the local standard deviation of the generalized residual is low, the unexplained variation tends to be similar to all the farms and therefore spatially correlated. This can be the case when a location characteristic was unobserved and omitted from the probit model leading to spatially correlated residuals.

3.2.4 Simulation (Module 3)

In order to be able to simulate the adoption of rural activities throughout the study area it is necessary to have data on location and farm characteristics for the entire area. Although simulations can be carried out for the survey farms, it may create a number of problems. A first problem that may occur is that the farm data cannot be presented in a spatially explicit way without violating farmer's privacy. Secondly, the dataset is not necessarily covering all the farmers in the entire area. Thirdly, farm survey data are often geo-referenced on the basis of the location of the farmstead. Usually the location of individual fields is not included and, as a result, specific conditions (*e.g.,* distance to road or soil drainage) for individual fields can not be derived. To resolve these problems, one may prefer to interpolate the farm household and production characteristics to the region and deal with a random sample of locations. In the simulation tool we apply a focal statistic procedure to interpolate farm survey data. This procedure results in maps for the mean and standard deviation of each variable in the farm survey illustrated by Figure 3.2. These maps are based on a local sample mean $\bar{x}_{i,j}$ for variable x_j at location i and a local sample standard deviation $\sigma_{i,j}^{\bar{x}}$ using an *a priori* defined number of nearest neighbors. The number of nearest neighbors taken into account for this focal statistic introduces spatial structure into the simulation tool. Therefore, it must be selected carefully taking different criteria's into account. Firstly, it must be selected in such a way that privacy of farmers can be guaranteed. Secondly, particularly in the case of clustered data, one should consider that the number of nearest neighbors influences the smoothness of the resulting maps. If the number of nearest neighbor is smaller than the number of farms within a cluster (represented by farms 1 to 3 clustered along a road in Figure 3.2), then the interpolated maps will have sharp transitions between different average or standard deviation values. In order to have smooth transition the chosen number of farm must be bigger than the amount of farms within a cluster. Thirdly, the amount of nearest neighbors taken into account should be as small as possible in order to properly describe the heterogeneity in the area.

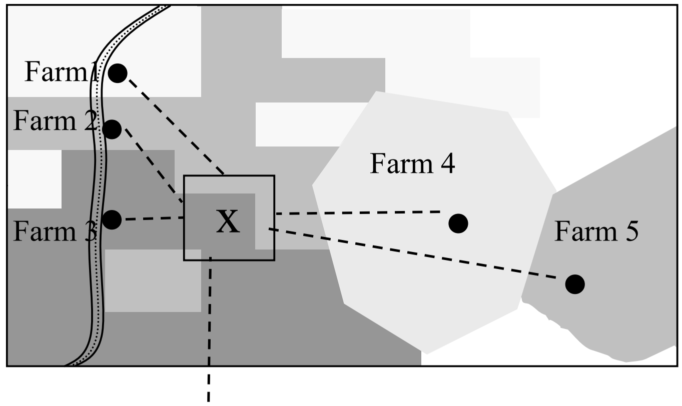

Figure 3.2: graphic illustration of the focal statistic procedure with various spatial distributions of farms

Similarly to the farm survey variables, the raw residual of the probit model will be taken into account in a spatially explicit manner. Therefore the same focal statistic is applied to the raw residual resulting in the average raw residual $\bar{\hat{u}}_i^r$ at any location i and its respective standard deviation $\sigma_i^{\bar{\hat{u}}_r}$.

Finally, all information needed for the simulation is available and the following simulation procedure can be applied:

1. Random draw of locations

   Simulations are run for randomly selected locations. The number of random points corresponds to the number of actual farmer observed in the study area. The simulation run starts with a random draw of locations.

2. Farm and site characteristics and raw residuals

   The randomly selected locations are overlaid with the interpolated farm household and production characteristics, the site characteristic maps (computed in module 2) as well as the interpolated raw residuals.

3. Draw farm characteristics

   Each farm household and production characteristic j is drawn for each random location i. The characteristics are generally drawn from a normal distribution: $\tilde{x}_{i,j} \sim N(\bar{x}_{i,j}, \sigma_{i,j}^{\bar{x}})$, where $\bar{x}_{i,j}$ is the local sample mean at location i of the farm household or farm production characteristic j of and where $\sigma_{i,j}^{\bar{x}}$ is the respective local sample standard deviation resulting from the previously described overlay.

4. Constrain variables

   Simulated variables may have to be constrained in order to be comparable to the original dataset. For example, discrete variables have to be rounded and variables with an explicit upper or lower limit have to be truncated.

5. Draw the raw residual

   The raw residual ($\hat{u}^r$) can be drawn from: $\tilde{u}_i^r \sim N(\bar{\hat{u}}_i^r, \sigma_i^{\bar{\hat{u}}_r})$, where $\bar{\hat{u}}_i^r$ is the local average raw residual and where $\sigma_i^{\bar{\hat{u}}_r}$ is the respective local standard deviation.

6. Prediction of the probabilities of adoption

   Finally, the generalized residual is computed allowing to predict for each random location the probability of adoption given by $\tilde{y}_i = \Phi(\tilde{X}_i \hat{\beta} + S_i \hat{\gamma} + \tilde{u}_i^g)$.

In addition, to simulate alternative scenarios we have to translate the often anecdotal description of scenarios into changes in farm or site characteristics. Scenarios for the rural area can be based on interviews with various key informants or policy documents. Based on this information, scenarios can be implemented by changing model parameters or changing the farm and site characteristics. Farm and site characteristics can be changed uniformly over the study area but they can also be modified in a spatially explicit manner.

3.2.5 Visualization and interpretation of patterns (Module 4)

In order to visualize adoption patterns, the predictions for the random locations under a specific scenario definition will have to be interpolated. In this case we use ordinary kriging as the best, unbiased, linear predictor (Cressie, 1990). The simulation procedure can be repeated several times resulting in different probability maps. The coefficient of variation over different simulation runs can be computed and acknowledges the importance of individual farm heterogeneity. It allows to compare the relative importance of variability per location but also to compare different rural services.

Econometric models have two major sources of variation: individual heterogeneity and unexplained random variation captured by the model residual. While individual heterogeneity cannot be reduced by collecting more data, unexplained random variation is the result of lack of data or understanding of the underlying phenomenon (adoption of rural activity) and therefore represents the uncertainty of the model. This uncertainty has been modeled through the explicit introduction of the residual into the prediction. Given the low explanatory power of probit models, the residuals takes up an important part of the variation. Consequently, the predicted patterns of rural activities could be driven by patterns of the residual rather than the patterns of the explanatory variables. In this case, it would make little sense implementing scenarios as the pattern would be mainly defined through unexplained drivers. It is therefore important to assess the influence of the residual not on individual level but on the pattern of rural activities. Intuitively, this can be done by comparing "corrected predictions", that are predictions with the explicit modeling of the residual $\tilde{y}_i^{corrected} = \Phi(\tilde{X}_i \hat{\beta} + S_i \hat{\gamma} + \tilde{u}_i^g)$ with "uncorrected predictions" that are the predictions without the modeling of the residual $\tilde{y}_i^{uncorrected} = \Phi(\tilde{X}_i \hat{\beta} + S_i \hat{\gamma})$. In order to analyze the residual on a pattern, both the corrected and uncorrected predictions need to be averaged over a bigger spatial unit: for each randomly selected location, the average over the farmers within a predefined neighborhood for the corrected and uncorrected prediction are computed. If the residual has no influence, then the average corrected and uncorrected predictions are equal, consequently the mean absolute difference over all random location is zero. If the mean absolute difference declines as the neighborhood increases, the influence of the residual decreases the bigger the spatial unit is. In this case the residual is mainly source of short distance variation, and the influence of the explanatory variables becomes more important for the predicted pattern than for the individual prediction.

3.3 Application of the tool

3.3.1 Study area

The simulation tool has been applied to the Gelderse Vallei (Figure 3.3). It is a diverse region under pressure of urban and rural development. Big cities such as Utrecht and Amersfoort grow towards the rural area and their residents create an increased demand for rural services. The urbanization presents a threat for the area but also creates opportunities for diversification. Agricultural systems in the region are diverse. The northern part with poorly drained peat soils is mainly used for grazing animal farming; while in the eastern part intensive livestock (mainly pig and chicken) farming prevails. The rest of the region is dominated by mixed arable farming.

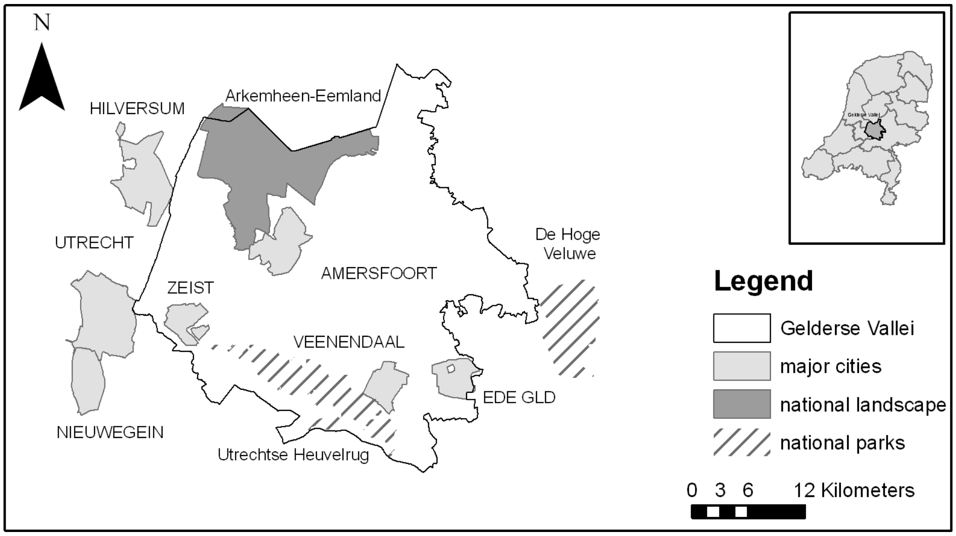

Figure 3.3: Study area Gelderse Vallei and the national landscape Arkemheen-Eemland with major cities (urbanized municipalities)

The region borders two national parks on the push moraines (hills) covered with forest vegetation. The parks are accessible and are mainly used for outdoor recreation such as walking and mountain biking. In the National Landscape Arkemheen-Eemland policy makers agreed to maintain three main qualities: (i) an open landscape and an important habitat for rare meadow birds (ii) the cultural historical heritage of past water management systems, and (iii) the inherent character of a typical peat landscape. In this area farmers can participate in special agri-environmental schemes for the creation and maintenance of meadow birds' habitat. In the area farm diversification takes place through the adoption of these agri-environmental schemes but also recreation and tourism, care services, short supply chains, on-farm food processing, renting out storage space and production of alternative energy (Naeff, 2006). Agri-environmental schemes, recreational activities, and short supply chains are the three most important forms of diversification and will be modeled in this chapter.

3.3.2 Data collection for the study area (Module 1)

The GIAB dataset (geographical information system for agricultural businesses) is an annual farm survey of all officially registered farmers in the Netherlands (Naeff, 2006). Since it contains the whole population of farmers there are no problems of sample selection and representativeness. This dataset includes the coordinates of the farm homestead and describes in detail the farm production (*e.g.,* hired labor, amount of machinery, size, type of farm) and farm household characteristics (*e.g.,* age, education, participation in environmental cooperatives). From this dataset, potential explanatory variables can be derived. Variable inputs are either directly included in the database (farm size and fertilizer use) or they can be derived (*e.g.*, labor input through the number of head of farms and off-farm work). A whole range farm household characteristic such as life cycle or education can also be computed. Next to the classical survey information about farm household and farm production characteristics, the dataset contains the Dutch standard economic size of eight farming activities (*e.g.,* arable, fruit, horticulture, and livestock) (LEI/CBS, 1998). The dataset does not contain information about capital or investment. Therefore, these two factors have not been taken into account in this chapter although they are suggested to be important in theory. As a result, they are assumed to be random. For this chapter, the 2005 GIAB survey has been used. This survey included specific questions about rural activities, namely adoption agri-environmental schemes, recreation and tourism, care services, short supply chains, on-farm food processing, renting out storage space and production of alternative energy. Because agri-environmental schemes (8.5% of the farms), recreational activities (2.2% of the farms) and short supply chains (3.5% of the farms) are the most frequent activities, they have been selected to illustrate the simulation tool.

Ground water levels (as a proxy for soil quality), distance to city, distance to the national landscape, distance to the national park and distance to attractive landscape (national park and national park) were found to be relevant site characteristics for the adoption of rural activities(Chapter 2). Maps of these characteristics were created on the basis of available topographic and soil maps

3.3.3 Results for farmer’s decision making (Module 2)

The GIAB dataset has been overlaid with the site characteristic maps. The resulting dataset is used for estimating the probit models of the adoption of agri-environmental schemes, recreational activities and short supply chains. The results are shown in Table 3.1. For all three activities age is significant. The adoption of agri-environmental schemes and recreational activities increases with the average age of active household members until 47 after which it decreases. The probability of adoption of short supply chains is higher for younger farm households. The probability of adoption of all rural activities is higher with higher education. For each rural activity specific knowledge is needed and higher education makes it easier to acquire this knowledge. Livestock intensity on the farm decreases the probability for adoption of agri-environmental schemes. The probability of adoption of agri-environmental schemes is increasing with farm size. The economic size of arable farm reduces the probability for adopting agri-environmental schemes. Organic agriculture influences the adoption of agri-environmental schemes positively. Organic agriculture uses land extensively and therefore organic farms can relatively easy take part in agri-environmental schemes. Site-specific characteristics are also important factors driving the adoption of agri-environmental schemes. Poorly drained soils and locations closer to major roads and far from national parks have a higher chance for agri-environmental schemes. The participation in environmental cooperatives, which main aim is to apply collectively to agri-environmental schemes, has not been taken into account in this regression in order to avoid simultaneity. But the membership of cooperatives can be seen as social networks and ways for knowledge exchange and, therefore, have been introduced into the other regressions. Participation in these cooperatives increases the probability for recreational activities. At the same time, the number of farm household heads is significant and indicates that recreation is labor intensive. Organic agriculture also increases the probability for recreation as well as the proximity to national parks and national landscapes. The distance to the large cities has a negative impact on the adoption of recreational activities, which can be explained by the fact that city dwellers will ask for services such as a café when they are further away from home. The probability of short supply chains is driven (like recreation) by the participation in environmental cooperatives, and the number of heads of farm. Nevertheless, it decreases when head of farms have other off farm main occupations. Organic production is also a significant variable, which can be explained by the lack of convenient supply chain for organic products, making it attractive to deliver local customers directly (Renting *et al.*, 2003). Economic size of fruit farms increases the probability for short supply chains while economic size of grazing animal farm decreases it. Indeed, fruit and vegetables can easily be sold to customers without processing, while dairy first needs to be processed. Distance to build up areas as well as to major roads allows to measure accessibility to the market and turns out being significant. Finally distance to attractive landscapes is a driver that can be explained with the fact that these areas attract city dwellers for recreation and therefore provides a market for farm products.

Table 3.1: Independent probit estimations for agri-environmental schemes, recreation & short supply chain

	Agri- environmental schemes	Recreation	Short supply chain
Farm household characteristics			
Average age (yr)	0.0560 (0.026)*	0.0579 (0.032)	-0.0026 (0.025)***
Average age squared (yr^2)	-0.0006 (0.0002)*	-0.0006 (-0.0003)	-0.0001 (0.0002)***
Maximum education (scale)	0.0690 (0.0211)**	0.0486 (0.0289)*	0.0680 (0.025)**
Participation in environmental cooperatives (binary)		0.9260 (0.19)**	0.4744 (0.179)**
Labor input			
Household with member having off farm main preoccupation (binary)			-0.6350 (0.154)**
Number of head of farms		0.1453 (0.07)*	0.2563 (0.0686)**
Farm production characteristics			
Livestock intensity (livestock units/ha)	-0.0001 (0.0006)*		
Land based size (ha)	0.0261 (0.0025)**		
Land based size squared (ha^2)	0.00001 (0.00)**		
Organic agriculture (binary)	0.5498 (0.165)**	0.8199 (0.17)**	0.8848 (0.151)**
Economic size of arable farm (€)	-0.0015 (0.0068)*		
Economic size of fruit farm (€)			0.0002 (0.0011)*
Economic size of grazing animal farm (€)			-0.0006 (0.002)*
Economic size of mixed farm (€)		-0.0009 (0.0003)**	
Site-specific characteristics			
Groundwater level[1]	-0.0682 (0.0175)**		
Distance to habitations (km)			-0.0675 (0.024)*
Distance to biggest cities shown in Figure 3.1 (km)		0.0577 (0.0137)**	
Distance to major roads (km)	-0.0915 (0.0317)*		-0.0903 (0.045)*
Distance to national park (km)	0.0456 (0.051)**	-0.0533 (0.015)**	
Distance to national landscape (km)		-0.0336 (0.014)*	
Distance to attractive landscape[2] (km)			-0.0271 (0.014)*
Constant	-3.4588 (0.6657)**	-3.3025 (0.844)**	-1.8190 (0.703)*
Mc Fadden pseudo R^2	0.24	0.13	0.14

[1] Scale based on the Dutch groundwater tables, low value = high ground water

[2] National park or national landscape

In order to assess the performance of the probit models, the generalized residuals for each of the three activities have been interpolated with a focal statistic procedure with a neighborhood of 10. Figure 3.4 shows the interpolated generalized residual and its standard deviation for each of the three activities. The interpolated generalized residual shows the spatial goodness of fit and shows a spatial pattern: agri-environmental schemes are underestimated (positive residual) in the national landscape and around the national parks. Recreational activities as well as short supply chains are overestimated (negative residual) next to the national parks. The fact that spatial patterns can be observed for the generalized residual of each activity shows the importance of modeling explicitly the residual, implicitly taking the observed pattern into account. The standard deviation of the generalized residual assesses the variability of the generalized residual. For agri-environmental schemes, the standard deviation of generalized residuals is important within the National Landscape Arkemheen Eemland. No clear pattern can be seen for the standard deviation of generalized residuals of recreational activities and short supply chains.

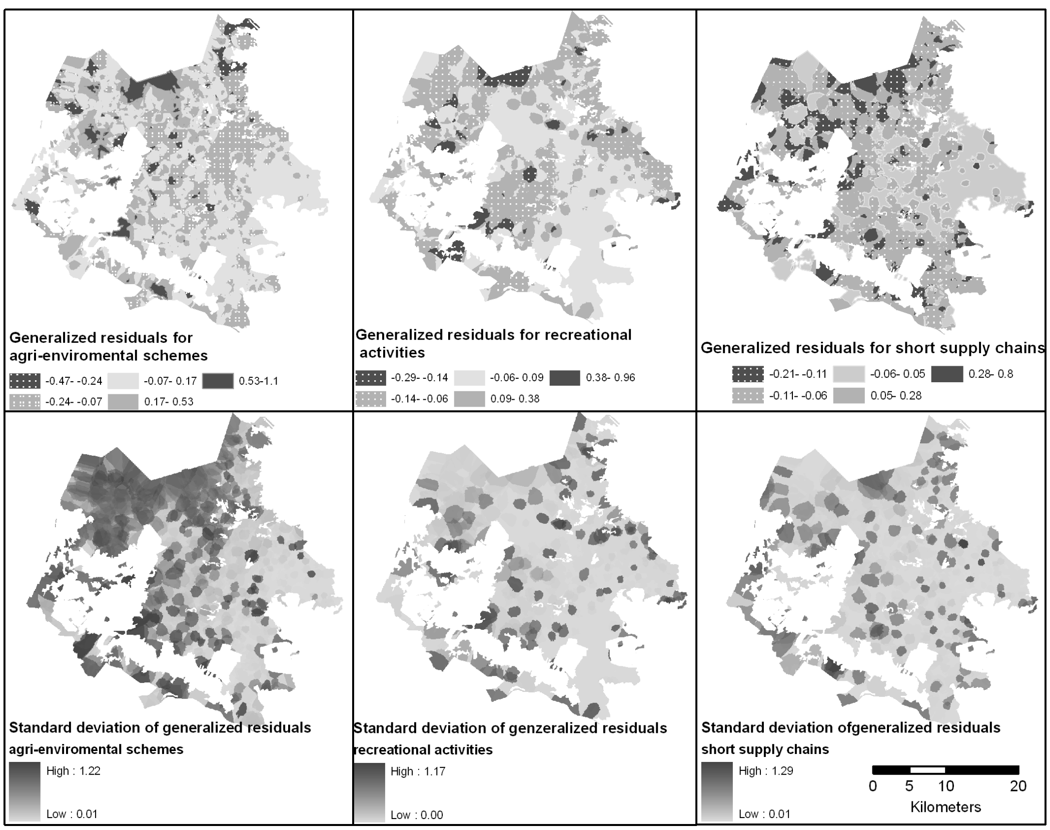

Figure 3.4: Generalized residuals and respective standard deviation for agri-environmental schemes, recreational activities and short supply chains

3.3.4 Simulation (module 3)

3.3.4.1 Base run

The local sample mean and standard deviation of the farm household and farm production characteristics that were significant in the probit model as well as the raw residual have been determined for the entire area. A total of 3700 locations, corresponding to the number of farmers active in the area, are randomly drawn within the agricultural area.

