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Investigating the effect of farmer land-use decisions on rural landscapes using an agent-based model approach.

Eleni Karali

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To my family

Στην οικογένειά μου

Own Work Declaration

I declare that this thesis was composed by myself, that the work contained herein is my own except where explicitly stated otherwise in the text, and that this work has not been submitted for any other degree or professional qualification except as specified.

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After four years and a 'few' days, my research and the writing of this thesis is…over. During this time, I met and worked with numerous people, without whom this experience and its outcome would not have been the same.

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Eleni Karali

Contents

List of Tables

List of Figures

Agri-**E**nvironmental **S**chemes…….	**AES**
Assessing **L**arge scale **R**isks for biodiversity with tested **M**ethods...	**ALARM**
Business **A**s **M**ight **B**e **U**sual……...	**BAMBU**
Choice-**B**ased **C**onjoint…….	**CBC**
Cluster……	**Cl**
Conjoint **A**nalysis……..	**CA**
Direct **P**ayments……	**DP**
Ecological **C**ompensation **A**reas…….	**ECAs**
European **U**nion……	**EU**
(Swiss) **F**ederal **O**ffice for **AG**riculture…….....	**FOAG**
GRowth **A**pplied **S**trategy……..	**GRAS**
Hectares……..	**ha**
Hierarchical **B**ayes……	**HB**
Integrated **P**roduction……..	**IP**
Intergovernmental **P**anel on **C**limate **C**hange……..	**IPCC**
Kaiser-**M**eyer-**O**lkin…….	**KMO**
Land **U**se and **C**over **C**hange……..	**LUCC**
Millennium **E**cosystem **A**ssessment……..	**MEA**
Organic **F**arming……...	**OF**
Principal **C**omponents **A**nalysis…….	**PCA**
Standard **D**eviation……..	**SD**
Socio-**E**cological **S**ystems……	**SES**
Special **R**eport on **E**missions **S**cenarios…….	**SRES**
Sustainable **E**uropean **D**evelopment **G**oal……	**SEDG**
Swiss **A**gricultural **P**olicy……	**SAP**

Thesis abstract

Land use and cover change (LUCC) is increasingly recognised as one of the most visible impacts of humans on nature. In rural areas, most of the observed LUCC is associated with agricultural activities. This has traditionally been attributed to the interplay of the socio-economic and political milieu, and the opportunities and constraints arising from the climatic conditions and physical attributes of land. Although there is no doubt that these factors influence farmer decisions, the mosaic of farming systems suggests that farmers do not always behave uniformly, even in areas with comparable socio-economic and environmental conditions. While the multi-facetted and varying nature of farmer decision-making is considered to be established knowledge in rural sociology, it is often neglected in LUCC models that typically describe it as homogeneous and rational in economic terms. This thesis presents an application of mixed-method social survey which aims at improving the representation of the diversity and complexity of farmer decision-making process in LUCC models. Different data collection methods (in-depth, semi-structured interviews, questionnaire) and analyses (thematic analysis, principal components analysis, cluster analysis, choice-based conjoint analysis) were used complementarily to identify the factors that facilitate or constrain farmer participation in environmental management practices (a), to identify the dominant farmer profiles (b) and to assess farmer preferences that influence land use decisions (c). Data collection was conducted in a study area located in the Canton of Aargau, Switzerland, where there is limited knowledge about farmer decision-making drivers and actions. Research findings were used to empirically inform an agent-based model that simulates farmer decisions. Paremeterised storylines were used to explore farmer decisions in alternative futures. An advanced and context-specific representation of human agents in modeling frameworks can make LUCC models valuable tools both for landscape analysis and policy making. In the face of new policy reforms, this thesis contributes to the achievement of this objective, by presenting an approach to explore and organize the heterogeneity of farmer behaviour and to make this usable in agent-based modeling frameworks.

Chapter One

Introduction

1.1 Land use and land cover change research; general introduction

Ecosystem changes have been taking place since life began (Anastasopoulou et al., 2007). Although for a long time these changes were primarily attributed to the interactions between natural forces that act on geological and biological processes, more recently it was suggested that they are equally much human-induced (Likens, 1991; Redman, 1999). Since the second half of the 20th century in particular, human activities are believed to have altered ecosystems at a scale and speed, which is unprecedented within human history (Grace, 2004; MEA, 2007).

One of the most visible impacts of humans on nature is land use and cover change (hereafter referred to as LUCC). Vitousek et al. (1997) reported that 39-50% of the global terrestrial surface has been affected by humanity, while more recently Hurtt et al. (2006) estimated that for the period 1700-2000, this fraction may have reached as high as 68%.

Alterations in the use and management of land have a direct impact on the provision of ecosystem services (provisional, supporting, regulating and cultural) (Vitousek et al., 1997) and thus on human well-being (MEA, 2003; 2005). In the context of global environmental change and the growing apprehension about the vulnerability, sensitivity and adaptability of natural and social systems, predictions about a rapid continuation of LUCC (Rounsevell et al., 2006a) have underlined the necessity to enhance the current understanding of the forces that drive landscape formation, in order to interact with them through land use planning and management, and minimise undesirable consequences.

Despite the existing evidence of intensive research related to the observation, monitoring and modelling of LUCC (Turner II et al., 2007), a complete insight into the mechanisms that underpin it has not been fully achieved yet (Rounsevell et al., 2006b). Constraints to an in-depth understanding of LUCC are related, to a large extent, to the analytical difficulties arising from the complexity of the natural system per se (Rindfuss et al., 2004), as well as the cross-scale and non-linear processes involved in the human-environment dynamics that underpin it (Lambin et al., 2001; Veldkamp and Verburg, 2004). It is the latter, specifically the difficulty in decoding the perplexity of human decision-making process and introducing it in modeling frameworks, that is most recently acknowledged as a limit to gaining further insights into LUCC (Karali et al., 2011).

'Land use science' is currently recognised as an area of research that accommodates expertise from different scientific backgrounds (Cheong et al., 2011). Most LUCC models, however, following the dominant trend in environmental research, have been mainly ecology-oriented (See Briassoulis, 2000; Verburg, 2006). In response to the acknowledgement of the impact of human activities on landscape formation, ecologists accepted that in order to better understand the way that ecosystems change, they had to also consider the people who manage them (i.e. Vitousek et al., 1997; Lowe et al., 2009).

A dialectic conceptualisation of the human-environment nexus, describing the impact of human activities on the environment, demonstrated the shift of environmental studies, from pure, applied ecology towards the social sciences. Observation of environmental change feedbacks on both nature and human societies, however, suggested that both of these should be seen as components of a 'complex adaptive system' (Berkes, 2004). Such arguments led to the development of socio-ecological systems (SES) approach, which portrayed the constant, two-way interactions between humans and nature (Gallopín, 1991; 2006).

SES embraces a detailed description of human behaviour (Beratan, 2007), and thus an active exchange of information between different scientific fields is required to operationalise this. As a result, interdisciplinary research steadily appeared along with the dominant disciplinary studies, and ostensibly opposing methods and approaches started being used complementarily in integrated studies of human-environment interactions (Cheong et al., 2011).

In addition to the philosophical challenges, however, the explicit incorporation of the human dimension in environmental studies was confronted by practical barriers. In the case of LUCC, for example, methods that have been traditionally used in ecological studies, such as the in situ experimental approach or the option of a laboratory setting, were impractical (Baker, 1989), unethical (Karali et al., 2009) and inefficient (Jager and Janssen, 2001), underlining the need for the use of models (Baker, 1989).

Despite its acknowledged suitability, the modelling approach has received criticism due to the limited or oversimplified representation of human behaviour that often entails. In LUCC models, for example, as in other environmental studies, human behaviour is usually described based on ad hoc or ex ante frameworks (Irwin and Geoghegan, 2001; Nightingale, 2009).

The most widely used framework draws its theoretical foundations from the 'Rational (actor) choice' theory (Manson, 2006). This theory describes the mainstream micro-economic view, which ascribes to humans perfect rationality, homogeneity and single-minded utility maximisation (Macal and North, 2005). These assumptions offer analytical tractability (Myers and Papageorgiou, 1991) and allow deduction. However, by neglecting the heterogeneity of human societies and the imperfection of human knowledge and cognition, this theory describes an ideal but unrealistic situation (Chase et al., 1998).

Empirical evidence showing that people often make suboptimal choices (Beratan, 2007), without always following the same decision-making pathway (Grothmann and Patt, 2005), stimulated the formulation of theories and frameworks that deviated from the established rational norms.

Simon (1955) introduced the 'satisficing' model and the concept of 'bounded rationality'. This model accounted for physiological and psychological limitations (Chase et al., 1998), and explained the mismatch between descriptive and normative behaviour (Dillon, 1998). Related to this, Tversky and Kahneman (1974, 1991) suggested that people tend to make satisfactory instead of optimal choices, as a result of the use of simple heuristics (i.e. representativeness, loss aversion) that limit cognitive effort[1].

More recently, socio-psychological frameworks placed more emphasis on the complexity of the human decision-making. For example, the theory of Planned Behaviour (Ajzen, 1991), an extension of the Theory of Reasoned Action (Fishbein and Ajzen, 1975), described human behaviour as the product of an individual's attitudes, subjective norms and perceived behavioural control.

Despite the existence of behavioural models that move beyond the basic economic assumptions, these have been only rarely used in LUCC models. This resulted not only from the durable disciplinary isolation of social and environmental sciences, which has challenged the conduct of interdisciplinary research (Fox et al., 2006; Hicks et al., 2010), but also from the limited potential of modelling techniques[2] used to model human-

[1] In broader terms, however, some researchers support that making a suboptimal choice by using less cognitive effort should also be considered as optimisation (see Chase, 1998; Jager et al., 2000).

[2] For an extensive review of the modelling techniques used in LUCC see Briassoulis (2000).

environment interactions to accommodate the complexity and diversity of human decision-making process (An et al., 2005).

Recent technological and computational advances allowed the development of new methods that were able to address these challenges and relax the simplified assumption of traditional analytic. One of the most promising approaches for future research is the agent-based modelling (hereafter referred to as ABM) (DeAngelis and Gross, 1992; Epstein and Axtell, 1996; Brown et al., 2005; Crooks et al., 2007).

ABM applications have crossed disciplinary boundaries and scientific interests (Bonabeau, 2002; Tesfatsion, 2006; Shen et al., 2006; Matthews et al., 2007). Its potential to simulate human-environment interactions (i.e. LUCC) is increasingly emphasized (Bonabeau, 2002; Pahl-Wostl, 2002; Becu et al., 2003; Bousquet and Le Page, 2004; Parker, 2005; Robinson et al., 2007; Acosta-Michlik and Espaldon, 2008), particularly due to its ability to represent the heterogeneity and complexity of human cognitive processes (Janssen, 2005; Murray-Rust et al., 2011).

Agent-based models are populated by software objects called 'agents' (Axelrod, 1997). In LUCC research, depending on the level of the analysis, agents may represent individual land managers (i.e. farmers or foresters), or actors that function at higher level of the organisational hierarchy (i.e. associations, organisations, countries). Agent types have distinct sets of attributes, which make them identifiable from the other agents (Gilbert, 2008) and a clearly defined goal that is consistent with their profile (Jager et al., 2000). Instead of having a central direction (Axelrod, 1997; Deadman, 1999; Smith and Conrey, 2007), agents follow behavioural rules which enable them to interact independently with other agents and their environment (O'Sullivan and Haklay, 2000; Berger et al., 2001; Berry et al., 2002). Behavioural rules vary in terms of the levels of complexity and sophistication; "from primitive reactive decision rules" (Macal and North, 2005, pp.73) to complex behaviour represented by artificial intelligence techniques (O'Sullivan and Haklay, 2000; Macal and North, 2005) and learning algorithms.

The platform on which agents operate and with which agents interact is the ABM environment. Although, under a wider spectrum of ABM applications, the 'environment' may represent abstract features, such as knowledge (Gilbert et al., 2001), in LUCC models it usually represents geographical space. In a similar rational to the agent behavioural rules,

specific rules can be set to govern the way that the environment changes over time (Gilbert, 2008).

ABM approach is closely related to the theory of emergent systems (Acosta-Michlik and Espaldon, 2008). Following a bottom-up approach, ABM provides a test bed which allows the investigation of emergent, large-scale patterns or phenomena, as derived from self-organisation processes and interactions between the investigated system elements (Holland, 1992; Deadman, 1999; Janssen, 2005; Crooks et al., 2007; Smith and Conrey, 2007). Depending on the programming architecture, ABM can also incorporate feedbacks. For example, agents may adapt their behaviour in response to changes in their 'environment' (Axelrod, 1997; Mellouli et al., 2003) or update their cognitive load through information exchange with other agents or observation (Gilbert, 2008).

ABM has the potential to support an explicit, micro-level representation of human behaviour. Although the introduction of this information into LUCC models is expected to improve our understanding of the processes that underpin landscape changes (Jager et al., 2000), some researchers still express their skepticism over the implications of such complex frameworks (O'Sullivan and Haklay, 2000; Couclelis, 2001). Such viewpoints highlight the importance not only of getting a detailed understanding of the factors and processes that formulate human decisions, but also of developing methods that allow the transparent incorporation of this information in LUCC models. This constitutes the departure point for the present thesis.

1.2 Thesis overview

1.2.1 Focus: Land use and land cover change in rural areas

With about 30% of the global terrestrial surface being covered by forest (FRA, 2005) and 40% by agricultural land and pasture (Foley et al., 2005), rural areas have become one of the hot-spots of LUCC research.

Agricultural land, in particular, comprises a typical exemplar of the pervasive human-environment interactions (Cooke et al., 2009). Farmland embeds some of the most influential activities with regard to the formation of rural landscapes (Schmitzberger et al., 2005; Valbuena et al., 2008) and economies. Decisions related to its management are mainly human-induced

and driven by socio-economic and political changes. The "Green" revolution and income growth in western societies for example constitute two of the most typical cases of such drivers, which accompanied by technological advances, have caused some of the most rapid and extensive alterations in rural landscapes during the last sixty years.

In response to their calls for maximization of food production and the establishment of subsidies based on production levels, traditional farming practices were gradually substituted by intensive activities. The expansion of cropland and pastures, the domination of high-yielding, irrigated monocultures and the excessive use of fertilisers, pesticides and energy had a profound impact on the wider environment. This included among others the destruction of natural habitats, species extinction, impoverishment of genetic diversity, soil erosion, depletion of nutrients, scarcity and pollution of water resources and loss of historical and cultural landscapes (i.e. Vos and Meekes, 1999; Antrop, 2004; Donald et al., 2006; Sattler and Nagel, 2010).

The wider acknowledgement of environmental degradation fostered the politicisation of environmental concerns in several countries (i.e. Cretegny, 2001). Policy makers worldwide faced the challenge to restructure agricultural sectors around multifunctional models, aiming at the maintenance of farmers' income, the production of healthy food, the preservation of landscape mosaics and the minimisation of the undesirable consequences to both nature and human societies (i.e. Barthelemy and Vidal, 1999).

In the European Union (EU), environmental concerns related to intensive agricultural practices were articulated with the mid-1990s reform of the Common Agricultural Policy. In practice, this was expressed by the introduction of cross-compliance[3] and a range of environmentally-friendly activities, as well as the replacement of production-based subsidies by area-dependent payments. Analogous reforms took place in non-EU countries. In Switzerland for example, food surpluses and high production costs urged for the decoupling of producer's support and production levels, and the establishment of direct payments based upon proof of ecological performance (Curry and Stucki, 1997).

In spite of the existence of regulatory mechanisms, in most parts of the world, participation in agri-environmental schemes and organic farming

[3] "The practice of granting public payments to farmers only if they comply with certain environmental standards" (Mann, 2005a, pp.471).

remains voluntary. The recognition that the achievement of the socio-ecological goals of agricultural policies is largely dependent on land manager mindsets underlined the necessity for research to concentrate on 'what is it that makes farmers want to behave in a certain way' (Battershill and Gilg, 1997, pp. 226).

Research exploring farmer behaviour commenced as early as the 1970s (i.e. Gasson, 1973). A climax in the number of studies, however, was observed in the 1990s, when the implementation of the agricultural policy reforms occured. These studies attempted to explore a variety of farm management decisions from different viewpoints, by drawing information from case studies worldwide (Table 1).

Table 1: Farmer decisions explored in studies of rural sociology and other relevant fields (countries where studies were conducted; A: Austria, AU: Australia, BE: Belgium, BF: Burkina Faso, BO: Bolivia, CA: Canada, CH: Switzerland, CO: Colombia, CR: Costa Rica, CZ: Czech Republic, DE: Germany, DK: Denmark, ES: Estonia, ET: Ethiopia, Europe: multiple cases studies across Europe, FI: Finland, FR: France, GR: Greece, I: Italy, ID: Indonesia, IN: India, KE: Kenya, NL: The Netherlands, NZ: New Zealand, LI: Lithouania, P: Portugal, Review: reference to multiple case studies, S: Spain, SE: Sweden, SL: Sri Lanka, SLO: Slovenia, UK: United Kingdom, US: United States of America, V: Vietnam).

Decision	Example authors
Farm strategies/styles	Fairweather and Keating (1994) (NZ), Busck (2002) (DK), Daskalopoulou and Petrou (2002) (GR), Meert et al. (2005) (BE), Schmitzberger et al. (2005) (A), Brodt et al. (2006) (US), Jongeneel et al. (2008) (NL), Barbieri and Mahoney (2009) (US)
Policy acceptance	Cocklin et al. (2007) (AU), Gorton et al. (2008) (Europe), (UK), Davies and Hodge (2007) (UK), Farmar-Bowers and Lane (2009) (AU), Morgan-Davies and Waterhouse (2010)
Agricultural technologies	Arayman et al. (2007) (NL), Rehman et al. (2007) (UK)
Pest and weed management	Macé et al. (2007) (FR), Mancini et al. (2008) (IN)

Environmentally friendly farming practices (Agri-environmental schemes, biodiversity measures, conservation)	Morris and Potter (1995) (UK), Wilson (1996) (UK), Battershill and Gilg (1997) (UK), Wilson (1997) (UK), Hart and Wilson (1998) (UK), Beedell and Rehman (1999) (UK), Willock et al. (1999) (UK), Falconer (2000) (Europe), Wilson and Hart (2000) (Europe), Damianos and Giannakopoulos, (2002) (GR), Mathijs (2003) (BE), Illukpitiya and Gopalakrishnan (2004) (SL), Mann (2005b) (CH), Davies and Hodge (2006) (UK), Michel-Guillou and Mosser (2006) (FR), Siebert et al. (2006) (global review), Hounsome et al. (2006) (UK), Macgregor and Warren (2006) (UK), Bewket (2007) (ET), Kessler (2007) (BO), Lambert et al. (2007) (US), Schenk et al. (2007) (CH), Herzon and Mikk (2007) (ES, FI), Ahström et al. (2008) (review), Defrancesco et al. (2008) (I), Prager and Nagel (2008) (DE), Atari et al. (2009) (CA), Espinosa-Goded et al. (2010) (S), Sattler and Nagel (2010) (DE), Vignola et al. (2010) (CR), Wauters et al. (2010) (BE)
Water pollution programmes	Barnes et al. (2009) (UK), Blackstock et al. (2009) (review)
Organic farming	Dimara and Skuras (2003) (GR), Darnhofer et al. (2005) (A), Zagata (2010) (CZ)
Crop choice	Ravnborg and Rubiano (2001) (CO), Mattison and Norris (2007) (UK)
Livestock choice	Tano et al. (2003) (BF), Roessler et al. (2008) (V)
Tree schemes	Kiptop et al. (2007) (KE), Arifin et al. (2009) (ID), Præstholm et al. (2006) (Europe)

Much variation was observed also with regard to the theoretical frameworks that LUCC studies refer to, usually reflecting the backgrounds and the perspectives of the researchers, and the diverse foci of the studies (Table 2).

Table 2: Examples of theoretical origins of studies exploring farmer decisions.

Theories and Frameworks	Example authors
Theory of Reasoned Action	Rehman et al. (2007), Barnes et al. (2009)
Theory of Planned Behaviour	Beedell and Rehman (1999), Mattison and Norris (2007), Gorton et al. (2008), Wauters et al. (2010)
Theory/ Concept of Acceptance	Schenk et al. (2007), Sattler and Nagel (2010)
Psychological (and Institutional) theories of behaviour	Willock et al. (1999), Blackstock et al. (2009)
Theories of Investments	Aramyan et al. (2007)
Strength-Weaknesses-Opportunities-Threats framework	Atari et al. (2009)
Incomplete Contract Theory	Jongeneel et al. (2008)
Hierarchical Theory of Choice	Darnhofer et al. (2005)
Decision-Systems Theory	Farmar-Bowers and Lane (2009)
Random utility framework	Lambert et al. (2007)

Heterogeneity was also observed in the research designs employed in different studies. For example some studies followed an inductive approach, with the aim to produce general concepts based on empirical data (i.e. Wilson, 1997), while other studies aimed at testing existing theories (i.e. Vanclay et al., 2006).

Data collection methods varied in nature, whether purely qualitatively or quantitatively oriented, or a mix, when studies presented results based on primary data (Table 3), or relying solely on existing literature to conduct reviews (i.e. Siebert et al., 2006; Ahnström et al., 2008; Blackstock et al., 2009).

Table 3: Methods of data collection employed in studies of farmer decisions.

Examples of data collection methods	Example authors
Survey/interviews	Battershill and Gilg (1997), Beedell and Rehman (1999), Ravnborg and Rubiano (2001), Mathijs (2003), Bewket (2007), Mattison and Norris (2007), Mancini et al. (2008), Barnes et al. (2009), Farmar-Bowers and Lane (2009), Vignola et al. (2010)
Q-methodology	Davies and Hodge (2007)
Conjoint analysis questionnaire	Tano et al. (2003), Arifin et al. (2009)
Workshops	Ravnborg and Rubiano (2001), Barnes et al. (2009)
Focus groups	Arifin et al. (2009), Vignola et al. (2010)
Informal discussions	Bewket (2007)

Table 4: Sampling strategies used for selecting farmers in different study areas, reflecting the study aims.

Sampling method	Example authors
Snowballing	Meert et al. (2005)
Stratified/Strata-proportional	Ravnborg and Rubiano (2001), Vignola et al. (2010)
Theoretical	Schenk et al. (2007), Farmar-Bowers and Lane (2009)
Purposive /Judgemental	Battershill and Gilg (1997), Barbiery and Mahoney (2009)
Random	Willock et al. (1999), Bewket (2007), Dimara and Skuras (2003), Illukpitiya and Gopalakrishnan (2004), Jongeneel et al. (2008)

Different sampling methods mirrored the objectives of the data collection process (Table 4). For example studies that aimed at describing a representative viewpoint employed random sampling (i.e. Willock et al., 1999; Bewket, 2007; Dimara and Skuras, 2003), while studies aiming at covering a maximum variation of opinions employed other methods such as the theoretical sampling method (i.e. Schenk et al., 2007; Farmar-Bowers and Lane, 2009).

Apart from the expected effect of economic factors, empirical research revealed a range of non-economic factors that influence farmer decisions (i.e. Wilson, 1997; Willock et al., 1999; Beedell and Rehman, 1999; Siebert et al., 2006). This evidence questioned the validity of the traditional view of farmers as 'true profit maximisers' (Bowers and Cheshire, 1983 as cited in Battershill and Gilg, 1997). Moreover, the lack of consensus regarding the magnitude and the trend of the effect that these factors have on farmer land-use decisions (Wilson and Hart, 2000; Defrancesco et al., 2008) raised doubts about the credibility of viewing farmer communities as homogeneous groups.

Nevertheless, despite the existence of evidence which suggests the need to account for the particularities of the SES embedded in individual case study areas, as well as the heterogeneity that is inherent in farmer communities (Busck, 2002; Darnhofer et al., 2005), the neoclassical micro-economic theory is still used and even recent studies consider profit maximization as the only strategy in which farmers engage (Rounsevell et al., 2003; Piorr et al., 2009). This contrast implies that representing the diversity and the complexity of real world SES in LUCC models, and human decisions in particular, remains a challenging area.

1.2.2 Research objectives

This project investigates the mechanisms that underpin LUCC in rural areas and explore its consequences on ecosystem services, through the construction and application of an empirically informed agent-based model. Motivated by the conceptual challenges that have been addressed in the relevant literature regarding the simplified and homogeneous representation of human dimension in models (i.e. Irwin and Geoghegan, 2001; Nightingale, 2009) the aim of this thesis is twofold: 1) to improve the current understanding of farmers' decision-making process and 2) to advance their

representation in LUCC models. This is expected to improve the understanding of the impact of farmer decisions on landscape formation and the ecosystem services provided by it.

Processes describing farmer decisions and the consequent LUCC will be explored under three integrated socio-economic and climatic scenarios; BAMBU (Business As Might Be Usual), GRAS (Growth Applied Strategy) and SEDG (Sustainable European Development Goal). These scenarios follow the storylines of the Intergovernmental Panel on Climate Change (IPCC) Special Report Emissions Scenarios (SRES).

Under the uncertainty about the number and the nature of the driving forces related to different aspects of global environmental change (IPCC, 2000) the use of scenarios is one of the most suitable methods for its assessment (Metzger, 2005). Scenarios provide sets of hypothetical conditions about alternative future images (Alcamo, 2001; Verboom et al., 2007). It is acknowledged that a single scenario is highly unlikely to incorporate all the changes that will be seen in the future (Metzger, 2005). However, the use of a range of scenarios can accommodate satisfactorily well the various conditions that we might experience (Metzger, 2005).

The research presented in this thesis was designed around the following two questions:

1. What can empirical research tell us about farmer decision-making with regard to LUCC?
2. How will farmer decisions affect the formation of rural landscape and the provision of ecosystem services in alternative futures?

Following the approach of 'Grounded theory' (Glaser and Strauss, 1967) which argues for the development of theoretical ideas based on empirical data (Sarantakos, 2005; Hodkinson, 2008), the human sub-model of the ABM in this thesis was empirically informed through a mixed-methods social survey. The design of the survey was based on the successive paradigm triangulation model (Sarantakos, 2005). A range of data collection methods (in-depth interview, questionnaire, choice experiment) and analytical approaches (thematic analysis, principal component analysis, cluster analysis, choice-based conjoint analysis) were used complementarily, in order to investigate farmer decisions from a variety of angles in a rural study area in Switzerland. Detailed descriptions of the design and the application of each method are provided in chapters two, three and four.

Although mixed designs have received criticism by some researchers who argue that the different assumptions of qualitative and quantitative research make their combined application incompatible, this approach has received support by others (Sarantakos, 2005). The latter authors propose that the symbiosis of different methodologies can increase the strength of the research design, as well as the quality of its results (Sarantakos, 2005; Darnhofer et al., 2005; Kiptop et al., 2007). This argument underpins the decision for the use of a mixed-method design in the present study.

1.2.3 Site description

The study area is situated in the Canton of Aargau, in the northern part of Switzerland (Figure 1), in proximity to the urban centers of Zurich and Basel. It covers approximately 99 km^2, extending from the more rugged first Jura chain, across the river Aare, to the Swiss plateau in the South (7.993353W, 8.169499E, 47.490812N, 47.300951S).

The mosaic of land uses and land covers that is present in the area creates a unique landscape of high aesthetic and ecological value. Farmland occupies 35% of the area, which divides into meadows and pastures (65%), arable fields (33%), permanent cultivations and other agricultural activities (2%). In addition to agricultural use, 44% of the study area is covered by forest and 21% by the built environment (all figures from Swiss Statistics, www.bfs.admin.ch).

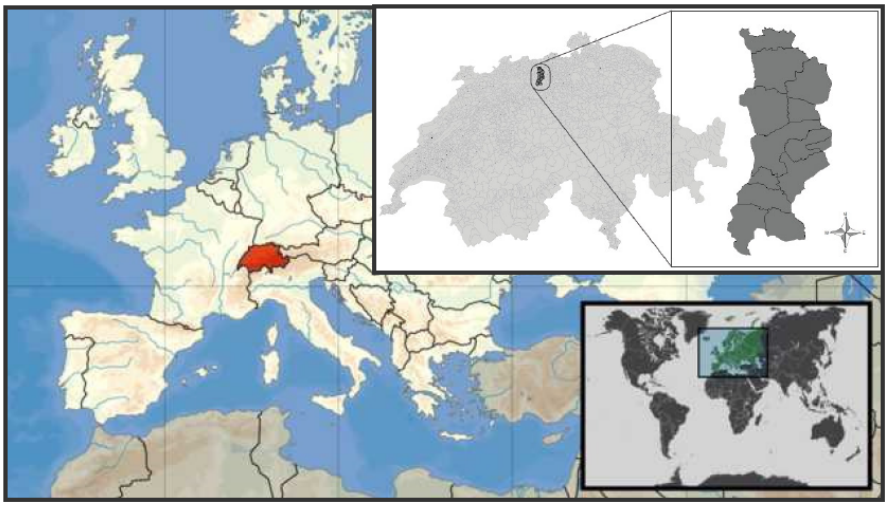
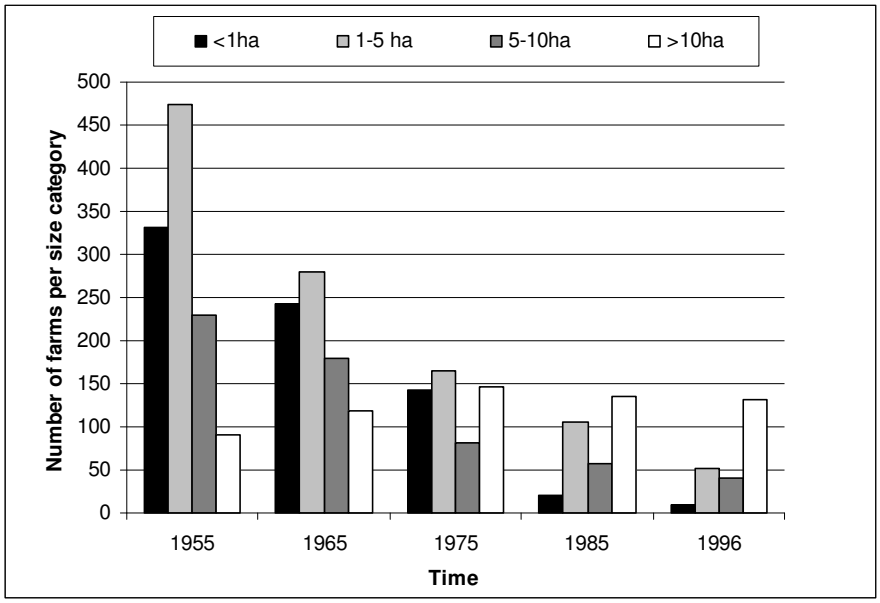


Figure 1: Map showing the location of the study area.[4]

[4] Background map retrieved from http://www.solarnavigator.net/geography/switzerland.htm

During the period 1980-2009, total agricultural land decreased by 4%, while significant structural changes have been occurring since the second half of the 20th century (Figure 2). Among other forces, policy has a catalytic impact on the formation of rural landscapes (Piorr et al., 2009). In Switzerland, for example, forested areas are under legal protection status (Hersperger and Bürgi, 2010), while legislative changes related to the Swiss agricultural sector, namely the reform of Swiss Agricultural Policy (SAP) in 1996, have regulated to a great extent farmer decisions, particularly of those farmers who are financially dependent on agricultural income. Nevertheless, contrary to the limited (almost absent) access of individual foresters to the decision-making process related to the management of forested areas, farmers have maintained the right to make decisions about the management of their farms even after the SAP reform. This means that farmers remain key actors not only with regard to the shaping of rural landscapes, but also in terms of the achievement of SAP goals.



(Source: Swiss Statistics)

Figure 2: Structural changes in farm size in the study area for the period 1955-96.

Despite evidence of intensive research on farmer decisions, particularly during the last fifteen years, this subject has not been systematically explored in the Swiss context, but for a very limited number of studies (i.e. Wilson and Hart, 2000; Schenk et al., 2007). The scarcity of scientific evidence highlights the existence of a gap related to this particular geographical area and sets this case study apart from other studies in this field.

1.2.4 Structure and contents

This thesis consists of seven chapters (Figure 3). Apart from this general introduction (Chapter one), the conclusions (Chapter six) and the epilogue (Chapter seven), all chapters are written after a series of papers. Chapters two, three and four present the insights achieved during the 'Concept Development' phase, while Chapter five describes the application of concepts developed and discussed in the three previous chapters. Insights gained at each stage of the research process comprised the basis for the development of subsequent work. Nevertheless, each chapter is written as an independent piece of work and thus it can be read on its own. Part of the material presented in this introduction has contributed to a peer-reviewed article (Murray-Rust et al., 2011) as a separate section (2.1. Land Managers) and two published conference proceedings (Karali et al., 2009; Karali et al., 2010). Papers after which chapters two, three and four were written are currently in revision (Chapter 2) and in review (Chapter 3 and 4), and the paper that chapter five is based on is in preparation for submission. Furthermore, a summary of this work also appears in the Ecochange project (FP6-036866) brochure.

Chapter two identifies the factors that facilitate and constrain farmers' participation in environmental management practices, as revealed from a thematic analysis of 24 in-depth, semi-structured interview texts. Research focused in particular on farmers' participation in agri-environmental schemes and the application of organic farming. This information was complemented by questions related to the past and present status of the farms, as well as farmer socio-economic profiles. Eighteen factors were identified and grouped in six themes. Social and political factors, household and individual profile characteristics as well as attributes related to the natural environment were all shown to influence farmers, suggesting that their decisions are not driven by economic incentives alone.

Adopting a quantitative approach, Chapter three describes the application of hierarchical cluster analysis for the construction of a typology of farmer behavioural profiles. Classification criteria were developed through principal component analysis of data showing farmer responses to statements related to the motivations that underpin their decisions and the objectives that they aim to achieve through these. Further statistical analysis was conducted for the parameterisation of the individual clusters. Findings

presented in this chapter indicated a new approach for the conceptualisation of human behaviour; as an emergent phenomenon from the interaction of different identities, rather than as the expression of discreet behavioural profiles. Moreover, this typology serves as a means to integrate the heterogeneity of farmers' behaviour in the ABM in chapter five.

Much of the early research on farmer decisions followed structurationist approaches (Battershill and Gilg, 1997). These assumed that all factors identified as influential (e.g. the 18 factors identified in chapter two) have the same level of importance to farmers. Farmer communities, however, are characterized by inherent heterogeneity (i.e. Busck, 2002). Therefore, farmers are expected to place different weights of importance on different factors, based on their preferences (Darnhofer, 2006). Chapter four illustrates an alternative approach to explore farmer preferences based on the application of choice-based conjoint (CBC) experiment. CBC is a method that originates from the research field of marketing. In this study however, CBC is used to explore the trade-offs between a set of factors influencing farmer decisions. The estimated values of relative importance are used in a utility function that describes farmer decisions in the model. These determine the selection of the crop rotations that farmers apply on their farms. This process is described in detail in Chapter five.

Chapter five presents an application of the conceptual framework of the agent-based model "Aporia". Aporia is used for the simulation of farmer land-use decisions in a rural case study area in Switzerland. The primary aim of this exercise is to explore the changes that take place on rural landscape and the provision of ecosystem services in alternative future scenarios, as a result of farmer decisions. These describe alternative ways that the socio-economic and climatic context might be in the study area in the years 2020 and 2050.

Chapter six provides a summary of the entire body of work presented in this thesis. It also presents the main findings and discusses some points that are worth being considered with regard to future research. Chapter seven is the epilogue of this thesis.

Chapter outlines, along with a statement of co-author contributions are given in the preamble at the beginning of each chapter. Copies of the questionnaires used at different stages of the social survey, analysis output and other relevant documents produced during the research process are provided on the CD-ROM annex of this thesis.

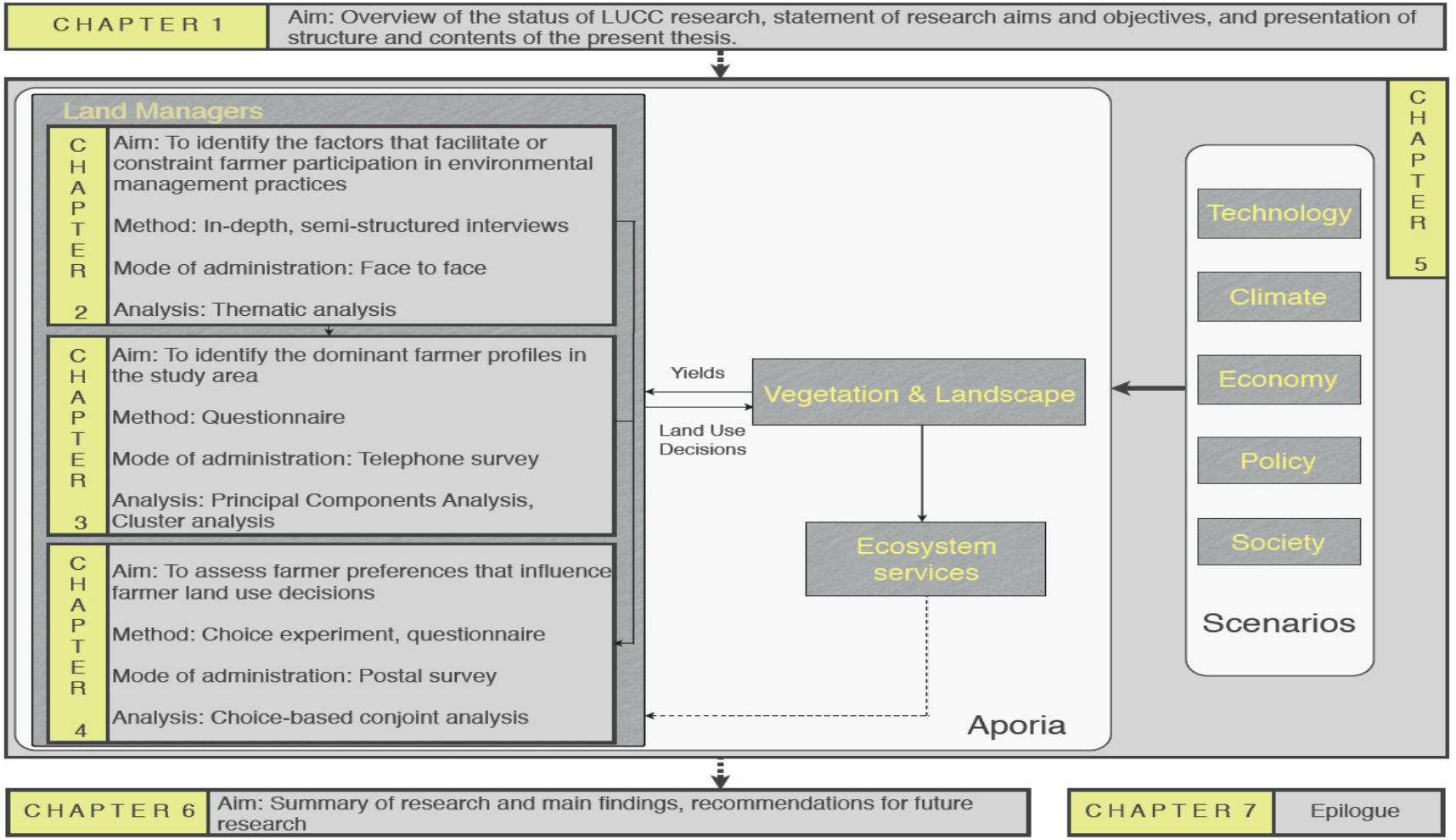


Figure 3: Visual representation of the thesis' structure and contents.

PART I: CONCEPT DEVELOPMENT

Chapter Two

Identifying factors that influence farmer participation in environmental management practices.

After an article by
Karali et al. (In revision a)

Chapter acknowledgements

I would like to thank Beat Brunner for his contribution to the conduct of the interviews and Dr. Anna Hersperger for her support during the data collection process.

Outline

This article identifies the factors that either constrain or facilitate farmer decisions to participate in environmental management practices in a study area located in the north of Switzerland. Participation in agri-environmental schemes (AES) and the application of organic farming (OF) were the focus for the study. Interview texts were analysed thematically and descriptive statistics were used to explore the characteristics of participants through their socio-economic profiles. Results showed that farmer decisions are influenced by factors related to the whole decision-making environment in which farmers operate (social, political, environmental etc.) rather than by economics incentives alone. Financial imperatives were, however, still of primary concern, suggesting that participation in environmental management practices results primarily from the aim of adapting to the recent agricultural policy reform and the subsidies arising from this, rather than from a shift towards 'greener' attitudes.

2.1 Introduction

Until the 1980s, Swiss Agricultural Policy (SAP) focused on economic objectives (Curry and Stucki, 1997), with an emphasis on consumer protection, the maintenance of farm-income and self-sufficiency in food production. By the early 1990s, the dominance of production-led incentives and the consequent intensive agriculture resulted not only in food surpluses and high production costs (Curry and Stucki, 1997), but also in the articulation of public concerns about the environmental impact of farming practices.

In response to this situation, the Swiss Federal Office for Agriculture (FOAG) proposed a shift in the objectives of the SAP. After an unsuccessful attempt in 1995, which largely followed the principles of the European Union's reforms of the Common Agricultural Policy, a new plan was put forward, which proposed to restructure the agricultural sector around a multi-functional model (Cretegny, 2001). This placed emphasis on the importance of agro-ecosystems to provide services in addition to food production, yet without compromising the competitiveness of the Swiss agricultural sector or threatening farm viability.

Contrary to findings reported for Europe (Espinosa-Goded et al., 2010), and other parts of the world (Kiptop et al., 2007), suggesting that farmers are still reluctant to commit to environmentally responsible management plans, 90% of Swiss farmers managed to adapt to the requirements listed in the 'Order of Direct Payments' (Mann, 2005a) and certify their farms as integrated production (IP) systems. In addition, 11% of Switzerland's utilised agricultural area is now farmed organically (FOEN/FSO, 2009).

However, as farmers rarely adapt passively to changes in agricultural policy (Long and van der Ploeg, 1994 cited by Darnhofer et al., 2005), it is important to identify what underpins land-use decisions (Macé et al., 2007). Although there is considerable knowledge in this area (Austin et al., 1996; Wilson, 1997; Damianos and Giannakopoulos, 2002; Dimara and Skuras, 2003; Darnhofer et al., 2005; Aramyan et al., 2007; Herzon and Mikk, 2007; Kiptop et al., 2007; Sattler and Nagel, 2010), studies have reported contradictory results regarding the extent or the trend of the effects of influential factors (Wilson and Hart, 2000; Defrancesco et al., 2008). This indicates the need to explore these factors in different contexts.

Planners and policy-makers have become increasingly interested in informing policy guidelines with findings from studies that employ participatory approaches (i.e. Darnhofer, 2006). The primary aim of this process is to minimise the policy features that discourage farmers from committing to long-term, environmentally-friendly farm management plans.

This paper contributes to this aim by identifying the factors that form the basis for farmer participation in environmental management practices. It also explores whether the wide acceptance of the reformed SAP indicates a pragmatic change in farmer attitudes and a shift to post-productivist behaviour or an opportunistic reaction to the 'green' incentives of the reformed agricultural policy, as seen in other regions (Wilson, 2001). A social survey was designed using in-depth, semi-structured interviews to investigate the factors that either facilitate or constrain farmer decisions regarding their participation in AES and the application of OF, in a study area in Switzerland. Information collected from twenty-four farmer responses was analysed through thematic analysis; an inductive approach which allows themes to emerge from the data without a priori knowledge. The analysis revealed eighteen factors that influenced farmer decisions that were grouped into six thematic categories; economy, society, policy, environment, household characteristics and farmer characteristics.

2.2 Research design

2.2.1 Case study area

The study area is located in the Canton of Aargau, in the north part of Switzerland (Figure 4). It is a north-south transect of 99 km^2, extending from the first Jura chain, across the river Aare, to the Swiss plateau in the South. The mosaic of land uses and land covers, and diverse topographic characteristics of the region create a unique landscape of high aesthetic and ecological value.

The study area has undergone extensive land use and cover change over the last decades. During the period 1980-2009, total agricultural land decreased by 4%, accounting today for 35% of the total area. The area covered by arable fields and permanent cultures decreased by 15% and 42% respectively, while an increase was seen in the area of meadows and pastures (2%). At present, more than half of the agricultural land in the study area is

used for meadows and pastures (65%), and almost one third of the area is arable (33%). A very small proportion of the area is used for permanent cultivations such as vineyards and orchards, and other agricultural purposes (2%). Forests account for 44% of the total land surface and 21% is covered by the built environment (all figures from Swiss Statistics, www.bfs.admin.ch).

Following the recent agricultural policy reforms, changes have been observed in farming practices in the area. The number of organic farms, for example, increased by 78% from 1996 to 2009, while the number of conventional farms decreased by 26% over the same period (Swiss Statistics, www.bfs.admin.ch).

The importance of this case study draws from the anticipated change in agricultural areas in the near future which is likely to arise from the status of legal protection of forested areas, dynamic rural-urban interactions and further agricultural and environmental policy changes. Moreover, there have been a limited number of studies exploring farmer behaviour in the Swiss context (Wilson and Hart, 2000; Schenk et al., 2007).

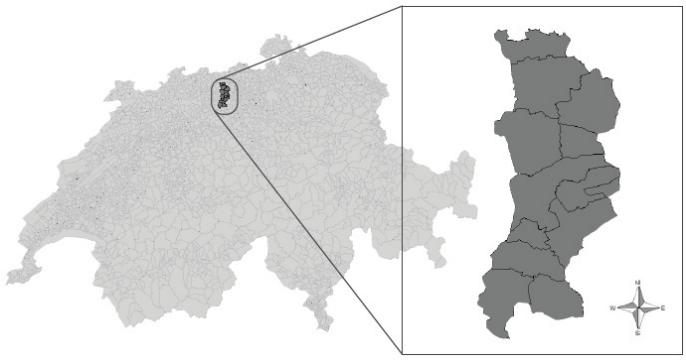


Figure 4: Map showing the location of the study area.

2.2.2 Methodological and analytical approach

This study adopted an approach based on a qualitative, thematic analysis of in-depth, semi-structured interviews. This approach was chosen because of the potential of in-depth interviews to provide an open, conversational exchange of information, allowing for the exploration of emergent themes (Sarantakos, 2005). The use of guidelines maintained the focus of the interviews, ensuring consistency, limiting human bias and increasing the comparability of the data collection process. Furthermore, as the majority of

the questions were open-ended, the use of guidelines neither prevented interviewees from expressing their own opinions nor directed them towards predefined choices. Drawing from the principles of 'Grounded Theory' (Glasser and Strauss, 1967), open, axial and selective coding was applied during the analysis of the interview texts in order to identify factors and themes. Basic quantitative methods were used for the description of the sample and the farm characteristics.

2.2.3 Data collection

Data were collected in January and February 2009. All 24 interviews were conducted *in situ*, by the same interviewer, in the local dialect. The familiar environment helped in establishing a feeling of mutual trust between the farmers and the interviewer, which facilitated the discussion. Interviews commenced with a detailed mapping of the interviewees' farming background, focusing on where, when and why they had decided to become involved in farming. Questions were then grouped into three parts: part I included questions about past and present farm status; part II focused on farmer decisions regarding participation in AES and the application of OF; and, part III elicited a description of farmer socio-economic profiles.

2.2.4 Sampling method

In order to capture the maximum variation in opinions (Busck, 2002; Davies and Hodge, 2006; Schenk et al., 2007; Soliva, 2007), participants were selected using a theoretical sampling method from a pool of purposeful samples (Macé et al., 2007). This method allowed attention to be paid to the location of farms. Moreover, a two-sided perspective (i.e. both farmers who participate or not in organic farming) was used to explore whether the same set of motivations could lead to different decisions and vice versa (Brodt et al., 2006), compared to the traditional one-sided approach (Darnhofer et al., 2005) which neglects the possibility of equifinality.

2.2.5 Ethical considerations

Following the guidelines of ethical research, interviewees were informed in advance of their participation in the survey about the nature and the aims of

the project, the way the data would be used, the person responsible for it, and their benefits and rights as participants. Confidentiality and anonymity of the interviewees were maintained during all stages of the study.

2.3 Results and discussion

2.3.1 Sample profile

The sample was dominated by male farmers. In many cases, the wives of the interviewees were also present during the interviews. However, despite being encouraged to participate in the discussion, they rarely did so. All of the interviewees lived and worked in the study area. Their ages ranged from 35 to 65 years, with the upper age limit being determined by the cross-compliance requirement that registered farm managers must be less than 65 years old to be eligible for direct payments (DP). The survey showed that 17 farmers owned their farms, 3 were co-owners and 4 were tenants, and that for 19 of them, farming was the primary occupation. The majority of interviewees came from a farming family, which is characteristic of the farming areas of Switzerland (Mann, 2007). Many interviewees had inherited their farms from their parents. In some cases the parents still lived on the farm and actively participated in farm-management decisions, in spite of being officially retired.

Haugen (1998), cited in Villa (1999), suggested that there are certain expectations for a farmer's family members, regarding their behaviour and decisions, and in many cases this results in the "collective having precedence over the individual" (Villa, 1999, pp. 328). This feeling of duty or obligation for young farmers, especially the males, to continue the farming history of their family, in conjunction with identity-related factors such as autonomy, joy of working in nature and connection with the land, influenced most participants' occupational choice.

A few interviewees initially viewed farming activities as a hobby, rather than as a source of income. This suggests that the rural population of the study area has entered a transitional phase, characterised amongst other factors, by the appearance of new profiles of land managers. Such changes in the structure and composition of rural populations raise questions about the effects these might have on landscape in the future. Burton and Wilson

(1999), for example, suggested that farmers with non-farming background are more likely to apply non-productivist practices.

In terms of farm characteristics, the average size of farm holdings managed by the interviewees (average=24.4ha, standard deviation; SD=12.3ha) was significantly higher than the Swiss national average of 16ha (Mann, 2005b; FOAG, 2006). Although this difference might reflect a regional variation in farm sizes as a result of the diverse biophysical and topographical characteristics, it might also be an indication of structural changes, mainly an increase in farm-holding sizes (Mann, 2005b).

In terms of farming systems and practices, 29% of the sample was involved in OF. In spite of all interviewees having joined the proof of ecological performance programme, the share of the farm that they allocated to AES varied significantly from 7% of the farm surface, which is the minimum allocation required by law, to 67%, with a tendency to allocate small parcels of land. Similar findings in other studies have been interpreted as a sign of opportunistic behaviour, as farmers often allocate to AES the minimum area of their farm that is required under policy guidelines, and intensively manage the remainder (Herzog et al., 2005). Nevertheless, this could also suggest the adoption of a diversification strategy, an interpretation that is supported by 83% of the interviewees being involved in more than one farming activity (i.e. both crop and livestock activities). Moreover, the data suggest that non-agricultural activities were well-established in farm management plans, as 63% of the sample was involved in some form of direct marketing (e.g. a farm shop) and 8% had on-farm sporting activities (e.g. horse riding).

2.3.2 Influential factors

A wide range of influential factors were found to either facilitate or constrain decisions to participate in agri-environmental schemes or organic farming. This section presents and discusses these factors in thematic categories, which reflect their common attributes (Table 5).

Table 5: Summarizing table showing the identified factors grouped in six thematic categories.

Themes	Factors
Economy	• Financial incentives • Non-farming income • Farm size
Society	• Customer preferences • Social image
Policy	• AES and OF characteristics • AES and OF delivery • Contract duration and guidelines • Application process and controls • Food legislation
Environment	• Climate and biophysical characteristics
Household characteristics	• Workforce • Family cycle
Farmer characteristics	• Health • Lifestyle • Risk aversion • Environmental attitudes and perceptions • Tenure-ownership status

2.3.2.1 Theme 1: Economy

- **Financial incentives**

The majority of farmers, who certified their farms as IP systems, indicated that their participation in AES was largely dependent on DP. This finding came as no surprise, as even after recent reductions, the level of producer support in Switzerland has only slightly decreased, accounting, on average, for 58% of farmer income (OECD, 2010). Furthermore, evidence showing that

DP exceeds the implementation costs of AES (Mann, 2003) suggests that farmer participation in these activities might be a decision driven not only by environmental but also by financial motivations. A few of the IP farmer responses echoed a 'higher yield, higher income' mentality, which explained why they decided not to apply OF. This concurs with other studies that concluded that productivist behaviour still prevails amongst farmers despite the greening of agricultural policies (Wilson and Hart, 2000).

A financial imperative, however, was also identified in the answers of participants who applied an OF system, when they referred to the necessity of subsidies to cover the cost of numerous controls and the income loss arising from the restrictions imposed on them. Furthermore, many of these farmers placed emphasis on the fact that they would have to abandon OF if subsidies ceased. This is in line with the findings of other studies that concluded that the maintenance and expansion of OF in European countries is highly dependent on DP (Offermann et al., 2009).

- **Non-farming income**

In spite of the contradiction between diversification into non-farming activities and what farmers have traditionally described as a 'real farmer' identity (Burton and Wilson, 2006; Brandth and Haugen, 2011), the recent decoupling of subsidies from production levels, in conjunction with the marginal income that farmers often earn from agricultural activities (Præstholm et al., 2006), have affected the allocation of available resources and capital to on- and off-farm activities (Gorton et al., 2008).

Farmer descriptions of the activities in which they were involved illustrated both on- and off-farm diversification. Although on-farm diversification was expected, since farmers have always done so in an attempt to meet their household needs, the expansion of pluriactivity is more recent. In the study area, farmer involvement in off-farm activities has likely resulted from the influence of nearby urban centres and the availability of part-time jobs, particularly in the fields of leisure and landscape protection. Farmer responses suggested that the dependency of their households on off-farm income influenced their land-use decisions, as it determined the level to which they were pragmatically able, and in some cases willing, to commit to a certain farming system or practice. This was especially evident when farmers explained the reasons why they decided not to switch to OF. This

decision would demand an increase in on-farm working hours, which could potentially lead to a decrease in the financial security provided by off-farm activities.