The matrix S has been computed by overlaying the randomly selected location with the site characteristics maps. In order to draw the farm household and production variables and the generalized residual, a focal statistic with 10 nearest neighbors has been applied to the farm household and production characteristics that turned out to be significant in at least on of the three probit estimations as well as the raw residual of each probit estimation. Because farms are clustered along the road in Arkemheen Eemland (as schematized by farm 1 to 3 in Figure 3.2), the a priori choice of 10 nearest neighbors allows to reach relatively smooth interpolation maps in this area without loosing too much heterogeneity for the rest of the area.

Farm household and production characteristics have been drawn from a normal distribution defined by the local sample mean and local standard deviation. Some variables, however, have been simulated differently or adjusted in order to have similar characteristics than the variable in the original GIAB dataset. Binary variables, namely participation in environmental cooperatives, organic agriculture, having household members working mainly off-farm get the value one if a random number drawn from a uniform distribution is smaller than the value drawn from the local normal distribution. Discrete variables, namely number of farm household heads have been rounded to the next integer. Some of the simulated variables, namely size, farming intensity negative values are sometimes drawn outside a credible range. Therefore a minimum size of 0.5 ha, corresponding to the smallest farm in the GIAB dataset as well as a farming intensity of zero have been assumed. Finally, for each random location, an economic farm size for each farming type occurring in the study area has been drawn. But farmers have to be classified as a single farming type. Therefore, for each location the farming type which had the highest economic size has been kept and values of economic size of the other farming types have been set to zero.

3.3.4.2 Scenarios

In order to illustrate the implementation of two different types of scenarios, the national landscape Arkemheen Eemland, for which local expert knowledge is available, has been chosen. Note that defining consistent local scenarios for this area goes beyond the scope of this chapter. Therefore two scenarios based on the trends identified in governmental publication have been selected, namely farm intensification and urbanization (NLAE, 2007) in order to illustrate the implementation of scenarios within the simulation framework:

1. Intensification of grazing animal farms, illustrating a uniform change of a farm characteristic. It has been modeled with an increase of 20% of the economic size for grazing animals, keeping farm size constant. As a result, the number of grazing animal per hectare increases for the farms that are specialized in grazing animals.
2. Urbanization with pressure of new housing around the city of Amersfoort, illustrating the spatially explicit changes by modifying maps from which site characteristics are derived. The National Landscape Arkemheen Eemland is mainly influenced by the city of Amersfoort. On the base of the development plan of the province of Utrecht, the currently planned extension (mainly in the North of the city) has been introduced in the city map, changing the boarder of the city. For this urbanization scenario, the distance between the random locations and the new city boarder has been recalculated and introduced into the simulation.

3.3.5 Visualizations for the study area (module 4)

3.3.5.1 Base run

The simulation procedure, described in module 3, has been applied ten times with the base run settings, resulting in ten sets of probabilities of adoption for each rural activity for 3700 locations in the area. These probabilities have been interpolated with an ordinary kriging procedure (with 10 nearest neighbors). The resulting patterns of the ten outcomes are summarized by calculating their average and coefficient of variance as shown for each activity in the top part of Figure 3.5. Precision of the prediction is assessed with the coefficient of variation, shown in the lower part of Figure 3.5.

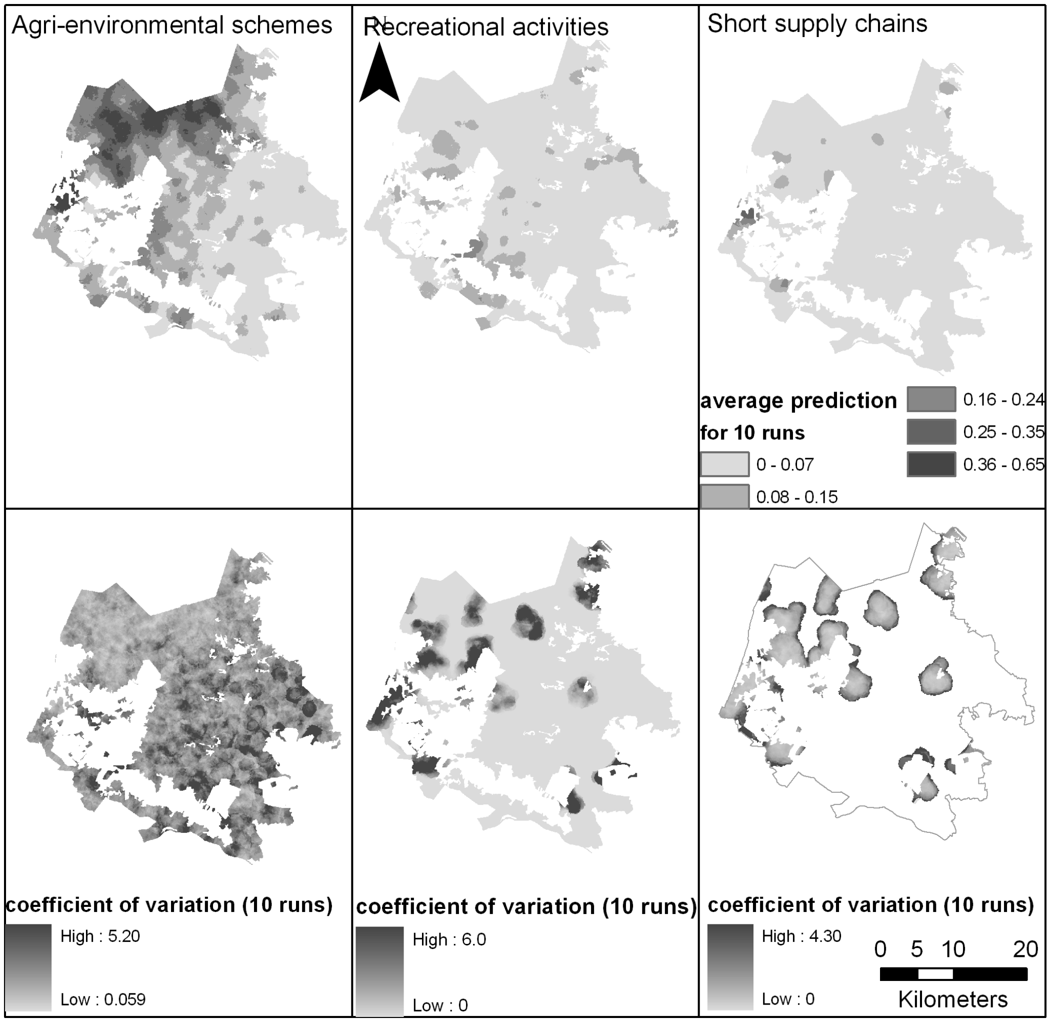

Figure 3.5: average and coefficient of variation of 10 outcomes of the base run for agri-environmental schemes, recreational activities and short supply chains

Agri-environmental schemes mainly appear in the national landscape as well on the boarder to the national park Utrechtse Heuvelrug. On the contrary, in the south western part of the study area the predicted adoption of agri-environmental schemes is low. A low coefficient of variation in locations with a high probability for agri-environmental schemes indicates that this prediction is rather precise implying that the adoption in this part of the study area can be predicted accurately.

Recreation emerges in the western part of the National Landscape Arkemheen-Eemland and next to both national parks. The coefficient of variation shows a rather different pattern than for agri-environmental schemes. Locations with a low or a high probability of adoption of recreational activity have a relatively low coefficient of variation, implying that the simulation framework is rather precise for the extreme predictions.

The coefficient of variation for recreation is relatively low compared to agri-environmental schemes. This implies that predictions are in generally more precise for recreational activities and therefore less sensitive to individual heterogeneity.

Short supply chains emerge in spots which are mainly located in the transition area between the cities (Amersfoort, Ede, Veenendaal, Utrecht and Zeist) as well as bigger agglomerations and attractive landscape for outdoor recreation (national parks and the national landscape). For many locations all 10 runs presented a zero probability to adopt short supply chains. As a result, the coefficient of variation is undetermined and cannot be computed. For these locations, one can only conclude that if the simulation tool resulted in all the runs with a probability of (almost) zero, the outcome is precise. For areas with higher predicted adoption of short supply chains, mainly within the identified spots, the coefficient of variation is low and certainly lower than for recreational activities and agri-environmental schemes indicating that these predictions are relatively precise and relatively less sensitive to individual heterogeneity.

In the simulation framework the residual is the major source of variation and predicted patterns of rural activities could be driven by patterns of the residual rather than the patterns of the explanatory variables. In order to analyze the importance of the residual on a pattern, both the corrected and uncorrected predictions have been compared at neighborhood of 2 km, 3 km and 5km. Table 3.2 shows the mean absolute difference for the first simulation run for each neighborhood. For each activity, the mean absolute difference decreases as the spatial unit increases. The relative variation due to the residual is reduced by half for agro-environmental schemes and recreation when a neighborhood is of 5 km is taken into account. It implies that, though for individual prediction the residual accounts for more than half of the variation, the influence of the residual on the pattern is much lower. Consequently, the predicted patterns are mainly driven by explanatory variables and the model is suitable for scenario analysis.

Table 3.2: Mean absolute difference between the corrected and uncorrected prediction at different levels of aggregation (relative variation driven by the residual (mean absolute distance/uncorrected sample probability of adoption) is given between parentheses)

	No aggregation	Neighborhood		
		2km	3km	5km
Agri-environmental schemes	0.0712 (0.70)	0.0370 (0.37)	0.0355 (0.36)	0.0345 (0.35)
Recreation	0.0175 (0.58)	0.0097 (0.32)	0.0086 (0.28)	0.0079 (0.26)
Short supply chains	0.0043 (0.43)	0.0031 (0.31)	0.0030 (0.30)	0.0029 (0.29)

3.3.5.2 Scenarios definition for the National Landscape Arkemheen Eemland

Figure 3.6 shows the changes due to intensification and to urbanization, as well as the assumed expansion of the city of Amersfoort based on the provincial zoning plan.

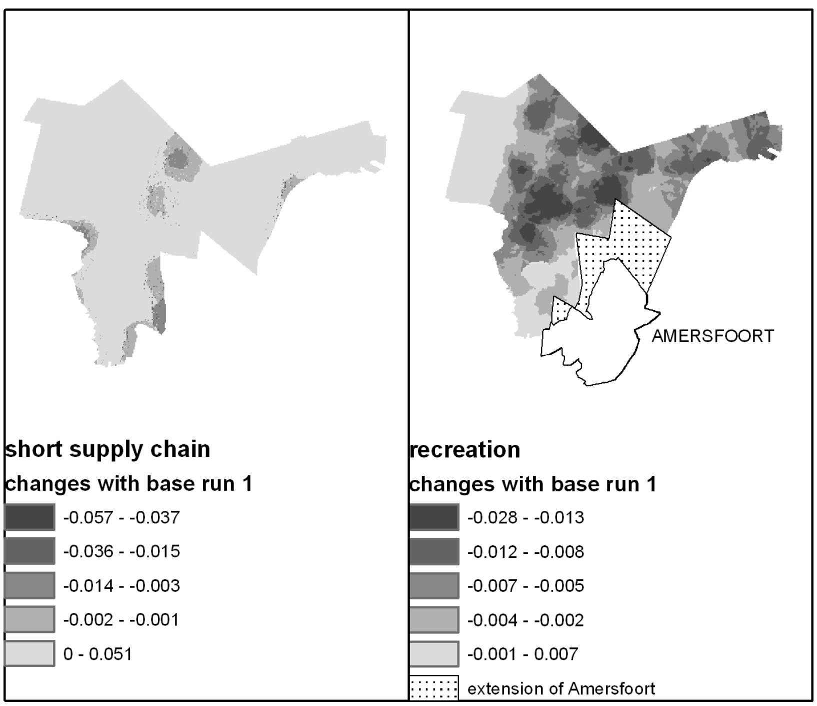

Figure 3.6: Visualization of changes for be base run 2015 two scenarios (grazing animal farming intensification and urbanization) implemented for Arkemheen Eemland

The intensification of grazing animals impacts the short supply chain adoption only. Figure 3.6 shows the results of this change. A decrease is observed on all locations for which the base run predicted short supply chains.

The distance to cities is only included in the model for recreational activities where the proximity to cities reduces the probability of observing recreation. No change is observed in the western part of the region as the boarder of the nearest city, Hilversum, did not change. Near Amersfoort, the impact of urbanization is quite diverse across the region. Areas such north of the extended Amersfoort show smaller changes than the north-west, though the change in distances to city has changed in a similar way for both areas. These non-uniform patterns of changes can be explained with the non-linear nature of the probit models. The marginal effects of the probit models are given by $\frac{\partial \Phi(X_i \beta + S_i \gamma)}{\partial x_{i,j}} = \phi(X_i \beta + S_i \gamma)\beta_j$. Therefore, the effects are individual and location specific. Usually the "average farmer" (with each explanatory variable at its sample mean) is used to assess the behavior of the marginal effect. Figure 3.7 shows the predicted probability of adoption of recreational activities as well the marginal effect for the "average farmer" at different distances from the city. Firstly, it shows that the bigger the distance to the city the higher the probability to adopt recreational activities. Secondly, the marginal effect shows that the impact of city growth is increasing the bigger the distance from the city over the relevant distance range of 20 km for the sub area Arkemheen Eemland. In other words, the impact of city growth is less important in the immediate transition area between the city and the country side, than for the area that is further away from the city.

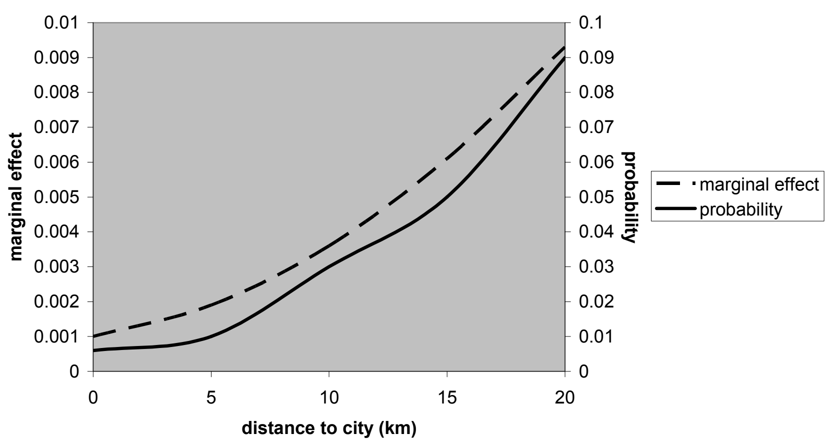

Figure 3.7: marginal effect of distances to cities and probabilities of recreation for the "average farmer" with different distance to the city

3.4 Discussion

The simulation tool assesses adoption patterns of rural activities at the level of the landscape. Our approach is rather different from existing other spatial approaches such as trade-off analysis (Stoorvogel *et al.*, 2004), spatial micro-simulations (Hynes *et al.*, 2009) or agent-based modeling (Happe *et al.*, 2006; Valbuena *et al.*, 2010b). Trade-off analysis models bio-physical conditions explicitly and investigates trade-offs between economic and environmental indicators. This is done by simulating one specific measure applied to a field. Our approach models farmer's decision making to adopt simultaneously various rural activities at farm level, without assessing any trade-off. Spatial micro-simulation differs from our approach by the way farm household and production characteristic are simulated. Indeed, it makes use of an algorithm that enables simulating a farm population within a spatial unit such as a postal code area that matches best the actual farm population in order to predict farm income. Our approach, however, simulates these variables on the base of their respective local distributions. Since the residual of the econometric models is also simulated, spatial correlation can be taken into account.

Compared to agent-based modeling, an advantage of our approach is that the method does not require the development of farmer typologies (Valbuena *et al.*, 2008), or for mathematical programming (Köbrich *et al.*, 2003). These rigid farm typologies which are usually based on cluster analysis (Agudelo *et al.*, 2003; Köbrich *et al.*, 2003; Iraizoz *et al.*, 2007; Tittonell *et al.*, 2010) assume that farmers with similar characteristics make similar choices. Salasya and Stoorvogel (2010) have shown that there might be important variation of farmers' decision making within farm types. The econometric model uses the currently observed farm and farmer heterogeneity to analyze farmers' decision making. This is of particular importance for studies aiming to visualize spatial adoption patterns.

There are four draw backs of our approach. Firstly, we depend on the quality of the data available and collected. Indeed, the used driving factors did not include capital or investment as economic theory would suggest. Secondly only the observed heterogeneity can be modeled. Changes leading to new drivers of farmers' decision making cannot be evaluated. Therefore, scenarios should be run for a time horizon for which it is realistic that drivers remain unchanged. Thirdly, independent probit models have been run ignoring that residuals of the various probit models might be correlated with each other. Pfeifer *et al* (2009) used a multivariate probit estimation and showed that residuals of different probit models for rural activities are correlated. But a multivariate probit introduces simultaneity between the different activities and renders the simulation, such as presented in this chapter, impossible. As independent probit estimation leads to consistent outcomes but not necessarily efficient outcomes (Wooldridge, 2002), the error made by independently estimating each model is not problematic. Fourthly, econometric models such as the probit model chosen for this chapter feature a rather low R^2. This suggests that most of the variation of farm diversification remains unexplained. Sources of unexplained variation are drivers of farm diversification that are relevant but omitted from the probit model: it can be unobserved farm household characteristics such as for example risk attitude (Barbieri and Mahoney, 2009), trust (Polman and Slangen, 2008), managerial skills (Nuthall, 2006), or farm production characteristics such as farm capital, investment or ownership (Maye *et al.*, 2009), or unobserved site characteristics such as a culturally important location which is not reflected on the available map, or the interaction between different farmers leading to spillover effects (Fleming and Lien, 2009). Omitted spillover effects site characteristics and all other omitted characteristics that are correlated to location lead to spatial correlation of the residual. In order to take this spatial correlation into account the residual has been modeled explicitly and introduced it into the prediction. In this way, heterogeneity of farmer is fully acknowledged and reflected in the simulation tool.

As raw residuals are kept constant when a scenario is implemented, scenarios can be biased. This is the case when a scenario influences a driver of farm diversification that is omitted from the probit model. For example, if price volatility for agricultural products increases in a scenario, risk adverse farmers might choose for adopting more agri-environmental schemes offering risk free income. Price volatility is not included in the probit model and therefore the prediction of the adoption of agri-environmental schemes might be underestimated.

In this chapter, we have shown that the importance of the residual on the predicted pattern is much lower than on the individual prediction. This suggests that the residual captures mainly short distance noise. The probit model, despite its relatively low R^2, does capture the proper patterns. Nonetheless, it is essential to model the residual as it takes the spatial correlation into account and therefore leads to a more accurate prediction. Moreover, any other study should model the residual in order to be able to test its effect on the predicted pattern.

3.5 Conclusion

The focus of European agricultural policy shifted away from production support towards more support the new demand for alternative functions of the landscape. In agricultural landscapes, farmers are one of the major actors who can contribute to these landscape functions. New agricultural policies are challenged as farmer's provision of rural activities do not necessarily emerge coherently within the landscape. Therefore tools to assess the spatial distribution of rural activities become essential to support policy makers.

This chapter presents such a simulation tool. Because it is based on drivers of farmers' decision making to supply rural activities identified with independent probit models, two problems connected to the residual is adopted. Firstly, due to the non-linearity nature the probit model, the computation of the residual is not straight forward. Secondly residuals may contain spatial correlation and they account for up to 80% of the individual variation. To address these issues the simulation tool models explicitly the non-linear residual.

The tool is applied to the adoption of agri-environmental schemes, recreation and short supply chains in the Gelderse Vallei. The base run shows that agri-environmental services near or within protected area (national parks or national landscape), where also recreation emerge. Short supply chains emerge near to the cities. We assessed the importance of the residual on the predicted pattern of each of these activities. We have shown that the importance of the residual on the pattern of rural activity is reduced by half compared to individual variation and therefore the model is suitable for scenario implementation.

Scenarios are implemented into the tool by changing farm or site characteristics. Their effect on the patterns of rural activities can be visualized. Due to non-linear nature of the probit model, the marginal effects are location specific. For the Gelderse Vallei, we show that in a farm intensification scenario, short supply chains are likely to be reduced on locations where currently short supply chains are observed, while in an urbanization scenario, recreation is likely to be reduced further away from cities.


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Chapter 4

Assessing spatial distribution of farm diversification under different rural development scenarios [6]

Abstract

Society values a whole range of landscape services other than food, feed and fiber such as recreation, biodiversity or cultural heritage. Landscape planning, nowadays, is expected to ensure the provision of theses services and therefore new approaches are needed to support decision making of land planners and policy makers. Landscape services are the combined result of biophysical landscape properties and human activities at the landscape scale. Consequently, their provision is co-defined by the spatial arrangement of human activities. In landscapes dominated by agriculture, most of human activities are performed by farmers whose decision making co-defines the quantity and quality of landscape services provided. Farmers contribute to the landscape by providing rural services. With changing agricultural and rural policies, the future provision of rural services to fulfill societal demands is not guaranteed. This study aims at mapping the spatial distribution of farm diversification under different explorative scenarios. For a Dutch landscape, scale-consistent storylines were developed by combining global storylines with local storylines resulting from key informant interviews. Subsequently, these storylines were translated into quantitative scenarios that were implemented into a simulation procedure based on spatially explicit econometric models of farmer's decision making. Results show that further market liberalization leads to a decrease of rural services in the study area. Both, a strong top down-policy and self-organizing local initiatives do not to support farmers sufficiently to provide rural services. In our study, only increased cooperation between government, farmers and citizens appears to result in a general increase of all rural services across the entire area.

Acknowledgments

The authors thank Alterra for making the GIAB database available and to Maaike van Scheppingen for her support for the interviews.

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[6] Pfeifer C., Sonneveld M.W.P., Stoorvogel J.J submitted to *Journal of Environmental Management*

4.1 Introduction

Society values a whole range of landscape services other than food such as recreation, biodiversity or cultural heritage (Willemen *et al.*, 2008). Landscape planning, nowadays, is expected to ensure the provision of these services and therefore new approaches are needed to support decision making of land planners and policy makers (Verburg *et al.*, 2009; de Groot *et al.*, 2010). Landscape services are the combined result of biophysical landscape properties and human activities at the landscape scale. Consequently, their provision is co-defined by the spatial arrangement of human activities. In landscapes dominated by agriculture, most of human activities are performed by farmers whose decision making co-defines the quantity and quality of landscape services provided. Farmers contribute to the landscape by providing rural services (Overbeek, 2009; Vandermeulen *et al.*, 2009). While these rural services can involve public goods that are jointly produced with food, resulting from multifunctional agriculture (OECD, 2001; Van Huylenbroeck *et al.*, 2007), other rural services can also be directly provided by farmers and are non-joint with agricultural production. This diversification results in on-farm rural activities such as bed and breakfast, on-farm shops and educational programs for children (Meerburg *et al.*, 2009). In addition, farmers can join agri-environmental schemes that compensate farmers for the provision of public goods such as habitat creation or increased biodiversity maintenance (Peerlings and Polman, 2004).

The on-going agricultural market liberalization and uncertainty about European common agricultural policies beyond the current financial framework ending in 2013 results in a high level of uncertainty for landscapes dominated by agriculture (Ramos, 2010), and it is unclear whether the future contribution of farmers to landscape services will be sufficient to ensure the provision of rural services demanded by society (Vandermeulen *et al.*, 2009).

Developing explorative storylines assessing changes of adoption of rural activities aim at investigating possible futures regardless of their probability to occur, in order to identify possible short-comings that need to be addressed by landscape planners and policy makers (van Ittersum *et al.*, 1998; van Vliet *et al.*, 2010). They include storylines that investigate different possible futures (Peterson *et al.*, 2003; Börjeson *et al.*, 2006). Most of the existing explorative scenarios for European rural areas are based on already existing global storylines, such as for example the Global

Environmental Outlook (GEO-4) (Valbuena *et al.*, 2010c) or European common agricultural policy scenarios (Piorr *et al.*, 2009). Because these storylines are developed for global or continental scales, they do not consider relevant local development. Therefore, locally relevant scenarios for rural landscapes, must be based on the storylines that are scale consistent, i.e. contain local and global drivers (Kok *et al.*, 2007). To do so, global storylines as for example the Global Environmental Outlook (GEO-4) (UNEP, 2007) have to be linked to local storylines.

In order to evaluate farmers' contribution to the landscape, adoption of rural activities need to be studied in a spatially explicit way. Tools to visualize farmers' decision-making at the landscape scale exist, such as spatially explicit agent based modeling (Happe *et al.*, 2006; Dalgaard *et al.*, 2009; Piorr *et al.*, 2009; Valbuena *et al.*, 2010c), spatial micro-simulations (Hynes *et al.*, 2009) or spatially explicit econometric models (Stoorvogel *et al.*, 2004), but these mainly focus on agricultural production. Chapter 3 developed a simulation procedure that visualizes farm diversification using spatially explicit econometric models. This procedure allows us to predict the spatial distribution of farm diversification under different scenarios.

The objective of this chapter is to develop a methodology to describe scale consistent landscape scenarios and to apply this method to assess the spatial distribution of farm diversification under various explorative scenarios. The methodology is applied to the Arkemheen Eemland National Landscape, a landscape dominated by agriculture in the Netherlands. Scale-consistent storylines are developed by combining global GEO-4 storylines with local storylines. Subsequently these storylines are translated into quantitative scenarios and introduced into a spatially explicit simulation procedure for farm diversification. Spatial distribution of farm diversification is visualized for each of these scenarios and discussed.

4.2 Study Area

4.2.1 Land use and related landscape functions

The Arkemheen-Eemland is an area of 125 km^2 located in the centre of the Netherlands (Figure 4.1). The area is dominated by peat soils (45%); clay soils (25%) and sandy soils (15%) (Stiboka, 1969). Land use is dominated by grassland (85%) that is mainly used for dairy farming. Most of the current landscape characteristics and landscape functions are closely connected to extensive agricultural practices. The landscape supports various landscape functions including the habitat for meadow birds, cultural heritage, recreation and education of citizens about culture (NLAE, 2007). Except for Bunschoten, most of the built-up areas are found near the borders of the area. The city of Amersfoort is the largest close-by residential area and has been expanding rapidly over the past years. As a consequence, pressure to transform agricultural land into residential areas has increased. Additionally, the area is increasingly regarded as a recreational area for residents in the region (Anonymous, 2008).

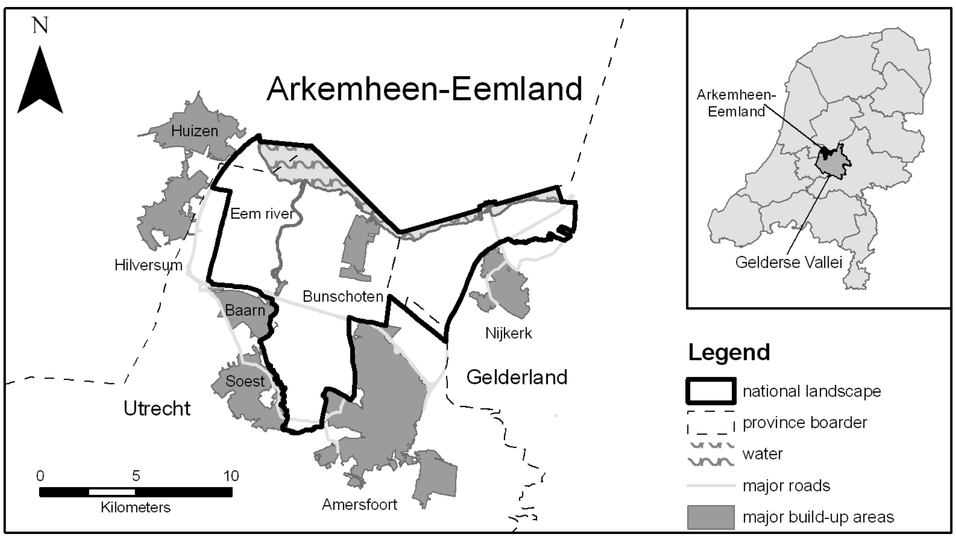

Figure 4.1: The study area Arkemheen-Eemland with major built up areas

4.2.2 Governance

The western part of the study area (Eemland) is part of the province of Utrecht, while the eastern part (Arkemheen) belongs to the province of Gelderland. The study area falls under different national and international regulations. Arkemheen and its surroundings around the firth of the river Eem fall under the EU directive for wild birds habitat protection (European Union, 1979). The protected area in Eemland belongs to the Dutch Society for Nature Protection, while Arkemheen belongs to the State Forestry Service. These organizations own the land and lease it to farmers with restrictive conditions allowing to implement a suitable management of habitat for meadow birds. Because of the particular importance for Dutch cultural heritage, Arkemheen-Eemland became a National Landscape, in which key landscape qualities must be maintained. These qualities include the openness of the landscape, the historic parcellation pattern and the character of a peat landscape (SVGV, 2006).

In order to enable bottom-up policies, a commission has been established that involves representatives of governmental organizations, agricultural organizations, nature conservation organizations and of the regional Waterboard (NLAE, 2007). Its objective is to facilitate projects that contribute to the maintenance and development of the area.

4.3 Methods

4.3.1 Simulating spatial patterns of on-farm activities

Chapter 3 developed a methodology that predicts spatial patterns of adoption of on-farm activities like agri-environmental schemes, recreation and short supply chains. The methodology makes use of micro-econometric models describing the adoption of these rural activities on the basis of farm-level data. The methodology can roughly be sub-divided into four distinct modules dealing with data collection, assessment of the micro-economic model, actual simulation and visualization of spatial diversification patterns (Figure 4.2).

A spatially explicit 2005 farm census of the Gelderse Vallei (Figure 4.1) (GIAB : Naeff, 2006) was combined with a GIS database with zoning plans, topographic and groundwater maps (module 1). Combining these datasets resulted in a dataset containing farm- and location characteristics. Data from the larger Gelderse Vallei region was used to estimate the econometric models to increase variability and introduce conditions that are not yet observed (such as intensive livestock) in the national landscape. This expands the possibilities to use the model for various scenarios. The dataset was the basis for the estimation of probit models of the adoption of agri-environmental schemes, recreation, and short supply chains (module 2). The choice of explanatory variables is based on an economic model in which farm households maximize their utility (Ellis, 1993; Sadoulet and de Janvry, 1995). The probit results are given in Table 3.1.

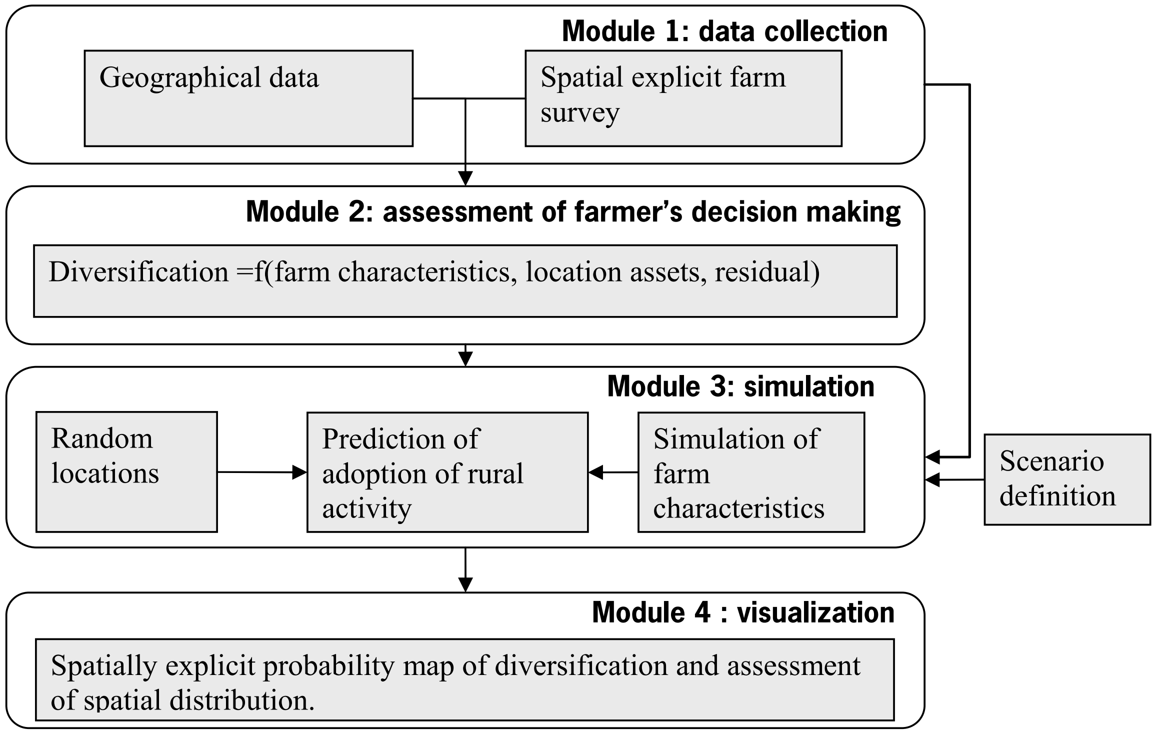

Figure 4.2: The simulation procedure for farm diversification

Within the simulation module (module 3), 3700 locations are randomly selected corresponding to the actual number of farms in the Gelderse Vallei in 2005. The base run in 2005 reproduces the actual spatial distribution of farm diversification. For each randomly selected location, farm characteristics and probit residuals are drawn from local distributions derived from focal statistics. Subsequently, probit models are used to predict the probability of adoption for each on-farm activity for each randomly selected point based on the simulated data. The probit residual is also simulated and explicitly introduced into the prediction in order to take spatial correlation into account (Pfeifer *et al*. 2010). In the last stage (module 4) the predicted probabilities are interpolated with an ordinary kriging procedure in order to visualize the spatial distribution of rural activities.

4.3.2 Defining coherent explorative scenarios for 2015

Scenarios can be developed with different degrees of stakeholder participation ranging from surveys to workshops depending on the objective of the study (Börjeson *et al.*, 2006). Surveys are usually used for predictive rather than explorative scenarios as the method limits creativity (Börjeson *et al.*, 2006). Workshops, on the contrary, generate the richest scenarios, and are chosen when the objective is to enable stakeholders to learn, to build a common vision, and to negotiate conflicting issues (Börjeson *et al.*, 2006; Volkery *et al.*, 2008). Workshops and surveys are relatively time consuming. Another method is the use of semi-structured interviews. This method is applicable when the study does not aim at interaction between stakeholders nor social learning or negotiation process, but at the creation of locally relevant storylines. This method is relatively fast and allows local and creative knowledge to contribute to the development of relevant explorative scenarios.

Semi-structured key informant interviews

The major stakeholders for the study area were identified by the commission for the National Landscape. Key informants (KI's) were identified who represented the State Forestry Service, the Waterboard, the Dutch Society for Nature Protection, the Landscape Fund, the province of Utrecht, the municipality of Bunschoten, real estate developers, the Governmental Agency for Land and Water Management as well as citizens. Semi structured interviews yielded their perception and vision on the National Landscape Arkemheen Eemland.

The interview consisted of two parts. The first was structured and aimed at cross checking hypotheses about the area identified through governmental publications. The second part of the interview was semi-structured, allowing new issues to come in. The interviewed person was asked to name the most important landscape functions in the area as well as their personal vision about the preferred use of the area. The interview was organized around functions identified in the vision of the National Landscape: nature, agriculture, recreation, cultural heritage, dwelling and water (NLAE, 2007). For each function, various present and future dimensions were addressed (Table 4.1).

Table 4.1: Landscape functions and their dimensions addressed during the semi-structured part of key informant interviews in the Arkemheen-Eemland national landscape.

Landscape function	*Dimensions addressed*
Agriculture	Current agricultural systems
	Drivers for changes in the agricultural systems
	Visual impact of change in agricultural systems
Nature	Definition and classification of nature areas
	Potential multifunctional use of nature areas
	Efficiency of current policy tools
	Societal willingness to pay for green services
Recreation	Entrepreneurship in the area
	Current and future role of recreation
Water	Current and ideal water management
Cultural heritage	Importance of cultural heritage and local identity
Dwelling and infrastructure	Current and expected population dynamics
	Current and expected economic evolution of the area

Downs-scaling global storylines

The semi-structured interviews resulted in KI storylines with emphasis on different dimensions of the various landscape functions. Some KI storylines can be combined resulting in a local storyline with a specific emphasis on one or two landscape functions. Each local storyline must be linked to specific global storylines that are developed in the Global Environmental Outlook (GEO-4 : UNEP, 2007). These global storylines that have been downscaled to the European level, giving a time consistent picture on how Europe looks like in 2015, 2032 and 2050 (Kok *et al.*, 2008). The following five storylines, using KI interviews and GEO-4 storylines could be identified:

I. *Market first* is a storyline in which markets are further globalized. In Europe there is growing demand for food resulting in intensification of agriculture towards 2015.

II. *Security first* is a storyline in which security overshadows all other values.

III. *Policy first* is a storyline in which environmental issues are addressed globally, with stronger coordinated policies by 2015 in Europe. Total amount of agricultural subsidies are reduced but farmers in less favored areas receive subsidies to maintain cultural heritage and biodiversity.

IV. *Sustainability first* is a storyline where a general bottom-up change towards sustainable behavior is observed. Actors at all levels and sectors will constructively work together. In Europe, agricultural subsidies are removed and replaced by payments for environmental services. This storyline is based on local development in the sense that behavioral changes are driven from bottom-up local initiatives.

V. G*lobal sustainability* (V) is a storyline in which global institutions set the environmental target, counting on strong local initiatives and local communities to implement local solutions. This is the case, as pointed out by Kok and Alcamo (2007), when strong global institutions coordinate local initiatives.

The specific implications for the National Landscape of each of the 5 scenarios were evaluated using the information of the key informants.

Introducing storylines into the simulation procedure

The storylines must be quantified and translated into model parameters to be used within into the simulation procedure. Two different types of changes can be modeled within the simulation procedure: uniform changes affecting the whole farm population and spatially explicit changes affecting farmers in certain locations only (Chapter 3). To quantify changes that affect all the farmers uniformly, scenarios can be quantified on the basis of observed statistical trends, expert and KI knowledge, as well literature in order to quantify credible changes. For spatially explicit changes, future zoning plans, policy documents and KI knowledge can be used.

4.4 Results

4.4.1 Schematization of KI storylines

The semi-structured part of the interview allowed for the ranking of landscape functions by considering the order in which the functions have been mentioned and the emphasis a given function was giving by a KI (Table 4.2).

Firstly, all KIs mentioned dwelling and infrastructure as important function of the area mentioning the planned growth of Amersfoort. Secondly, none of the stakeholders mentioned cultural heritage as a function but more as a *"raison d'être"* of the area. Thirdly, stakeholders 1, 2, and 4 have mentioned a high correlation between the nature and water function in the area. Therefore, these two functions are taken together. The various KI storylines differ mainly for three landscape functions: recreation, agriculture and nature/water. Four different local storylines can therefore be identified depending on which of these 3 functions has been stressed: i. nature/water (KI 1 and 2) ii. agriculture (KI 3) iii. agriculture and nature/water (KI 4 and 5) and iv. recreation and nature/water function (KI 6, 7 and 8). KI 9 mentioned that all functions were equally important (Table 4.2).

Table 4.2: Key informant (KI) prioritization of landscape functions for the Arkemheen-Eemland national landscape (++ priority, + important, – less important, and 0 not mentioned; prioritized functions in grey)

KI	Dwelling & infrastructure	Nature/ Water	Agriculture	Recreation	Cultural heritage
1 : State Forestry Service	+	++	-	-	0
2 : Dutch Society for Nature Protection	+	++	-	-	0
3 : Municipality	+	-	++	-	0
4 : Governmental Agency for Land and Water Management	+	++	++	-	0
5 : Landscape Fund	+	++	++	+	0
6 : Waterboard	+	++	0	++	0
7 : Real estate developer	++	+	0	++	0
8 : Citizen of Amersfoort	+	++	0	++	0
9 : Province	+	+	+	+	0

4.4.2 Local storylines and their translation into quantitative scenarios

The link between local storylines and GEO-4 storylines based on landscape function prioritized and major assumptions is shown in Table 4.3. Focus on agriculture corresponds to the storyline *market first* (I) assuming trade liberalization. Focus on nature/water function corresponds to the *policy first* (III) storyline assuming strong regulation. Focus on the combination recreation and nature corresponds to a *sustainability first* (IV) storyline based on the assumption of an increased bottom-up farmer-citizen relationship and finally the focus on the combination of agriculture and nature/water corresponds to a *global sustainability* (V) storyline based on the assumption of a fundamental mental change, where governmental organizations and farmers cooperate. The *security first* (II) global storyline could not be linked to any of the local storylines.