- **Farm size**

Some interviewees mentioned the size of their farms in reference to their net income. Such references were mainly made by farmers who did not apply OF. In the case of small farm holdings, for example, farmers thought that OF would produce insufficient yield levels which would not allow for the cost-efficient distribution of expenses, while in the case of large farms, farmers indicated that OF would require a larger workforce, which would not be cost effective.

2.3.2.2 Theme 2: Society

- **Customer preferences**

After the acknowledged negative impact of modernised agricultural practices on the environment, safety and nutritional value of food produce have now become key issues for consumers (i.e. Grunert, 2005). Farmer responses indicated that direct marketing was well-embedded in the majority of participant farm management plans. Consequently, some interviewees described that they had to be proactive in responding to customer preferences that may lead to modifications in farm management in order to guarantee sales. Likewise, they indicated that the food industry required them to meet specific standards, related not only to the nutritional value of the products, but also to their appearance, particularly for the case of fruits.

- **Social image**

In spite of the fact that direct marketing was an important source of income, the close customer-producer relationship *per se* was reported as one of the elements that many participants enjoyed about their job. Social recognition seemed to be important to the farmers involved in this study. Interviewees referred to the significance of "having satisfied customers", "being

esteemed" and "trusted", implying that potential changes on their farms were likely to be driven by their aim to meet their customer expectations in order to be socially accepted. The high importance that farmers attach to social acceptance has also been reported in other studies which concluded that in their attempt to meet social expectations and thus to improve their image, farmers often apply environmentally-friendly practices without being aware of their ecological benefits (Michel-Guillou and Moser, 2006; Atari et al., 2009). In this study, the importance that farmers placed on social values was also reflected in their ranking of different types of values. Social values, explained as "what my family and my community think is a good decision", were ranked as the most important, followed by profit, environment and tradition.

2.3.2.3 Theme 3: Policy

- **AES and OF characteristics**

Several studies have reported that the similarity of an AES or OF to the currently applied practice increases the relative advantage of this management strategy compared to alternatives, and facilitates adoption (i.e. Wilson and Hart, 2000). In contrast the need for renewal, removal or establishment of new elements on farms is more likely to discourage farmers from taking such a decision even though these decisions are likely to result from a thorough evaluation of the possible options, rather than from a less conscious judgement (Busck, 2002). Mattison and Norris (2007), for example, found that one of the main concerns of farmers about biofuel production was whether it would fit easily into their management plan. In a similar way, the majority of interviewees stressed that the readiness of their farms to meet the requirements of AES and OF had a positive effect on their decision to participate. On the other hand, farmers who did not apply OF, although in some cases they acknowledged the direct and complimentary benefits of this farming system, indicated that the high degree of specialisation of OF would make interdependent activities (i.e. the cultivation of organic fodder to meet the livestock demands) incompatible. This example highlights the caution required when assessing the influential power of perceptions on farmer decisions.

- **AES and OF delivery**

The amount, content and timing of policy information plays a vital role in the farmer decision-making process (Wilson and Hart, 2000; Præstholm et al., 2006; Schenk et al., 2007). Although the farmers in this study were satisfied overall with the information available to them, they mentioned several problems.

Some farmers referred to being 'bombarded' with a large amount of complex information, which was difficult to understand and evaluate. The difficulty of translating science into practice created confusion and caused reluctance to trust and use the distributed information. Farmers also highlighted the importance of the format in which information was available. Although today the use of the internet and computers is widespread in everyday life, this is not yet the case in all farming communities. For example, many farmers mentioned that they were aware of many web sources of information, but they were unwilling or did not possess the knowledge to access them. Moreover, the importance of information being synchronised with the annual farm-management plans was underlined, as farmers need enough time to evaluate the available options and to prepare their farms for potential changes.

In terms of channels of information there were no clear trends regarding the efficiency of farmer social networks. Some farmers appeared to be satisfied with the current situation, while others were not. The most likely explanation for this difference of opinion was the farmers' proximity to their social network, which possibly determined the level of information exchange, as well as the expectations that farmers had from their network. For example, some farmers only sought basic information regarding practices or machinery, while others looked for more specialised advice. Extension officers and agricultural schools were mentioned as the main providers of information, while advisors in the private sector were likely to be contacted in cases where farmers sought specialist advice. Some farmers stated that they were willing to undergo training i.e. attend courses, in order to gain additional knowledge. However, one-to-one delivery of information was still mentioned as the preferred approach. A similar outcome was found for UK farmers, who thought of information provided by agronomists and other farmers as more helpful, compared to that provided through websites or the press (Mattison and Norris, 2007). This is probably because short

channels based on personal relationships create an environment of trust, but also because of the high cost of training. Overall, these outcomes agree with conclusions from other studies, which underlined the importance of farmer networks (Acosta-Michlik and Espaldon, 2008) and their potentially positive influence on the decrease of transactional costs related to participation in AES (Falconer, 2000).

- **Contract duration and guidelines**

The long duration of AES contracts, the ongoing changes in their legal framework and the lack of clear guidelines were considered to be some of the main factors discouraging farmers from participation. In addition to farmers feeling more comfortable with short-term rather than long-term farm-management plans (Hart and Wilson, 1998; Darnhofer, 2006), budget restrictions in the FOAG at the time that AES were introduced, resulted in a decrease in the amount of money available for DP. Although, this reduction was not directly applied to farmer support, the FOAG increased the requirements that farmers had to meet, in order for the SAP aims to be fulfilled, without providing additional financial support. The uncertainty caused by such unexpected changes in the terms and conditions of AES contracts in the past, resulted in farmers feeling reluctant to commit over the long-term, and to evaluate the new measures with scepticism (Schenk et al., 2007). The limitations of long-term contracts are especially important where tenancy arrangements lead to farmer insecurity (Myyrä et al., 2007) or when farmers do not have a successor and are close to retirement age.

- **Application process and controls**

The bureaucratic application process of many AES and OF, as well as the continuous and strict follow-up controls were also given as primary obstacles to participation. Some farmers were discouraged from registering for all eligible schemes, as the monetary compensation was considered to be too low compared with the time required for paperwork when making an application. Moreover, farmers clearly stated that they would like to see fewer coercive controls and restrictions, since these were seen as compromising their autonomy and flexibility, and also as an additional cost.

- **Food legislation**

The interdependency of the sectors that are involved in the current agro-industrial complex implies that agricultural policy does not operate in a vacuum (Farmar-Bowers and Lane, 2009). Instead, agricultural policy both affects and is affected by a number of other policies and programs. SAP has put strong emphasis on increasing consumer protection and ensuring the production of high quality products with minimum environmental cost. This means that every stage of the life-cycle of a food product needs to meet certain standards. Therefore, farmers are obliged to follow the guidelines related to food-production pathways and to adjust their management in order to comply.

2.3.2.4 Theme 4: Environment

- **Climate and biophysical characteristics**

Farmers provided general comments about the local climatic conditions (i.e. precipitation levels, drought events, etc.), as well as more specific details about the biophysical features of their farms (i.e. topography and soil quality). The frequency with which farmers refer to these factors suggests that their effect was stronger for decisions to apply for OF, rather than participation in AES. In both cases, however, it was clear that the first question to be answered was whether a practice could reasonably be applied on a farm. This shows that the initial steps of the decision-making process are not subjective.

2.3.2.5 Theme 5: Household characteristics

- **Workforce**

The working capacity of a family farm had a catalytic effect on the choice of the farming system for many of the interviewees. The high labour requirements of OF, for example, was cited as a main reason why many farmers decided to apply IP instead. In many cases the presence of weeds on farms would require extra manual work, and as labour supply in farming families is usually fixed (Latruffe and Mann, 2008), farmers thought that

their commitment to this system would make the management of their existing labour force inflexible. Moreover the need for hired labour was seen not only as an additional cost, but also as a decision which would decrease the level of DP per family farm worker (Latruffe and Mann, 2008). Following the same rational, in cases where there was a surplus of within family human capital, farmers were more willing to apply more labour demanding practices such as OF.

- **Family cycle**

Darnhofer (2006, p.232) reported that "farmer decisions often need to accommodate the constraints and opportunities arising from the stage of the farm family cycle". For example, even if all other influential factors were the same, the existence of a successor is expected to have a strong influence on farmer investment behaviour (Potter and Lobley, 1992).

In an attempt to stimulate farm continuation and increase the number of viable farms, FOAG introduced a succession policy by setting an age limit (65) above which farmers would not be eligible for DP. This probably explains why farmers who were close to the retirement age and did not have a successor seemed less willing to change their land-use or management style in practice, and in some cases their answers implied that they were even thinking about disinvesting, since they would soon be ineligible for producer support. Conversely, farmers with successors were keen on making decisions that would improve both the environmental status and profitability of their farms, in an attempt to pass on a successful farming business (Calus et al., 2008), even if this required an increase in investment capital. Many farmers, however, seemed to recognise the difficulties of farming, mainly the heavy workload and its uncertainty, and stated that although they were keen to have successors, they would rather have their children not entering the farming sector. This relates to the effect of lifestyle that is discussed later, and indicates that the shift of the agricultural sector to the post-traditional era is characterised not only by technological changes, but also by a divergence of farmer mindsets (Villa, 1999), the influence of which is expected to be more apparent in the coming generation.

2.3.2.6 Theme 6: Farmer characteristics

- **Health**

Farming is demanding in terms of physical activity and thus directly related to health. Surprisingly, therefore, the effect of health on land-use decisions has not been studied much (Hounsome et al., 2006). The importance of health for farmers and their families was underlined in the interviews, mainly in relation to the level of physical effort that they were able or willing to make. Studies in developing countries have reported that better health care for farmers is likely to result in intensification of farming practices (Kiptop et al., 2007). However, there is no evidence to suggest that this would also be the case in Switzerland, as participant responses implied that a farmer in good health would be willing to become involved in more physically demanding, but environment-friendly activities such as OF.

- **Lifestyle**

Whilst many interviewees made general comments about a desired way of life, only a small proportion mentioned lifestyle explicitly as a factor influencing their land-use decisions. This is probably due to the difficulty in occupations related to the management of land to distinguish personal life from work life. It appears that interviewees who considered "quality of life" or "balance of time between work and personal life" important, either had a secure source of income that was not related to agriculture, or considered farming practices as a hobby. This does not necessarily mean that they were not interested in or not influenced by materialistic incentives. This concurs with arguments present in other studies which describe farmers as moving away from the traditional "peasant lifestyle" that was dominant during the pre-industrial era (Villa, 1999). It also suggests that farmers have re-evaluated priorities in their lives and do not unquestionably set the success of their farms over their personal life.

- **Risk aversion**

Farming is strongly influenced by uncertain variables such as the weather, the economy and policy, and because of this, farmers often behave in risk-

averse ways (Van Huylenbroeck et al., 2001). In the study area, some farmers used past experience, such as the selection of practices with known outcomes, short-term management plans (Ziervogel et al., 2005) or diversification of income sources, in an attempt to cope with uncertainty. However, some farmers implied that they were willing to introduce new practices or even to change the overall strategy of their farms, despite the potential risks of such a decision. This implies that risk is perceived and assessed differently between individuals. Risk aversion in this study appeared to be inversely related to the degree of financial security and the extent to which off-farm sources contributed to total farm income.

- **Environmental attitudes and perceptions**

Switzerland has a long tradition of OF and other environmental farm management practices. The likelihood of farmers acknowledging the benefits of these practices for the wider environment and developing positive environmental attitudes increases with familiarity (Wilson and Hart, 2000). In the study area, reference to "eco-zones" and "sustainability" showed that farmers who applied OF had positive attitudes toward environmental protection. Such references were not restricted to the farmers who applied OF, although they were less frequent, implying that under different circumstances, the number of farmers applying OF could be larger. As expected, however, in spite of acknowledging the environmental benefits of good farming practice, some of the farmers who did not apply OF, did not identify this system as a more environmentally-friendly alternative. This illustrated heterogeneity in perceptions and judgement (Schenk et al., 2007). A possible explanation for this lack of perception regarding the environmental benefits of OF is that many of these farmers had recently switched from conventional farming to IP. Thus they probably evaluated their current farming activities as more environmentally-friendly than those previously applied or compared to other non-agricultural uses that involve land consuming and energy demanding activities i.e. industrial activities. Moreover, the fact that these farmers do not recognise the benefits of OF suggests that they are less likely to convert to this system (Darnhofer et al., 2005).

- **Tenure-ownership status**

Farming practices applied by tenants often reflect their landlords' decisions (Wilson, 1997). Even in cases where tenants are not obliged to follow their landlords' preferences, the insecurity they feel due to their tenancy status increases risk aversion and the lack of willingness to engage in land improvements that require high investment, have a time-lagged pay-back period or reduce the liquidity of their capital (Daskalopoulou and Petrou, 2002; Myyrä et al., 2007; Calus et al., 2008). Similar findings were observed for farmers in this study area. Tenant-farmers were often constrained from maximising their income either because their decisions were in conflict with those of their landlords, or because the applied practices were restricted by the investments they were willing to make.

2.3.3 Policy caveats

The voluntary nature of AES application, and particularly of OF, highlights that participation rates, as well as the proportion of a farm that is allocated to these practices are still largely dependent on the mindsets of individual farmers. The current participation rates in AES and the total area that is under OF in Switzerland contrast with evidence from other case studies in Europe, which report a mismatch between farmer decisions and policy maker expectations (Calus et al., 2008). Nevertheless, even in the case of Switzerland, there is still no evidence to suggest that farmer attitudes are becoming 'greener' after the 'greening' of the SAP.

The majority of farmers who participated in this study stated that they would probably have to switch to conventional practices, if DP were ceased. Such statements indicate opportunistic behaviour and, potentially, the weak contribution of the current policy frameworks to farmers' behavioural change. As a result, policy-makers are increasingly interested in findings from studies that employ participatory approaches, in an attempt to inform policy guidelines and to minimise policy features that discourage farmers from committing to long-term, environmentally-friendly farm management plans (Darnhofer, 2006; Davies and Hodge, 2006; Herzon and Mikk, 2007; Kiptot et al., 2007).

Many of the constraining factors mentioned by farmers in this study were primarily related to the design, communication and implementation of

policy. Table 6 summarises these factors along with an indication of their importance, based on the frequency that they appear in participant answers. Although, there is no doubt that the SAP has managed to embed environmental protection into farmland management (Herzog et al., 2005), the existence of such constraints signals the need to rethink and, possibly, reshape some of its mechanisms. The results of this study suggest a number of policy-relevant conclusions which are further discussed below. The design and implementation of policy based on these issues would require a long time horizon. However, it is believed that these could address most of the constraints identified in participant responses, and contribute to the enduring commitment of farmers to environmentally-friendly management.

Table 6: Qualitative evaluation of the relative importance of constraints on farmer decisions based on the frequency of appearance in respondent answers.

	Constraining factors	**Importance**
Design	Bureaucratic application process	++
	Changes in the legal framework of AES/OF	++
	Long duration of schemes	++
	Rules that match with local conditions	+
Communication	Accessibility to information	+
	Information format	++
	Timing of information distribution	+
	Limited support related to innovations	+++
	Weak social network and co-operatives	++
	Cost of training	+
Implementation	Numerous and coercive controls	++
Other	Biophysical and environmental characteristics	+++
	Labour force availability	+++
	Environmental attitudes	++
	Health	+
	Distribution of expenses	++

(+: low importance, ++: medium importance, +++: high importance)

Most of the ecological benefits of environmental farm management practices are not achieved in the short-term. It is important, therefore, that farmers are encouraged to commit to extensive management plans for a longer period of time. The recent changes in the terms and conditions of AES appeared to make farmers less trustful of the policy process and as a result, farmers were less keen to participate in schemes with long-term contracts. In order to rebuild an environment of mutual trust, there is a need to establish robust policy frameworks, with clear terms and conditions that secure farmer rights, particularly for tenants. A possibility here would be to introduce flexibility in contract time span and to give farmers the opportunity to commit to contracts of different durations and incremental benefits. Such an approach would establish farmer autonomy, and could increase their willingness to extend contract durations.

Many of the farmers who considered coercive controls and the bureaucracy of the application process to be the main barriers to their participation in AES/OF, did not emphasise the existence of practical limitations (e.g. biophysical constraints, limited labour capacity, etc.). Such responses indicate that a straightforward and less time-consuming application process, and fewer controls would probably encourage farmers to apply for the maximum number of environmentally-friendly schemes.

Easy access and well organised distribution of information are important, especially if timed to coincide with annual farm management calendars. As the status quo is expected to have a strong influence on human decisions (Gintis, 2000), it is suggested that farmers are given sufficient time to explore and evaluate all of the available alternatives arising from a policy measure in order to accept the benefits of a potential change.

Finally, the need to strengthen farmer social networks and restructure the extension services was implied when participants referred to information distribution. Small-scale farmers are expected to be the first to withdraw from environmentally-friendly practices because of difficulties in applying a cost-effective distribution of the expenses related to AES/OF. This is important, since 44% of the farms in the study area are less than 10 ha (Swiss Statistics, www.bfs.admin.ch). In this respect, special attention should be paid to small-scale farmers, as identified also in other studies (Roessler et al., 2008). The organisation of training events, exhibitions et cetera and the promotion of one-to-one communication between extension officers and

farmers are expected to stimulate interactions and information exchange, and contribute to the strengthening of farmer social networks.

2.4 Conclusions

Thematic analysis of in-depth interview texts identified eighteen influential factors that were grouped within 6 thematic categories; economy, society, policy, environment, household and farmer characteristics.

The presence of a range of non-economic factors in farmer responses highlighted that their decisions cannot be explained on the basis of economics alone. Yet, participant responses still reflected the financial imperatives that underpin their decisions. Given the high level of subsidies currently provided for extensive and organic farm management, it seems likely that acceptance of the SAP reform is opportunistic in response to the economic incentives of environmental farming practices, rather than arising from farmer 'green' attitudes. This suggests that further increases in subsidies for societal and environmental services will probably result in the expansion of extensive farming practices, but not necessarily change farmer behaviour.

Nevertheless, participant responses showed that profit making and positive environmental attitudes are not necessarily mutually exclusive, but can co-exist and co-shape farmer decisions. This also suggests that the traditional conceptualisation of the profit-oriented farmer as a 'polluter' or the environmentally-oriented farmer as uninterested in materialistic benefits is not valid. Moreover, farmer responses illustrated heterogeneity in perceptions and evaluation pathways. For example, farmers considering the same factors did not always make the same decision.

Although the findings of this study provide detail about the factors that influence the land-use decisions of Swiss farmers with respect to participation in environmental farming practices, this is only a single snapshot in time (Kiptot et al., 2007; Gorton et al., 2008). This highlights the need for follow-up studies to explore the factors that influence farmer participation (or not) in environmental management practices in response to possible changes in their decision-making environment.

Chapter Three

Decoding the heterogeneity of farmer behaviour.

After an article by
Karali et al. (In review b)

Chapter acknowledgements

I would like to thank Beat Brunner for his contribution to the conduct of the telephone survey and Dr. Anna Hersperger for her support during the data collection process.

Outline

This paper explores the heterogeneity of farmer profiles and constructs a typology to represent this in models simulating farmer decisions. Empirical information was collected through a telephone survey, in the north part of Switzerland. Data on motivations and objectives related to farmer land-use decisions were assessed using Principal Component Analysis. The identified components were used as classification criteria in a cluster analysis, revealing four farmer profiles; business-oriented, lifestyler, multifunctionalist and traditionalist. The research findings indicate that although profit is important for farming continuation, profit maximisation is not always the dominant determinant of farmer land-use decisions. Analysis showed that farmers' interest in improvement of environmental quality, enhancement of social image and farm business succession is sometimes equally important. Statistical analysis showed that differences between the constructed profiles are not restricted to motivations and objectives alone. As expected, however, a certain degree of overlap was observed in some cluster characteristics. Among other conceptual implications which are further discussed in this paper (multicausality, validity of dichotomous behavioural frameworks, concept of identities), this overlap comes to remind that models can only provide a simplified representation of reality.

3.1 Introduction

Land use and cover change (LUCC) is an emergent phenomenon. It involves complex, non-linear processes that take place within and between ecosystems and human societies, over different spatial, temporal and organisational scales (Rindfuss et al., 2004; Turner II et al., 2007). In rural areas, most of the observed LUCC is associated with agricultural land (Schmitzberger et al., 2005; Valbuena et al., 2008), and it has mainly resulted from the interplay of the past and current demographic, economic, political and ecological drivers. The existence of diverse agricultural land-use patterns, however, even in areas with comparable socio-economic and environmental conditions (Schmitzberger et al., 2005) reinforces the argument that farmers do not always behave uniformly (Wilson, 1997; Edwards-Jones, 2006), even under a fair degree of regulation (i.e. cross-compliance).

In contrast to the neoclassical, micro-economic theory that describes farmers as a homogeneous group of single-minded, profit maximisers, empirical studies have shown that farmers follow an evaluation process of opportunities and constraints that are present at the time of the decision-making, and make choices that result from the interaction of their internal and external characteristics (i.e. Austin et al., 1996; Wilson, 1996; 1997; Damianos and Giannakopoulos, 2002; Aramyan et al., 2007; Herzon and Mikk, 2007; Sattler and Nagel, 2010). Although there is no evidence to suggest that farmer decisions are devoid of financial motivations, such findings imply the existence of other influential factors and social processes (interaction, collaboration, norms, social structures and institutions) (Ajzen, 1991; Wilson and Hart, 2000) that are not restricted to economics. After acknowledging that observed landscape changes are, to a large extent, human-induced (Likens, 1991; Redman et al., 2004; Ohl et al., 2007), this caveat demonstrates the importance of shining a light into the 'black-box' of the land manager decision-making process (i.e. Macé et al., 2007).

Data describing behaviour of individual land managers at a farm level can contribute significantly to a better understanding of observed land-use decisions (Irwin and Geoghegan, 2001; Lambin et al., 2001). However, the excessive amount of information that results from the description of individual land managers urges for the development and use of approaches

that would organise this heterogeneity and make it usable both in LUCC analysis and policy making (Emtage et al., 2006).

In environmental sociology, the development of conceptual and multidimensional mental constructs, introduced by Weber as 'ideal types' (Månson, 2000) and more recently referred to as 'typologies' (Bailey, 1994), is a method that has been widely used for this purpose. Household attributes (Briggeman et al., 2007; Lambert et al., 2007; Van Doorn and Bakker, 2007), asset characteristics (Daskalopoulou and Petrou, 2002; Álvarez-López et al., 2008), management styles (Busck, 2002; Schmitzberger et al., 2005; Brodt et al., 2006), farmer goals, attitudes, and perceptions (Fairweather and Keating, 1994; Morris and Potter, 1995; Walter, 1997; Lobley and Potter, 1998; Solano et al., 2001; Fish et al., 2003; Mathijs, 2003; Darnhofer et al., 2005; Brodt et al., 2006; DEFRA, 2006) are just some of the criteria used for categorising the diversity of farmers' behaviour.

The objective of this paper is to identify the dominant farmer behavioural profiles in a study area located in the Canton of Aargau, Switzerland and to explore whether the diverse patterns of agricultural land-use systems could be interpreted as a function of their heterogeneity. To achieve this objective two main research questions were investigated. Can farmer behavioural profiles be restricted to, or deviate from, the profile described in mainstream micro-economic theory? Do farmers who are grouped into different profiles adopt different farm management strategies? To answer these questions a Principal Component Analysis (PCA) and cluster analysis were applied to the identification of a range of behavioural profiles, and further statistical analysis was conducted for the parameterisation of these profiles. The use of quantitative methods in this paper is suggested as complementary to qualitative analysis, rather than being an alternative. The outcomes of this study will in future research be used to describe farmer behaviour in a LUCC simulation model, using an agent-based approach.

3.2 Materials and methods

3.2.1 Study area

The study area is located in the Canton of Aargau, in the northern part of Switzerland (Figure 4). This is a peri-urban area of approximately 99 km^2

which extends from the more rugged Jura chain, across the river Aare, to the Swiss plateau in the South (7.993353W, 8.169499E, 47.490812N, 47.300951S). The region has a mosaic of land uses and land covers, and diverse topographic characteristics, creating a unique landscape of high aesthetic and ecological value. Farmland occupies 35% of the area's surface, 44% is occupied by forest and 21% by the built environment. In terms of the workforce, 69% of the active population is employed in the tertiary sector, 29% in the secondary sector and only 2% in the primary sector (all figures are from Swiss Statistics, www.bfs.admin.ch).

The study area has experienced LUCC over the last decades, including land consolidation and farm size increases. During the period 1980-2009, the total land area used for agriculture decreased by almost 4%, while the total number of farms reduced by 79% from 1955-1996.

Following policy reforms in 1996, the Swiss agricultural sector has been restructured around a multifunctional model (Cretegny, 2001). The primary objectives of the reforms were to increase the area of farmland under environmentally-friendly management and decrease the negative consequences of intensive farming activities, without compromising the competitiveness of the Swiss agricultural sector or threatening farmer viability. One of the most radical changes involved the decoupling of subsidies from production levels and the establishment of producer support upon proof of ecological performance. Swiss cross-compliance has been described as one of the strongest forms of regulatory mechanisms in the world (Mann, 2005b) as farmers are obliged to meet a range of requirements related both to their socio-economic profile and the management of their farms, in order to receive direct payments.

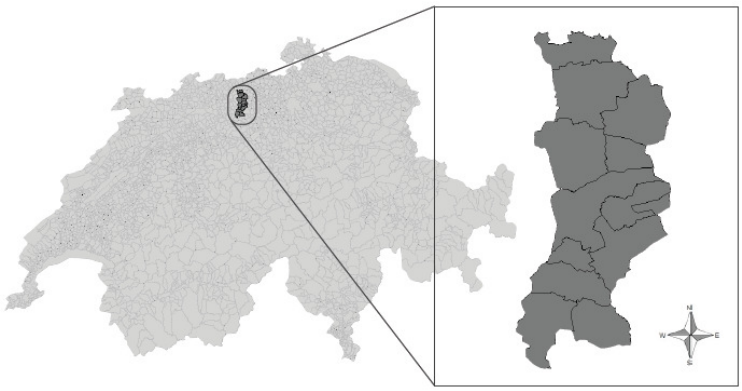


Figure 4: Map showing the location of the study area.

The reforms themselves have already changed the farming practices applied in the area. The number of organic farms, for example, has increased by 78% from 1996-2009, while the number of conventional farms has decreased by 26% over the same period. Taking into account the dynamic rural-urban interactions, the status of legal protection of all forested areas in the country (Hersperger and Bürgi, 2010) and the recent changes in the political context associated with the agricultural sector, LUCC is expected to continue into the future.

3.2.2 Data collection

Data were collected through a telephone survey from June until August 2010. This comprised a questionnaire with mainly close-ended questions, which aimed at gathering information about farmer motivations, objectives and intentions, as well as household and farm characteristics.

In order to promote participation and to increase the relevancy of the study to interviewees, all statements included in the close-ended questions were derived from answers collected through an earlier farmer survey using in-depth interviews (Karali et al., In revision a). The importance of all statements was assessed on a 5-point Likert scale. As this research topic has not been widely explored in a Swiss context, all questions included an 'other' category, which gave the opportunity for interviewees to provide additional information. Pre-testing was undertaken with farmers in the area to assess the clarity of the questionnaire.