In order to quantify these storylines, observed statistical trends from Dutch national farm statistic, expert and KI knowledge from the interviews, as well governmental documents from the area, have been used to define credible changes.

Table 4.3: linkage between global and local storylines for the Arkemheen- Eemland national landscape

	Local storyline	*Landscape function prioritization*	*Assumption of the local storyline*	*Global storyline*
I	*Coping with international markets (KI 3)*	Agriculture	Trade liberalization	Market first
II	-	-	-	Security first
III	*Meadow birds above all (KI 1,2)*	Nature/water	Strong regulation	Policy first
IV	*Towards a consumptive landscape (KI 6, 7, 8)*	Nature/water-Recreation	Strong bottom-up citizen-farmer relation	Sustainability first
V	*Cooperation for the better (KI 4, 5)*	Agriculture-Nature/water	Mental change for strong cooperation	Global sustainability

Base run for 2015

Because the aging of the farmer population is not a uniform process through the whole area, a base run in 2015 that models farm life cycle needs to be evaluated. The trend observed between 1999 and 2005 in the Gelderse Vallei region suggests that average age of heads of farm increases by 2.1 years over 10 years over the whole farmer population. Life cycle analysis shows that the farmer population rejuvenates when younger farmers are coming in replacing old farmers. Following the trend between 1999 and 2005, 45% of the head of farms will exit over the next 10 years of which 70% are taken over by younger farmers. To model the average increase over the distribution of the whole farmer population, the average age of head of farms of was increased by 10 years for a random selection of 55% of the farms. For all other farms the average age of the head of farm was decreased by 7.5[7] years assuming a take-over by younger farms resulting in an increase of average age of heads of farm of 2.1 years over the whole farmer population in the area. Table 4.4 shows how the base run 2015 and the different storylines have been translated into scenarios for the simulation procedure.

[7] computed as follows [2.1years-55%*10years]/45%=-7.5 years

Table 4.4: Translation of scenarios into model parameters for the scenarios in the Arkemheen-Eemland national landscape.

Scenario	Base run	coping with internation al markets	meadow birds above all	consuming the landscape	cooperation for the better
Farm household characteristics					
Farm takeover	45%	45%	30%	60%	30%
Maximum education					+1
Participation in environmental cooperatives		- 50%		+100%	+300%
Labor input					
Households with off farm income		+11%		-10%	
Number of heads of farms		+6%		+10%	
Farm production characteristics					
Livestock intensity		+20%	-20%		-10%
Land based size farms		+30%			
Farms with organic agriculture		- 70%	+20%		+20%
Economic size of arable farm		+23%			
Economic size of fruit farm		+88%			
Economic size of grazing animal farm		+ 60%	-30%		-10%
Economic size of mixed farm		+39%			
Site-specific characteristics					
Groundwater level			+ 20 cm		
New eco-neighborhoods					Yes
Expansion of Amersfoort		Yes	Yes	Yes	Yes

Coping with international markets (I)

In this storyline, agricultural subsidies will be drastically reduced by 2015 in Europe. The world demand for dairy products grows due to the demand from developing countries (FAO, 2006; OECD-FAO, 2008). As a result farmers will intensify to stay competitive in the world market. Farmers grow in terms of economic size and land size. For this scenario, aging of the farm population is modeled similarly to the base run. The probability of head of farms working off-farm increases by 12 %. This corresponds to the trend in the Gelderse Vallei between 1999-2005 (Naeff, 2006). It is also assumed that farmers give less importance to environmental issues and don't participate in environmental cooperatives. A decrease of 40% of the probability of joining an environmental cooperative has been assumed (trend in the Gelderse Vallei between 2003 and 2005). Intensification of farming has been modeled with a 20% increase of livestock units per hectare and a 5 ha increase of farm land has been assumed based on the national trend observed between 2005-2007 (Martins, 2008). Due to this intensification, fewer farmers produce organically certified products. This is modeled with a 70% decrease of the probability to be organic and corresponds to the level of organic production of 1999 in the Gelderse Vallei (Naeff, 2006). The economic sizes of the farm have been extrapolated to 2015 based on the national trend observed between 1990 and 2007 (LEI, 2008). Finally, like for the other scenarios (except the base run) , the city of Amersfoort has extended towards the limits of the National Landscape as shown in Figure 4.3 based on the zoning plans.

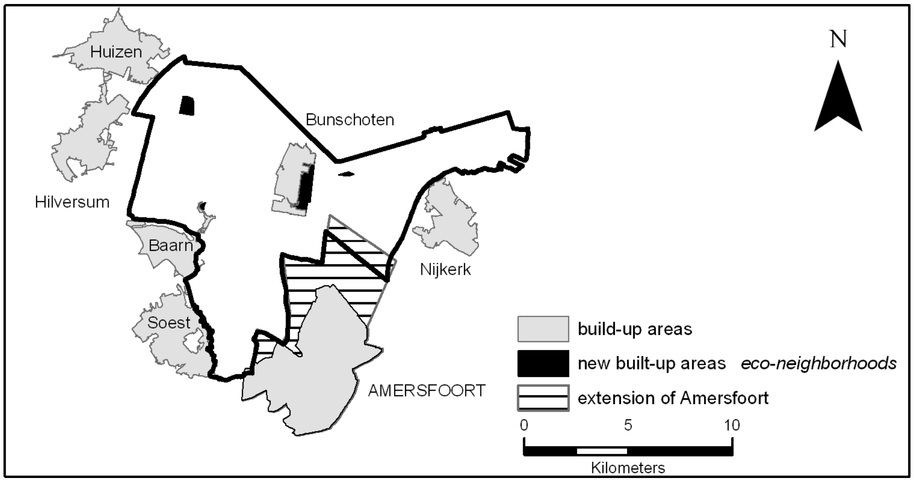

Figure 4.3: Possible extension of built-up areas and new developments (eco-neighborhoods) in the national landscape of Arkemheen-Eemland

Meadow birds above all (III)

For this local storyline, it is assumed that the State Forestry Service and Dutch Society for Nature Protection will implement the optimal habitat for meadow birds by increasing ground water levels. Subsidies are made available by 2015 for paying farmer to steward the landscape in Arkemheen-Eemland. Farmers farm extensively, mainly organically, the economic size of dairy farming is reduced and many members of the household work off farm. Quantitatively, this scenario foresees an increased probability of organic production by 20%, corresponding to a slight increase compared to the stagnation of the number of organic farms in the Netherlands since 2003 (Biologica, 2009). The average ground water level is assumed to increase by 20 cm. Young farmers are more reluctant to take over farms and only 30% of the farms are taken over compared to 45% observed between 1999 and 2005 in the Gelderse Vallei. Finally, we assume a decrease of economic value cattle farming of 30%, corresponding to a plausible yet important loss compared the trend used in the previous scenario.

Towards a consumptive landscape (IV)

In this storyline, the landscape is a consumption good. Due to the growth of the city of Amersfoort, more people come to the area and the demand for rural services increases. Farmers become rural entrepreneurs and provide on-farm shops, care or education services, on-farm cafés or bed and breakfasts. Income from diversification and agri-environmental schemes are sufficient and no intensification takes place. Innovative and well skilled young people take over the farms. Translation into the simulation model implies a higher rate (60 %) of farms that are taken over by 2015. More farmers are member of one or two already existing environmental cooperatives and work together with the State Forestry Service and the Dutch Society Nature Conservation, resulting in a doubling of the participation in environmental cooperatives. Moreover, average number of head of farm increase by 10% and the number of head of farms with main other occupation decrease by 10% in order to have sufficient on farm labor for diversification. Land size, economic size, probability for organic agriculture and intensity are unchanged.

Cooperation for the better (V)

Cooperation for the better is a storyline with new forms of cooperation between government, farmers and citizens. Consequently, new forms of institutions allow increased payments for farmers to maintain the landscape. In this frame, the prohibition to construct within the National Landscape is relaxed. On past industrial areas, and on locations where farmsteads are abandoned, new small eco-neighborhoods are created (2-10 houses) where a landscape tax is raised. These new funds and governmental funds are given to a newly created commission for the preservation of meadow birds in which all the major stakeholders are represented. An optimal habitat for meadow birds can be created without changing ground water level as diversity in pastures is reached with a coordinated and diversified use of fertilizer (mentioned by KI 4). Due to the high level of subsidies made available, more farmers decide to produce more extensively and therefore the economic size and livestock intensity reduce by 10%. Organic production increases by 20% similarly to the meadow bird above all scenario, and education by one unit on the education scale (each unit represents one achieved level of education in the Dutch education system). The probability to join an environmental cooperative in such a way that 90% of the farmer participate (implying a 300% increase of the probability of participation).

Farm take-over is modeled similarly to the *meadow birds above all* scenario. Finally the eco-neighborhoods have been introduced as mentioned by KI 5 as extensions of built-up area (Figure 4.3).

4.4.3 Results of modeled scenarios

Base run in 2015

Figure 4.4 shows the spatial distribution of the base run in 2015 for agri-environmental schemes, recreation and short supply changes (upper part), as well as the respective change between 2005 and 2015 due to ageing of the farmer population (lower part). It shows that in 2015 most of Arkemheen Eemland has a rather high take-up of agri-environmental schemes except for the border areas. Recreation takes place mainly in the south of the study area, while short supply chains are important next to major agglomerations. The spatial distribution of recreation and short supply chains is almost unchanged in 2015.

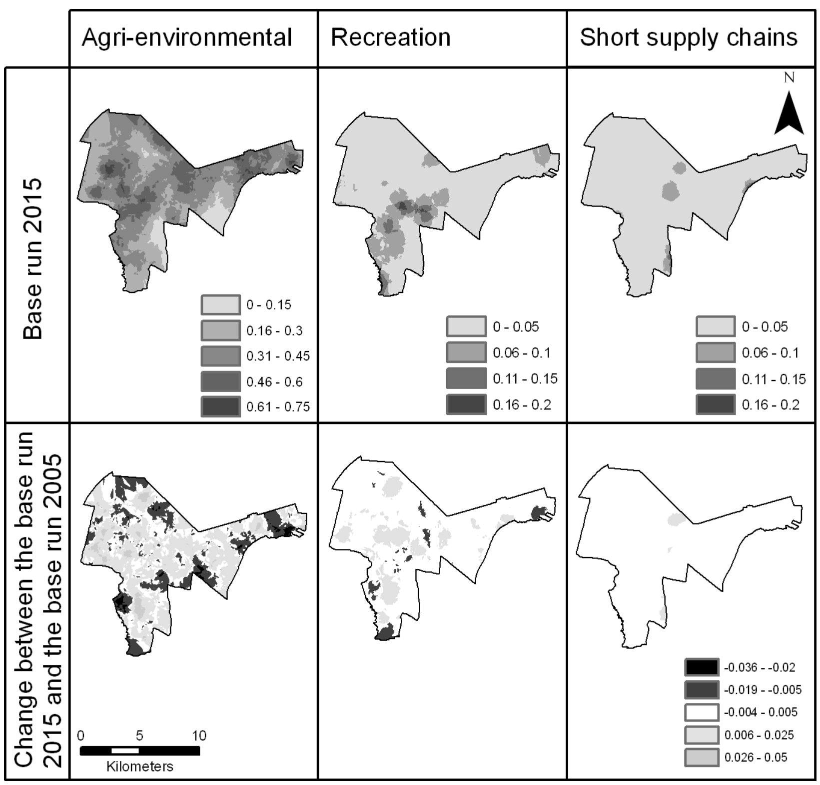

Figure 4.4 : Spatial distribution of the probability of farm diversification in 2015 and changes compared to the base run in 2005 in the national landscape of Arkemheen-Eemland

Cope with international markets (I)

Figure 4.5 shows the changes of probabilities of farm diversification respective to the base run 2015, for agri-environmental schemes, recreation and short supply chain for each scenario. The first column refers to the changes for the scenario I. Agri-enviromental schemes strongly decrease in the whole area driven by the intensification of farming, and the decrease in organic farming. The changes are more pronounced on locations where involvement in agri-environmental schemes takes place for the base run 2015. Recreation strongly decreases driven by farm intensification on locations where the base run 2015 predicted a high adoption. Only a small spot in the east has a slight increase of recreation. Finally, the amount of short supply chains increase where short supply chains could be observed in the base run of 2005.

Meadow birds above all (III)

Changes for scenario III are shown in the second column of Figure 4.5. Agri-enviromental schemes increase in Arkemheen, where also the EU bird directive is in force. In addition, the south of the study area also experiences an increase in the take-up of agri-environmental schemes, while some spots in Eemland show a decrease: the most northern part of decrease lies within the EU bird directive boundaries. The observed pattern is a result of increased ground water, extensification of agriculture, more organic agriculture and aging farm of the population that negatively impacts the take-up of agri-environmental schemes. Furthermore recreation decreases in the center of the area. Finally, the adoption of short supply chains decreases near to Amersfoort, Nijkerk and Soest. In this scenario, recreation increases in the west of the area, which is less affected by the growth of the city of Amersfoort. In those locations, the take up of agri-environmental schemes has the tendency to decrease, suggesting that there might be a trade-off between agri-environmental schemes and recreation.

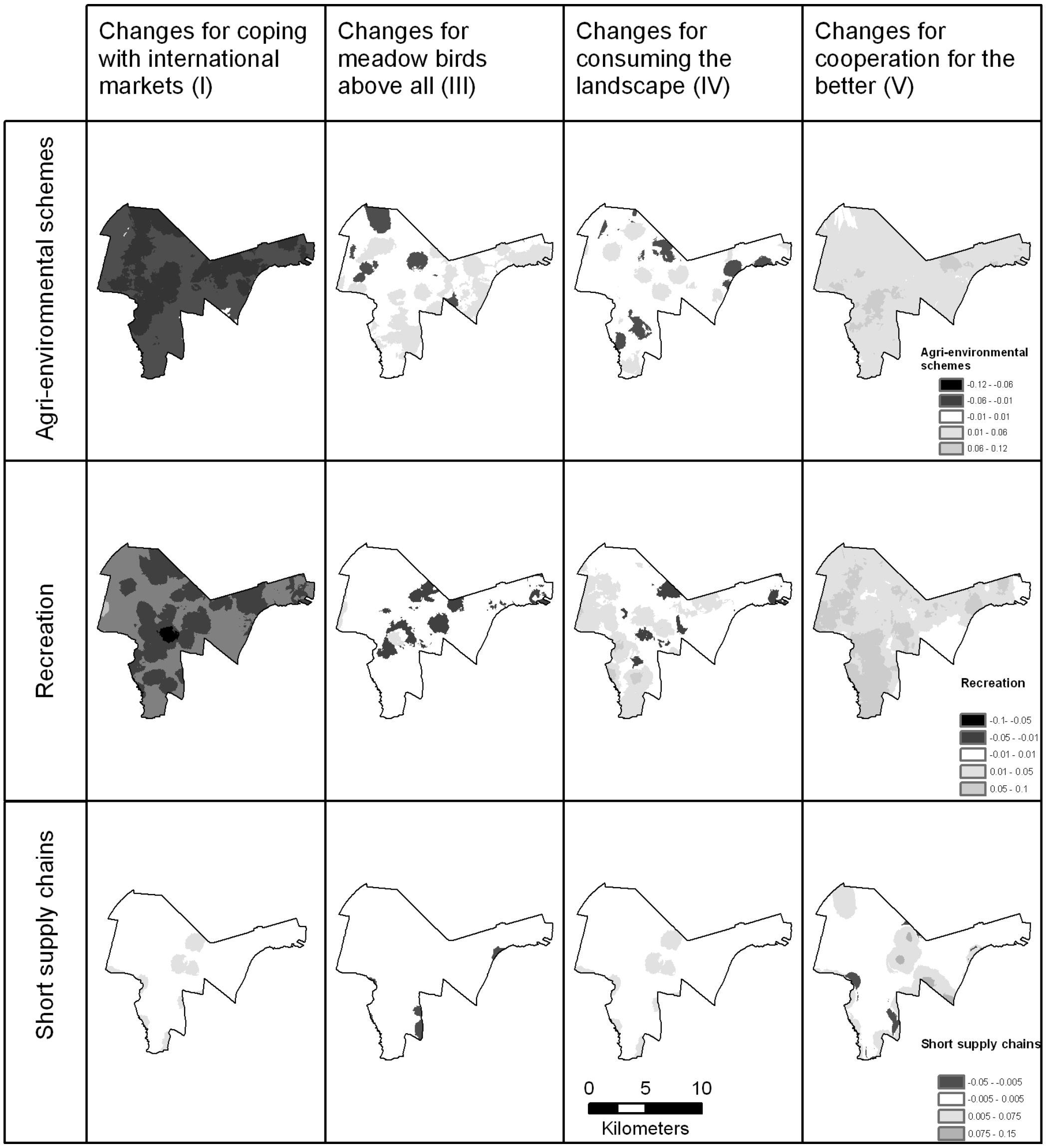

Figure 4.5: Changes in the probabilities for farm diversification in the Arkemheen-Eemland national landscape respective to the base run for each of the 4 scenarios

Consuming the landscape (IV)

Changes for scenario IV are shown in the third column Figure 4.5 and show that patterns of the adoption of agri-environmental schemes remain the same compared to the base run: some parts in the area have an increased take up of agri-environmental schemes whereas others have a decrease, also in the Arkemheen part that falls under the EU habitat directive. Recreation increases mainly in the western part of the area, where no city growth has been assumed. Finally short supply chains increase on the already predicted location in the base run 2015, driven by the lower aging of farm population.

Cooperation for the better (V)

Changes for scenario V are shown in the last column of Figure 4.5. The maps show an overall increased take-up of agri-environmental schemes within the whole region, driven by extensification of farming, increased organic agriculture and lower average aging of the farm population. Recreation increases almost in the whole area but mostly in the center of the area. Only the surroundings of Amersfoort, where the impact of city growth is more important than agricultural extensification, increased organic production and participation in environmental cooperatives remains unchanged.

4.5 Discussion

Coping with international markets (I) and cooperation for the better (V) are two extreme and opposed scenarios. In the first one, the diversification decreases as a result of intensification, whereas in the second one diversification increases through better cooperation allowing to exploit synergies through the participation in environmental cooperatives.

The two other scenarios, meadow birds above all and consuming the landscape, give a more differentiated picture. For both scenarios the agri-environmental reduce in some parts of the EU habitat directive areas. This suggest that strong top-down approaches or self-organizing bottom-up approaches neither allow to reach a suitable habitat for meadow birds, which only can be reached with cooperation between the different stakeholders. Indeed, evaluations of the agri-environmental schemes in the Netherlands indicates that the uptake of agri-environmental schemes in 2000 and 2005 was not sufficient to create a suitable habitat for meadow birds (Kleijn *et al.*, 2004; Wiertz and Sanders, 2007). Short supply chains are only weakly influenced by the different scenarios, with the exception of the cooperation V, where relaxing the existing construction prohibition allows the creation of a new markets for local products.

The scenarios visualize the contribution of farms to the landscape functions by computing a probability to diversify. The approach does not take into account that some of the rural services (for example recreation) can be provided by other actors in the region. Moreover, the used approach also excludes the rural services that are externalities of agriculture. Some of these services are in fact ecosystem services enhanced by farmers (Antle and Stoorvogel, 2006). Few studies have looked at the provision of this type of goods and services. One exception is Antle and Stoorvogel (2008) who investigate agricultural carbon sequestration in soils by coupling spatially explicit disciplinary data and models from environmental sciences and economics to simulate the farming system. Adapting the simulation procedure used in this chapter to model indirect rural services could be an interesting future extension to support the discussions about multifunctional agriculture and land-use in Europe (Slangen *et al.*, 2010).

Finally, four methodological issues are worth mentioning. Firstly, the elaboration of the local storylines has been based on key-informant interviews. In this manner local expert knowledge can be taken into account. The approach does not allow for the identification of inconsistencies, negotiate or be part of learning process as it would be the case with a participatory stakeholder workshop (Alcamo *et al.*, 2006; Westhoek *et al.*, 2006; Pahl-Wostl, 2008). In the particular case of Arkemheen Eemland, the negotiation and learning process took place prior to the study when the vision for the National Landscape (NLAE, 2007) was elaborated and therefore the use of a more participative approach would probably lead to similar results. Indeed, during the interviews some of the stakeholders have mentioned that their storylines are in accordance with the results of negotiation processes with other stakeholders.

Secondly, the GEO-4 storylines are developed on the global and continental scale. Consequently drivers from national and provincial scale have not been considered. To introduce these scale levels, key informants at that level will need to be included.

Thirdly, the local storylines have been translated into model parameter by using trends, expert knowledge and hypothesis that result in plausible changes. From this perspective, the results presented in this chapter are illustrative allowing to explore different future rather than a prediction of rural services supplied by farmers. Another way to define the scenario parameter is the SAS (story and simulation) approach that link qualitative and quantitative storylines (Alcamo, 2008). It is an iterative procedure between experts who quantify the storylines and stakeholders who adapt the storyline and comment the quantification based on the results presented by the experts. Such an approach could easily be implemented for the approach presented in this chapter when a more participatory approach to scenario development is chosen.