3.2.3 Sampling strategy

Contact details of 110 farmers were available upon the beginning of the survey (60% of the registered farmers in the area). From this list, 24 farmers who had participated in a prior survey were excluded from the potential sample, as their answers formulated the statements included in the current questionnaire. Moreover, seven farmers who were interviewed in both surveys during pretesting were also excluded. From the remaining contact details, forty farmers finally participated in this survey (a response rate of 50.6%). The aim of this sampling strategy was to consider a representative sample. However, it is acknowledged that farmer availability and

willingness to participate in the survey may have introduced some bias to the sample.

3.2.4 Data analysis

3.2.4.1 Data reduction

Given the size of the sample, not all statements included in the questionnaire could be used as criteria to classify participants in different behavioural profiles. In order to reduce the number of variables, PCA was applied to all statements related to motivations underpinning farmer land-use decisions and the objectives that they pursue through these decisions.

PCA aims to capture the variability of the collected responses, and to produce a number of components by grouping the initial set of variables (Pallant, 2007). The suitability of data for factorial analysis was assessed by taking into account the determinant of the R-matrix, the values of the correlation coefficient, the Bartlett's test of sphericity and the total Kaiser-Meyer-Olkin (KMO) measure (Field, 2005; Pallant, 2007). Because of the size of the sample, parallel analysis was not applicable, so the final decision regarding the number of the extracted components was based on the Kaiser's criterion (eigenvalues >1) and the observation of Cattell's scree plot. Finally, the internal consistency of the extracted components was evaluated based on the calculation of the Cronbach's alpha (a) value (Field, 2005; Pallant, 2007).

3.2.4.2 Farmer classification

Farmers who participated in the survey were grouped through an agglomerative, hierarchical classification, based on the components extracted from the PCA. Ward's method was used as the clustering method and squared Euclidean distance as the distance measure of the clusters. Ward's method was considered the most suitable to minimise variability within clusters and increase differences among them, as it computes the sum of the squared distances within the clusters and aggregates these with the minimum increase in the overall sum of squares. The final number of clusters was determined by the distance of the dendrogram branches and confirmed by the absolute difference of the agglomerative schedule coefficients.

3.2.4.3 Cluster parameterisation

Descriptive statistics and a series of non-parametric tests using farm, household and farmer characteristics and intentions as exploratory variables were conducted to identify potential similarities and differences between the clusters of the constructed typology.

3.3 Results

3.3.1 Socio-economic characteristics of the participants

Age in the sample ranged from 35 to 66 years, with an average age of 53 (standard deviation; SD=9). The period of participation in farming activities ranged from 1 up to 40 years with an average of 20 (SD=11). The overall financial viability of the farms was largely dependent on farming activities, as for 82% of the sample, agricultural income contributed more than 50% of the total revenue, and for 46% of the sample, more than 75%. Overall, participants owned more than 50% of the total agricultural surface they managed, and only seven farmers were renting (or only owning) their farms. Farm continuation after retirement was very likely for the majority of the interviewees with 70% being either certain or expecting to have a successor.

3.3.2 General farm characteristics

In total, the sample of farmers managed 864.4 hectares (ha) of farmland, which is about 25% of the total surface occupied by agricultural activities in the study area. The farm holding sizes ranged from 6 to 50ha, with an average size of 21.6 (SD=12.2). Thirty-one participants reported that they applied an integrated production (IP) system, meeting at least the minimum requirements of cross-compliance for receiving direct payments. As expected, application of organic farming (OF) was less widespread compared with IP, but still rather high in total, as almost one in four farmers were involved in OF. The farm surface allocated to agri-environmental schemes (AES) ranged from 7%, which is the minimum area required by law for a farm to receive IP certification, to 100%. The presence of mixed farming activities was dominant in the sample, with only one farmer being involved in a single-production activity. Nevertheless, a high level of specialisation

was identified, with thirteen farmers allocating more than 60% of their farm surface to arable activities, and twenty-two farmers to fodder cultivation and livestock. Finally the extent to which non-food activities were integrated into farm management plans varied. Biofuels, for example, were rarely present, whilst non-agricultural activities such as farm shops, horse riding, etc., were common.

3.3.3 Identification of classification criteria (PCA)

Sixteen statements included in questions related to farmer motivations and objectives were included in the first run of the PCA. From this group, five items were discarded from the analysis due to low communality and individual variable KMO values. The determinant of the R-matrix of 0.067 (>0.00001), in conjunction with the values of the correlation matrix coefficients (>0.3), the highly significant Bartlett's test of sphericity (p=0.001) and the overall KMO measure (0.557), confirmed the suitability of the dataset for factorial analysis. At the end of the PCA, the number of variables (from that point called 'components') was reduced to four. All extracted components had eigenvalues above one and explained 64.05% of the total variance. The number of extracted components was also supported by the scree-plot, which showed a cut-off point after the fourth component.

The high loadings of individual statements to only one component indicated a clear structure, and the values of the Cronbach's *a* confirmed their internal consistency and reliability. Despite recommendations for a Cronbach's *a* minimum value of 0.7, in this study 0.4 was considered to be acceptable, as this indicator is very sensitive to the number of items that are included in a scale. In cases where data from ten or fewer items are analysed, Cronbach's *a* is expected to have a low value, without indicating an unreliable scale (Pallant, 2007). Table 7 shows the loadings of each item included in the analysis to the four extracted components, after varimax orthogonal rotation was applied to the data, in order to facilitate their interpretation. The same table presents the communality of the statements included in the analysis, the variance explained by each of the components and their Cronbach's *a* values.

Table 7: Summarised results of the PCA of farmer responses to statements related to their motivations and objectives. Entries in bold indicate the statements comprising each component. Negative signs indicate an inverse correlation between statements and constructed components.

	Components				Communalities
	1	2	3	4	
Motivations					
Participation in AES enhances my image as a good farmer	**0.793**	-0.062	0.077	-0.018	0.638
Direct payments contribute to a large extent to my total income	-0.223	**0.752**	-0.044	0.017	0.618
I had to meet the requirements of the current agricultural policy	-0.417	**0.486**	0.256	-0.247	0.536
AES improve the soil quality of my farm	0.294	0.020	0.148	**0.749**	0.669
AES have benefits for the environment	0.021	-0.391	0.041	**0.667**	0.600
Objectives					
Develop an environment-friendly farming system	**0.734**	-0.285	0.126	0.128	0.652
Maintain the traditional landscape	**0.578**	0.133	-0.137	0.285	0.452
Maximise my profit	0.124	**0.802**	0.057	-0.185	0.697
Improve farmer-customer relationship	0.270	-0.149	**0.831**	0.096	0.794
Improve the productivity-status of my farm	-0.332	0.313	**0.665**	0.257	0.716
Pass a successful business to my successor	-0.030	0.095	**0.607**	-0.543	0.673
Eigenvalues	2.914	1.692	1.262	1.177	
% of Variance	26.49	15.38	11.48	10.70	
Cronbach's *a*	0.523	0.582	0.544	0.431	

3.3.4 Interpretation of the classification criteria

The process of interpreting the components is as important as their extraction. In this case, the results of the PCA were defined as follows:

Component 1: Enhancement of social image

This component groups together statements that are related to the social image of the land managers. Farmers who score highly for this component are likely to apply environmentally-friendly practices and maintain traditional landscapes in their attempt to meet the demands and preferences of their community and to be socially accepted.

Component 2: Maximisation of profit

Statements included in this component are tied to profit-making. Farmers with a high score for this component are likely to make decisions driven by the aim of meeting the eligibility requirements for cross-compliance and receive direct payments.

Component 3: Succession of farm business

This component embraces statements that relate to the notion of a 'family farm'. Farmers who score highly for this component are likely to make decisions that would promote the establishment of a productive and financially successful farm business, in order to secure farm continuity.

Component 4: Improvement of environmental quality

This component comprises statements related to the benefits of farmer participation in AES. Farmers who have a high score for this component are expected to make environmentally sound decisions, acknowledging the parallel benefits of improving the quality status of their farms and protecting the wider environment.

3.3.5 Agent-type identification (Cluster analysis and parameterisation)

Participants were classified by using the four components extracted from the PCA as classification criteria (Figure 5). Observation of the dendrogram showed a clear cut-off point, indicating the existence of four different clusters (Figure 6). The number of clusters was also confirmed by the coefficient values at the agglomerative schedule.

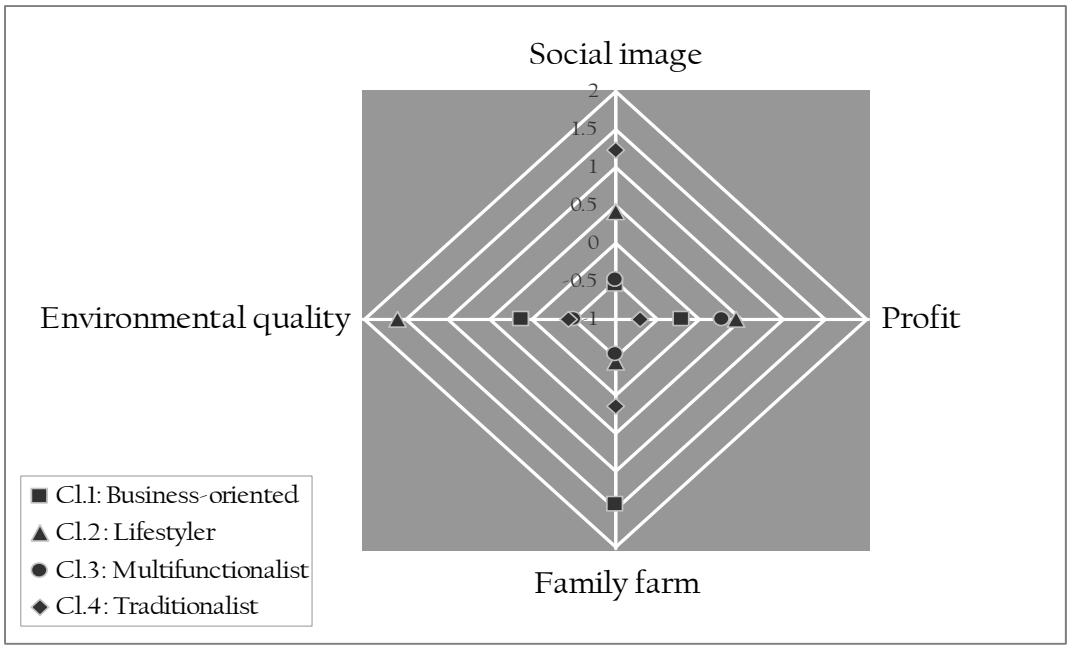


Figure 5: Radar diagram showing the score of the four identified clusters for the four PCA components.

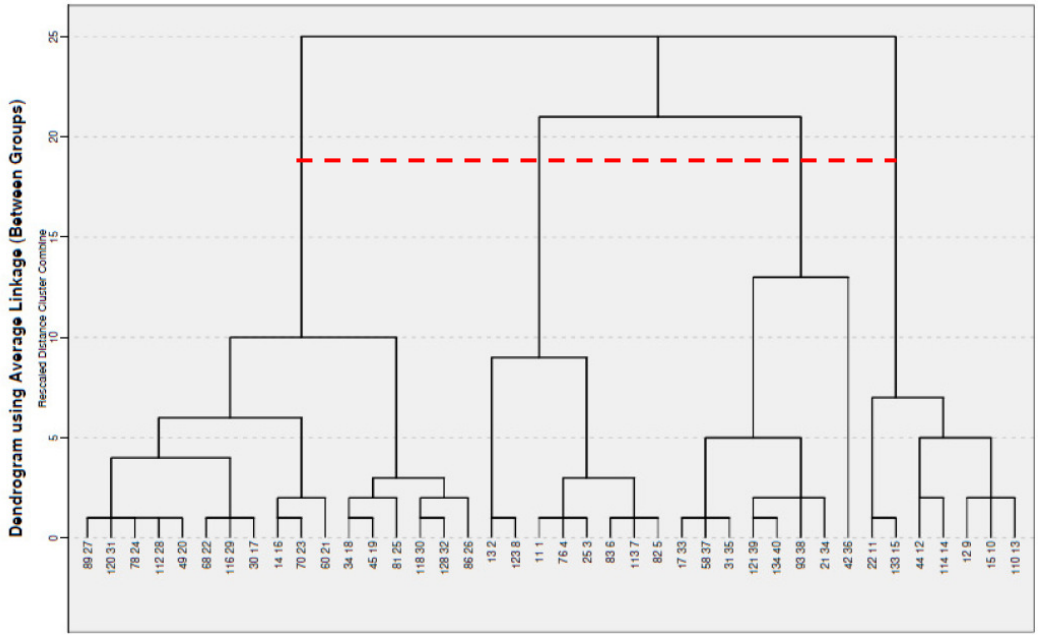


Figure 6: Dendrogram showing the number of participants comprising each cluster (x-axis) and the distance of the clusters at each classification stage (y-axis) as defined by the hierarchical classification.

Table 8: Farm and management characteristics per cluster.

Variables	Pearson χ^2 (df)	Cl. 1	Cl. 2	Cl. 3	Cl. 4
Farming system*	8.58 (3)				
Integrated production (%)		100.0	57.1	88.2	50.0
Organic farming (%)		0.0	42.9	11.8	50.0
ECA (%)#		7.0-30.0, 16.0 (9.0)	13.0-70.0, 35.0 (21.0)	7.0-100.0, 25.0 (23.0)	9.0-45.0, 22.0 (11.0)
Farm size (ha)***#	12.81 (3)	20.0-50.0, 33.6 (10.2)	8.0-20.0, 12.4 (4.6)	8.0-50.0- 20.1 (12.4)	6.0-35.0, 21.0 (10.0)
Winter cover (%)		25.0	42.9	52.9	12.5
Fallow (%)		14.3	50.0	25.0	12.5

(*p≤ 0.05, **p≤ 0.01, ***p≤ 0.005, #range, mean, standard deviation)

Table 9: Farmer characteristics per cluster.

Variables	Pearson χ^2 (df)	Cl. 1	Cl. 2	Cl. 3	Cl. 4
Age (years)#		35-66, 51 (10)	40-64, 55 (8)	39-66, 51 (10)	45-65, 56 (6)
Farming experience (years)#		10-39, 22 (12)	8-30, 16 (8)	1-40, 19 (12)	9-33, 23 (9)
Existence of successor (%)***	19.48 (6)	75.0	0.0	43.8	87.5
Tenure: Owned land (ha)*#	9.41 (3)	0.5-44.0, 19.1 (13.2)	0-9.5, 4.9 (3.8)	0-38.0, 12.5 (8.8)	0-19.0, 10.2 (7.0)
Rented land (ha)#		6.0-28.0, 14.5 (7.3)	1.0-16.0, 7.4 (6.1)	0.0-24.0, 7.6 (6.3)	0.0-27.0, 10.8 (9.5)

(*p≤ 0.05, **p≤ 0.01, ***p≤ 0.005, #range, mean, standard deviation)

Table 10: Information environment characteristics and social interactions per cluster. % of participants that consider the sources of information mentioned above either as important or very important.

Variables	Pearson χ^2 (df)	Cl.1	Cl.2	Cl.3	Cl.4
Family members (%)*	10.61 (3)	87.5	71.4	64.7	100.0
Use my own expertise (%)		100.0	100.0	100.0	100.0
Farmers' association (%)		75.0	42.9	70.6	50.0
Follow my neighbour decisions (%)		62.5	71.4	47.1	87.5
Research institutes (%)		62.5	57.1	64.7	75.0
Private consultant (%)		37.5	14.3	17.7	25.0
Internet (%)		75.0	57.1	52.9	50.0

Table 11: Intentions regarding future farming strategies per cluster.

Intentions	Probability per cluster (%)			
	Cl. 1	Cl.2	Cl.3	Cl.4
On farm diversification	37.5	28.6	58.8	62.5
Apply organic farming	37.5	42.9	23.5	62.5
Introduction of biofuels	50.0	0.0	29.4	0.0
Introduction of non-agricultural activities	75.0	57.1	52.9	62.5
Increase area under ECAs	37.5	57.1	35.3	62.5
Intensify farm practices	37.5	14.3	35.3	25.0
Apply...				
practice with highest output price	75.0	42.9	94.1	87.5
practice with best yield under climate change	75.0	85.7	47.1	75.0
practice with highest subsidy	87.5	100.0	94.1	100.0
traditional practices	75.0	100.0	88.2	100.0
environment-friendly practices	75.0	100.0	52.9	75.0
practices that provide ecosystem services	75.0	57.1	52.9	37.5
Buy land	87.5	42.9	94.1	75.0
Sell my farm	12.5	16.7	6.7	0.0
Rent my farm	0.0	33.3	6.7	50.0
Partially sell and rent my farm	75.0	50.0	66.7	50.0

20% of the participants were allocated to the first cluster (Cl.1), 17.5% to the second (Cl.2), 42.5% to the third (Cl.3) and 20% to the fourth (Cl.4). Despite the relatively small number of farmers classified in each category, statistical analysis showed significant differences between each cluster in terms of farm and management characteristics (Table 8), farmer socio-

economic profiles (Table 9) and their sources of information (Table 10), which strengthened the validity of the classification result. Probability calculations were used to describe farmer intentions (Table 11). Cluster labels describe the overall behavioural orientation of the farmers who belong to each group, as this was reflected in the analysis.

3.3.7 Cluster descriptions

The 'business-oriented' cluster (Cl.1) included experienced farmers with different ages. On average, farmers in this group managed the largest farm holdings in the sample and owned more than half of their farm area. Farming was their primary source of income, contributing to the majority of the farmers more than 75% of their total revenue. Activities included in the current farm management plans (i.e. absence of OF, rare application of fallow), as well as farmer intentions, echoed a strong business focus. The high score for the 'succession of farm business' component indicated that farm continuation is important to this type of farmer. The existence of a successor who would take over the farm in the future, in conjunction with their relatively young age explained the high possibility of them making decisions that will improve farm efficiency and productivity, and accumulate capital. The calculated probabilities for farmer intentions to increase the farm area designated as ecological compensation areas (ECAs) and to involve intensive management in the future, implied that current participation in environmentally-friendly practices was more likely a decision driven by financial imperatives and to a lesser extent by concern for environmental improvement, at least in comparison to other more environment-oriented farmers (i.e. Cl.2: lifestyler). Moreover, business-oriented farmers saw benefits in non-traditional farming activities (i.e. biofuels). Finally, these farmers appeared to have a wide range, but also targeted interactions with other actors who served as information sources. Apart from the views of family members, that were highly valued, business-oriented farmers consulted farmer associations, the internet and research institutes, and were more likely to use a private consultant than farmers in other groups. The characteristics of this group describe one of the most typical profiles of land managers in rural areas in Switzerland. Given the high frequency with which this profile is observed in reality and the very small difference in the size of

this cluster compared to the smallest cluster, the lifestylers, it is believed that this type of farmers could have been underrepresented in the sample.

'Lifestyler' farmers (Cl.2) comprised the second oldest group of farmers. They managed the smallest farms in the sample and, on average, they rented more than half of their farmland. Although, a high variation existed with respect to their dependency on farming income, farmers in this group did not disregard the materialistic benefits obtained from agriculture. Lifestylers engaged in an 'economic' farming style (van der Ploeg, 2000; van der Ploeg et al., 2000), and both their decisions and intentions were environmentally aware, consistent with their high score for the component 'improvement of environmental quality'. The relatively shorter experience of these farmers in farming activities might explain their tendency towards environmentally-friendly practices (i.e. the largest land allocation to ECAs, high participation in OF activities and fallow application) (Burton and Wilson, 1999). In line with their management plans, lifestyler farmers were well informed about climate change and its effects on crop productivity, and were expected to select farming activities appropriately. A notable characteristic of this group, in terms of their intentions, was a complete lack of interest in biofuels. The absence of a successor was another important characteristic, as any decisions that had a long term pay-back time or involved high investments, such as farmland expansion were avoided. Moreover, it was expected that at the end of the farm life cycle, the absence of a successor would facilitate decisions targeted at the liquidation of assets. Finally, lifestyler farmer intentions implied that they were likely to follow an imitative behaviour by copying other farmer decisions, if they believed these met their goals.

The third cluster was the 'multifuctionalist' farmers (Cl.3). This was one of the two youngest groups and, on average, the third most experienced. Multifunctionalist farmers manage the third largest farm holdings in the sample and the proportion of their owned land was higher compared with farmers in the other clusters. For more than 70% of the farmers of this group, 50% of their total income came from agriculture. Information about farming activities showed that OF was applied by only a minority of this group, while the remaining farmers applied an IP system. Despite similarities with the business-oriented farmers concerning a focus on farm expansion, both their current farming practices and their intentions indicated that they differed from the narrower agri-business focus of the business-oriented

cluster. Multifunctionalist farmers were expected to respond actively to market fluctuations, which agreed with their only positive score for the 'maximisation of profit' component and their intention to introduce new crops as long as these were profitable (e.g. biofuels). Nevertheless environmentally-friendly practices were not totally excluded from their management plans. For example, more than 50% of the group included winter cover, 25% set their farm under fallow and, on average, 25% of their farm area was allocated to ECAs. However, as for the business-oriented group, these decisions were expected to be primarily driven by the aim of meeting the requirements of the Swiss Agricultural Policy in order to benefit from the incremental financial compensation received for increasing the farm area allocated to ECAs, beyond the minimum of 7%, and to a lesser extent by environmental concerns. Moreover, the probability to look for information regarding the effect of climate change on crops or for new environmentally-friendly activities implied that, under certain circumstances, farmers in this group will be involved more actively in extensive management of their farms in the future. Farmers of this group were the least likely to consult other family members when making decisions about their farms, and although they considered other farmers in the area to be important, they were the least likely to follow other farmer decisions. Conversely, they were likely to use information provided by farmer associations, the internet and research institutes.

The final cluster comprised the 'traditionalist' farmers (Cl.4). This cluster included both the oldest and most experienced farmers. On average, farmers of this group rented almost as much farmland as they owned and more than 50% of their income came from agriculture. OF was applied by 50% of this cluster, and farmer responses indicated the existence of an even larger pool of potential OF participants. The high score for the 'enhancement of the social image' component indicated that decisions made by these farmers were to a large extent socially driven, in an attempt to meet not only their personal goals, but also those of society. For example, their decision to allocate around one-fifth of their farm areas to ECAs and the high possibility to look for environmentally-friendly practices might not only result from their objective to contribute to the maintenance and improvement of the environment per se, but also from their attempt to improve their social image. Traditionalist farmers were very likely to adopt an on-farm diversification strategy, which was probably an artefact of the self-sufficient

management style applied in the past. Nevertheless, they appeared less likely to modify their overall farm strategy. Furthermore, farmers in this group were keen on applying practices to maintain the traditional character of the landscape. This probably explains why biofuels were indicated as a highly unlikely option, signifying a cultural resistance against any practices that were not well embedded in the area as they could potentially affect the aesthetic value of the landscape. Perhaps surprisingly, farmers in this group were regularly updated about crop prices, subsidies and climate change effects on crop productivity. As with the lifestyler farmers, this group was likely to follow their neighbours' decisions. However, in this case, imitative behaviour was interpreted as the aim of not being excluded from the rest of the community.

3.4 Discussion

This study has shown that although farmer decisions are influenced by financial incentives, their motives and objectives do not relate solely to economics (i.e. Gasson, 1973; Solano et al., 2001). Moreover, the emergence of four clusters and the existence of statistically significant differences between these agree with other studies that have underlined the inherent heterogeneity in farmer communities (Busck, 2002; Darnhofer et al., 2005).

Comparison of the descriptions attached to the typology derived in this paper with those presented in other studies revealed certain similarities. For example, the business-oriented farmers had characteristics that resembled those of the 'dedicated producers' (Fairweather and Keating, 1994), the 'committed conventional' (Darnhofer et al., 2005) and the 'yield optimiser' (Scmhitzberger et al., 2005). Lifestyler characteristics were closer to those of 'stewards' (Walter, 1997), 'committed organic' (Darnhofer et al., 2005), 'environmental stewards' (Brodt et al., 2006), while the traditionalist group exhibit some similarity to farmers described in other studies as 'traditionalist' (Schmitzberger et al., 2005). The length of the temporal scale, when placing these studies into a chronological order, suggest that farmer behaviour is a durable characteristic (Busck, 2002). In spite of the observed similarities, however, the lack of complete agreement implies that farmer typologies are context specific (Busck, 2002), suggesting the need for their parameterisation with case-study specific data.

Equally important to the identification of different types of behaviour and decision-making strategies is the interpretation of the causal factors. In this study, the description of mechanisms that underpin the four constructed behavioural profiles and the conclusions regarding the 'role' of the characteristics in which these differed were restricted. Looking at the farm-holding sizes, for example, it was noted that extensive activities in the study area were more widely applied by farmers who managed small assets, agreeing with Mann (2005b) who concluded that shrinking farms in Switzerland were more likely to accommodate such activities, compared to those that are expanding. In this study, small-scale farmers (i.e. lifestylers) clearly expressed positive environmental attitudes that were stronger compared with those managing larger farms (i.e. business-oriented). However, whether farm size suppressed any production-oriented decisions (Burton and Wilson, 2006) or was a distinct characteristic of environment-oriented farming style could not be deduced with certainty.

Observation of the socio-economic profiles of the four clusters showed that their characteristics could not always predict successfully farmer behaviour, when investigated in isolation. An example of this involved the variable that indicated the existence of a successor. Several studies have already identified the catalytic effect of planned succession on farmer decisions, which often predicts expansionist behaviour (Potter and Lobley 1992; Walter, 1997; Calus et al., 2008). From the cluster descriptions, it was observed that whilst this prediction agreed with the expected behaviour from the business-oriented farmers, it contradicted the way that traditionalist farmers were anticipated to perform. Exploring the characteristics of the latter, it is hypothesised that the effect of an existing successor was probably confounded by the effect of age, which prompted traditionalist farmers to express a more repetitive behaviour. Having different behaviours expressed by farmers that had similarities in such a catalytic factor, demonstrated that farmer decisions are not formed by single, unidirectional, cause-effect relationships, but instead from the complex interactions of numerous factors.

The wider acceptance of OF activities by lifestyler and traditionalist farmers, and their limited presence in the management plans applied by farmers in the other two clusters indicated a potential correspondence between farmer attitudinal orientation and decisions. This hypothesis is further supported by findings reported in other empirical studies (Gasson, 1973; Morris and Potter, 1995; Darnhofer et al., 2005; Brodt et al., 2006; Davies

and Hodge, 2006) and behavioural theories (Ajzen, 1991), which have underlined the need to take into account the effect of farmer behavioural characteristics in order to better understand their land-use decisions.

At the moment, however, there is evidence to suggest that production-oriented behaviour and opportunism are still dominant in farmer communities (Wilson, 2001; Fish et al., 2003). After the agricultural policy reforms of the mid 1990s, an increasing number of farmers switched to the application of environmentally-friendly practices in an attempt to meet the requirements of cross-compliance. As such, in many countries including Switzerland, production-oriented strategies are no longer seen as financially optimal. Although these policy changes and the associated subsidies aim to achieve a behavioural change in the long-term, at present one can conclude with certainty that they have led to a short-term adaptation. This also suggests that the level of influence ascribed to behavioural factors should be assessed with caution (Burton, 2004).

Finally, with respect to the objectives that farmers pursue, analysis showed a frequent co-reference of social and environmental objectives, implying the influential power of public opinion on farmer decisions (Busck, 2002; Michel-Guillou and Moser, 2006; Atari et al., 2009). In a Swiss context, this is not surprising, particularly if we consider that the current format of agricultural policy was largely shaped by public environmental concerns (Curry and Stucki, 1997; Cretegny, 2001). Moreover, results suggest that goals that traditionally have been considered to be mutually exclusive, i.e. economic incentives and environmental concerns, currently co-exist in farmer decisions (Wilson and Hart, 2000; Macé et al., 2007). Such findings bring into question the validity of the conventional dichotomy between profit-oriented and environment-oriented farmers. It is anticipated that such evidence will be more important, as multifunctionality becomes better embedded in farm management plans and subsidies become even more attached to environmental and societal services rather than to production.

3.5 Methodological and conceptual implications

Most of the problematic areas discussed in the previous section provide the basis for arguments built around the weaknesses of classification methods for the study of human behaviour (Burton and Wilson, 2006; Brodt et al., 2006; Nightingale, 2009). It is suggested, however, that as long as these issues

are acknowledged and their implications are confronted, classification methods in general and typologies in particular can still be useful tools in behavioural studies.

The shortcoming in this study of not being able to draw robust conclusions with respect to the role of the characteristics that differed among clusters highlighted the value of using different methods complementarily (Kiptop et al., 2007). While statistical tests and other quantitative methods are undoubtedly important for ascertaining where heterogeneity lies, they can provide only limited explanatory information for an in-depth understanding of farmer behaviour. This information is important both for understanding the mechanisms that underpin LUCC and minimising any undesirable consequences that might result from them, as well as for predicting farmer responses to policy changes. The methods and type of analysis employed in qualitative research can provide better insight into the underlying processes, facilitating the interpretation of quantitative results (Darnhofer et al., 2005). Therefore, it is argued that methodological synergy can significantly contribute to the informative power of typologies.

Failure to allocate a distinct farming strategy to each of the identified clusters, and the similarities identified between certain pairs of these suggests that similar land-use decisions are not necessarily made by like minded land-managers, and vice versa (Solano et al., 2001; Brodt et al., 2006). This probably results from the fact that humans in real life are unlikely to belong to a single behavioural type or always follow the same decision-making pathway (Grothmann and Patt, 2005). Instead, they are more likely to shift from one type to another depending on the circumstances at the time of a decision being made.

Although, this overlap between clusters has often been seen as one of the main limitations of typologies, when employed in studies of human behaviour, this study suggests that it is considered as an indication that typologies should be used to conceptualise human behaviour at a different analytical level. Following Burton and Wilson (2006) and their suggestion for the use of identities, the application of fuzzy sets theory is recommended (Zadeh, 1965; Klaua, 1965 as cited by Gottwald, 2010). According to this theory the phenomenon under study, for example human behaviour, is seen as a 'set', which is comprised of different elements, for example identities. These elements have different degrees of membership, reflecting their gradual contribution to the formulation of the 'set'.

Furthermore, while it is clear that an exhaustive list of influential factors might be important, this is not enough for the operationalisation of such a conceptual approach. Future research needs to focus on exploring the trade-offs between the elements comprising the observed behaviours, as differences in their relative importance may reveal disparities between clusters which now seem to converge.

3.6 Conclusions

The findings of this study underlined the heterogeneity of farmers in the study area and indicated the inappropriateness of their description as homogeneous, single-minded, profit-maximisers. Despite the existence of distinct differences between the constructed clusters, however, analysis showed an overlap among them, highlighting the complexity of human behaviour. Taking into account that each individual is unique, typologies can describe reality explicitly, only if each cluster portrayed one person, which would largely negate their purpose.

An increasing number of studies report that this is a transitional phase for rural areas due to the occurrence of socio-economic, political and demographic changes (Verboom et al., 2007; Verburg et al., 2008). The structure and synthesis of rural populations, for example, experience continuous changes due to the entrance of land-managers who embody values and objectives that diverge from the traditional food production orientation. Therefore, identifying, interpreting and integrating land manager diversity should be considered as a priority both in LUCC analysis and policy making. Technological and computational advances have resulted in the development of sophisticated modelling techniques, such as agent-based models that can support 'diversity' into human behaviour sub-models. In this context, as long as typologies are supported by the complementary use of different methods and the acquisition of times series of social data, it is suggested that they can serve as a functional alternative to the single, average, land-manager profile that has been traditionally used in LUCC models.

Chapter Four

Assessing farmer preferences that influence land use decisions.

After an article by
Karali et al. (In review c)

Chapter acknowledgements

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Outline

This paper explores the trade-offs that influence farmer preferences for different farming activities in a study area in the northern part of Switzerland. A hierarchical Bayes approach was applied to responses from a choice-based conjoint experiment in estimating part-worth weighting factors that reflect the importance farmers place on a set of attributes and their levels when making land-use decisions. Change in income and the type of farming activity were found to be the two most important attributes, followed in rank order by environmental impact, social feedback, level of risk and required effort. The high preference for activities related to environmental management suggests a shift in farmer choices away from traditional food-production activities. Conversely, non-food activities were identified as the least preferable, reflecting a cultural resistance to activities that are not well-established in the local, social landscape. Analysis of participant choices after segmentation, using a typology of behavioural profiles as a covariate, showed heterogeneity in farmer preferences. Trade-offs estimated for each cluster differed from total sample preferences. These agreed, however, with relevant parts of the narratives of each behavioural profile, suggesting a relationship between preferences and behaviour.

4.1 Introduction

Agricultural land with favourable conditions is a scarce resource in Switzerland since more than 70% of the country's surface is occupied by the Alps and the Jura mountains (OECD, 2002). Currently, almost all suitable land for farming is already in use and the current policy framework which legally protects forested areas (Hersperger and Bürgi, 2010), in conjunction with the densely populated lowlands (FOAG, 2006) leaves few opportunities for agricultural expansion.

Since the 1996 agricultural policy reform, however, the role of agricultural land is no longer restricted to food production, but includes the provision of public commodity and non-commodity ecosystem goods and services (Cretegny, 2001). As a result, agricultural land is now expected to perform a range of functions and to achieve multiple goals, despite its limited availability.

During this transitional post-reform period, multifunctionality is anticipated to increase competition between farmer objectives, and thus between farming activities (Rounsevell et al., 2006a), leading, potentially, to conflicts (Morgan-Davies and Waterhouse, 2010). Although farmers aim to best utilise farm resources, it has been shown that their decisions are not solely targeted at optimal allocation of capital and resources in production terms (Darnhofer, 2006) or guided strictly by policy dictates (Wilson, 1997). Instead, farmers often pursue rewards beyond profit (Dimara and Skuras, 2003; Brodt et al., 2006; Herzon and Mikk, 2007; Kiptop et al., 2007; Sattler and Nagel, 2010), following evaluation and decision-making pathways that differ (Wilson, 1997; Edwards-Jones, 2006), based on their individual preferences (Darnhofer, 2006).

The failure of policy makers to take this into account when designing or communicating new policy instruments explains to a certain extent the observed disparities in farmers' participation in new, usually voluntary, schemes (i.e. agri-environmental measures (Roessler et al., 2008)), which are not always positively related to profitability (Neill and Lee, 2001). Mismatches between policy-maker expectations and farmer land-use decisions (Regione Veneto, 2006 as cited by Defrancesco et al., 2008; Calus et al., 2008) highlight the need for research to identify and evaluate the importance of the economic and non-economic factors that influence farmer decisions, and the imperative for policy makers to use this information

effectively if the extensive management of agricultural land is a desirable goal.

The study presented here explores farmer preferences and their effect on farmer land use decisions. Specifically, the primary objectives of the study include the assessment of trade-offs between a set of factors with respect to the importance that farmers place on them and the investigation of a potential relationship between farmer preferences and behavioural profiles. For this purpose, two (null) hypotheses are proposed, a) that all factors included in the analysis had the same level of relative importance and b) that no differences exist in farmer preferences when these are estimated from behavioural profiles.

In order to explore these hypotheses, an experiment using choice-based conjoint analysis, was performed in a study area located in the north of Switzerland. Several studies have referred to the difficulty of acquiring information to elicit farmer preferences with regard to their land-use decisions (Bakker and van Doorn, 2009; Morgan-Davies and Waterhouse, 2010). The main challenge in doing this is that people are not always willing to reveal personal information or are not conscious of the magnitude of the importance that they place on them (Bakker and van Doorn, 2009). In this study, the selection of the choice-based conjoint method was driven by its potential to provide a systematic evaluation of both qualitative and quantitative attributes, which is consistent with land managers opting for benefits that do not always have a formal market price. Moreover, the trade-off approach concurs with the way that humans evaluate alternative options when they make decisions (Alpizar et al., 2001). Thus, the selected conjoint method provides a more realistic approach compared to more commonly applied methods such as those using ranking or rating (Orme, 2000).

4.2 Materials and methods

4.2.1 Study area

The study area is located in the Canton of Aargau, in the northern part of Switzerland. It is a north-south transect of 99 km^2, across the Aare-Valley, extending from the more rugged first Jura chain, to the Swiss plateau in the South (7.993353W, 8.169499E, 47.490812N, 47.300951S).

The mosaic of land uses and land cover that is present in the area creates a unique landscape of high aesthetic and ecological value. Farmland occupies 35% of the area, which divides into meadows and pastures (65%), arable fields (33%), permanent cultivations and other agricultural activities (2%). In addition to agricultural use, 44% of the study area is covered by forest and 21% by the built environment (all figures from Swiss Statistics, www.bfs.admin.ch).

Legislative changes including the recent agricultural reforms, the abolition of milk quotas, the introduction of cross-compliance and area-based payments upon proof of ecological performance have all led to changes in farmland management. For example, the number of organic farms increased by 78% from 1996 to 2009, while the number of conventional farms decreased by 26% over the same period. Further changes are anticipated to occur in the future, raising questions about the potential implications for landscape dynamics and the provision of ecosystem services.

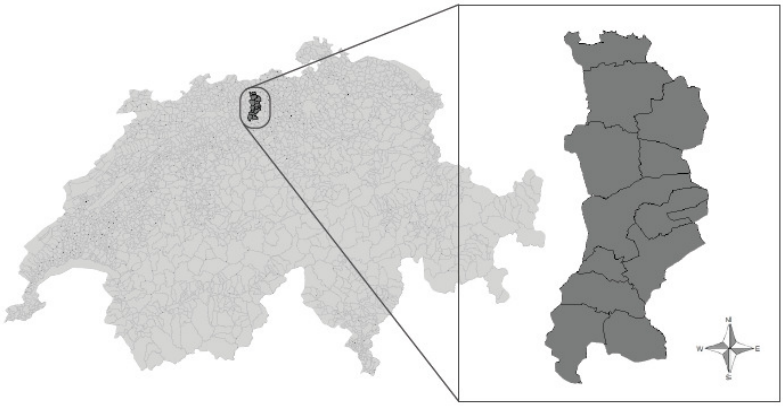

Figure 4: Map showing the location of the study area.

4.2.2 Choice-based conjoint analysis

Originating in marketing research, conjoint analysis (CA) was initially developed to model consumer preferences (e.g. Green and Srinivasan, 1978; Green and Srinivasan, 1990) and measure their perceived values of specific product characteristics. More recently CA applications have crossed disciplinary boundaries. In environmental research, CA methods have been used for the investigation of farmer preferences for characteristics of different crop varieties (Baidu-Forson et al., 1997a) and cattle traits (Tano et

al., 2003), socio-economic or technical interventions (Baidu-Forson et al., 1997b), forestry contracts (Arifin et al., 2009) and policy priorities (Morgan-Davies and Waterhouse, 2010), as well as for the exploration of public preferences for policy measures (Moran et al., 2007; Morgan-Davies and Waterhouse, 2010), landscape functions (Müller and Schmitz, 2002) and specific land uses such as wind farms (Álvarez-Farizo and Hanley, 2002) and pig production systems (Krystallis et al., 2009).

The theoretical basis for the method draws on Lancaster's (1966) 'Consumer theory' which asserts that preferences can be explained by a set of independent attributes and their levels (Sayadi et al., 2009). In other words, the theory suggests that an individual makes a decision by evaluating the trade-off between the characteristics that describe the alternative options of a considered product.

Preference structure is described by a utility (U) function (Eq. 1), which assesses the performance of a set of alternatives across a number of attributes. Based on participant responses, in a choice experiment CA transforms individual choices into estimated parameters (Baidu-Forson et al., 1997a; Farber and Griner, 2000) or part-worth weighting factors (w_n) (hereafter referred to as part-worths), reflecting the relative importance that respondents place on each attribute (X_n) (Farber and Griner, 2000).

$$U(x)= w_1*X_1 + w_2*X_2 + w_3*X_3+....+ w_{n-1}*X_{n-1}+ w_n*X_n \quad \text{(Eq. 1)}$$

Different types of CA share the same underlying principles. However, differences in their design, and the resulting advantages and weaknesses, make the selection process among the existing CA methods dependent on the aim and the characteristics of the study. In this study, taking into account the number of attributes, the number of choice tasks and the mode of questionnaire administration, Choice-Based Conjoint (CBC) analysis was considered to be the most appropriate method.

In CBC experiments, participants are presented with a set of choice tasks. Each choice task includes a fixed number of scenarios, which result from random combinations of the levels that describe the attributes included in the study. Instead of being asked to rank or rate attributes or scenarios, respondents are asked to assess each choice task individually and to indicate their preferred scenario (Orme, 2009). Finally, part-worths are estimated

from the choices indicated by the participants for the total number of choice-tasks.

4.2.3 Selection of attributes and attribute levels

The first step in designing a CBC questionnaire is to identify the attributes and levels that will inform the scenarios included in the choice tasks. This step must ensure that attributes are relevant to the participants and described by meaningful and realistic levels (Byrne et al., 2012). Given that conjoint analysis results are attribute-specific (i.e. under different attribute/ attribute level combinations results might differ), using unimportant attributes may force respondents' to follow a simplified reasoning, resulting in an overestimation of the importance of the more relevant attributes. In order to increase the relevance of these scenarios to participants, this study considered results from a prior survey with farmers in the region that focused on identifying the factors which facilitate or constrain certain farm-level land-use decisions (Table 12).

Table 12: Factors influencing farmer land-use decisions in the study area.

Themes	Attributes
Economy	Financial incentives (Direct payments); Off-farm income; Farm size
Society	Customer preferences; Social image
Policy	AES and OF characteristics; AES and OF delivery; Contract duration & guidelines; Application process and controls; Food legislation
Environment	Climate & biophysical characteristics
Farmer & household characteristics	Health; Lifestyle; Risk aversion; Environmental attitudes & awareness; Tenure-ownership status; Workforce; Family cycle

(Source: Karali et al., In revision a)

Table 13: List of attributes and their levels used in the CBC experiment. The annotated definitions were given to the interviewees to clarify potentially ambiguous concepts.

Attribute	Attribute level	Definition
Farming activity	1. Crop	
	2. Livestock	
	3. Environmental management	- Activities that aim at the protection of species habitat, improvement of biodiversity, or improvement of soil and water quality.
	4. Non-food	- Timber, eco-tourism, bio-energy crops
Required effort	1. Less work	- The effort that a farmer will have to invest in if a specific farming activity is chosen. Effort can be related either to the on-farm workload i.e. a labour-intensive activity, or to paperwork i.e. bureaucracy of a subsidy application.
	2. No change	
	3. More work	
Social feedback	1. Negative	- Feedback from the general public and other local farmers about the farming activity (i.e. appreciate or complain) because of its effects on the environment, food supply and quality, or their property.
	2. None	
	3. Positive	
Environmental impact	1. Degrade	- The way in which the activity will affect the soil and water quality, the level of biodiversity and the quality of the agricultural landscape
	2. Maintain	
	3. Improve	
Level of risk	1. Low	- The level of risk, for example, due to volatile markets (e.g. variability in output prices), climate change (e.g. variability in yields), or lack of experience in new farming activities.
	2. Medium	
	3. High	
Change in income	1. -10%	
	2. No change	- The income that might be earned or lost for the chosen option.
	3. +10%	

Including all of the identified factors in the questionnaire was not considered possible, as this would require a very large number of choice

tasks. Taking into account the complex and repetitive design of the CBC questionnaire, this would likely be onerous for respondents and possibly affect their choices. Hence, an elimination process was followed. The main aim of doing this was to extract the most suitable attributes for this type of experiment, covering all the themes that are present in Table 12, but also to select an appropriate number of attributes that, when combined with their levels, would generate a valid questionnaire that could easily be completed by the participants.

Six attributes were selected as the most relevant for the aim of this exercise (Table 13). Attribute levels were determined for each attribute using expert judgement. To avoid potential bias in the composition of the choices, all attributes, except the farming activity, were described by the same number of levels, following an ordinal scale (Müller and Schmitz, 2002). In cases where levels could be misinterpreted, an explanatory definition was also attached (Table 13). Moreover, in order to avoid the possibility of an arbitrary choice of levels, the suitability of the latter was discussed and confirmed with farmers in the study area during the questionnaire pre-testing. Nevertheless, it is acknowledged that choosing levels to describe both quantitative and qualitative attributes in a single survey is difficult, since it is virtually impossible to verify their appropriateness, due to the absence of one 'supplier' offering the various alternatives, as it is often the case in more traditional marketing applications.

4.2.4 Questionnaire construction

The SSI Web platform was used for the development of five versions of a 'paper and pencil' CBC questionnaire. All versions were built by applying the complete enumeration method, using a seed of one (one fixed and eleven random choice tasks). Each choice task included four scenarios, which is equal to the number of levels of the attribute farming activity (the attribute with the maximum number of levels). No 'None' option was included in the choice task, in an attempt to force participants to confront the trade-off between the given alternatives. Table 14 illustrates a choice task example.

In total, each participant was presented with twelve choice-tasks and forty-eight choices. In order to ensure that the designed questionnaires would permit stable estimations, its validity was evaluated by the CBC design efficiency test, and its clarity was confirmed through pre-testing.

Table 14: Example of choice task.

Attributes	Option 1	Option 2	Option 3	Option 4
Farm activity	Crop	Livestock	Environmental management	Non-food
Required effort	More work	No change	Less work	More work
Social feedback	None	Positive	Positive	Negative
Environmental impact	Degrade	Maintain	Enhance	Enhance
Level of risk	Medium	Low	Medium	High
Change in income	+10 %	No change	-10%	+10 %

4.2.5 Data collection

Data were collected between June and August 2010. Potential participants were initially contacted by mail, to inform them of the aim and the design of the study. Farmers were then contacted by phone to ascertain their willingness to participate in the CBC exercise. From this sample farmers who participated in the previous survey and whose answers generated the initial list of attributes that were considered in the development of the questionnaire were excluded.

Thirty-two farmers agreed to participate in the choice experiment, giving a response rate of 40.5%. A copy of the questionnaire translated into German was distributed by mail, accompanied by an acknowledgement letter and additional guidelines explaining how to complete the questionnaire. This approach was considered the most appropriate since in a previous survey in the study area, farmers indicated their lack of familiarity with computers (Karali et al., In revision a). Moreover, due to the structure of the questionnaire its administration would not have been feasible as part of a telephone survey. To compliment the information produced from the CBC, a separate telephone survey was conducted to collect data on the socio-economic and behavioural profiles of the farmers, as well as the farm characteristics (Karali et al., In review b). All thirty-two farmers who agreed to participate in the survey returned their questionnaires. However, only twenty-three of these were correctly and comprehensively completed, and thus were valid for analysis.

4.2.6 Analysis

A hierarchical Bayes (HB) approach was applied in the estimation of part-worths that represent the relative importance of attributes and the zero-centred differences of attribute levels. The value of HB is in its potential to estimate part-worths at an individual-level, unlike other approaches that are limited by performing the analysis at the aggregate-level, neglecting within sample heterogeneity (Orme, 2000; Howell, 2009). Moreover, several studies have reported the effectiveness of HB in estimating accurate part-worths for choice data even with a low number of responses per participant (Allenby and Gineter, 1995; Lenk et al., 1996), which was one of the main reasons that supporting its selection in this study.

In HB "[…] the algorithm estimates how different the respondent's utilities are from the other respondents in the study" (Howell, 2009, pp.2). Thus individual utilities are dependent on sample average utilities and vice versa. Starting with an arbitrary sample average of zero, the HB algorithm performs thousands of iterations (in this study 10,000 iterations were performed), after which estimates are stabilised updating at every instance both individual and sample utilities (Howell, 2009),

The "SMRT-Market Simulator" tool was used in this study to calculate utilities at the sample level, where all responses were treated together, and then at the cluster level, where responses were segmented using the clusters of a behavioural profile typology as a covariate.

Normality tests (Anderson-Darling) were performed to explore the distribution of the scores obtained for each attribute and attribute level. Based on their output, a choice between parametric (ANOVA) and non-parametric tests (Kruskal-Wallis) was made, in order to investigate if differences existed in the importance estimated for each variable. Where a statistically significant difference was identified, post-hoc comparisons were performed, in order to identify the attribute or attribute level that differed by the most each time.

4.2.7 Farmer types

Based on data collected through a telephone survey, an agglomerative, hierarchical classification was used to develop a set of four behavioural profiles. Ward's method was used as the clustering method and squared

Euclidean distance as the distance measure of the clusters. Details of this procedure are discussed elsewhere (Karali et al., In review b). Table 15 provides an overview of the main characteristics of the behavioural profiles represented by each cluster.

Table 15: Summary of the main characteristics per cluster.

Clusters	Description
Business-oriented	Experienced farmers with different ages. They manage large farm holdings and they own more than half of the land they manage. Farming activities are their primary source of income. They have a strong business focus and the succession of their farm business is very important to them, as the majority of these farmers have successors. They see benefits in non-traditional farming activities and have a wide range of social interactions.
Lifestyler	Old farmers, who are not very experienced. They manage small farms and they rent more than half of the land they manage. They apply an economic farming style and their decisions aim primarily to improve environmental quality. They frequently look for information regarding the effects of climate change on crop productivity. Their distinct characteristics include their complete lack of interest in biofuels and the absence of successors.
Multifunctionalist	Relatively young farmers, with medium experience levels. For the majority, over 50% of their income comes from agricultural activities. Despite their orientation towards farm expansion, they are not characterised by a narrow production focus. These farmers are expected to respond actively to potential changes. Profit maximisation is one of their primary goals. However, environmentally-friendly management practices are included in their management plans.

Traditionalist	The oldest and most experienced farmers. They own almost as much land as they rent and they earn more than 50% of their income from farming activities. They are keen on maintaining the traditional agricultural character of the landscape and their decisions are likely to be socially inclined. As with lifestyler farmers they are characterised by a complete lack of interest in biofuels. Despite their age, the existence of a successor probably explains their regular update on prices, subsidies and the effect of climate change on crop productivity.

(Source: Karali et al., In review b)

4.3 Results

4.3.1 Sample profile

The twenty-three farmer respondents were all male. Their ages ranged from 35 to 66 years (mean=52, SD=9), with a mean farming experience of 19 years (min-max=5-38, SD=10). Overall, these farmers managed 502.1ha of farmland. Farm holding size varied from 8 to 50ha (mean=21.8, SD=12.5). 70% of the respondents met the requirements of the reformed agricultural policy with farms certified as 'integrated production', whilst the remainder (30%) were involved in organic farming activities. Only 48% of the sample was confident of passing their farms to their successors. Uncertainty about farm continuation of the remainders explained their reluctance to make long-term plans.

4.3.2 All respondent preferences

The Kruskal-Wallis test revealed a statistically significant difference in the utilities calculated for the six attributes included in the CBC questionnaire (χ^2 (2)= 46.65, $p<0.001$), rejecting the first (null) hypothesis. Moreover, one-way analysis of variance (ANOVA) showed that statistically significant differences between the part-worth values of the different attribute levels existed for all attributes, except for the level of risk (Table 16).

Table 16: Average relative importance (%) of each attribute and the zero-centred differences of each attribute level for all respondents. One-way ANOVA results (p-values) indicate whether statistically significant difference exist between the part-worth values of the different attribute levels (NS: Non Significant).

Attributes and levels	p-value	Zero-centred differences	Average importance (%)
Farming activity			23.47
Crop	0.006	11.14	
Livestock		1.89	
Manage the environment		23.07	
Non-food		-36.09	
Required effort			10.01
Less work	0.008	6.97	
No change		9.43	
More work		-16.40	
Social feedback			13.15
Negative	<0.001	-27.34	
None		8.16	
Positive		19.18	
Environmental impact			18.58
Degrade	<0.001	-53.71	
Maintain		23.21	
Improve		30.51	
Level of risk			10.36
Low	NS	10.70	
Medium		4.74	
High		-15.44	
Change in income			24.43
-10%	<0.001	-76.92	
No change		8.09	
+10%		68.82	
Total		0	100%

Calculation of average importance values showed that the change in income and farming activity were the two attributes that farmers would consider first if they had to make a decision about their farms. Environmental impact and social feedback followed in order of importance, while the level of risk and required effort were identified as the least important (Table 16). Perhaps unsurprisingly, the part-worths of the different attribute levels showed that workload increase, negative social

feedback, environmental degradation, high risk and income decrease were least preferred, agreeing with our a priori 'rational' expectations.

Among the four different types of farming activities, the highest and lowest preference was attached to non-traditional agricultural activities. Activities related to environmental management received the highest part-worth value, while a highly negative preference was estimated for non-food activities. Although this result does not necessarily indicate that non-food activities are unattractive, it shows that all other characteristics of farming activities being the same, respondents would prefer less to apply non-food activities compared to other farming activity options.

Analysis of the socio-economic profiles of the respondents and their farm characteristics showed that farmers involved in organic farming had higher utility values for the farming activity attribute compared with farmers who had certified their farms as integrated production systems ($p=0.004$). The opposite was observed for the utilities of the change in income attribute ($p=0.015$). Also, utilities for the social feedback had a medium, positive correlation with farm size ($r=0.476$, $p=0.022$).

4.3.3 Preferences per cluster

A behavioural typology composed of four clusters (Table 15) was used as a covariate, in order to establish whether differences in farmer preferences correlated with different behavioural profiles. A trial statistical test showed significant differences for certain attributes and attribute levels; social feedback ($p=0.018$), crop ($p=0.038$), less work ($p=0.016$) and more work ($p=0.032$). Due to the small number of respondents in each cluster, however, statistical analysis was not considered appropriate. For this reason, the following will consider only the descriptive statistics of the part-worth values for the four clusters (Table 17).

Change in income was the most important attribute for business-oriented and multifunctionalist farmer choices, while the type of farming activity was shown to be the primary concern of the lifestyler and traditionalist farmers. The level of risk was the least important attribute for multifunctionalist and traditionalist farmer choices. Social feedback was the least important attribute for the lifestylers, and required effort the least important for the business-oriented farmers.

Table 17: Average relative importance (%) of each attribute and the zero-centred differences of each attribute level per behavioural cluster.