Fourthly, simulating and visualizing famers' decision making based on a micro-economic model, raising a number of technical issues among others connected to the modeling of farmers' heterogeneity. Chapter 4 discusses the technical choices that are implicitly made by using the simulation procedure applied in the current chapter.

The current chapter is a first attempt to investigate quantitatively explorative rural development scenarios that are specific to the characteristics of the area in a spatially explicit way. The result identifies a "window of opportunity" within which changes can take place as well as important drivers behind changes. The downscaling procedure of large scale scenarios is a novel way to insure a plausible quantification of the storylines. KIs may have utopian visions on the evolution of the area and therefore arguments in their storylines might be contradictory and lead to unrealistic and implausible quantification. The downscaling procedure from the large scale storyline based on the major assumption in fact allows to address contradictory arguments within KI storylines, by enforcing the remaining assumptions from the large scale storyline on the unrealistic assumptions of a KI.

4.6 Conclusion

This chapter is a first attempt to investigate the future of rural areas at a landscape scale, by assessing the distribution of farm diversification under different explorative scenarios. Scale-consistent scenarios have been developed by combining large scale scenarios from literature with key informant storylines. This approach allows us to identify the area specific conditions under which it might be difficult to reach the societal objectives. Therefore, it enables local policy makers to understand better where farmers contribute the functions of agricultural landscapes.

For the Dutch landscape Arkemheen Eemland, we found that further market liberalization leads to a decrease of rural services, most obviously for the uptake of agri-environmental schemes. Furthermore, a strong top down-policy, or self-organization of local initiatives neither can support farmers in such a way that the provision of direct rural services are sufficient to achieve societal demands for a consumptive countryside, and more particularly to comply with EU directives. Only increased cooperation between government, farmers and citizens appears to enable to create conditions in which farmers can continue to support the uptake of agri-environmental schemes, recreation and short supply chains.

Chapter 5

Spatial spillovers in rural areas: the role of positive externalities in farm diversification[8]

Abstract

A farmer diversifying into non-food activities might reduce the cost of diversification for neighboring farms. The objective of this chapter is to test whether these spillover effects lead to a clustering of diversified farms. A farm household utility maximization framework allowing for externalities of diversification is developed and empirically tested with a spatial autoregressive probit model using a Bayesian estimation approach. Results show that diversified farms cluster near to attractive landscapes, distant from big cities, and at locations with low soil quality. Moreover, farmers located in a diversified neighborhood have a higher probability to diversify, confirming the spillover hypothesis.

[8] Pfeifer C., Jongeneel R.A, Stoorvogel J.J, submitted to *European Review of Agricultural Economics*

5.1 Introduction

Over the last 20 years a new societal demand for rural areas has emerged as a whole range of alternative rural services next to the traditional agricultural production receives increasing attention (Overbeek, 2009). The resulting rural area is sometimes referred to as a consumptive countryside (Marsden, 1999) or an area with a post-productivist or multifunctional regime (Cloke and Goodwin, 1992; Wilson, 2001and 2009). Simultaneously, the European common agricultural policy (CAP) has undergone various reforms (Ackrill *et al.*, 2008, pp. 175-178). Since the 2003 Fishler reform, subsidies are increasingly decoupled from production (EC No 1782/2003) and emphasis is put on rural development (OECD, 2009; Klug and Jenewein, 2010). Moreover the 2008 Health Check of the CAP implied a transfer of additional money from the first pillar to the second pillar, *i.e.*, the EU's rural development policy (RDP). Two of the three main thematic axes of the European Rural Development Program, namely improving the countryside and diversification of the rural economy) aim at supporting the alternative rural services (European Union, 2005).

Though farmers are not the only stakeholder in rural areas, they nonetheless stay one of the most important actors. In their role as users and managers of the land, they can diversify and supply a whole range of rural services. Farm diversification is here defined as the on-farm generation of income from other sources than traditional agricultural production, namely food, feed and fibers (Meert *et al.*, 2005). Farm diversification is here understood to be the allocation of a farm specific resource to alternative activities (Meert *et al.*, 2005) also referred to as rural activities. Strategies and service supply of farmers can be extremely varied. Examples of alternative activities that can be supplied on-farm are recreational activities (*e.g.,* bed and breakfast, renting out of bikes), care services (offering assisted day care to people with special needs), short supply chains (on-farm shops and home delivery) or on-farm processing. In addition, farmers can diversify by participating in agri-environmental schemes (AES). AES are contracts through which the government financially compensates farmers for costs involved with more environmentally friendly farm management and the associated production of green services (Peerlings and Polman, 2004).

Insight in the drivers behind farm diversification is a first prerequisite for efficient policies focusing on rural services. Most approaches explaining farm diversification are based on farm production and household characteristics (Fleming and Lien, 2009). Only a few approaches looked at site characteristics and the role of external economies of scale (Van Huylenbroeck *et al.*, 2007; Wilson, 2009). Chapter 2 shows that a diversified farm might result in spillover effects. In other words, farm diversification tends to cluster. This might result from externalities from a diversifying farmer affecting the cost of diversification for neighboring farms. Moreover, interactions between services can generate positive (and potentially also negative) spillovers. For example, the adoption of an agri-environmental scheme might increase the attractiveness of a landscape for recreational activities. Subsequently, recreational activities as well as care services may attract more people to rural areas creating a market for on-farm shops. An individual farmer will take these positive externalities into consideration for his own decision to diversify. Consequently, these spillover effects may result in clusters of diversified farms: "hotspots of diversification".

So far, these spillover effects have not been analyzed empirically. The objective of this chapter is to empirically test whether these spillover effects play a role in the Gelderse Vallei in the center of the Netherlands (Figure 5.1). We developed a farm household utility maximization framework allowing for externalities of diversification. Subsequently, the derived equation for farm behavior explaining farm diversification is empirically estimated in the context of a spatial autoregressive model with different specifications of the spill over effect. The result section discusses drivers of farm diversification as well as the extend of the spill over.

5.2 Materials and Methods

5.2.1 Study area

The Gelderse Vallei (Figure 5.1) is a diverse region with a high pressure from urban and rural development. Cities such as Utrecht and Amersfoort do not only grow towards the rural area, but their residents also create an increasing demand for recreation, care and nature. As a result, the urbanization represents a threat for the rural area but it also creates opportunities for diversification. Agricultural systems in the Gelderse Vallei are diverse. The northern part, with poorly drained peat soils, is mainly used for dairy farming, while in the eastern part intensive livestock (mainly pig and chicken) farming prevails. The region borders two national parks on the push moraines (hills) covered with forest vegetation. These parks are accessible and are mainly used for outdoor recreation such as walking and mountain biking. In the North, the National Landscape Arkemheen- Eemland is a landscape for which the policy maker agreed to maintain three main qualities: an open landscape with presence of rare meadow birds, cultural historical proves of past water management system, and the inherent character of a peat landscape. In this area farmers can apply to special agri-environmental schemes aimed at the creation of meadow birds' habitat.

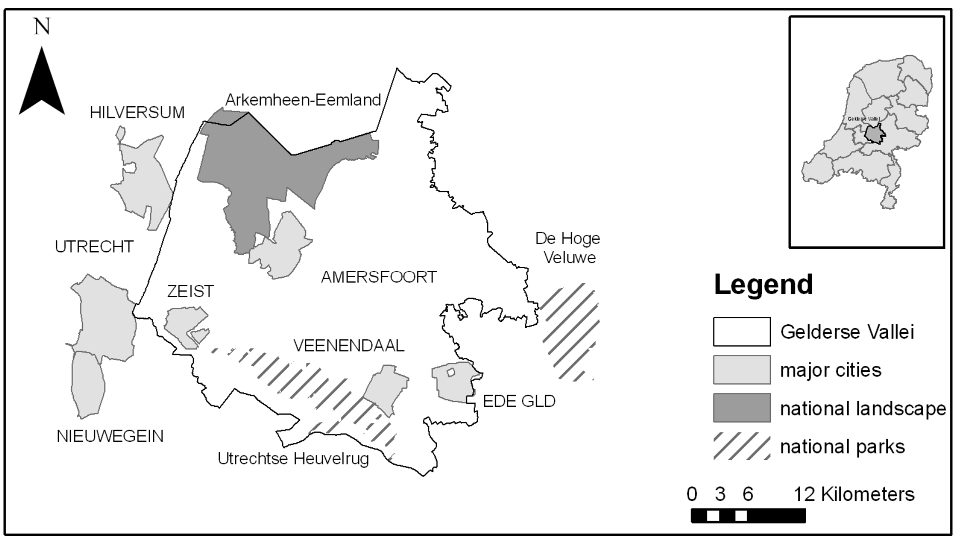

Figure 5.1: study area Gelderse Vallei (left) and the national landscape Arkemheen-Eemland with major cities (right)

5.2.2 Data

Geo-referenced farm data for the area are available through the Dutch farm census GIAB (Naeff, 2006). This dataset includes information about farm characteristics like farm size, farm specialization, number of children, education level, participation in environmental cooperatives (cooperatives that collectively apply for agri-environmental schemes) and organic production, but also has data on specific activities such the adoption of agri-environmental schemes provided by the Dutch government, care services, short supply chains, recreation, renting out of storage space, and alternative energy production (mainly solar and wind). The farm census data has been linked to topographic maps of the Netherlands (Stiboka, 1969 and 2000[a,b]), allowing to take site characteristics (*e.g.*, distance to the road, distance to national parks) into account. Farm diversification, defined here as adopting the alternative non-food activities mentioned in the survey, is shown in Figure 5.2. The Figure shows that the northern and western parts of the region are much more diversified than the eastern part.

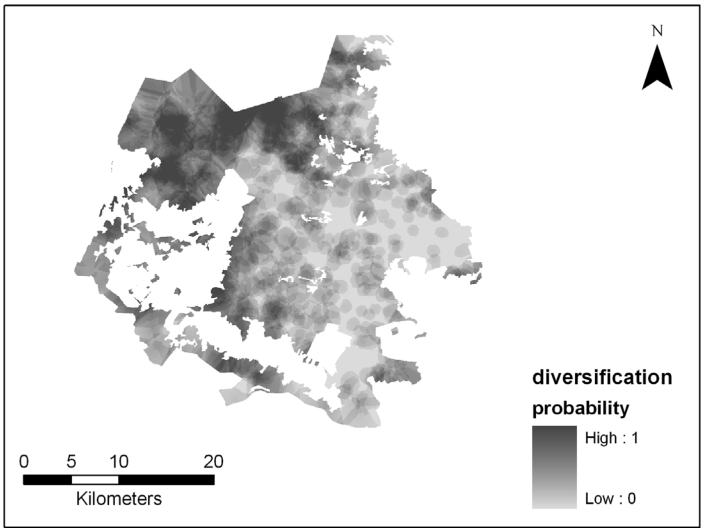

Figure 5.2: probability of observing farm diversification on agricultural land in the study area (based on an ordinary kriging (Cressie, 1986) with 15 nearest neighbors)

5.2.3 Theoretical model

Decision making about farm diversification can be modeled using a farm household utility maximization model (Ellis, 1993; Sadoulet and Janvry, 1995; Henning and Henningsen, 2007[b]). The farm household is assumed to make choices about the produced quantities of food, farm diversification, the allocation of labor, as well as the allocation of other inputs.

The farmer faces a utility maximization problem and maximizes a utility function *U(.)* subject to a number of constraints:

$$\max U = u(c_m, c_l | z_H) \tag{1}$$

where c_m is a composite consumption good, and c_l represents leisure time. The utility function is assumed to depend on a vector of farm household characteristics (z_H), which might include for example the life cycle stage and/or attitudes of the farm household.

Utility maximization is subject to a time constraint and a production technology *F(.)*, with the time constraint being:

$$l_f + l_o + l_a \leq T \qquad (2)$$

Where $l_i \geq 0 \forall i \in [f,o,a]$ $c_l \geq 0$ l_f is time allocated to food production, l_a is time allocated to alternative activities (farm diversification), and l_o is the amount of time allocated to off-farm activities. The time spent on various activities might not exceed the total number of hours available *T*. Moreover it is assumed that the farmer faces a well-behaved production technology *F(.)*, which in its most general implicit form may be written as

$$F(q_f, q_a, l_f, l_a, x_o, x_a | Z_F, S) = 0 \qquad (3)$$

The production technology links the output quantities q_f (food) and q_a (alternative output from farm diversification) to inputs, or more specifically to labor inputs l_f and l_a, variable production inputs x_a solely allocable to the alternative output and other non allocable inputs x_o, The technology is conditional on the level of farm characteristics z_F, such as quasi-fixed capital and land inputs, and spatial location *S*, which comprises location characteristics such as soil quality and proximity to cities. Note that the specification allows certain inputs to be directly linked to certain outputs (*e.g.*, x_a and q_a). Moreover, this multiple input-output technology allows for jointness of production, implying that the different outputs might not be independent of each other. Theoretically, jointness of production can have two different sources: technical interdependencies and non-allocable inputs (OECD, 2001). Technical interdependencies emerge through jointness in output and arise when the production function of alternative outputs depends on food output of the farm (Lau, 1972). Jointness due to non-allocable inputs refers to the case where the same non-allocable input is used for food production and alternative activities(Havlik *et al.*, 2005).

Finally the farmer's utility maximization is constrained by the following budget constraint:

$$p_f q_f + p_a q_a - C\ (r_o, r_a | q_f, q_a, h) + v + w_o l_o \geq p_m c_m \qquad (4)$$

where the left hand side represents the profit from on-farm activities and income from off-farm labor (l_o) with w_o being the off-farm wage. Profit consists of revenues from food production ($p_f.q_f$) where p_f is the price of food, revenues from diversification activities (p_a q_a) where p_a is the price of the alternative output, minus the costs associated with the production of food output q_f and diversification output q_a, plus income transfer v (*e.g.*, the single farm payments; cf. (European Union, 2003))[9].

Similar to the production technology, the cost function $C(.)$ is kept in its most general form and depends on input prices r_o and r_a associated with the use of inputs x_o and x_a. In addition, $C(.)$ is a function of an exogenous neighborhood effect h, which provides a measure for the number of diversified farmers in the neighborhood of the farm whose behavior is analyzed. The exact neighborhood specification will be discussed later. It is important to note at this stage that marginal costs of alternative output $C_a(.) = \partial C(.)/\partial q_a$ has no a priori sign. When it is non-increasing in h: $\frac{\partial C_a(r_a|q_a,h)}{\partial h} \leq 0$ then the marginal cost for diversification output for a given farmer might decrease when farmers in his neighborhood are diversifying. This effect might be due to several factors, such as network effects (*e.g.*, reduced transaction costs due to sharing of knowledge and information between neighboring farmers (Polman and Slangen, 2008), interaction effects (*e.g.*, a farmer starting up an on-farm shop or agri-tourism activities might profit from the landscape conservation activities generated by his neighbors (Pfeifer*, et al.*, 2009)), and other spillovers (*e.g.*, endogenous social norms, mimicking (Haagsma and Koning, 2005, Evans *et al.*, 2006). Alternatively, when $\frac{\partial C_a(r_a|q_a,h)}{\partial h} \geq 0$ then diversifying farmers are dispersing, which can be the result of local competition.

Finally, the budget constraint in equation 4 implies that income from on-farm and off-farm activities must be greater or equal to expenditure on consumption ($c_m p_m$).

Note that the general specification of the production and the cost functions including non-allocable inputs might give rise to economies of scope[10]. Indeed, it allows for the case in which it might be less costly to provide the alternative output in combination

[9] Whereas for convenience sake a fixed market price is attached to the alternative output, in reality the remuneration of the alternative output, might be a more complex function $p_a = R_a(q_a)$, with, for example, the remuneration being a function of the level of output or other variables such as location, input (hectares of land), etc. Cf. the case of alternative outputs having a public good character and being subject of certain government contracts, specifying various clauses and conditions.

[10] Economies of scope refer to cost savings which result from scope rather than scale. Economies of scope exist when it is less costly to combine two or more lines of production in one firm rather than to produce them separately. As such this concept should be distinguished from returns to scale.

with food production rather than providing the alternative output alone at some trajectory of the cost function (Panzar and Willig, 1981; OECD, 2008).

In more general terms it can be shown that the reduced form of food output and alternative output will be a function of output and input prices, as well as on off-farm wage, the neighborhood effect *h*, total available time *T*, exogenous transfers ν, farm household characteristics z_H, farm characteristics z_F, and farm location S.

$$q_f = g_f(p_f, p_a, r_a, r_o, w_o | h, T, v, z_F, z_H, S) \quad (5a)$$

$$q_a = g_a(p_f, p_a, r_a, r_o, w_o | h, T, v, z_F, z_H, S) \quad (5b)$$

Note that as usual output is none decreasing in own price, e.g. $\frac{\partial q_f}{\partial p_f} \geq 0$ and $\frac{\partial q_a}{\partial p_a} \geq 0$, and non-increasing in activity-specific input prices, e.g. $\frac{\partial q_a}{\partial r_a} \leq 0$.[11]

5.2.4 The empirical model

From the farm household model with positive externalities, the general form of the supply function for alternative output was derived (Equation 5b). Unfortunately, the available survey data only mention whether an alternative activity is adopted but does not provide information on the intensity of adoption. Therefore, a spatial autoregressive probit model specification (Anselin, 2006), which allows for introducing the spillover effect to explain farm diversification has been used. A probit specification makes use of a latent model, in this particular case, corresponding to the unobserved quantity of alternative output supplied and is given by

$$y^* = \rho W y^* + X\beta + \varepsilon \quad (6)$$

from which the reduced form

$$y^* = [I - \rho W]^{-1} X\beta + u \text{ with } u = [I - \rho W]^{-1} \varepsilon \quad (7)$$

can be derived. In Equation 6 and 7, y* is a vector containing the unobserved supplied quantities of alternative output for each of the n farmers, *X* a (*n* x *k*) matrix of

[11] In a household maximization framework with a multiple input output production function assuming jointness of production and separable consumption and production decisions, only the change of an output price and a solely allocable input price has a theoretically defined effect Henning, C.H.C.A., Henningsen, A., 2007. AJAE appendix: modeling farm households' price responses in the presence of transaction costs and heterogeneity in labor marketsavailable at http://agecon.lib.umn.edu .

explanatory variables comprising farm household and farm characteristics, site characteristics (*S*), and β is vectors of coefficients.

The selection of explanatory variables is based on Equation 5b. However, because the data set consists of cross-section data concerning a clearly defined region, variation of prices over farms is expected to be limited. An additional complication is that price data are often lacking. As such it was decided to leave price variables out of the *X* matrix. Total amount of labor has been approximated by the number of head of farms and farm characteristics by farm size (in hectare), and with a binary variable indicating whether farms are organic. Farm household characteristics have been introduced by including the average age of head of the farms, the level of education, and the participation in environmental farmer cooperatives. Participation in these cooperatives can be interpreted as a proxy measure for the social capital a farmer has, as well indicate his involvement in societal issues. The choice of site specific characteristics is based on the approach described in Pfeifer *et al.* (2009) and includes distance to cities, major roads, national park and national landscape as well as the ground water level, which could be computed for each farm. Unfortunately, no information was available about fixed cost, labor input, income generated and external transfers.

Finally, W is an a priori defined spatial contiguity or weighting matrix (n x n) taking neighboring effect (h) into account, with ρ being the autoregressive coefficient (Beron and Vijverberg, 2004; Anselin, 2006). The specification of the weighting matrix W imposes an explicit spatial structure to the model. There is little guidance from the literature in the choice of the structure of the weight matrix, which then needs to be specified depending on the specific assumptions that are made (Anselin, 2006). Point information is usually accounted for by applying a critical distance band and/or k-nearest neighbors criteria. A distance band weighting matrix implies that the influence of the neighborhood is limited to a fixed pre-selected band, whereas the k-nearest neighbor criterion implies that the distance band is different for each observation but takes an equal number of neighbors into account. The autoregressive coefficient ρ measures the magnitude of the neighborhood effect. A positive significant ρ coefficient suggests a clustering of diversified farms while a negative ρ coefficient suggests dispersion of alternative activities.

The binary observed outcome of the latent model is given by

$$y_i \begin{cases} 1 \text{ if } y_i^* \geq 0 \\ 0 \text{ if } y_i^* < 0 \end{cases} \tag{8}$$

The marginal probabilities for the i^{th} observation resulting from the spatial autoregressive probit model is calculated as

$$p(y_i = 1 | x_i) = p(u_i < \left[(I - \rho W)^{-1} X\beta \right]_i \ / \sigma_i) \tag{9}$$

where similarly to the standard probit model the right hand side probability is the systematic component of the latent variable $\left[(I - \rho W)^{-1} X\beta \right]_i$. The spatial lag $\rho W y^*$ introduces simultaneity into the latent model, leaving u distributed n-dimensional normal. As a result, the multivariate probit specification requires the integration of a joint distribution over the other n-1 dimensions. The computation of this integral is in practice not feasible with the classical maximum likelihood approaches (Anselin, 2006).