Attributes and levels	Zero-centred differences				Average importance (%)			
	1	2	3	4	1	2	3	4
Farming activity					19.91	29.95	18.71	30.81
Crop	-39.97	3.99	6.42	82.99				
Livestock	30.27	-10.54	-0.61	-4.72				
Environmental management	5.82	62.86	14.46	12.10				
Non-food	3.88	-56.31	-20.27	-90.36				
Required effort					5.51	11.29	10.88	10.73
Less work	-10.50	12.34	23.09	-22.54				
No change	14.01	15.92	9.66	-3.85				
More work	-3.51	-28.26	-32.75	26.39				
Social feedback					18.58	6.57	14.42	12.75
Negative	-17.49	-2.48	-46.09	-21.38				
None	0.73	-10.82	21.95	4.86				
Positive	16.76	13.31	24.14	16.53				
Environmental impact					13.68	17.76	19.30	22.71
Degrade	-16.12	-58.26	-56.81	-77.87				
Maintain	16.29	29.10	12.38	49.82				
Improve	-0.18	29.16	44.43	28.05				
Level of risk					12.52	13.66	10.43	3.93
Low	4.73	30.03	4.97	6.82				
Medium	21.51	6.93	-0.61	-1.37				
High	-26.24	-36.96	-4.36	-5.45				
Change in income					29.80	20.77	26.25	19.07
-10%	-93.45	-70.41	-82.73	-53.98				
No change	10.09	16.21	9.06	-6.47				
+10%	83.35	54.20	73.67	60.45				
Total					100	100	100	100

*1: Business-oriented, 2: Lifestyler, 3: Multifunctionalist, 4: Traditionalist

4.4 Discussion

4.4.1 Sample's preferences

The attribute with the highest relative importance was change of income (24.43%), reflecting farmers' strong entrepreneurial behaviour and the dominance of financial considerations. This was not surprising, especially if one considers that agricultural activities comprised the primary source of income for the majority of the respondents and that in general the income

farmers earn from these is often marginal (Præstholm et al., 2006). Farmers applying an integrated production system placed higher importance on this attribute compared with those applying organic farming ($p=0.015$). This suggests that compliance of a large proportion of the farmer communities with the reformed agricultural policy requirements was likely driven by financial incentives. The part-worths estimated for the increase, decrease and no change in income reflected the effect of loss aversion on participant decisions (Gintis, 2000). The higher part-worth (in absolute numbers) estimated for the income decrease level compared with that estimated for income increase, agrees with the idea that people often have a higher preference for minimising loss rather than increasing gain (Gintis, 2000).

Conversely, the required effort attribute had the lowest importance (10.01%). This finding was somewhat at odds with the results of a previous survey in the same study area which concluded that the readiness of a farm to meet the requirements of new practices (i.e. participation in agri-environmental schemes or the application of organic farming) was considered to be very influential and acted positively on the selection of practices that did not require significant changes (Karali et al., In review a). The low importance that was estimated for the required effort in this study implies that farmers are probably unwilling to make a choice that would bring into question their perception of themselves as hard workers. However, it might also relate to the fact that respondents indicated their preferred scenarios hypothesing that their choices would be applied only to a 10% of their farms rather than to the total surface. Nevertheless, such contradictions illustrate the importance of exploring the relative importance of influential factors, and the potentially distorting picture that arises when the importance of different factors is evaluated singly.

Part-worths for the different options of the attribute level of risk showed that respondents preferred a low risk activity rather than an alternative that would be high in risk. However, the utility value for this attribute (10.36%) showed that overall respondents were not risk averse, probably as a result of their long-term experience in farming activities and the related skills and knowledge that they have accrued.

The social feedback attribute received the fourth highest utility (13.15%), which agrees with other studies that describe farmers as aiming to meet society's expectations of them (Michel-Guillou and Moser, 2006; Atari et al., 2009), usually in an attempt to avoid being perceived as a 'polluters'.

Moreover, a medium, but positive correlation was found between the social feedback attribute and farm size (p=0.022, r=0.476). As farmers with large holdings often exhibit a lower participation in environmentally friendly practices compared to farmers with small farms (Mann, 2005b), this correlation might reflect their concern about whether or not they were still approved by their society.

With a utility value of 18.58%, the environmental impact attribute was ranked third. It is possible, however, that the level of importance estimated for this attribute reflects not only the positive environmental attitudes of respondents, but also their aim of improving the productivity of their farms.

The results for the farming activity attribute are especially interesting. This had the second highest utility value (23.47%), with farmers applying organic farming considering it to be more important than those who had met the basic requirements of the reformed agricultural policy and had certified their farms as integrated production systems (p=0.004). Traditional food-production practices received positive part-worths. Livestock activities were less preferred (1.89%) compared with crop activities (11.14%), which was probably a reaction to the recent abolition of milk quotas. Contrary to other studies that suggest that farmers are rather reluctant to commit to environmentally-friendly farming practices (Espinosa-Goded et al. 2010), respondent choices in this study showed that activities related to environmental management were the most preferred. Taking into account the currently high participation in the Proof of Ecological Performance programme (Mann, 2005a), one could conclude that 'green' attitudes are well-embedded in Swiss farmer behaviour. However, the evidence indicating that financial incentives and perhaps opportunism (Wilson, 2001; Fish et al., 2003) have a strong influence on farmer decisions raises questions about whether or not this is also the case for Switzerland. Although, the part-worth placed on this activity type reflects a shift away from the narrow food production orientation, it is also likely that this could result from the regulatory mechanisms of the reformed Swiss Agricultural Policy, rather than from farmer green attitudes.

Conversely, part-worths for non-food activities indicated that respondents prefer not to include these activities in their farm management plans. A possible explanation for this negative preference is that respondents distinguish between farmer and forester identities (see definitions in Table 13). Nevertheless, it may also suggest respondents' aversion towards the

cultivation of biofuels as a result of their cultural resistance and dislike of activities that could potentially impact negatively on the local landscape, or the adverse trends that might be expected for this type of activities in the future.

The examples discussed above demonstrate a limitation of the CA methods. Despite their potential to explore human preferences and to evaluate qualitative and quantitative factors (Sayadi et al., 2009), they do not provide any information about the motivations that underpin respondent choices (Morgan-Davies and Waterhouse, 2010). This highlights the strength of mixed method studies to provide a more complete understanding of farmer preferences.

4.4.2 Cluster preferences

Segmentation of participant choices using a typology of behavioural profiles showed that individual cluster preferences differed from that portraying the total sample's preferences. Part-worths of the attributes and attribute levels estimated for the individual clusters were consistent with the description of behavioural profiles, suggesting a relationship between preferences and behaviour (Darnhofer, 2006).

Starting with the business-oriented farmers, the change in income activity had the highest part-worth both within the cluster and the attribute, and the required effort had the lowest part-worth for these. These values reflect the strong business focus of this group. Moreover, business-oriented farmers were the only cluster with a positive part-worth for non-food activities, echoing the intention of these farmers to cultivate biofuel crops.

Lifestyler farmers had a high positive part-worth for the environmental management activity and largely negative part-worth for non-food activities. These values reflect the objective of applying environmentally friendly management practices, as well as a lack of interest in cultivating biofuel crops. Change in income was ranked second in importance for lifestyler farmers, which is consistent with their desire for not only positive environmental practices, but also economic benefits. Furthermore, this cluster had a very high preference for low risk activities and vice versa. In both cases the lifestyler farmer part-worths for these levels were larger than for any other cluster, which probably results from their shorter experience in farming compared with the other farmers.

Multifunctionalist farmers are expected to respond actively to changes in their surrounding environment. For this reason, low specialisation and high flexibility are distinct characteristics of their farm management plans. This agrees with the observed absence of a high preference for any of the farming activities included in the analysis for this group. Furthermore, despite their aim to maximise profit, this farmer cluster does not necessarily exclude environmentally farming practices from farm management, which is consistent with the high part-worth for the environmental improvement level.

Traditionalist farmers are interested in maintaining the traditional character of the agricultural landscape and so they dislike management activities that could deteriorate landscape aesthetics. This probably explains both the very high utility of this type for the farming activity attribute and the very low part-worth for non-food activities. Being the oldest and most experienced farmers is consistent with the very low utility estimated for the level of risk.

4.5 Conclusions

This study demonstrated an application of choice-based conjoint analysis for the estimation of the relative importance of a set of factors on farmer land-use decisions. The highest relative importance estimated for the change of income attribute showed that farmers are still largely influenced by financial incentives, as change of income had the highest relative importance. Equally high, however, was the relative importance of the farming activity and the environmental impact attributes, suggesting that farmers in the study area would not apply profitable activities unquestionably. Likewise, the results showed a high preference for environmental management activities. This suggests a shift away from the traditional, narrow focus on food-production. However, whether this shift results from 'green' financial incentives, or a change in farmer 'green' attitudes could not be concluded with certainty. Moreover, respondent choices suggested resistance towards the cultivation of biofuel crops, which is reflected in their current limited cultivation area. The low preference for these activities probably results from farmer aversion to management practices that are not well embedded in the local, social landscape.

Despite the agreement of farmer preferences when estimated at a sample level with our a priori expectations, post-segmentation analysis revealed discrepancies in preferences of farmers belonging to different clusters. Given that farmers of different behavioural profiles also differed with regard to the characteristics of their farms and the practices that they applied, this finding underpins the importance of taking into account personal preferences to understand land use systems. Among others, the extraction of semi-quantitative information about farmer preferences and related behaviour that was demonstrated in this study may potentially contribute to a more accurate description of the complexity and the heterogeneity of farmers' decision-making in empirically-informed land use/cover change models (i.e. through the construction of land manager decision rules), providing a functional alternative to the single, profit-maximising profile.

PART II: CONCEPT APPLICATION

Chapter Five

Exploring the effect of farmer decisions on rural landscape change and the provision of ecosystem services in alternative future scenarios.

After an article by
Karali et al. (In prep.)

Chapter acknowledgements

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Outline

This paper presents findings from the application of an integrated LUCC model, "Aporia", for a case study located in the north part of Switzerland. Aporia uses an agent-based approach for the simulation of farmer land-use decisions. Farmer behaviour is empirically informed in the model with data collected through a multi-phase social survey. This information is used to describe agent profiles and preferences. Secondary data is used to inform other components of the model (i.e. market). Application of Aporia allows the exploration of the effect of farmer land use decisions for alternative futures by implementing different socio-economic and climate change scenarios. Output from a first set of simulations indicates that farmer decisions are primarily driven by subsidies, technology, climate and social feedback. Although statistically significant differences existed in terms of the diversity, inputs and nuisance associated with the regimes selected by farmers of different clusters, variations were smaller than expected and observed in reality. Furthermore, disagreement between the modelled and expected decisions in some simulations highlights the challenge of representing human behaviour in LUCC models, and suggests that the model should incorporate further decisional mechanisms.

5.1 Introduction

Land use and cover change (LUCC) is recognised as one of the most visible impacts of humans on nature. In Europe, agriculture is one of the most important land uses (Rounsevell et al., 2006a; Schmit, 2006; Verburg et al., 2006) and much of the observed LUCC in rural regions is related to it. Apart from the high percentage of the European surface that is occupied by farming activities, the socio-economic and political changes, and the technological advances of the twentieth century have caused rapid and extensive modification of agricultural land use patterns (Rounsevell et al., 2003). This has involved among others transformation of farm structural characteristics, intensification of farming practices and farmland abandonment (Paracchini and Britz, 2010).

Changes in the use and management of farmland have consequences that usually extend beyond farm boundaries (Stoate et al., 2001). Although throughout the history of agriculture, farming practices have developed important ecological niches (Walls, 2006) most of the recent LUCC in agricultural areas have had adverse impacts on ecosystem services (Vitousek et al., 1997), and as a result on human well-being (MEA, 2003; 2005). These have included, but are not restricted to, the destruction of natural habitats, decrease in species abundance and diversity, soil erosion, depletion of nutrients, scarcity and pollution of water resources and loss of historical and cultural landscapes (i.e. Vos and Meekes, 1999; Stoate et al., 2001; Antrop, 2004; Donald et al., 2006; Sattler and Nagel, 2010).

In response to the calls for the sustainable management of farming areas, understanding the mechanisms that underpin LUCC has become paramount (Rounsevell et al., 2003). Traditionally, LUCC was considered as the outcome of the opportunities and constraints that arise from the climatic conditions and physical attributes of land. Although there is no doubt that these factors are influential, the emergence of heterogeneous patterns of farming systems, even in areas with similar physical conditions (Schmitzberger et al., 2005), suggests that rural landscapes are affected equally as much, if not more so, by human decisions.

Due to their key role with regard to the management of farmland, decision-making by farmers has been already widely researched (i.e. Morris and Potter, 1995; Beedell and Rehman, 1999; Austin et al, 2001; Damianos and Giannakopoulos, 2002; Darnhofer et al., 2005; Hounsome et al., 2006;

Defrancesco et al., 2008; Zagata, 2010; Sattler and Nagel, 2010). In Europe, scientific interest in this issue peaked at the time of the agricultural policy reforms in the 1990s, as the voluntary participation in environmentally friendly practices underlined that the success or failure of the policy reforms and the achievement of policy goals is dependent on farmer mindsets (Wilson, 1996).

Findings from empirical studies converged on two general conclusions; a) that farmer decisions are influenced significantly, but not only, by financial incentives or other economic factors (i.e. Wilson, 1997; Willock et al., 1999; Beedell and Rehman, 1999; Siebert et al., 2006) and b) that farmer communities are characterised by an inherent heterogeneity in terms of farmer characteristics and decision making (i.e. Busck, 2002; Darnhofer et al., 2005).

More recently, the multi-facetted and varying nature of farmer decision-making has become considered as 'established knowledge' in the field of rural sociology. In LUCC models, however, despite the increasing integration of the human dimension (Bakker and van Doorn, 2009), human behaviour is still often described by simplified frameworks that portray land managers as homogeneous and rational in economic terms (i.e. Rounsevell et al., 2003; Piorr et al., 2009).

The use of behavioural frameworks that go beyond the basic economic assumptions has been restricted, to a large extent, by the limited potential of the techniques used to model human-environment interactions (i.e. LUCC), to accommodate the complexity and diversity of human decision-making process (An et al., 2005). Recent technological and computational advances, however, have allowed the development of new methods that are able to address these challenges. Agent-based modelling (ABM) is one of the new techniques that has been widely applied during the last two decades for the simulation of human-environment interactions (Bonabeau, 2002; Pahl-Wostl, 2002; Bousquet and Le Page, 2004; Parker, 2005; Acosta-Michlik and Espaldon, 2008) and LUCC in particular (i.e. Becu et al., 2003; Parker et al., 2003; Deadman et al., 2004; Robinson et al., 2007; Matthews et al., 2007; Acosta-Michlik and Espaldon, 2008; Robinson and Brown, 2009). Among other advantages of this method, ABM has the ability to support complex frameworks that describe the heterogeneity and complexity of human cognitive processes (Janssen, 2005; Murray-Rust et al., 2011). It also allows the investigation of emergent, large-scale patterns or phenomena that arise

from self-organisation processes (Holland, 1992; Deadman, 1999; Janssen, 2005; Crooks et al., 2007; Smith and Conrey, 2007) in hypothetical scenarios.

This paper presents findings from the application of an integrated LUCC model, "Aporia" (Murray-Rust et al., 2011). Aporia uses an agent-based model approach to simulate farmer decisions within rural landscapes. The aim of the application presented here is to explore the impact of farmer decisions on the formation of landscapes and the ecosystem services that they provide under alternative future scenarios. The research focuses on a study area located in the northern part of Switzerland. Farmer decision-making was empirically informed with primary data collected through a multi-phase social survey (Karali et al., In revision/review a, b, c), while secondary data from official sources and the literature were used to describe other components of the model (i.e. landscape, market etc.). The rest of the paper provides an overview of the model components, discusses the simulation contexts and presents the simulation outputs.

5.2 Materials and methods

5.2.1 Study area

The study area is located in the Canton of Aargau, in the northern part of Switzerland (Figure 7). It is a north-south transect of 99 km^2, extending from the more rugged first Jura chain, across the river Aare, to the Swiss plateau in the South. The mosaic of land uses and land covers, and diverse topographic characteristics of the region create a unique landscape of high aesthetic and ecological value.

The study area has undergone LUCC over the last decades. During the period 1980-2009, total agricultural land decreased by 4%, accounting today for 35% of the total area. During the same period, the area covered by arable fields and permanent cultures decreased by 15% and 42% respectively, while a small increase was seen in the area of meadows and pastures (2%). Currently more than half of the agricultural land in the study area is used for meadows and pastures (65%) and almost one third of the area is arable (33%). A very small proportion of the area is used for permanent cultivations such as vineyards and orchards, and other agricultural purposes (2%). Moreover, forests account for 44% of the total land area and 21% is covered by the built environment (all figures from Swiss Statistics,

www.bfs.admin.ch). Forested areas in Switzerland are under legal protection status, leading individual foresters to almost no access to decisions related to the management of these areas. Farmers, however, remain the key decision makers with respect to farm planning, even after the recent reforms of the Swiss Agricultural Policy and the introduction of cross-compliance. For this reason the Aporia model simulations focused on farmer decisions.

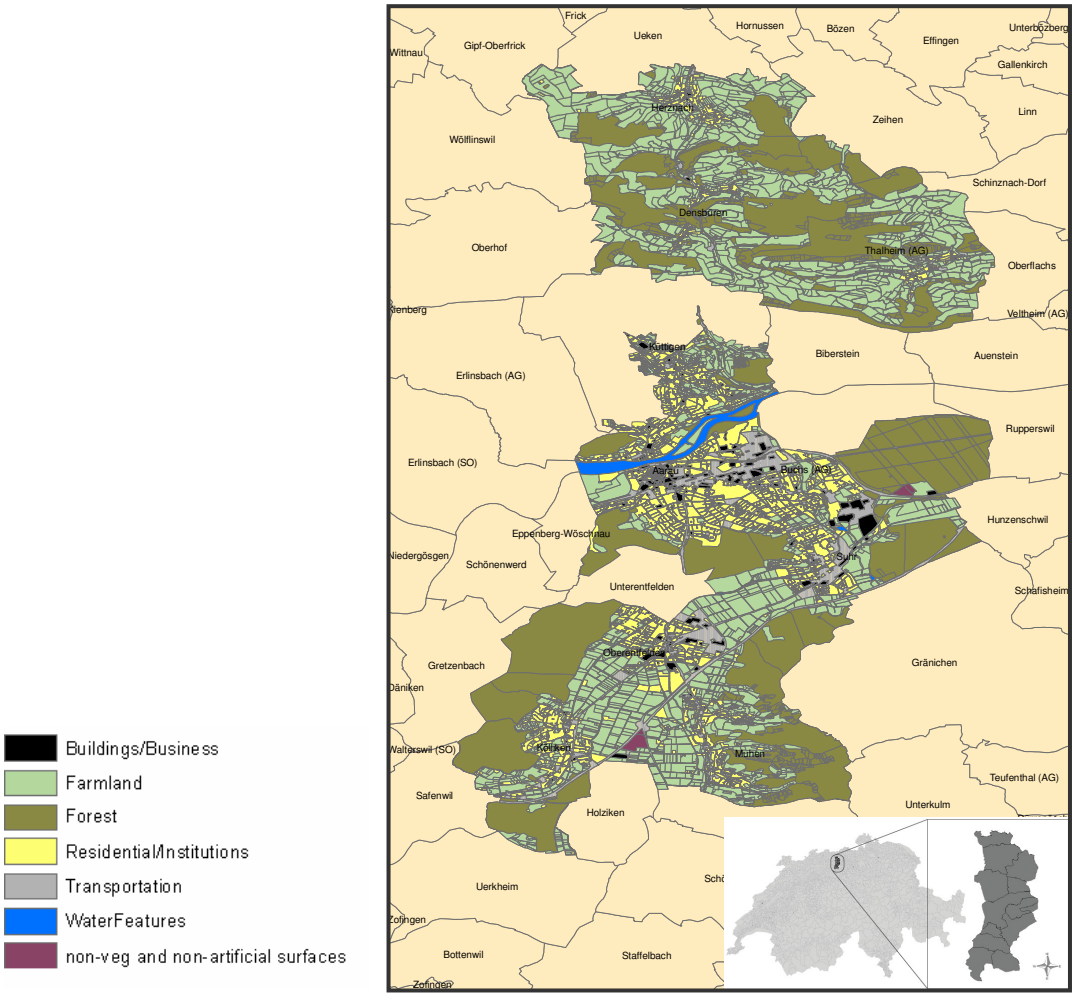
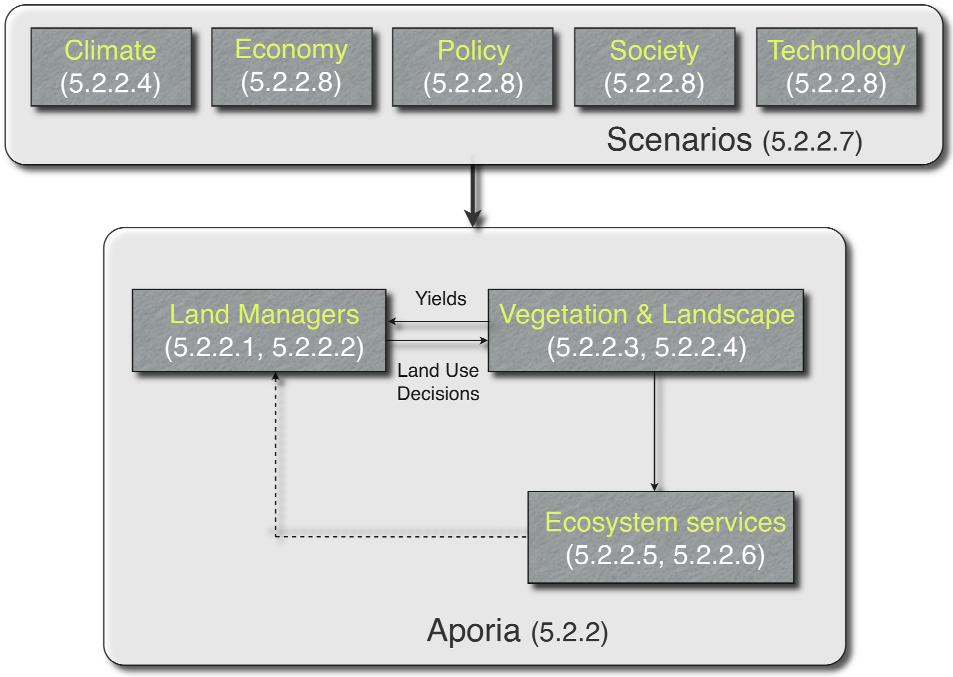


Figure 7: Map showing the location of the study area and the proportion covered by different land use types.

5.2.2 Model overview

Figure 8 illustrates the conceptual framework of Aporia. A detailed description of this framework is provided in Murray-Rust et al. (2011). The following paragraphs in this section will describe the particularities of the

different components when Aporia was applied in the study area described above.



Adapted from Murray-Rust et al. (2011)

Figure 8: Overview of Aporia conceptual framework.

5.2.2.1 Farmer agent profiles

In the current version of Aporia, farmers are the only land managers represented. In an attempt to reflect the heterogeneity that characterises farmer behaviour in reality, farmer behaviour is described in the ABM through a typology of empirically informed profiles. Although in many ABM applications human decision-making is described as a function of farmer or household socio-economic characteristics (i.e. Deadman et al., 2004; Ziervogel et al., 2005; Acosta-Michlik and Espaldon, 2008; Moreira et al., 2009), in this study, farmer profiles were constructed from behavioural characteristics.

Responses of forty farmers in the study area to statements relating to the motivations that underpin their land-use decisions and their goals were assessed using Principal Component Analysis. The four components identified from this analysis; improvement of environmental quality, enhancement of social image, farm business succession and profit

maximisation were used as criteria in an agglomerative, hierarchical classification. Clusters were determined with the use of Ward's method (as the clustering method) and squared Euclidean distance (as the distance measure of the clusters). The approach aimed to minimise the variability within clusters and increase the differences between them. The analysis revealed four distinct profiles. (A detailed description of the classification is provided in Karali et al., In review b).

The first cluster is called 'business-oriented'. This group comprises experienced farmers with different ages. They manage large farm holdings and they own more than 50% of the land they manage. Farming activities are their primary source of income. Farmers in this group have a strong business focus and as the majority of these farmers have successors, farm business continuation is very important to them. They see benefits in non-traditional farming activities and have a wide range of social interactions from which they collect information regarding the management of their farms.

The second cluster and smallest group was the 'lifestylers'. This group include old farmers, but with less experience in farming compared to the other groups. They manage small farms and they rent more than 50% of the land they manage. They apply an economic farming style and their decisions aim primarily to improve environmental quality. Farmers in this group are up to date about the effects of climate change on crop productivity. Their distinct characteristics include a complete lack of interest in biofuels and the absence of successors.

The third cluster is the 'multifunctionalist' group. This group has relatively younger farmers, with medium experience. For the majority of the farmers in this group, agricultural activities contribute to over 50% of their income. Despite their orientation towards farm expansion, they are not characterised by a narrow production focus. These farmers are expected to respond actively to potential changes. Profit maximisation is one of their primary goals. However, environmentally-friendly management practices are not excluded from their management plans.

'Traditionalist' farmers form the fourth cluster. Farmers in this group are the oldest and most experienced. They own almost as much land as they rent and they earn more than 50% of their income from farming activities. They are keen on maintaining the traditional character of their landscape and their decisions are likely to be socially-inclined. As with lifestyler farmers they are characterised by a complete lack of interest in biofuels. Despite their

age, the existence of a successor probably explains why farmer in this group look regularly for information regarding prices, subsidies and the effect of climate change on crop productivity.

5.2.2.2 Farmer agent decisions

In an attempt to improve weed control or to enhance the nutrient status of farmland, real-world farmers make decisions about multi-annual crop rotations rather than for a single crop. Farmer decision-making in Aporia follows the same rational, with crop rotations hereafter referred to as regimes.

When an applied regime comes to an end, farmer agents evaluate individually a fixed list of regimes and make a new decision; either to apply a new regime or repeat the same one. Each regime consists of one or more managements and each management includes a land cover (i.e. wheat, barley etc.) and a set of management practices (intensive, extensive or organic). In the present application of Aporia, the list of regimes that farmers evaluate every time they have to make a decision was based on information collected through social survey, where participants described the regimes that they currently apply on their farms. In order to avoid too much complexity and maintain the list of regimes to a manageable number, it was assumed that a regime can only include land covers that are managed with practices of the same intensity level. However, as there is no practical limit in terms of the number or the types of regimes that can be evaluated by farmers, the Aporia framework allows the exploration of farmer reaction to both currently applied and new regimes.

Evaluation of regimes is based on a utility function that describes the performance of each regime (U) across a set of economic (S_{econ}), environmental (S_{env}) and social (S_{soc}) scores, the importance of which is reflected in the associated weights (λ_1, λ_2, λ_3) (Eq. 1).

$$U= \lambda_1 * S_{econ}+\lambda_2 * S_{env}+\lambda_3 * S_{soc} \quad \text{(Eq. 1)}$$

In contrast to structurationist approaches (See Battershill and Gilg, 1997), which assume that all factors taken into account by farmers during their decision-making process are of equal importance, in this study, farmers may weight the importance of economic, environmental and social scores,

according to their preferences. This means that different farmers may allocate different utility values to the same regime.