5.2.5 Estimating the empirical model

Various estimation techniques exist in order to address cases where the classical maximum likelihood approach cannot be applied. For the spatial autoregressive probit case in particular an estimator based on Bayesian Markov Chain Monte Carlo (MCMC) methods has been developed and programmed within the Spatial Econometrics Toolbox (www.spatial-statistics.com: LeSage and Pace, 2009). This algorithm overcomes the complication introduced by the n-dimensional integral for which no algebraic closed form solution exists. The Markov Chain Monte Carlo simulation method makes use of conditional joint distributions of the parameters of interest to be estimated. Draws from these distributions allow to reproduce samples with properties similar to the parameters of interest. Generating a sufficient (predefined) number of random draws from those distributions allows one to compute the statistics of all the parameters of interest. The simplest algorithm within the MCMC family, is the Gibbs-sampler. It draws a value for one given parameter conditional on the previous draws of all parameters of interests, based on the conditional joint distributions. Note that the Gibbs-sampler needs to be initialized. To avoid the influence of initial value-choices, the first 20 % of the draws are usually omitted, which is usually referred to as correcting for burn-in replications (Koop, 2003).

To derive the conditional posterior distributions of the spatial autoregressive probit model, the Bayesian estimation procedure requires prior densities for each parameter to be specified. For spatial probit models independent priors are usually assumed for β and ρ coefficients (i.e. $\pi(\beta,\rho)=\pi(\beta)\pi(\rho)$ where π stands for probability). β is usually assigned a normal prior $\beta \propto N(c,T)$ and ρ a uniform prior (LeSage and Pace, 2009). For this chapter uninformative priors have been specified following this standard practice. This implies that coefficient estimates are only data driven and not influenced by any believes based on past experiences. Based on these choices with respect to the priors, the following posterior distribution can be obtained (LeSage and Pace, 2009, p. 284):

$$p(\beta \mid \rho, y^*) \propto N(c^*, T^*) \tag{10}$$

where $c^* = (X'X + T^{-1})(XSy^* + T^{-1}c)$, $T^* = (X'X + T^{-1})^{-1}$, where $S = (I_n - \rho W)$ and $p(\rho \mid \beta, y^*) \propto |I_n - \rho W| \exp\left(\frac{1}{2}[Sy^* - X\beta]'[Sy^* - X\beta]\right)$. The distribution of y* follows a multivariate truncated normal distribution, which is given by

$$y^* \sim TMVN\{(I_n - \rho W)^{-1} X\beta, [(I_n - \rho W)'(I_n - \rho W)]^{-1}\} \tag{11}$$

(LeSage and Pace, 2009). It is not possible to sample directly from this distribution because the truncation bounds of this distribution depends on the value taken by *y*. To overcome this, Geweke (1991) proposed a procedure that builds up a truncated multivariate normal distribution based on the observed data using a Gibbs sampler. Details about this procedure can be found in Lesage and Pace (2009, pp 285-287).

The Gibbs sampler for the autoregressive probit estimation can be summarized in the following steps:

0. select initial values for ρ, and y^*, a number of replications and a number of burn-in replications;
1. draw β from $p(\beta \mid \rho, y^*)$ from its distribution given initial values (step 0);
2. draw ρ from $p(\rho \mid \beta, y^*)$ given the initial value (step 0) and β computed in step 1
3. draw y^* by :
    a. Applying the "Geweke procedure" for identifying the truncated distribution of y^* :

    $y^* \sim TMVN\{(I_n - \rho W)^{-1} X\beta, [(I_n - \rho W)'(I_n - \rho W)]^{-1}\}$

b. Drawing y* from $p(y^* \mid \beta, \rho)$ given β computed in step 1 and ρ computed in step 2 from the distribution identified in step 3a.

Steps 1 to 3 are repeated until the in step 0 predefined number of replications is reached. The probit parameters β and ρ are computed, while correcting for the burn-in replications.

5.2.6 Interpreting spatial autoregressive probit estimates

Marginal effects for a spatial autoregressive probit model feature two particularities: they contain spillovers between observations (farms) and are non linear. The spillover effects are related to the weighting matrix which captures the information about a pre-selected group of neighboring observations. This implies that a change in variable $x_{i,r}$ that is the r^{th} explanatory variable for observation i, not only has an effect on the outcome y_i but also has an effect on the outcome of the neighboring observation y_j $(i \neq j)$. Three different effects can be identified. First there is a direct effect of a change of the r^{th} explanatory variable for observation i ($x_{i,r}$) on y_i. Second, there is an indirect or spillover effect to neighbors, i.e. the effect of the same change on $x_{i,r}$ but on the outcome on neighbor j. A third effect that could be distinguished is an indirect interaction effect, i.e. the feed-back effect of the second effect on y_i: i.e. the effect changes in y_j $(i \neq j)$ induced by the change in $x_{i,r}$ on the outcome of farm i. As can be seen from the reduced form equation (see Equation 9) this third impact is already implicitly included in what we here call the direct effect. Together the first and the second effect denoted before make up the total effect of a change in $x_{i,r}$. Usually average direct, indirect and total effects are calculated over the whole sample. The average total effect then can be interpreted as the (average) effect on y_i when r^{th} explanatory variable is changing by the same amount across all n observations.

Due to the non-linear nature of probit models, the marginal effects are not constant across all the observations but depend on the level of the explanatory variables. In a non-spatial probit model this non-linear relation is given by $\partial E[y \mid x_r] / \partial x'_r = \phi(x_r \beta_r)\ \beta_r$, where $\phi(\cdot)$ is the density of the normal distribution. As has been shown by Le Sage and Pace (2009, p. 294) the marginal effects for spatial autoregressive probit models can be computed as

$$\partial E[y \mid x_r] / \partial x'_r = \phi[(I_n - \rho W)^{-1} I_n (\bar{x}_r \beta_r)] \bullet (I_n - \rho W)^{-1} I_n \beta_r \qquad (12)$$

where • stands for an element by element multiplication and $\bar{x}_r$ represents the sample average of variable x_r. This expression generates an (n x n) symmetric matrix, the trace of which provides the average direct marginal effect, whereas the average of the i^{th} row sum of this matrix represents the average total marginal effect, since it also includes the effects from all neighbors (*i.e.*, from all $x_{j,r}$ $(j \neq i)$ on y_i). By definition, the difference between the total and the direct marginal effects is the indirect marginal effect.

5.2.7 Weighting matrix selection

There is little guidance from the literature on how to specify weighting matrixes, therefore the usual approach is to choose a priori different weighting matrix and test several specifications. The two most common weighing matrixes types for point data are the distance band matrix and nearest neighbor matrix. Distance band matrixes are based on a distance threshold: if the distance between farm i and farm j is smaller than the threshold value, the $w_{i,j}$ element of the weighting matrix j is set equal to 1 and zero otherwise. In this case, each observation has a fixed neighborhood extend with a varying number of neighbors. For a nearest neighbors matrix $w_{i,j}$ get the value 1 if farmer i and farmer j are neighbors within the a priori selected order of neighborhood. In this case each observation has a fixed number of neighbors, but the extend of the neighborhood taking into account is varying. All the matrixes are usually row standardized in order to facilitate the computations of the models and to interpret the neighborhood as the average of the neighboring values (Anselin, 2006, LeSage and Pace, 2009). Weighting matrices using a 2 km and 5 km band criteria and 5 and 15 nearest neighbors criteria have been constructed. The average distance for 5 neighbors is 600m, and 15 neighbors is 1km.

In order to rank weighting matrixes and identify the extent of the spillover, it would be interesting to apply a Bayesian model comparison, in which models differ only by their weighting matrix (LeSage and Pace, 2009). However, this procedure necessitates the computation of the marginal likelihood of each of the considered models. This computation is not trivial for a non-linear probit model as is used here, and was therefore not yet feasible (LeSage, 2010). Nonetheless, the goodness of fit of the different models can be assessed by comparing the predicted and observed diversification. Indicators are the quadratic probability score (also referred to as Brier score) and the logarithmic probability score (Brier, 1950). The quadratic probability score corresponds to the average squared deviation between predicted probabilities $(\hat{y}_i)$ and their outcomes (y_i): $QPS = \frac{1}{n}\sum(\hat{y}_i - y_i)^2$ and can be seen as being the equivalent of the mean-squared error in a discrete choice model. The logarithmic probability score is given by $LPS = -\frac{1}{n}\sum\left[y_i * \ln(\hat{y}_i) + (1 - y_i) * \ln(1 - \hat{y}_i)\right]$ and compared to the quadratic probability score it penalizes large errors more. For both quadratic probability score and logarithmic probability score it holds that the lower the score the higher the accuracy of the prediction of the model.

5.3 Results and discussion

The estimation results explaining the participation behavior of farm households are presented in Table 1, which provides results for different weighting matrices, as they were previously described. As Table 5.1 shows, the parameter estimates with respect to the farm household and the farm characteristics are rather similar over the different models. Life cycle (average head of farmer's age and its square) turns out to be a significant explanatory variable. The parameter estimates imply that around an average age of the head of farm of 40 years, there is the biggest chance to diversify. The maximum level of education also increases the probability that a farmer will diversify. As such this confirms the idea that for many activities such as care services and on-farm shops, a higher human capital is need. Farm size and its square have opposite signs indicating that, relative to farms of intermediate size, small farms (which are mostly hobby farms) and big farms have a lower probability to diversify. For the intermediate size category, farm diversification might be interpreted as a survival strategy for those farmers who wish to increase in scale but fail in doing so due to the lack of available land (Meert *et al.*, 2005). As turns out from the results, being an organic farm also increases the probability to diversify. Generally these farms have a more extensive mode of production then regular farms and can for that reason more easily be combined with agri-environmental schemes as well as with care activities In comparison to conventional products, organic products are known to have a more expensive supply chain (Baecke *et al.*, 2002). Therefore, it is often profitable to sell these products on-farm or directly deliver them to the customer (short supply chains). Participation in an environmental cooperative has a positive impact on the decision to diversify. This confirms that farmers do not only apply collectively for contracts but they also form a social network (Slangen, 1994). Environmental cooperatives also provide other roles: they organize trainings; act as a think tank in the region and share experience with each other. As Table 5.1 further shows, location also turns out to play a role in the decision making: farms located near to the major roads, near to an attractive a landscape that is one of the national parks or near the national landscape and further away from the big cities (Amersfoort, Ede, Utrecht, Veenendaal, Zeist) show an increased probability to diversify. Ground water level, which is a well-known proxy for soil quality in the Netherlands indicates that on wetter, less productive soils farmers have a higher probability to diversify. It can be concluded that diversified farms will therefore cluster on locations with wet soils, further away from big cities and in proximity of an attractive landscape. This also reflects the patterns of diversification observed in Figure 5.2.

Assessing ρ, which is significant and positive for all the assessed models (Table 5.1), allows to conclude that with respect to the uptake of alternative output activities spillover and interaction effects between farms exist. As such these effects re-enforce the clustering of alternative output producing activities. Indeed, a positive ρ implies that a farmer has a higher probability to diversify in a diversified neighborhood. When comparing the McFadden R-squares for the spatial models (M1-M4) with the non-spatial reference model (M0), it can be seen that including the spatial autoregressive term into the models strongly increases the goodness of fit, while all the other coefficients remain similar. This suggests that the contribution of adding the neighborhood is important, even if spatial aspects are already (partially) covered (*e.g.*, soil quality, distance to cities, etc.). As such this analysis confirms the finding earlier obtained in Chapter 2, which concluded that there exists a tendency for diversified activities to cluster to certain locations.

The probit model coefficients can only be compared across different models in terms of a ratio with an other explanatory variable (Wooldridge, 2002, p 459). For sake of illustration, the ratio $\frac{\rho}{\beta_{size}}$ has been computed. It shows that the importance of the neighborhood increases as the average neighborhood size increase. Since all the coefficients only slightly vary across the models, ratios with other variables would lead to a similar conclusion.

Table 5.1 : Spatial probit estimation with different weighting matrices for farm diversification in the Gelderse Vallei (p-values between parentheses)

Model Coefficient (t-prob)	Without weighting matrix (M0)	5 nearest neighbors (M1)	15 nearest neighbors (M2)	2km band (M3)	5km band (M4)
farmer characteristics					
average age	0.0149 (0.1490)	0.0346 (0.0244)	0.0368 (0.0175)	0.0353 (0.0169)	0.0342 (0.0277)
average age square	-0.0002 (0.0783)	-0.0004 (0.0058)	-0.0004 (0.0041)	-0.0004 (0.0042)	-0.0004 (0.0066)
Maximum education	0.0341 (0.0154)	0.0530 (0.0009)	0.0501(0.00 20)	0.0466 (0.0031)	0.0465 (0.0045)
social network	1.6947 (0.0000)	2.2093 (0.0000)	2.144 (0.0000)	2.0964 (0.0000)	2.0787 (0.0000)
farm characteristics					
Size	0.0113 (0.0000)	0.0141 (0.0000)	0.0134 (0.0000)	0.0131 (0.0000)	0.0133 (0.0000)
Size squared	-0.00001 (0.0017)	-0.00002 (0.0000)	-0.00005 (0.0014)	-0.00002 (0.0012)	-0.00002 (0.0019)
organic	0.5104 (0.0001)	0.6740 (0.0000)	0.6505 (0.0000)	0.6701 (0.0000)	0.6651 (0.0000)
Site characteristics					
ground water level	0.0138 (0.1548)	0.0232 (0.0557)	0.0312 (0.0167)	0.0393 (0.0328)	0.0485 (0.0017)
distance to road	-0.0618 (0.0235)	-0.1054 (0.0001)	-0.0929 (0.0002)	-0.0878 (0.0001)	-0.1067 (0.0002)
distance to city	0.0108 (0.0061)	0.0133 (0.0194)	0.0103 (0.0495)	0.0082 (0.0818)	0.0083 (0.0793)
distance to attractive landscapes	-0.0392 (0.0000)	-0.0475 (0.0000)	-0.0309 (0.0001)	-0.0210 (0.0091)	-0.0161 (0.0490)
ρ		0.1508 (0.0014)	0.3558 (0.0000)	0.4740 (0.0000)	0.5621 (0.0000)
Constant	-1.31980 (0.0004)	-1.8604 (0.0002)	-1.7998 (0.0000)	-1.6759 (0.0003)	-1.5621 (0.0015)
ρ / β_{size}	0	10.69	26.55	36.18	42.26
McFadden R-squared (based on posterior mean)	0.1561	0.5410	0.5461	0.5539	0.5658
Quadratic probability score		0.1066	0.1061	0.1056	0.1056
Logarithmic probability score		0.3573	0.3554	0.3531	0.3528
Draws*	100000	8000	8000	8000	6000

* The number of draws and omissions corresponds to the maximum that was feasible in matlab. The first 20% of the draws were omitted. Chi-squared convergence test (Geweke, 1992) did not reject the hypothesis that the coefficients resulting from the first 20% of the draw and from the last 50 % of the draws are similar for each coefficient in each regression and convergence can be assumed.
Note : various proxies characterizing labor input were not significant and therefore not shown. This unexpected irrelevance of labor might be due the binary measurement of farm diversification that does not take into account that some of the activities are labor intensive (care farm) while others are not (some agri-environmental schemes).

Furthermore, all goodness of fit measurement, namely the Mc Fadden R-squared and also the previously mentioned quadratic probability score and the logarithmic probability score suggest that the bigger the average extend of the neighborhood, the better the model prediction. Furthermore, the fixed distance band *W*-matrices turn out to work better than a per-individual varying band (due to taking a given number of neighbors taken into account). This implies that geographical proximity to a diversified farmer rather catches better the spillover effects, than the proximity within a network of diversified farmers. The extend of the spillover lasts at least up to 5 km.

Although, the obtained results clearly detect an interaction effect between different farmers and activities, it is difficult to grasp the exact mechanism or the causal explanation for this phenomenon. Different types of alternative activities might have different externalities and affect their neighborhoods differently. In addition, farmers can and often do adopt more than one activity. The specification presented in this chapter ignores that a farmer might also be faced with negative externalities (for example, a farmer with an on-farm shop might saturate the local market and hamper the neighboring farmer from doing the same). Our results suggest that on average the spillover effect is positive.

In order to assess the spillover effect for the different alternative activities, a multivariate spatial probit, that estimates simultaneously the different diversification choices would be needed chapter 2. Unfortunately, these type of models have not yet been developed for the spatial case.

Table 5.2 shows the direct and indirect marginal effects for the “average farm”, which are only calculated for the spatial autoregressive probit models with weighting matrices based on the 15 nearest neighbors-criterion and the distance band of 2 km criterion. Because social networks and organic are binary variables, these computed marginal effects are difficult to interpret. Therefore the discrete changes corresponding to a direct effect for these variables are computed. They consist of comparing predicted probabilities of the “average farm” when the given binary variable is 1 with the probability when the binary variable is 0 .

Table 5.2 : Direct, indirect and total marginal effects at the mean value for 2 different models describing farm diversification in the Gelderse Vallei (p-values between parentheses)

Model	15 nearest neighbors (M 2)			5 km band (M4)		
Marginal effects (t-prob)	Direct	indirect	Total	Direct	Indirect	Total
Farmer characteristics						
average age	0.03472 (0.0363)	0.0002 (0.0774)	0.03492 (0.0423)	0.0342 (0.0511)	0.0327 (0.0784)	0.0684 (0.0499)
average age square	-0.0004 (0.0084)	-0.00024 (0.0374)	-0.00064 (0.0117)	-0.0004 (0.0087)	-0.0004 (0.0356)	-0.0008 (0.0145)
maximum education	0.05066 (0.0003)	0.0028 (0.0277)	0.05094 (0.0062)	0.0466 (0.0092)	0.0431 (0.0316)	0.0901 (0.0119)
social network	2.1658 (0.0000) [0.6798]*	1.1884 (0.0002)	3.3542 (0.0000)	2.0835 (0.0000) [0.645]*	1.9251 (0.0001)	4.036 (0.0000)
Farm characteristics						
size	0.0136 (0.0000)	0.0075 (0.0007)	0.0211 (0.0004)	0.0134 (0.0000)	0.0121 (0.0006)	0.0254 (0.0000)
size squared	-0.000016 (0.0001)	-0.000009 (0.0078)	-0.00002 (0.0002)	-0.00002 (0.0003)	-0.00001 (0.0067)	-0.00031 (0.0005)
organic	0.6571 (0.0000) [0.2431]*	0.361 (0.0044)	1.1020 (0.00005)	0.6667 (0.0000) [0.2602]*	0.6198 (0.0037)	1.2946 (0.00092)
Site characteristics						
ground water level	-	-	0.0491 (0.0401)	-	-	0.0763 (0.0162)
distance to road	-	-	-0.1457 (0.0009)	-	-	-0.1700 (0.0027)
distance to city	-	-	0.0161 (0.1028)	-	-	0.0159 (0.1699)
distance to attractive landscapes	-	-	-0.04812 (0.0004)	-	-	-0.0402 (0.0188)

[.]* point estimation of a discrete change : $pr\left[y|x_i = 0, \overline{X}, \overline{Wy}\right] - pr\left[y|x_i = 1, \overline{X}, \overline{Wy}\right]$

Note that all direct and indirect marginal effects have the same sign: the change affecting one farmer will never produce the opposite effect for its neighborhood. The direct effect is always bigger than the indirect effect, implying that a change in any of the explanatory variable has a bigger influence on the farmer himself than on its neighborhood.

Direct and indirect marginal effects can also be calculated for the site characteristic variables. However, since changes in local conditions affect simultaneously all the farmers (for example, distance to city) only the total effect is shown.

Most of the previous empirical studies about farm diversification did not take the neighborhood effect into account and therefore ignored the spatial dynamics of farm diversification. As our results emphasize, by doing so, an important driver is omitted.

But the results show that the omitted variable bias might be rather small, as the parameter coefficients between the spatial and the non-spatial model are similar. Rather than addressing the omitted variable bias, the value added of introducing the neighborhood explicitly in this chapter is to get insight into the spatial dynamics of farm diversification. In addition, taking into account the spillover effects almost doubles the explanatory power of the models. In the study area some locations (notably wetter soil which in the Netherlands are less productive soils, areas near to attractive landscape and further away from big cities) are more suitable for farm diversification than others. Farmers on those locations are more probable to diversify and this dynamics might be the result of positive externalities from diversification on their neighborhood. It is questionable whether policies can support the emergence of diversification hotspots on other locations. The counterpart of the hotspot, is the "cold-spot" where only little diversification takes place. This might be the result of a lacking local market for the alternative activities. On locations where local demand for alternative activities exists and is not yet developed, policies taking the form of an initial investment into diversification might be a stimulus (*e.g.*, axis 2 policies of the CAP's second pillar) to the diversification of the whole area and thus viability of rural area is increased.

5.4 Conclusion

Policies for rural development aim at increasing the viability of rural areas and better adapting agriculture to the changed societal preferences. Farmers can contribute to this objective by diversifying. This chapter shows that the location and the neighborhood of the farmer are important drivers of farm diversification. Results indicate that diversified farmers cluster on locations with lower quality of soil, near to attractive landscape and away from big cities. For all spatial autoregressive probit models fitted, the spillover-effect turned out to be significant. This implies that farmers are more likely to diversify when their neighborhood is diversified. Neighborhood specification based on a distance band performed better than the one based on a number of nearest neighbors. Economic theory suggests that the clustering could be explained due to positive externalities. Although our research clearly identified the importance of spillover and neighborhood effects, it did not allow for an in-depth examination of the mechanisms explaining these effects. Our findings suggest that more attention should be paid to interactions between farmers as well as between various alternative activities than is currently done in the literature.


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Chapter 6

Synthesis

6.1 Introduction

The provision of landscape services became an important policy objective in countries with competing spatial claims (Willemen *et al.*, 2008). In landscapes dominated by agriculture these services are the combined result of bio-physical characteristics and farmers' decision making. This thesis focuses on the spatial patterns of farm diversification and looks at the intentional contribution that farmers make to the provision of landscape services. The thesis has adopted an economic approach to assess farmers' decision making and this is combined with geo-statistical approaches that provide insights into the spatial patterns of farm diversification. The first section of this chapter discusses the methodological choices and the technical issues linked to the various spatial techniques used in this thesis. The second section discusses the patterns of farm diversification that have been identified in other chapters. The third section discusses the implications of this research for the development and implementation of new policies. The fourth section provides a short outlook for future research. Conclusions are in the last section.

6.2 Modeling spatial patterns

There are two fundamentally different approaches for assessing spatial patterns of individual decision making: statistical approaches and agent-based ones. The statistical approach is used to investigate decision making and its drivers in a location-specific context. It functions best if many observations are available and is mainly used for extrapolation. The agent-based approach, on the contrary, is more appropriate when the interaction between individuals is crucial or when yet unobserved behaviour needs to be modelled. Recently, various agent-based models for rural areas have been developed that link farmers' decision making to the landscape (Happe *et al.*, 2006; Valbuena *et al.*, 2008; Mena *et al.*, 2010; Valbuena *et al.*, 2010a; Valbuena *et al.*, 2010b; Wainwright and Millington, 2010).

This thesis makes use of, and develops, existing statistical approaches for empirically testing the spatial patterns of farm diversification. It draws on existing spatial econometric approaches to investigate these patterns, as well geo-statistical techniques that can be used to both represent farmers' decision making and to handle spatial correlation from statistical models.

The spatial econometric approach

Theoretical micro-economic models, such as the farm household utility maximization framework used in this thesis, are used to identify and understand factors that influence farmers' decision making. These models are translated into statistical models by assuming a systematic relationships and a stochastic part (e.g. adding of error terms etc.) that can be estimated with econometric techniques and enable the identification of the statistically significant influences on farmers' decision making. However, such micro-economic models often ignore location, even though agriculture is nearly always a land based (and thus spatially specific) activity. For this reason, the results are likely to suffer from bias, due to an omitted variable, as well as spatially correlated residuals (LeSage and Pace, 2009). The literature identifies three different ways to include spatial information and ensure unbiased and efficient parameter estimation (Anselin, 2006; LeSage and Pace, 2009):

i. include location specific variables
ii. include a spatial autoregressive variable (spillover)
iii. include a mechanism for spatial error correction.

This thesis used approaches i) and ii). Approach i) is applied in *Chapter 2,* where location variables were introduced into the theoretical and empirical model. The selection of these location variables is important, since many bio-physical characteristics within a landscape are correlated. Therefore, a careful choice of potential proxies for location must be made in order to avoid colinearity. However, these proxies are not likely to fully capture the full location characteristics. The analysis therefore employs two other spatial econometric models to address this issue (Anselin, 2001; LeSage and Pace, 2009). First there is the spatial autoregressive model (approach ii), which is applied in *Chapter 5*. This model includes an autoregressive dependent variable term (ρWy) which aims to capture the correlation between an observation and the neighbourhood in which it is located. Secondly, location can be accounted for by introducing a spatial error correction term (approach iii). This specification allows the spatial correlation that has not been described in the model to be captured in the 'spatial' error term. The autoregressive and the error correction models take location into account without explicitly measuring and explaining it. Location is captured by an *a priori* defined neighbourhood (W) that corrects for the spatial influences that may have been incorrectly identified or measured (Anselin, 2001). However, the autoregressive parameter term can also absorb spatial trends and thus be misleadingly used to conclude that patterns are solely due to the existence of a spillover effect. Thus it is important to base the econometric model on a theoretical economic model that explains the existence of the spillover and includes location variables into the set of explanatory variables.

To provide an efficient and unbiased estimator of farmer's decision making about diversifying an empirical model should include biophysical characteristics (i), the autoregressive explained variable (ii) and spatial error correction (iii). Additionally it should take into account that various rural activities can be adopted simultaneously. Unfortunately, there is no available model that fulfils all these criteria. For this reason, this thesis uses different models to assess the spatial patterns of farm diversification. Each specification assesses one aspect of the spatial patterns but each has its specific limitations. The separate assessment of farmers' adoption of rural activities (Chapter 2) allows an investigation of synergies between activities, but does not take into the spillover effect or the spatial correlation of the residual. By contrast, the spatial autoregressive probit model (Chapter 5) acknowledges the spillover effect, but cannot investigate the correlation between the different activities. In principle neither these two models addresses the potential spatial correlation of the residual (error-correction).

Visualizing farmers' decision making

In order to visualize patterns of farm diversification, farmers' decision making needs to be represented in a spatially explicit way. Geo-statistics offer a whole range of techniques to interpolate point information. It is crucial to introduce the residual into the spatially explicit prediction (Chapter 3), because the econometric models, discussed above, have a rather low explanatory power (R-squared between 0.1-0.4). Regression kriging (Cressie, 1990) is an interpolation technique used in geo-statistics that includes the residual into the computation. Generally, the prediction providing by regression kriging is a weighted average of explanatory variables and the residual (Solow, 1986). Although the use of an average can be a realistic hypothesis for bio-physical data, it makes little sense to average farm characteristics over an area, as this means that the heterogeneity of individual farms and farmers is averaged out and lost. Therefore, the simulation tool described in Chapter 3 simulates the individual farm characteristics as well as the residual based on local distributions, thereby preserving the heterogeneity the characteristics of individual farms and farmers.

The regression model used in the simulation tool (and more generally for the regression kriging) can not handle the simultaneous choice of rural activities or interactions between different farmers (spillover resulting from the spatial autoregressive process). Therefore, separate and non-simultaneous probit models of farmers' decision making for each rural activity are applied. However, results from applying more advanced econometric techniques have shown the existence of a spillover effect and a correlation between diverse activities (Chapters 2 & 5). These effects are absorbed by the residual which is likely to contain a spatial correlation (Chapter 3). To take this into account, the residual is simulated and explicitly included within the prediction. When it comes to simulating various future scenarios, this error is assumed to be constant and new or changing synergies are ignored (Chapter 4). The results show that statistically significant synergies, namely the correlation between recreational activities and other services (Chapter 2), as well as the spillover effect (Chapter 5), are both positive. This suggests that the estimated changes in the adoption of rural activities under the different explorative scenarios (provided in Chapter 4) might be underestimates, since they ignore part of the identified spatial correlations.

None of the econometric models used in this thesis fully capture location and therefore there is a possibility that they might yield biased and/or inefficient results. Fortunately, the results from the models provide converging results. This suggests that the bias and inefficiencies are negligible. The use of spatial methods provides a method for identifying the drivers of spatial processes rather than correcting for the potential biases and inefficiencies within the simple aspatial economic model.

6.3 Interpreting patterns of farm diversification

Spatial patterns in the Gelderse Vallei

The previously discussed spatial methods yielded two explanations for the observed patterns of farm diversification: the relevance of bio-physical characteristics in farmers' decision making and the spillover effect resulting from interactions between farmers. The model was used to assess the adoption of short supply chains, agri-environmental schemes and recreation in the Gelderse Vallei. Short supply chains and other services (such as renting storage space and care services) emerge in proximity to built-up areas and settlements, where there is local demand (see Chapters 2 and 3). Agri-environmental schemes for nature conservation emerge mainly on wet soils with low productivity (Chapters 2 and 3). Finally, recreation emerged further away from big cities and close to, or within, attractive landscapes (see Chapters 2 and 3). In addition, the density of existing rural activities and agri-environmental schemes surrounding a farm turned out to increase the probability of adopting a recreational activity. These results indicate that different activities are adopted at different locations. Farmers in national parks and within areas where diversification had already occurred adopted more activities than elsewhere (Chapter 2). In diversified neighbourhoods there is not only a higher adoption rate of rural activities, but this also has a positive impact on the neighbouring farmers, through a spillover effect that reduces the 'cost' of diversification (Chapter 5). All the spatial dynamics identified in this study point out the complementary of rural activities that cluster and form "diversified hotspots". In these hotspots, farmers' diversification activities play an important role in enhancing the landscape functions.

Temporal dynamics at the national scale

This thesis, on the spatial dimension of farm diversification, draws on different sources of data, dating from 1999 and 2005 in the Gelderse Vallei. It does not assess the time-dynamic dimension of farm diversification in detail. However, national statistic from 1999 to 2009 provide insights into the evolution of farm diversification (Figure 6.1). This data suggests that this thesis investigated farm diversification when it was at its peak, between 2003 and 2005, a time when Dutch milk prices but also world food prices were relatively low (Meester, 2010). Farm diversification has decreased in more recent years, though it has stabilized at a slightly higher level than in 1999.

The adoption of agri-environmental schemes experienced an important peak around 2003, followed by a strong decline. This evolution can be linked to policies. The Dutch government was offering agri-environmental schemes that made relatively few demands (in terms of farming practice) at a time when Dutch milk prices were decreasing. Subsequent reviews show that these schemes did not meet their environmental objectives (Kleijn *et al.*, 2001; Wiertz and Sanders, 2007; Leneman and Schrijver, 2008) and this led to new (and more demanding) schemes being introduced in 2005, which coincided with an increase in world food prices (Leneman and Schrijver, 2008). As a result the opportunity costs of agri-environmental schemes increased and traditional food production became more profitable again, due to higher prices. Typical contract duration for agri-environmental schemes is six years, explaining the gradual decline in the number of farmers that adopt agri-environmental schemes.

The role of farm diversification in rural development had gained in attention in the years 2000 and increased policy support can explain the initial growth of farm diversification. However, from 2004 on, the decrease of farm diversification suggests that there was not a sufficient demand for rural activities, which is nowadays seems to be closed to saturation. Although this may insinuate that farm diversification is not profitable at the national scale, it does not exclude the possibility that, some rural areas might have continued to increase their viability through farm diversification (Veen *et al.*, 2010).

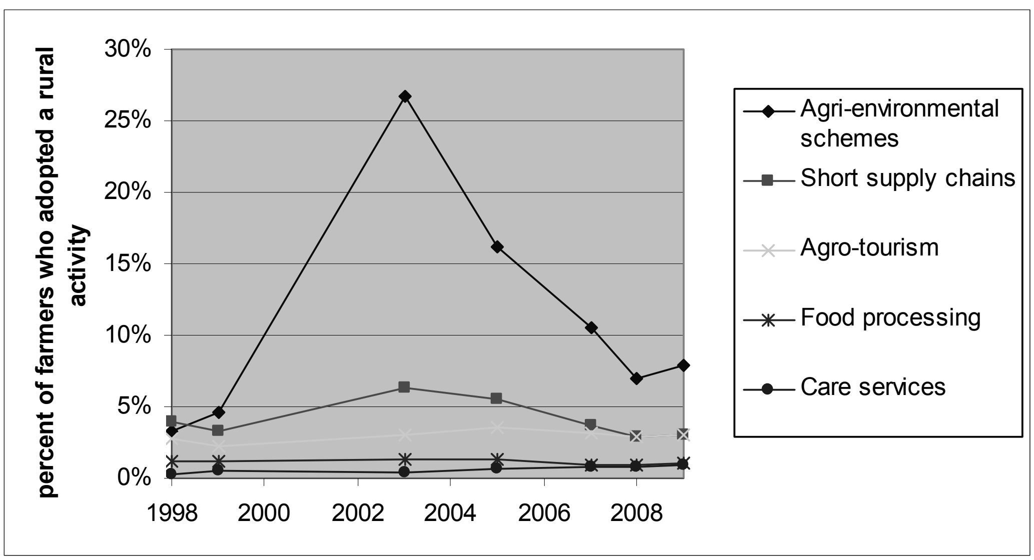

Figure 6.1 : Percent of farmers who adopted a rural activity in the Netherlands (1998 -2009) (source CBS)

Some (Chaplin *et al.*, 2004; Meert *et al.*, 2005) argue that farm diversification can allow farmers to increase their income without increasing pressure on the environment and thereby to create new employment opportunities in rural areas outside of the agricultural sector (Wilson, 2008). As such farm diversification is a potentially interesting option for policy-makers to increase the viability of rural areas. However, temporal analysis at national scale suggests that farm diversification is not always successful. It is hampered by several factors. Firstly, in order to diversify a farmer requires an entrepreneurial spirit and knowledge about the activity (Andersson *et al.*, 2009). Some farmers may need support in acquiring (or increasing) both these aspects of 'human capital' (Meert *et al.*, 2005). Additionally, farm diversification requires capital investment, which might not be accessible to farmers facing a critical financial situation (Sharpley and Vass, 2006). In addition, farmers might face a regulatory environment (Halliday, 1989) that constrains the transition towards diversification (e.g. construction regulations). Finally, it is the rural areas closest to big cities that appear to have the most potential for farm diversification, as these have the most local demand for rural services (Chapter 5).

6.4 Policy implications and the regulation of rural services

This section discusses a number of implications for developing and implementing new policies. The focus will be on the regulation of rural services and are discussed in the context of site specific policies for rural development.

The regulation of rural services

When discussing farm diversification it is essential to distinguish between intentional and unintentional rural services. And, when discussing the regulation of rural services it is important to distinguish between private rural services and public rural services. These distinctions are shown in Table 6.1.

Table 6.1 Classification of rural services

Rural services	Intentional	Unintentional
Private	Services with market (recreation)	-
Public	Services for which a market has been created (agri-environmental schemes)	Services without market (e.g., cultural heritage)

Private rural services are services that result from a rural activity that has a market and therefore they are always intentional. Public rural services have characteristics of public goods and are, to a certain degree, non-rival or non-excludable (Cooper *et al.*, 2009; Bunte *et al.*, 2010). Generally, these services (for example, cultural heritage) do not have a market and, from an economic perspective, emerge as a by-product of agriculture. As such, public rural services are usually unintentional. However, for some public goods, market-based incentives, such as agri-environmental schemes, have been introduced. They aim to motivate farmers to intentionally contribute to the provision of landscape services by compensating them for adopting less intensive farming practices on their fields or to really invest in long-term rural services (Diakosavvas, 2010).

Private rural services are likely to emerge if the regulatory framework and the spatial planning system are flexible enough to allow for innovation and if access to investment capital is warranted (Chapter 5). The spill-over effect suggests that supporting early adopters and/or providing start up capital can initiate a transition towards a diversified rural area.

By contrast, public rural services are unlikely to be provided without on-going support. Their provision can be ensured in two different ways: with traditional policy tools, such as top-down regulations, or with market oriented tools aiming at setting the right level of incentives for farmers to voluntarily adopt rural activities (Romstad, 1999; Wiskerke *et al.*, 2003). Incentive-based regulations are seen as a better way to promote private and public benefits from privately owned agricultural land (Latacz-Lohmann and Van der Hamsvoort, 1998; Buckwell, 2009). These incentives can take the form of payments for environmental services or public goods, which could even be auctioned. They can be seen as a market oriented tool that expresses societal demand for public goods (Dupraz *et al.*, 2003). In addition, under the WTO rules, these payments are considered to be non-distorting (Beard and Swinbank, 2001) In addition, they also stabilize farm incomes (Meert *et al.*, 2005).

At the European level, the current debate about the future of the European Common Agricultural Policy after 2013 suggests that the existing farm income support - in the form of single farm payments (SFP) - might be reduced or even phased out and be (partly) replaced by increased payments for public goods (Meester, 2010). The results presented in this thesis show that there is an interaction between agri-environmental schemes and other rural activities. Policies would be more efficient if they sought to make use of this spillover effect, i.e. future payments for public goods should be closely linked to rural development policies. In this perspective, an integral European rural development policy that includes environmental services alongside food production might be more efficient than the current 'two pillar' system. Next to agricultural or food production and rural services, farmers also contribute to public goods that can only be assessed at higher spatial scale (national or continental) such as food safety. These services should not be forgotten in future policies, suggesting that, farmers' contributions to society needs to be assessed at various spatial scales.

Developing context specific policies

Incentives that support the adoption of rural activities in suitable locations need to be based on context specific policies. Therefore, and in accordance with the subsidiary principle of the European Union, rural policies should be delegated to the member states and lower political levels (Grethe, 2008). Context and site-specific knowledge also needs to be acquired from local stakeholders. New participatory approaches and increased cooperation between various stakeholders should therefore play a stronger role in policy development and implementation. These participatory processes can result in the identification of synergies and trade-offs. They may also resolve inconsistencies between regulations at different levels (Reed, 2008). In Dutch rural areas these participative processes are increasingly occurring within, what are known as, "Communities of Practice", groups of people (including stakeholder policy makers and scientists) informally bound together by shared expertise and a passion for a joint enterprise (Bouma *et al.*, 2008). These communities request the tools they need to support them to learn about the regional dynamics, to visualize the outcomes of their intended actions etc. (Sterk *et al.*, 2010).The tool developed in Chapter 4 contributes to this type of decision making support. The scenario development presented in Chapter 5 only consulted direct stakeholders to inform policy-makers and did not involve an interactive process between stakeholders, policy makers and scientists. This choice was based on the needs of the direct stakeholders in the area (Chapter 4). However the tool could be adjusted to a more participatory approach and be used for action research.

6.5 Outlook and future research

Up to now, payments for public rural services have taken the form of agri-environmental schemes. In the Netherlands they have been based on the losses of income and increased effort involved in more extensive land management (Schrijver *et al.*, 2009). However, with the emerging new paradigm of creating markets for public goods to meet societal demand, rural services need to be valued differently. Economists have developed many monetary valuation techniques to value public goods and there is no consensus about which is the most accurate method (Randall, 2002; Champ, 2003). Two major issues hamper market-based payments for public rural services: quantifying the rural services provided by the adoption of a rural activity and structuring the incentives in a way that insures the spatial coordination of various rural activities.

Quantifying rural services

In order to develop efficient policies, payments for rural public goods should be based on the rural services provided, rather than on the adopted rural activity (Randall, 2002; Engel *et al.*, 2008; Kerkhof *et al.*, 2010). This thesis has focused on farmers' intentional decisions to adopt rural activities. It has not sought to quantify or evaluate the resulting provision of rural services. Nevertheless, understanding the spatial patterns of farm diversification does constitute a first step toward quantifying the provision of intentional rural services. Indeed, an intentional rural service depends on the quantity and quality of the rural activity adopted, together with the location characteristics that define the effect of such adoption on the landscape.

The simulation tool developed in Chapter 3 predicts the adoption of rural activities. Future research might seek to assess the intensity of the adoption of a rural activity, such as predicting the amount of hectares of land within agri-environmental schemes (or even the quality of the services provided), the amount of beds for tourists or the number of available care places at care farms.

In order to define a location specific effect of the adoption (or the intensity of adoption) on the landscape, a "rural services quantification procedure" needs to be defined. This procedure would link the rural activity with the bio-physical characteristics of an area in order to define the location specific effect of adoption on the landscape.

Defining a procedure for quantifying rural services remains a challenge, as many issues surrounding this procedure have not yet been addressed. Firstly, the link between a specific rural activity and its effect on the landscape needs to be better understood. For environmental services, such as biodiversity maintenance, the impact of a conservation activity (or a bundle of activities) on the landscape could be assessed in field experiments. For other activities, such as maintaining cultural heritage, a set of indicators should be developed in order to quantify the effect of adoption (Gulickx *et al.*, 2010). Secondly, such a quantification procedure should consider that some activities only contribute to a rural service if various rural activities are adopted simultaneously at different locations. This is for example the case with the conservation activities needed to form an ecological corridor (Opdam *et al.*, 2006). Such rural services only emerge through synergies between activities that are spread across a landscape or higher spatial scale (Termorshuizen and Opdam, 2009). Such spatial scale interactions, which result from synergies between different rural activities, need to be assessed and measured in more detail in order to correctly quantify the rural services provided by individual farmers.