In order to integrate variation in farmer preferences, the weights of importance (λ_1, λ_2, λ_3) of the utility function were empirically informed from a choice based conjoint (CBC) experiment (Karali et al, In review c). In CBC experiments, participants are presented with a set of choice tasks. Each choice task includes a fixed number of scenarios, which result from random combinations of levels describing the attributes to be evaluated. An example of a choice task included in this study is shown in Table 18. Respondents are asked to assess each choice task individually and to indicate their preferred scenario (Orme, 2009). Taking into account the combinations included in the chosen scenarios, weights of importance are estimated for each attribute.

Table 18: Example of a choice task.

Attributes/Options	Option 1	Option 2	Option 3	Option 4
Social feedback	None	Positive	Positive	Negative
Environmental impact	Degrade	Maintain	Enhance	Enhance
Change in income	+10 %	No change	-10%	+10 %

Using the typology of farmer profiles described above as a covariate, farmer responses were segmented to calculate farmer preferences for each profile (Table 19).

Table 19: Relative importance (%) of the three attributes included in the utility function per farmer type.

Attributes/Clusters*	Bus.	Lif.	Mult.	Trad.	Average
Social feedback	21.5	22.6	21.0	45.8	25.7
Environmental impact	24.4	35.3	33.8	23.4	30.7
Change in income	54.1	42.1	45.2	30.8	43.6
Total	100	100	100	100	100

Bus: Business-orientedm Lif.: LIfestyler, Mult.: Multifunctionalist, Trad.: Traditionalist

The second component of the utility function relates to the three partial scores (S_{econ}, S_{env}, S_{soc}). These scores were computed as sums of the values given to a set of relevant indicators. Although there are no restrictions

with regard to the indicators that can be used to describe these scores, care was taken in choosing factors that farmers would consider in reality. Table 20 presents the nine indicators that were used as proxies for the economic, social and environmental scores in this study. Indicator values for each regime were calculated as the average of the standardised values given to the managements that comprise that regime. Further detail about the conceptualisation of each indicator is discussed in Robinson et al. (In prep.)

Table 20: Indicators used for the calculation of the partial scores of the utility function.

Partial scores	Indicators	Assessment criteria
Economic	Yield	Gross Margin (CHF)
	Market Prices	
	Subsidies	
	Fixed and Variable costs	
Environmental	Nitrogen Inputs	Kg N/ ha
	Land Cover Diversity	Simpson's Index
Social	Nuisance	Expert judgement
	Access to Green Space	Expert judgement
	Cultural Landscape	Farm management books (years)

5.2.2.3 Landscape

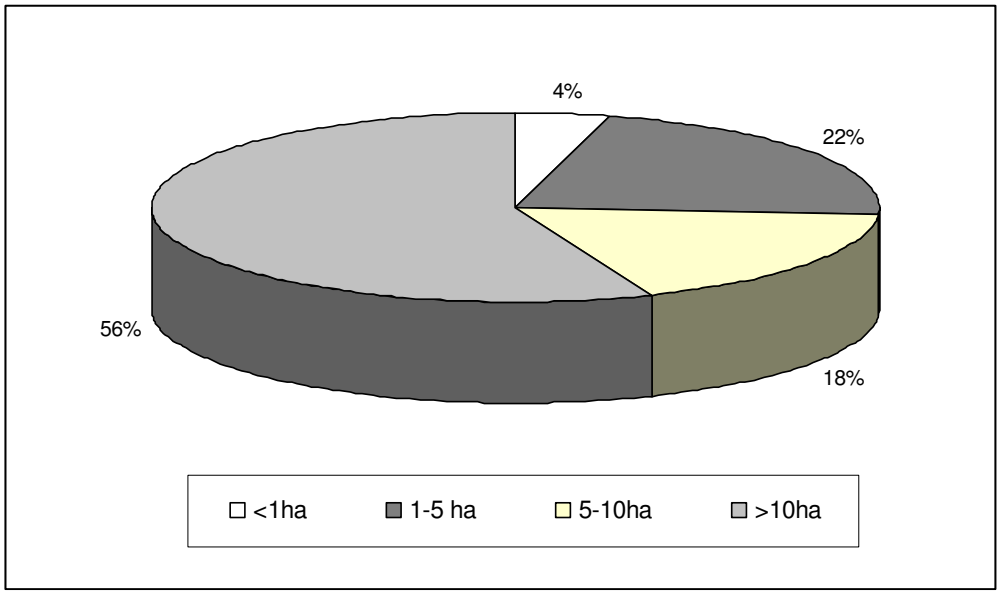
Due to confidentiality restrictions, access was not allowed to historical data showing the land cover and ownership at a parcel[5] level for the study area. Thus it was not possible to produce a spatially explicit output for the application of Aporia. Instead, an artificial (stylised) landscape was constructed for the model applications.

The first step in the reconstruction of the landscape (Figure 8) was the identification of agricultural land parcels. A dataset showing the different land uses present in the study area was overlain with parcel data. Parcels were then classified according to the land use type that covered the maximum share of their surface. In order to facilitate this procedure, certain land use classes included in the initial classification were merged into more generalised categories.

[5] In this study 'parcel' is defined as an individual piece of land comprising a farm.

Focusing on the parcels that were designated as 'agricultural land', the second step involved the construction of farms. Census data provided the number of farms within a range of farm size categories for the study area (Figure 9), from which a distribution of farm sizes was created. A farm size value was chosen randomly from the farm size distribution. An agricultural parcel was then systematically identified on the landscape and neighbouring parcels were added to it until the total surface of the parcels was equal to the selected farm size value. This process continued until all parcels of agricultural land were allocated to farmers.

Agricultural parcels were then populated with the regimes. This considered the regimes described by farmers who participated in the survey. A regime was represented on the landscape only if it occupied more than 30% of the farm surface. In order to calibrate the model, managements and regimes were 'tagged' in order to restrict the unlimited application of the most profitable regimes only. Tags reflected special skills, machinery or farm conditions that are required for the application of certain regimes (i.e. potatoes, carrots, grassland etc.).



(Source: Swiss Statistics, 1996)

Figure 9: Farm size distribution within the study area.

5.2.2.4 Vegetation growth

Farm management activities in Aporia are restricted to sowing and harvesting of different managements. Dates on which these activities take place were informed from records of forty-seven farms across Switzerland, including two from the Canton of Aargau (Dr Calanca, Agroscope, personal communication). Current and past vegetation yields were based on official data available for Switzerland (Agridea, 1996-2009).

During simulations, vegetation growth is controlled by the weather. This effect is implemented through the integration of Aporia with the dynamic vegetation model LPJ-GUESS (Smith, 2001). Land cover types included in Aporia were mapped with the Crop Functional Types[6] (CFT) modelled by LPJ-GUESS in order to group all land cover types according to their function in the ecosystem and resource use (Aporia-Input; Management file; Appendix). Although, it is assumed that the attributes of each parcel (i.e. soil conditions, historical land uses etc.) do not affect productivity, this coupling allows the vegetation module in Aporia (Figure 8) to respond to annual variability and gradual change in vegetation growth with the climate scenarios, depending on the CFT (Climate effect file; Appendix).

Crop yields are also affected by technological development. The effect of technology varies between different scenarios, according to the socio-economic and technological conditions described within them. In Aporia, the influence of the technology effect is informed with values reported in the literature (Abildtrup et al., 2006).

5.2.2.5 Food production

Land cover types and vegetation growth determine one of the ecosystem services considered in this study; food production. Food production is defined as the crops produced for human consumption. Food production is calculated by transforming crop yields to energy, by taking into account the total number of crops within a parcel, the crop yields expressed in number of tonnes per ha produced in this parcel, the calorific content of the crop per tonne and the area of the parcel.

[6] "CFTs are generalized and climatically adapted plant prototypes designed to capture the most widespread types of agricultural plant traits" (Bondeau et al., 2007, pp. 681)

5.2.2.6 Meat production

Apart from the managements that produce food for human consumption, certain managements produce feed for meat (grazing or fodder). In Aporia, meat production was calculated by converting vegetation yields to meat yields. This conversion follows a three step process. The first step calculates the energy content that can be provided from the tonnes of the associated managements that are sold annually and their calorific value per tonne. The second step, considering the energy demands for sustaining different types of meat (in this study, this is cattle), converts the energy that is available by fodder or grazing managements to tonnes of meat. In the third step, the amount of meat is converted to energy for human consumption. This crop-meat conversion calculation assumes that all the energy produced from grazing or fodder management is used for meat production.

5.2.2.7 Scenario development

Three hypothetical scenarios were used to set alternative contexts for the model simulations for the period 2000-2050 (Figure 8). The scenarios were downscaled from the scenarios developed in the ALARM project[7] (Spangenberg, 2007). These scenarios follow three different IPCC Special Report on Emissions Scenarios (SRES) trajectories; a business-as-might-be usual (A_2), a neoliberal, growth approach (A_1F_1) and a more environmentally sustainable pathway (B_2).

Scenario downscaling for the study area was based on a participatory approach. This approach was used to maximise the diversity of local stakeholder viewpoints and to increase the saliency, credibility and legitimacy of the developed storylines (Rounsevell and Metzger, 2010; Bohunovsky et al., 2011). Eight regional stakeholders from different sectors, including agriculture, forestry, regional planning as well as non-governmental organisations participated in a workshop to construct the scenario storylines. Participants made different assumptions about climate, agricultural, economic and societal changes, and envisioned alternative futures for the study area. Brief narratives of the three storylines are given

[7] ALARM; Assessing LArge scale Risk for biodiversity with tested Methods, FP6 Contract number: GOCE-CT-2003-506675

below, while a more detailed description of the scenario development process is discussed in Bohunovsky et al. (2011).

5.2.2.8 Scenario parameterisation and description

Scenario parameterisation (Table 21) was based on values reported in the literature (Abildtrup et al., 2006). These values refer to the European Union member countries. In the absence of Swiss values, however, these were used as a proxy for the study area. Based on expert judgement, some values were adapted to better reflect the stakeholder description of the downscaled scenarios.

BAMBU (Business-As-Might-Be-Usual) follows the A_2 SRES storyline. In this scenario, society is characterised by strong individualism and low social and environmental responsibility. People express little concern for the traditional character of the landscape. Policy instruments are regionalised (Rounsevell et al., 2005) and aim at synergies between environmental protection and economic development. There is a small but gradual decrease in the level of subsidies that farmers receive for farming activities. In parallel, a small decrease in market prices encourages farmers' interest in productivity and increases their dependency on inputs.

GRAS (GRowth Applied Strategy) follows the A_1F_I SRES storyline. This scenario describes a liberal world (Spangenberg, 2007), characterised by strong economic growth and technological progress. People follow a materialistic and consumerist lifestyle (Abildtrup et al., 2006). They have a low interest in environmental sustainability, but are interested in recreation and access to greenspace. Policy measures aim to adapt to environmental issues as they arise, rather than to avoid these problems at source (Spangenberg, 2007). Technological improvements result in substantial changes in crop yields, which increase more than twofold by 2050. At the same time, most of the fixed and variable costs of farming activities and the prices of agricultural produce decrease gradually. Farming activities are no longer supported by direct payments. As a result farmers, make choices that aim to achieve high crop productivity.

Table 21: Model parameterisation per scenario relative to the baseline (value = 1.0) for two future time slices (2020 and 2050).

Variable/Driver	Description	Baseline year	BAMBU		GRAS		SEDG	
		2000	2020	2050	2020	2050	2020	2050
Technology	Yield change due to technological improvements	1.00	1.31	1.77	1.67	2.68	1.04	1.09
Area subsidies	Changes in subsidy values relative to year 2000							
Intensive managements			0.9	0.8	0	0	0.9	0.8
Extensive managements		1.00	0.9	0.8	0	0	0.9	0.8
Organic managements		1.00	0.9	0.8	0	0	1.07	1.17
Prices	Changes in market prices relative to year 2000							
Cereal prices		1.00	0.92	0.80	0.83	0.59	1.12	1.31
Meat prices		1.00	0.98	0.95	0.96	0.89	1.10	1.24
Costs	Changes in costs relative to baseline year							
Seed		1.00	1.08	1.21	1.20	1.49	0.94	0.85
Machinery		1.00	1.06	1.16	0.88	0.70	1.32	1.79
Pesticide		1.00	1.02	1.04	0.88	0.69	1.47	2.18
Fertiliser		1.00	1.07	1.18	0.94	0.85	1.61	2.59
Labour		1.00	1.14	1.35	1.51	2.28	1.10	1.25
Social feedback								
Nuisance	Regime contributions to smell, noise and health		45%		45%		10%	
Access to Green space	The potential use of the location covered by a certain regime for recreational purposes		20%		45%		45%	
Tradition	Number of years that regime is present in the area.		35%		10%		45%	

SEDG (Sustainable European Development Goal) follows the B_2 SRES storyline. This scenario is the opposite of GRAS. In the SEDG world, economic growth is no longer a primary aim. People adopt a sustainable lifestyle, as environmental protection and equity are considered to be priorities. People value both greenspace and traditional landscape features highly. There is a strong sense of community. Alternative forms of farming appear, accompanied by a wide application of environmentally-friendly practices. Rural development and environmental protection are particularly important in this scenario. This justifies the increase in subsidies allocated to agricultural activities especially when these are managed organically. Moreover, there is a steady increase in the prices of agricultural produce, by about 25% in year 2050. The cost of conventional chemicals (i.e. pesticides, fertilisers) is higher compared to the baseline, further restricting their use. As a result, nuisance from farming activities is not considered to be an issue by society.

5.2.2.9 Aporia initialisation

Aporia farmers were represented by 20% 'Business-oriented', 17.5% 'Lifestyler', 42.5% 'Multifunctionalist' and 20% 'Traditionalist' farmers. This proportion was based on the output of the cluster analysis. In order to maintain the anonymity of the farmers who participated in the survey, farmer profiles were randomly allocated on the landscape.

Grassland dominates the farmland surface, covering about 63% of the total area, followed by cereals (23%) and a mixture of other land cover types (12%). Although this proportion of land covers resulted from the regime population process described in paragraph 5.2.2.3, it also resembled reality adequately (see 5.2.1 case study description). About 60% of the agricultural land area is used for grazing. Other types of fodder cover less than 10% of the farmland, while the remaining area is used for the production of food for human consumption. Extensive management practices are used on a little less than 90% of the farmland, while the remaining land being managed equally intensively and organically.

5.2.2.10 Aporia simulations

Simulations commenced in the year 2000 and were run for fifty years. Each model time step equates to one year. Two sets of Aporia simulations were performed for each scenario. The first set can be considered as the baseline simulation for each scenario. In the second set of simulations the effect of technological improvements on crop yields was 'switched-off', in order to explore farmer decisions when productivity is influenced by climate change alone.

5.3 Simulation results and discussion

5.3.1 Baseline simulation

5.3.1.1 Changes in land cover types

Simulated land cover changes in 2020 and 2050 showed a decrease in the farmland area covered by grassland and the gradual domination of cereals in all three scenarios (Figure 10 a, b, c). Only artificial meadows as a type of grassland remained on the landscape for all scenarios. This management was included in crop based regimes and is used as fodder. Oilseed rape was absent from the BAMBU scenario in both 2020 and 2050, while legumes and maize covered a larger area in GRAS compare to the other two scenarios.

With regard to land cover types, farmer decisions in the BAMBU scenario did not differ much between 2020 and 2050 (Figure 10b). This was probably due to the relatively small change assumptions in the economy and technology for this scenario. Larger differences in land cover by 2050 were found in the other two scenarios, with the changes in GRAS scenario being more pronounced.

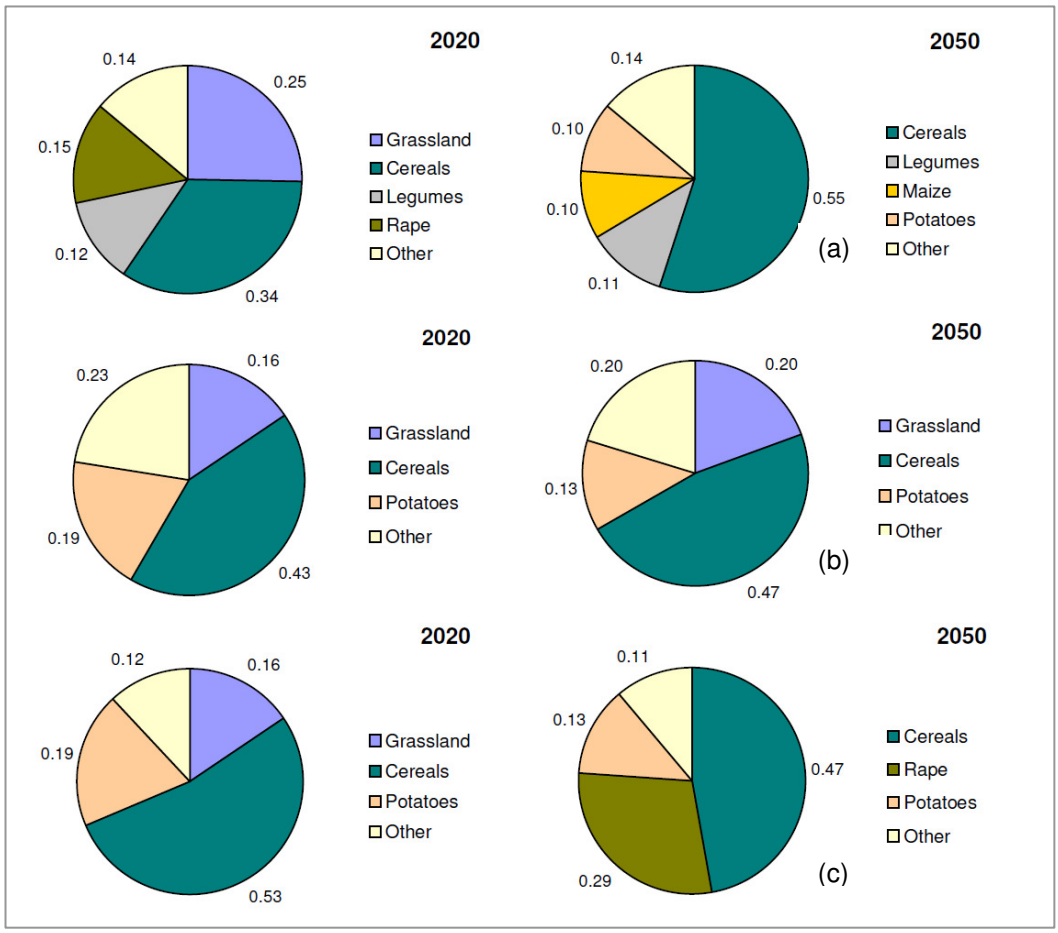


Figure 10: Simulated change in the proportion of land cover types present in 2020 and 2050 for each scenario: (a) GRAS, (b) BAMBU, (c) SEDG

5.3.1.2 Changes in farm activity types

Simulations for all three scenarios revealed the disappearance of grazing by 2050. The loss of grazing and the associated managements across all three scenarios can be explained in two ways. First, although the effect of technological improvements was common across all management types, the effect of climate on grassland yields, although it was positive, was smaller compared to other management types. This made grassland less 'competitive' from a production perspective. Secondly, a lack of topographic constraints in the model allowed for the unlimited conversion of grassland to cropland, which would not have occurred in practice on steep slops.

Food production for human consumption was dominant in all three scenarios in both 2020 and 2050 (Figure 11), but each scenario attained a maximum cropland area at different moments in time.

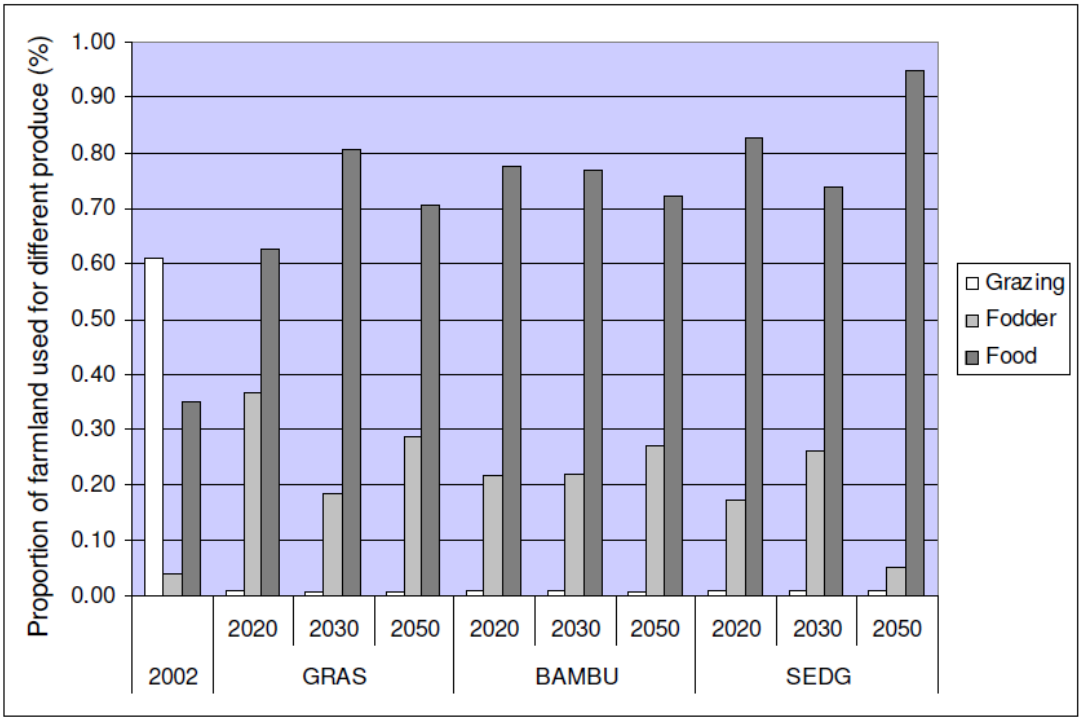


Figure 11: Change in the proportion of land used for different farm activities per scenario in 2020 and 2050.

The proportion of land used for different farming activities remained relatively stable for a long time in BAMBU (reflecting the small land cover changes), but changes were more noticeable in GRAS and SEDG (Figure 11). It is also worth noting that regimes related to bioenergy production were absent in simulations for all scenarios.

5.3.1.3 Changes in the provision of food and meat production

Although farmers allocated a larger proportion of their farmland to the production of food for human consumption in the SEDG scenario compared to the other two scenarios, the small effect of technology on crop yields resulted in an overall lower energy content produced from food crops (Figure 12). Larger changes in the level of food production during

simulations resulted from the effect of technological improvements on crop yields in the other two scenarios.

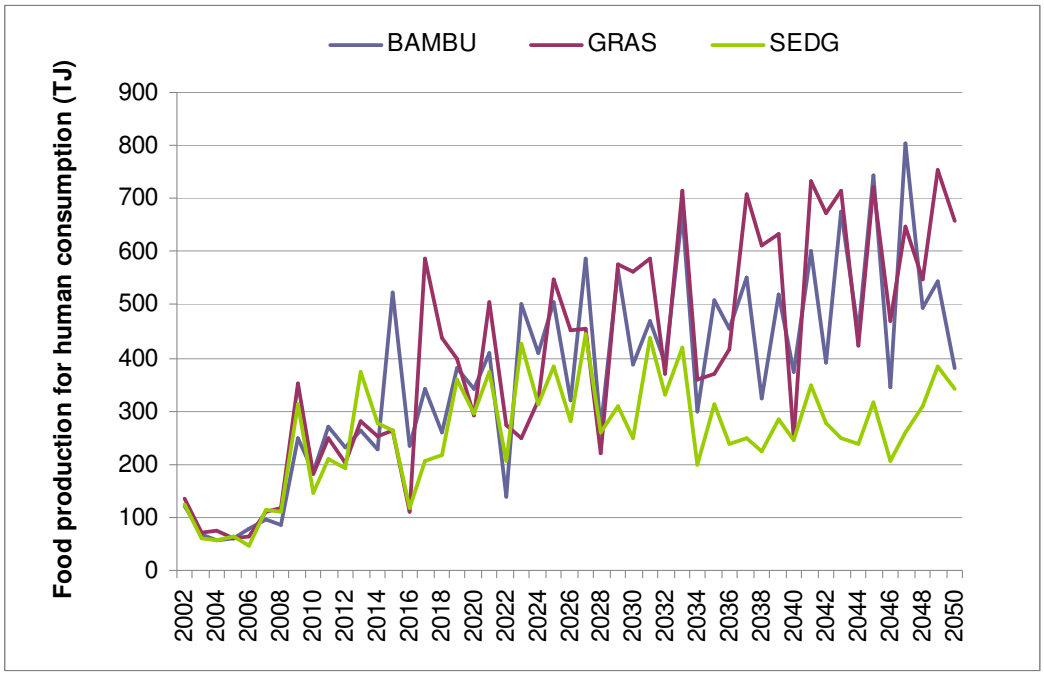


Figure 12: Energy available from food production (human consumption) per scenario.

Energy available from meat production (Figure 13) was calculated by taking account of both fodder from grazing and from crops. Although this is not a direct output of the Aporia, the conversion of fodder to meat was estimated from the yields of the associated crops that are sold annually, their metabolisable energy for the production of cattle and the amount of energy that humans derive from the consumption of the meat produced (see section 5.2.2.6). This graph is based on the assumption that all produced fodder is used to support the production of meat.

The amount of energy available from meat production followed similar patterns in the BAMBU and the SEDG scenarios, which remained relatively stable apart from a few sharp increases at some time steps. There was, however, a distinct difference in the GRAS scenario, in which fodder production supported a much larger meat production compared to the other scenarios (see Figure 13), which increased gradually throughout the simulation period. Moreover, although the proportion of farm activities in

the BAMBU scenario resembles that of the GRAS scenario (Figure 11), Figure 13 demonstrates the different magnitude of the effects of climate and technology on the production of crops used for the maintenance of meat production mainly from 2020 onwards.