Spatial coordination

The synergies, discussed above, suggest that in order to maximize rural services, incentives to farmers should seek to spatially coordinate the adoption of rural activities. Examples of this type of incentives include collective agri-environmental schemes in the Netherlands (Franks and McGloin, 2007) and nature conservation auctions in Australia (Connor *et al.*, 2008). These collective agri-environmental contracts enable the spatial coordination of, for example, various habitat creation activities that form an optimal habitat within the landscape (Glasbergen, 2000; Renting and Van Der Ploeg, 2001; Slangen *et al.*, 2008). In the Netherlands the government compensates groups of farmers, often organized in an environmental cooperative, for their coordinated conservation activities. The nature auction in Australia coordinates various activities as a bundle of services. This later approach is a price revelation mechanism that goes beyond coordinating activities and could be considered for application within Europe.

These new types of incentives require new institutions that enable farmers and other stakeholders in rural areas to coordinate their actions. Over recent decades, The Netherlands has experimented with such bottom-up policy approaches (Hendriks and

Tops, 1999; Meerburg *et al.*, 2009). Two different types of institutions have been established, through which farmers and other stakeholders in rural areas can organize themselves: i. the "rural area committee" (Gebiedscommissie), and ii. self-organizing farmer and citizen initiatives.

The new "rural area committees" have been established as a result of the decentralization of political power from the national level to the provincial and regional levels (Slangen *et al.*, 2010). These committees typically involve all the stakeholders with claims on the landscape. One example is the National Landscape Commission in Arkemheen Eemland, which involves the provinces of Gelderland and Utrecht, municipalities, water boards, nature conservation organizations, farmer organizations and representatives of the nearby urban areas (Chapter 5). The committees aim at a more participatory approach for developing rural areas, in order to benefit from synergies and to negotiate trade-offs. But in many cases, they only advise the provinces about improvements and new regulations (Derkzen, 2010; Slangen *et al.*, 2010). In the particular case of Arkemheen Eemland, the committee developed a common vision about the National Landscape of Arkemheen Eemland that identified and addressed the potential synergies and trade-offs and facilitated the coordination of funding and other rural development activities within the area (Chapter 4).

Other, self-organizing initiatives have emerged that involve farmers and, in certain cases, other stakeholders. These include environmental cooperatives that usually only involve farmers interested in applying for individual and collective agri-environmental schemes. Sometimes, these cooperatives also coordinate other issues, such as the promotion of local products (Renting and Van Der Ploeg, 2001). Additionally, very diverse rural associations have emerged that bring together farmers, citizens, and sometimes scientists. The "Landscape Fund" in Eemland brings farmers and citizens together to find new funds, from private sources, to support farmers' nature conservation activities (Kloen *et al.*, 2007). Initiatives, such as the Regional Innovation Centre, which opened in Eemland in 2009, aim at broadening the knowledge base within rural areas by bringing farmers, nature conservationists and scientists together (Roep *et al.*, 2008; Wielinga *et al.*, 2009). The effectiveness of these initiatives in contributing to nature conservation and rural development is yet not well understood, partly due to the diversity of the emerging institutions (Wiskerke *et al.*, 2003; Slangen *et al.*, 2008). In order to better understand how these new institutions can increase coordination between different stakeholders and motivate them to voluntarily provide high quality rural services, research is needed that seeks to identify the factors that contribute to the successful collective management of rural areas.

6.6 Conclusions

Society values a wide range of services from the rural areas. In a landscape dominated by agriculture these services are jointly defined by bio-physical characteristics and farmers' decision making. Farmers can contribute to maintaining and enhancing the landscape by adopting rural activities. However, there is no guarantee that farmers will adopt these rural activities at the locations that will optimally enhance the landscape, nor that sufficient rural activities will be adopted. This thesis has contributed to the understanding of why and where farmers contribute to the provision of landscape services, by assessing their decisions about adopting rural activities. It is intended that this information will be of practical value to policy makers. The various studies have shown that :

- Location matters in farmers' decisions to diversify. Soil drainage, distance from a city, distance from an attractive landscape; and the existing density of rural activities are all contributory factors. In addition there is a spillover effect of farm diversification, leading to the clustering of rural activities.
- Patterns of farm diversification can be assessed by visualising farmers' decisions to adopt rural activities. These can be modelled with no loss of individual heterogeneity, by simulating farm characteristics and the residual of the econometric models based on local distributions.
- Scenario analysis shows that in the National Landscape Arkemheen Eemland; there is still a potential for increasing farm diversification. The provision of landscape services can be enhanced through farmers' contributions and the support of participative policy approaches.

Though this thesis has not attempted to quantify the rural services resulting from farm diversification, the methodologies developed do constitute a first step towards a site specific quantification of farmers' contribution to landscape services and therefore towards context and site specific policies to enhance public goods from agriculture.

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Summary

Society values a whole range of landscape services other than food such as recreation, biodiversity and cultural heritage. These services are the joint result of patterns of bio-physical characteristics and human activities. In agricultural landscapes, farmers' decision making co-defines the quantity and quality of landscape services. Farmers can actively change their contribution to landscape services through adopting new income generating rural activities, i.e. diversification. Yet, there is no guarantee that these activities will emerge coherently within the landscape. Because of the relationship between the adoption of these activities and bio-physical characteristics these patterns of adoption are crucial. The objective of this thesis is to get insights into the spatial patterns of farm diversification and to assess how these patterns may change in the future. The study focuses on the Gelderse Vallei in the centre of the Netherlands.

Chapter 2 looks at the role location (in terms of site specific natural conditions as well as neighbouring dynamics) plays in influencing farmers' decision making about diversification. It also investigates the extent to which low returns from primary agricultural production have stimulated farmers to find new strategies – one possible explanation of recent trends in diversification. This chapter examines the number and kind of activities adopted. The results show that landscape attractiveness is a driver of diversification. Daily recreation most frequently occurs close to national parks and agri-environmental schemes are more likely to occur on relatively wet soils. Diversification activities can produce positive externalities: new activities have the tendency to emerge next to already existing ones. This explains the formation of "diversification hotspots" in the landscape. Finally, diversification is found to be sensitive to returns from primary agriculture production.

Chapter 3 presents a spatially explicit simulation tool for farm diversification that visualizes the adoption patterns of various rural activities: agri-environmental schemes, recreational activities and short supply chains. It is based on a micro-economic model describing the decision making of farmers and seeks to identify the driving factors behind the adoption of the rural activities described in Chapter 2. The relation with the relevant driving factors at the farm-level is empirically identified by

applying a probit model to farm-level data in combination with a GIS database. The resulting empirical probit model is used to simulate the adoption of a particular rural activity for the region, resulting in different patterns of potential adoption. In order to acknowledge individual farm variability and to take potential spatial correlation into account, the probit residual is explicitly modelled. By changing the input parameters of the model, alternative scenarios, representing site specific changes in the region, can be evaluated.

Chapter 4 aims at visualizing the distribution of farm diversification under different explorative scenarios and investigates where the adoption of rural activities takes place. Scale-consistent storylines were developed by combining global storylines from the literature with local storylines from key informant interviews. These storylines were then translated into quantitative scenarios that were used within the simulation tool developed in Chapter 3. The results show that further market liberalization would lead to a decrease of rural services in the study area. Neither a strong top down-policy, nor self-organizing local initiatives appear to provide enough support to encourage farmers to provide additional rural services. In the study area the only approach that appears to enable a general increase of all rural services across the entire area is increased cooperation between government, farmers and citizens.

Chapter 5 investigates the formation of diversified hotspots by testing for the existence of a spillover effect (resulting from the reduced cost of diversification in a diversified neighbourhood). The farm household utility maximization framework used in Chapter 2 is extended, with positive externalities for diversification, and is empirically tested with a Bayesian spatial autoregressive probit model. The results show that diversified farms are clustered around attractive landscapes, distant from big cities, and at locations with a poor soil quality. Moreover, farmers located in a diversified neighbourhood are more likely to diversify, confirming the spillover hypothesis.

Chapter 6 synthesizes the methodologies and results from the previous chapters. It discusses how the different methodologies relate to each other and describes the insights that can be gained from bringing the different spatial dynamics of farm diversification together. Finally, the methodologies and results from the thesis are put in the broader context of future rural development.

Samenvatting

De maatschappij hecht ni*et al*leen waarde aan voedselproductie, maar ook aan een heel scala van landschapsdiensten zoals recreatie, biodiversiteit en culturele erfenis. De beschikbaarheid van deze diensten is het resultaat van de interactie tussen enerzijds patronen van biofysische karakteristieken en anderzijds menselijke activiteiten. In agrarische landschappen zijn het de beslissingen van de agrariërs die medebepalend zijn voor zowel het aanbod als de kwaliteit van de voortgebrachte landschapsdiensten. Agrariërs kunnen hun bijdrage aan de voorziening in landschapsdiensten wijzigen door nieuwe inkomensgenererende rurale activiteiten te gaan uitvoeren. Dit staat bekend als diversificatie. Toch is dat op zichzelf nog geen garantie dat de activiteiten die zo tot stand komen ook coherent zijn met het landschap. Vanwege de relatie die er bestaat tussen de adoptie van rurale activiteiten en de bio-fysische karakteristieken van de omgeving zijn de patronen in de adoptie van activiteiten van cruciaal belang. Het doel van dit proefschrift is inzicht te verschaffen in de ruimtelijke patronen van bedrijfsdiversificatie en na te gaan hoe deze patronen mogelijk in de toekomst zouden kunnen veranderen. De studie richt zich op de Gelderse Vallei, een gebied dat is gelegen in het centrum van Nederland.

Het tweede hoofdstuk in deze studie kijkt naar de rol van locatie (gedefinieerd in termen van locatie-specifieke factoren alsook in termen van de dynamiek uit naburige locaties) in de beslissingen die agrariërs nemen met betrekking tot diversificatie. Ook wordt gekeken in welke mate lage inkomsten uit primaire agrarische productie als stimulans fungeren voor boeren om nieuwe overlevingsstrategieën te ontwikkelen –dit is een mogelijke verklaring van de waargenomen recente trends in diversificatie. Gekeken wordt wat het aantal rurale activiteiten die agrariërs ondernemen verklaard. De uitkomsten laten zien dat landschap een drijvende kracht is bij diversificatie. Dagrecreatie vindt meestal dicht bij nationale parken plaats en agrarisch natuurbeheer heeft een hoge kans om voor te komen op relatief natte gronden. Ook is gevonden dat diversificatie-activiteiten positieve externaliteiten kunnen voortbrengen: nieuwe activiteiten vertonen de neiging te gaan ontstaan in de buurt van alreeds bestaande rurale activiteiten. Dit verklaart het voorkomen van diversificatie hotspots in het landschap. Tenslotte werd gevonden dat de mate van diversificatie gevoelig is voor de opbrengsten uit primaire landbouwactiviteiten.

Hoofdstuk 3 beschrijft een ruimtelijk expliciete simulatietool voor bedrijfsdiversificatie. Hiermee kunnen de gesimuleerde adoptiepatronen voor verschillende rurale activiteiten (agrarisch natuurbeheer, recreatieactiviteiten en huisverkoop activiteiten) worden gevisualiseerd op gebiedsniveau. De tool is gebaseerd op een micro-economisch model dat het beslissingsproces van boeren beschrijft en de belangrijkste drijvende krachten daarbij, zoals eerder beschreven in hoofdstuk 2, daarbij in beeld brengt. Het effect van de drijvende krachten op bedrijfsniveau zijn empirisch bepaald met behulp van een probit model. De modelschattingen worden gecombineerd met een GIS database, die de ruimtelijke factoren meeneemt. Het probit model wordt gebruikt om er de adoptie van specifieke rurale activiteiten voor de hele regio mee te voorspellen. Afhankelijk van de aannames resulteren verschillende potentiele adoptiepatronen. Teneinde rekening te houden met de variatie tussen individuele bedrijven en om de ruimtelijke correlatie goed mee te nemen. Door de input parameters van het model aan te passen kunnen verschillende scenario's worden doorgerekend.

Hoofdstuk 4 heeft als doel de verdeling van bedrijfsdiversificatie zichtbaar te maken onder verschillende verkennende scenario's. In het bijzonder waar de verschillende activiteiten plaatsvinden wordt voorspeld. Schaal-consistente verhaallijnen zijn ontwikkeld door visies vanuit de literatuur te combineren met de visies van geïnterviewde sleutelinformanten. De resulterende verhaallijnen zijn toen vertaald in kwantitatieve scenario's, die vervolgens zijn gesimuleerd met de tool zoals die eerder is ontwikkeld in hoofdstuk 3. De uitkomsten laten zien dat verdere marktliberalisatie tot een daling van het aantal rurale diensten dat wordt geprojecteerd voor de studieregio. Noch een sterk top-down beleid, noch zelforganisatie door middel van lokale initiatieven bleek de agrariërs voldoende prikkels te geven. De enige benadering die soelaas lijkt te bieden (toename van rurale activiteiten) is om samenwerking tussen boeren, burgers te bevorderen.

In hoofdstuk 5 wordt nader ingegaan op het verschijnsel van diversificatie-hotspots. Hiertoe wordt getoetst of er sprake is van spill-over-effecten tussen bedrijven (bijvoorbeeld effecten resulterend in verlaging van transactiekosten in een gediversificeerde omgeving). Het eerder in hoofdstuk 2 gebruikte nutsmaximalisatie huishoudmodel voor agrariers, wordt uitgebreid met een externaliteit-effect. Het model wordt empirisch geschat als een Bayesiaanse autoregressief probit model. De uitkomsten laten zien dat gediversificeerde bedrijven geclusterd zijn in attractieve landschappen, op afstand van steden, en op locaties met een matige grondkwaliteit. Verder blijkt opnieuw dat boeren die hun bedrijf in een al gediversificeerde omgeving hebben zelf ook een relatief hoge kans hebben om zich te gaan diversificeren. Dit bevestigt dus opnieuw de spill-over hypothese.

In hoofdstuk 6 wordt een synthese gegeven van de methodologieën en resultaten uit de eerdere hoofdstukken. De onderlinge verschillen en relaties worden besproken. Nagegaan wordt welke inzichten kunnen worden ontleend aan het bij elkaar brengen van verschillende ruimtelijke dynamiek in bedrijfsdiversificatie in de landbouw. Tenslotte worden de toegepaste methodieken en gevonden resultaten in de bredere context van de toekomstige plattelandsontwikkeling geplaatst.


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Was it free will or destiny? Although this question will remain unanswered, writing this PhD has definitely been a great journey to experience freedom and its boarders.

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To act responsible in a globalized world, one needs to understand the linkages between relevant issues. The Land Dynamics course in Kenya contributed to that understanding, and opened my eyes on research in the South. Great thanks go to Tom Veldkamp, who made my participation possible, as well as all the teachers and participants. I also would like to thank Treazah and Moses for showing me Kenya beyond science.

Freedom in one's mind

During my PhD, I got the chance to travel to Nepal for SCI. On this trip, thanks to Sudyumna and Dharana, I discovered that freedom might be in one's mind: a fascinating thought that brought me to Kenkon, a center for oriental practice in Wageningen. I would like to thank Sydney for making me discover week after week ways to cultivate freedom in one's mind.

When freedom is too much

During a PhD, there are now and then days when freedom is difficult to handle. I have been very fortunate to have great people around me to support me on those days. From an academic perspective, I could always count on two women who believe in me, more than I probably believe in myself. I am grateful to Professor Ann van Ackere for having pushed me to commence a PhD and for all her support over the last years. I also would like to thank Alison Burrell, for all the good talks about science and life, for the carrier planning, and her support.

I always could count on my good friends Monique, Chrissi, Luciana and Kristina, and therefore a particular thanks goes to them for making difficult days brighter.

Finally, I am specially grateful to my family, in particular to my parents, my sister (to whom goes a special thanks for the creation of the cover of this thesis) and my Opi, for always being there when I need them, for providing me a frame of reference, and for accepting my *nomadism*. The world is so big that one might sometimes get lost. It is, therefore, so good to know that there is a save place to call home.

About the author

Curriculum vitae

Catherine Pfeifer is born on the 14.11.1980, in Lausanne, Switzerland. In 2005, she finished her master (diplome d'études superieures specialisées) in economics at HEC Lausanne. Her master thesis focused on competing land use claims in Swiss Alps. From 2005-2006, she worked as teaching assistant, and contributed to the development of a master course on Real Estate management taught by 5 professionals. In 2006, she started her PhD studies at Wageningen University on a joint position between the Land Dynamics group and the Agricultural Economics and Rural Policy group. Her research on Dutch rural areas has been presented in international conferences and published in peer reviewed as well as policy-oriented journals. She is now post-doc on a joint ILRI (international livestock research institute) / IWMI (international water management water institute) position.

List of publications :

Pfeifer C., Jongeneel R., Sonneveld M., Stoorvogel J. *(2009)*, Landscape properties as drivers for farm diversification : a Dutch case study, *Land Use Policy* 24-4, 2009.

Pfeifer C., Stoorvogel J., Jongeneel R. *in review* A spatially explicit simulation tool for farm diversification, *Agricultural Systems*

Pfeifer C., Sonneveld M., Stoorvogel J., *submitted*, Assessing spatial distribution of farm diversification under different rural development scenario, *Journal of environmental management*

Pfeifer C., Jongeneel R. *in review*, Spatial spillovers in rural areas : the role of positive externalities in farm diversification, *European Review of Agricultural Economics.*

Annex to statement
Name Catherine Pfeifer
PhD candidate, Wageningen School of Social Sciences (WASS)
Completed Training and Supervision Plan

		Department/ Institute	Year	ECTS
I.	**Courses**			
	Mansholt Introduction course	MG3S	2007	1.5
	PE&RC Introduction course	PE&RC	2007	1
	New Institutional Economics	MG3S	2007	4
	Scenario Development : understanding and applying multi-scale and participatory concepts and tools	PE&RC	2007	1.4
	Discrete Choice modeling	MG3S	2007	4
	Econometrics of panel data	MG3S	2007	1.5
	Bayesian econometrics	MG3S	2008	4
	Spatial econometrics	MG3S	2008	4
	Mace-Summer school : Agrarian Reform and Rural Development - Changes in Institutions and Organisations, Communication and Governance Structures – in Budapest	MACE	2007	2
	Mace-Summer school : Agricultural Policy analysis –in Warsaw	MACE	2008	2
	Getting to the bottom of Mont-Kenya : analysis of land dynamics and sustainable development in an interdisciplinary perspective	PE&RC	2009	4
	Multifunctional land-use (SIL 32306)	SIL	2006	6
	Inventarisation and soil technique (SIL 30306)	SIL	2006	6
	PhD assessment	Wageningen Graduate Schools	2006	0.3
	Techniques for writing and presenting a scientific paper	Wageningen Graduate Schools	2008	1.2
	Career assessment	Wageningen Graduate Schools	2009	0.3
	How to write a grant application	NWO talent class	2009	1
	Find a job in the 21st century	NWO talent class	2009	0.5
	Moving on in your career	NWO talent class	2010	0.5
	Spatial methods PhD discussion group	PE&RC	2006-2010	1

II.	**Presentation at conferences and workshops**			
	Understanding relations in nature and economy : an application to the rural countryside in Wageningen (paper - 3 days)		2007	1
	Eurogeo – Amsterdam (paper -3 days)		2007	1
	Mansholt PhD day 2007		2007	1
	EAAE Workshop Rennes (paper - 3 days)		2007	1
	EAAE conference in Gent (poster-4 days)		2008	1
	Sense symposium		2008	0.3
	MACE conference in Berlin (paper-2 days)		2009	0.5
	EAAE Workshop Giessen (paper 3 days)		2009	1
	Presentation at MGS peer review		2009	1
	SGA (Swiss society for agriculture economics and rural sociology) Jahrestagung In Tänikon (2 days)		2010	0.5
	Colloque international de UNIL/EPFL/HES : Quelle place pour l'agriculture dans le projet urbain en Suisse ? (3 days)		2010	1
III	**Teaching and supervising activities**			
	Rural Economic Analysis – (AEP31306) – 5 afternoons	AEP	2007/2008/2009	2
	Multi-Functional Land Use (SIL 32306) – 1 afternoon	LAD	2007/2008/2009	0.5
	Bachelor student (1 period)	LAD	2008	1
	MSc Student (1-period)	LAD	2009	1
	TOTAL	``		58.7

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