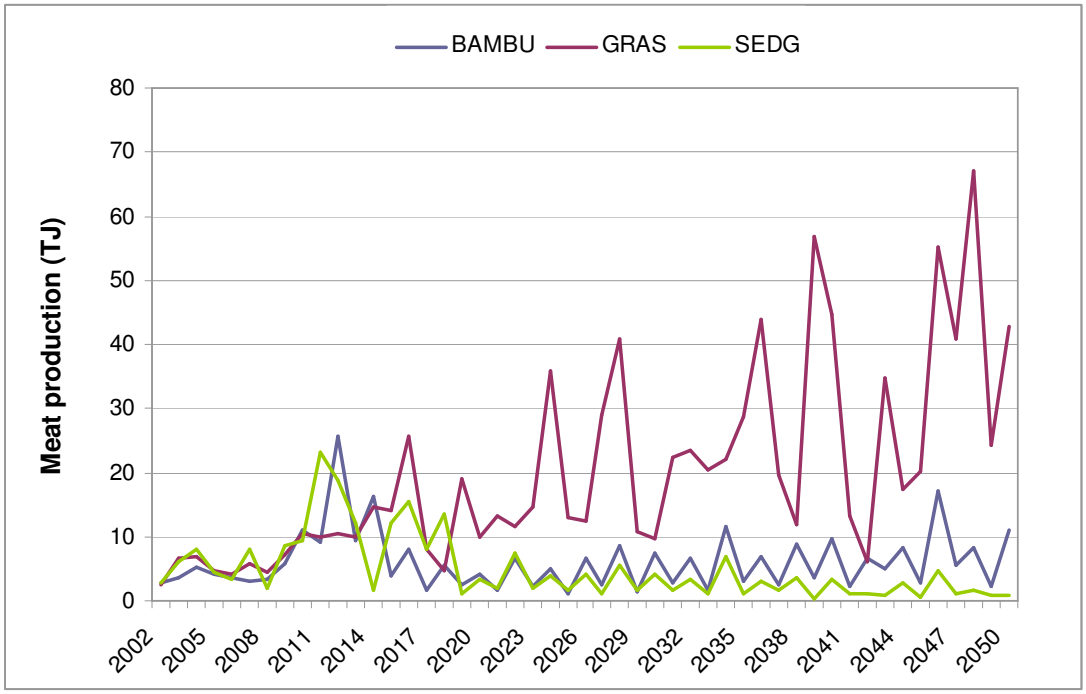


Figure 13: Energy available from meat production per scenario.

5.3.1.4 Changes in the level of farm management intensity

The results for the level of intensity characterising the practices used in farmland management were surprising. In particular, the area of farmland managed intensively in the SEDG scenario increased, which contradicts the storyline narrative (Figure 14). This result illustrates the influence of the societal feedback on farmer decisions. Society in the SEDG scenario does not consider nuisance[8] to be important since it is not assumed to occur in an environmentally-oriented world. Farmer preferences, however, were the same across all scenarios and so by relaxing the importance of this indicator in the model, farmers were able to choose management actions with a high nuisance score. This highlights the importance of considering behavioural evolution in farmer choices. Adapting farmer preferences to the average

[8] Nuisance is concept which reflects society's perceptions on the potential harm that might be caused by farming practices.

perspective of society would have likely produced an output that was more consistent with the SEDG storyline description.

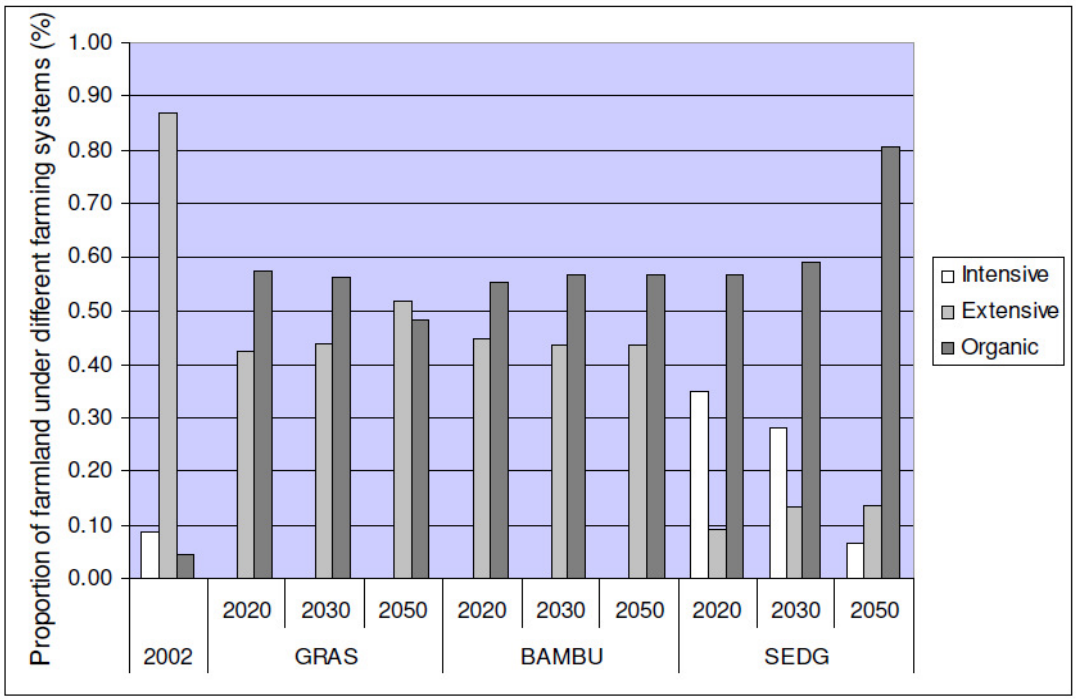


Figure 14: Changes in the proportion of farmland under intensive, extensive and organic management per scenario.

Nevertheless, the overall area under organic regimes was still higher in the SEDG scenario compared with other intensity levels. Although organic farming is associated with lower yields, higher market prices, as well as the subsidies that farmers receive for organic farming in Switzerland offset the income losses due to low productivity. The effect of subsidies was demonstrated clearly in 2050 of the SEDG scenario, when the relative difference between the subsidies farmers received for organic and other management subsidies becomes as high as 37% (See Table 21). In the other two scenarios, a large shift in the intensity of farm management practices was also observed in year 2020 compared to the baseline conditions.

5.3.2 Perturbed technology simulations

As expected the output of the two simulations for the SEDG scenario (with and without the technology effect) were almost identical (Figure 15). The

absence of technology did not influence farmer decisions much, as the value of the associated coefficient of yield changes was already low in the baseline run (Table 21).

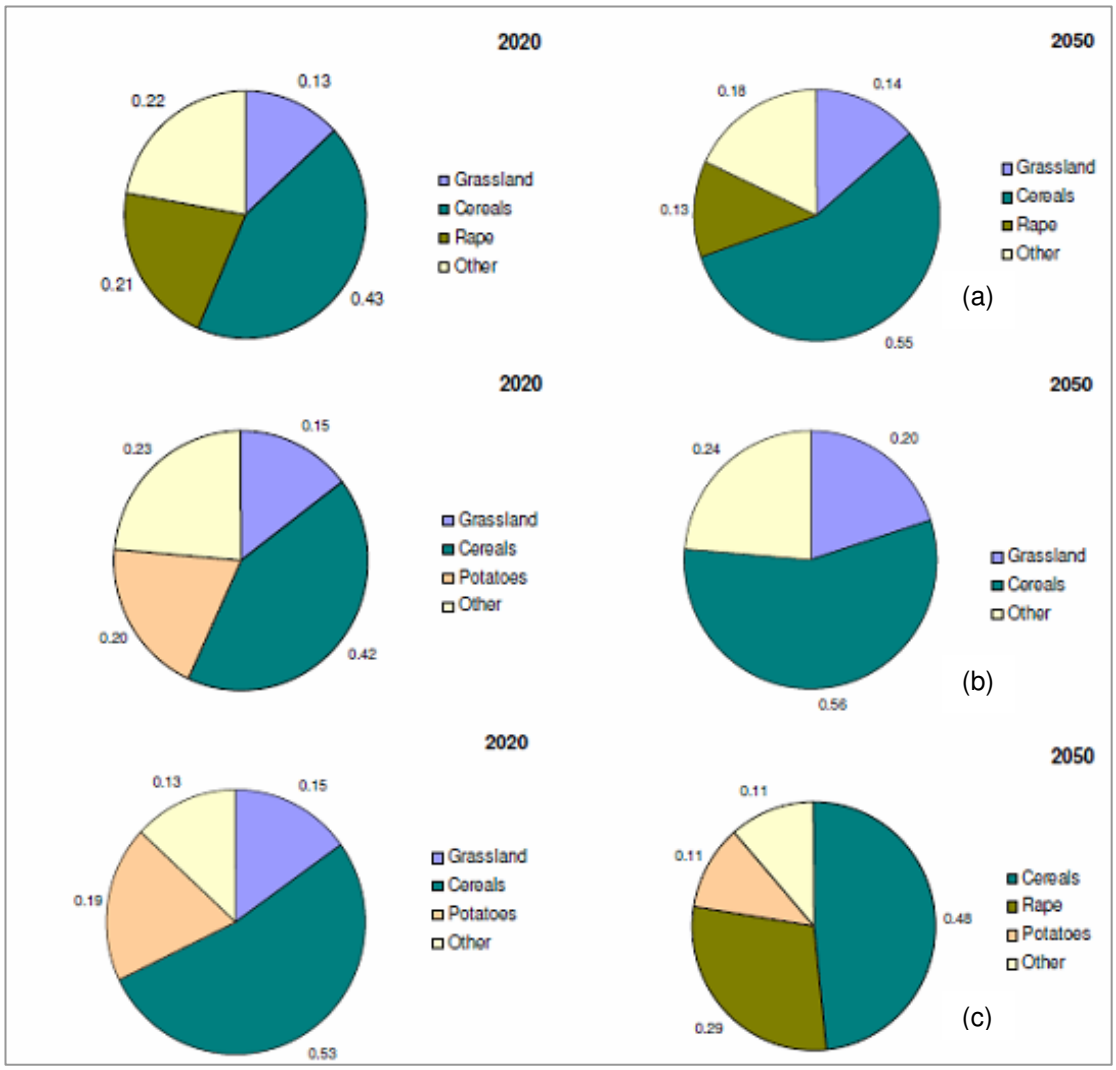


Figure 15: Changes in the proportion of land cover types present in the landscape in 2020 and 2050: (a) GRAS, (b) BAMBU, (c) SEDG (Run 2).

By contrast, the absence of the effect of technology in the GRAS scenario influenced farmer decisions significantly (Table 21). This is reflected both in the types of land cover, as well as their proportions in the landscape. For the BAMBU scenario, the difference between the baseline and the perturbed integration was small in 2020, but became pronounced in 2050. The 2020 results were not expected as the technology factor on its own increased baseline crop yields by 31% in the baseline run (Table 21). The

similarity of the outputs of the two simulations suggests that in the case of the BAMBU scenario, the effect of climate on crop yields is more important. Similarly to baseline simulations (run 1), however, the second set of simulations demonstrated the gradual dominance of cereals on the landscape and the parallel decrease in the farmland area occupied by grassland.

The absence of technology change also brought about differences in farm activity types and in the intensity of farmland management. Farmers in the GRAS scenario made decisions that maintained grazing in the landscape. Even in this scenario, however, grazing covered a smaller area compared to the baseline year (Figure 16).

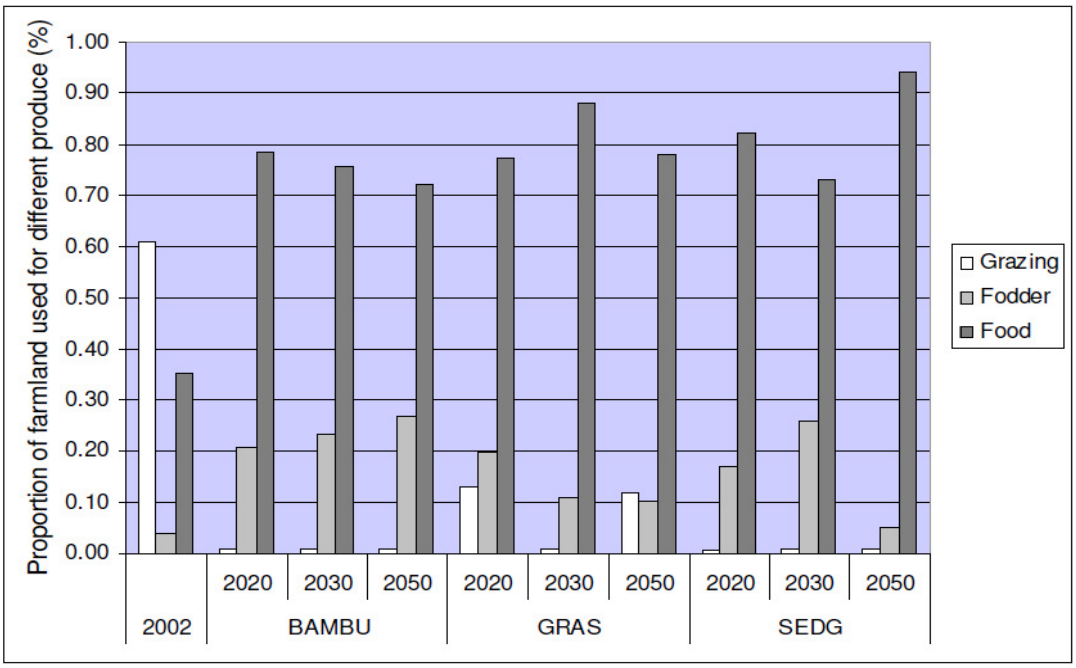


Figure 16: Change in the proportion of farmland used for different farm type activities per scenario (Run 2).

Moreover, intensive management practices were applied over a larger area in all scenarios in the perturbed simulations as compared to the baseline simulations (Figure 14, 17). This probably results from farmers selecting regimes with higher yields, in an attempt to maximise their income.

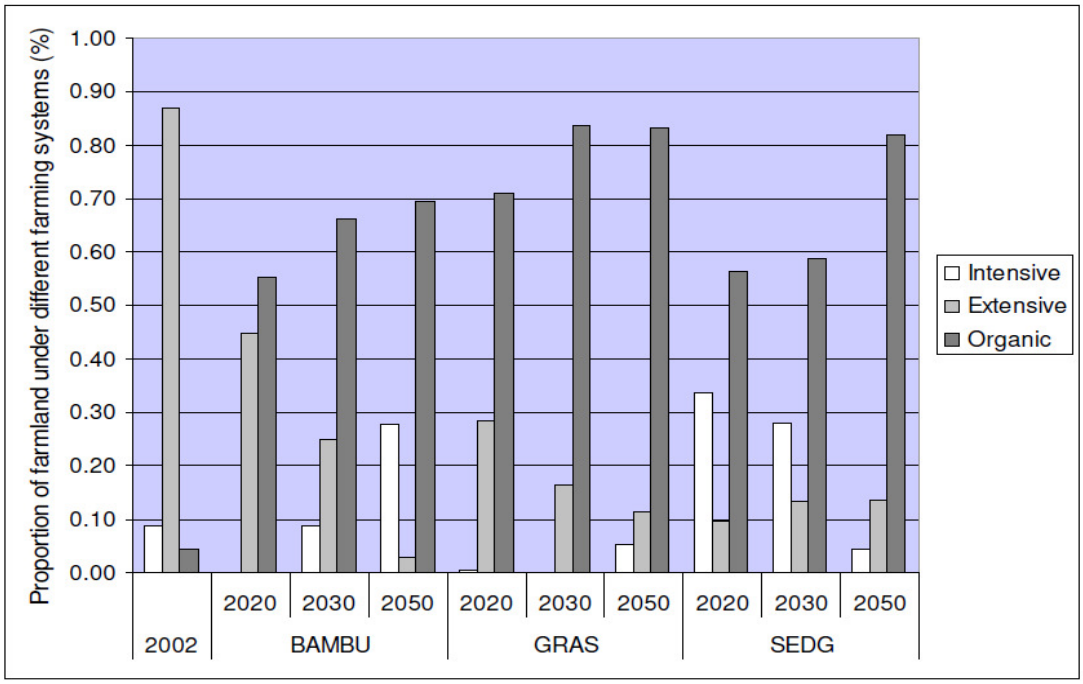


Figure 17: Change in the proportion of farmland under intensive, extensive and organic management per scenario (Run 2).

Furthermore, as expected, the lack of technological improvements decreased the energy content available from food production in all three scenarios (Figure 18).

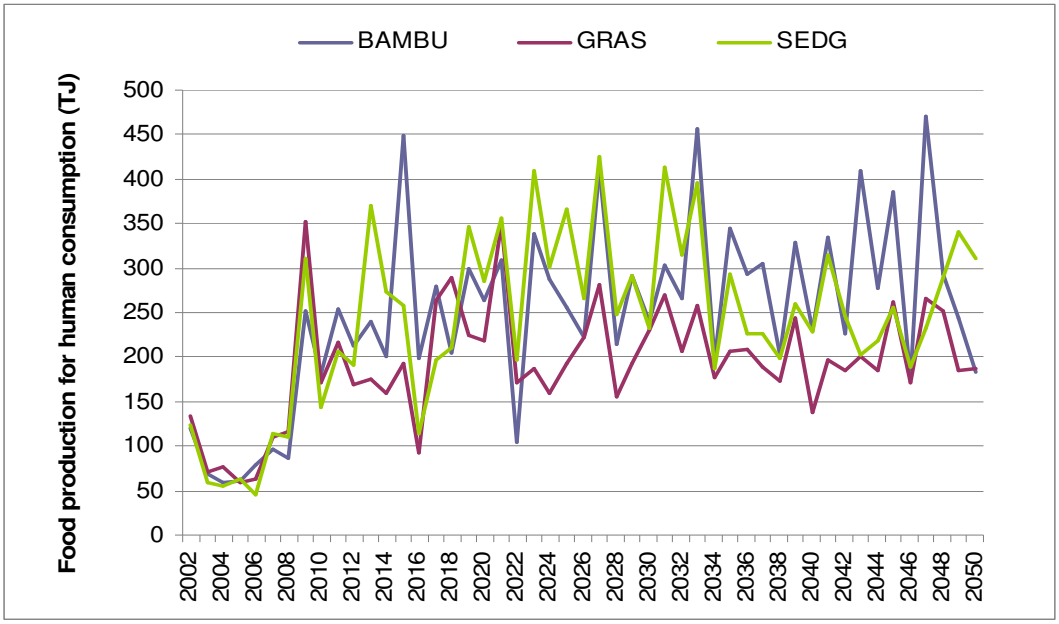


Figure 18: Energy available from food production (human consumption) per scenario (Run 2).

Smaller changes were observed in the SEDG scenario, as the effect of technology for this was already small compared with the BAMBU and the GRAS scenarios. In the absence of technological improvement, climate change would create better conditions for the production of food in the SEDG and the BAMBU than in the GRAS scenario (Figure 18).

Energy from the production of meat was lowest in both of the SEDG scenario simulations. In the absence of technological development, the other two scenarios showed interchangeable peaks at different points in time. Nevertheless, the difference in meat production between scenarios was much smaller in runs without technology than with it (Figure 19).

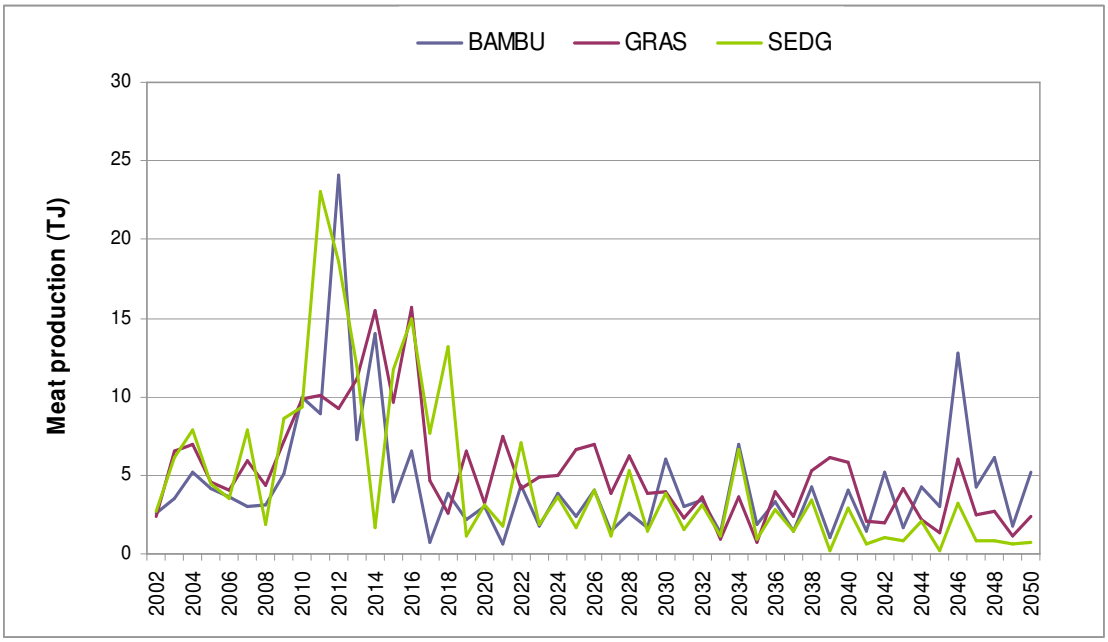


Figure 19: Energy available from meat production per scenario (Run 2).

5.3.3 Farmer profiles

In addition to the similarities and the differences that exist within and between scenarios with respect to management (land cover and management practices), it is important to explore if and how other characteristics of regimes differ according to farmer profiles.

Non-parametric tests (Kruskal-Wallis) showed that farmers who belong to different clusters selected regimes that varied with respect to diversity ($p<0.001$), inputs ($p<0.001$) and nuisance ($p<=0.001$) scores. This result supports arguments about the importance of considering the diversity

of human behaviour in order to explore and better understand their LUCC choices. The medians for the different profiles across indicators and scenarios (Table 22) highlight some important points.

Table 22: Median values of diversity, inputs and nuisance scores per farmer type.

		Business-oriented	Lifestyler	Multifunctionalist	Traditionalist
DIVERSITY	BAMBU-2020	0.6	0.8	0.6	0.6
	BAMBU-2050	0.6	0.8	0.6	0.6
	SEDG-2020	0.8	0.6	0.6	0.7
	SEDG-2050	0.8	0.6	0.4	0.6
	GRAS-2020	0.8	0.6	0.8	0.8
	GRAS-2050	0.8	0.6	0.8	0.8
INPUTS	BAMBU-2020	1	1	1	1
	BAMBU-2050	0.73	1	1	1
	SEDG-2020	1	1	1	1
	SEDG-2050	1	1	1	1
	GRAS-2020	1	-0.09	1	1
	GRAS-2050	1	0.005	1	1
NUISANCE	BAMBU-2020	1	1	1	1
	BAMBU-2050	1	1	1	1
	SEDG-2020	1	1	0.33	1
	SEDG-2050	1	1	0.33	1
	GRAS-2020	1	1	1	1
	GRAS-2050	1	1	1	1

First, farmer decisions in the BAMBU scenario agree better with the description of farmer profiles based on the social survey. Being the most environmentally-oriented group, lifestyler farmers, for example, chose to apply more diverse regimes, while business-oriented farmer tend to select regimes that are associated with a higher nitrogen application. This is probably because the socio-economic context described in the BAMBU scenario most resembles the current situation.

Conversely, the GRAS scenario results were surprising. In this scenario, 'lifestyler' farmer choices are characterised by a lower value for the

input indicator, which describes an increased use of nitrogen. This result demonstrates the adaptation of farmer behaviour in different socio-economic contexts. For example, farmers who currently exhibit environmentally sensitive behaviour might switch to energy/input demanding decisions in a more economically-orientated world, especially if environmental management practices were not supported by subsidies (as for GRAS). This is probably because although lifestyler is the group with the highest environmental concern, change in income is still the factor with the greatest importance for their decision-making.

In the SEDG scenario, multifunctionalist farmers make decisions that result in higher nuisance levels compared to the decisions reached by other cluster profiles. This probably arises from the lower importance weight that multifunctional farmers have for the social feedback. As multifunctional farmers represent almost half of the farmers simulated in the model, then this effect explains the increase in the farmland area managed intensively for this scenario (Figure 14, Figure 17).

Despite the aforementioned differences, additional simulations in which farmers' behaviour was represented by an 'average' profile resulted in the same output with regard to farmer decisions (i.e. the same proportion of land uses that appeared at a landscape level for different timeslices). It is possible that the effect of the heterogeneity of farmers' behaviour has been confounded by the dominance of the economic weight in the utility function that underpins the farmer decision-making process. However, the output of these simulations does not provide evidence that would confirm such a hypothesis.

5.4 Conclusions

The Aporia model simulations presented here explored the effect of farmer decisions on landscape change and the provision of food and meat production for different future scenarios. Farmer decisions were found to differ in different scenarios as a result of the effects of assumed alternative subsidies, technological development, climate and social feedback. Differences were also found due to the effect of different farmer types responding to the nuisance, inputs and diversity characteristics of different regimes. Although, this suggests that farmer preferences had an influence on the simulated decisions, differences in decisions made by farmers of different

profiles were smaller than those observed in practice. This might also have resulted from the fact that some of the more environmentally-friendly regimes were also the regimes with the highest gross margins. Thus, such regimes could be equally evaluated as the 'most preferred' both by farmers who were environmentally- and financially-oriented. Moreover, substitution of the four different profiles by an average profiles produced the same simulation output.

Disagreement between the modelled and expected decisions in some simulations highlights the challenge of representing human behaviour in LUCC models, and suggests that the model should incorporate further decisional processes. For Aporia, this includes introducing the influence of topography on decision making and empirically informing the social feedback mechanism. Further testing of the model (e.g. through sensitivity analysis) would also enhance its use in explaining farmer decisions.

Chapter Six

Conclusions

6.1 Summary

The aim of the research presented in this thesis was twofold; a) to explore certain mechanisms that influence farmer land use decisions and b) to improve the representation of the diversity and complexity of farmer decision-making process in LUCC models. Application of different data collection methods (in-depth, semi-structured interviews, questionnaire) and analyses (thematic analysis, principal component analysis, cluster analysis, choice-based conjoint analysis) were used complementarily in three phases: to identify the factors that facilitate or constrain farmer participation in environmental management practices (Chapter two), to identify the dominant farmer profiles (Chapter three) and to assess farmer preferences that influence land use decisions (Chapter four). Data collection was conducted in a study area located in the Canton of Aargau, Switzerland, where there is limited knowledge about farmer decision-making drivers and actions. Furthermore, research findings were used to empirically inform an agent-based model that simulates farmer decisions in alternative future scenarios until 2050 (Chapter five). The present chapter summarises the research conducted in this thesis, assembles the main findings achieved during the 'Concept Development' and 'Concept Application' phases and concludes by providing some food for thought with regard to future research.

6.2 Main findings

Landscape change is an emergent phenomenon, produced by myriads processes that take place between natural environment and human societies. Despite the existence of many influential top-down processes either regional (i.e. policy instruments, market) or global, in most cases land-use decisions are taken by individual land managers at the local level. This suggests that integrating the diversity and the complexity of land manager decision-making is essential for a better understanding of LUCC.

Due to the multi-facetted and varying nature of human decision-making, there is a wide range of methodological and analytical approaches that can be employed to answer different research questions. Chapters two, three and four of this thesis demonstrated the application of a mixed-

methods social survey to explore different aspects of farmer decision-making.

The use of in-depth, semi-structured interviews, in chapter two, provided an open, conversational environment where farmer-interviewees had the chance to express their own opinions about the factors that either constrain or facilitate their decisions to participate in environmental management practices. Instead of directing participants to the assessment of pre-defined choices, the study presented in this chapter followed an inductive approach, allowing the exploration of emergent themes.

Farmer responses suggested that participation in environmental management practices is underpinned by a financial imperative. Frequent reference to the importance of producer support indicated that the wide acceptance of the reformed agricultural policy most likely resulted from farmers' attempt to comply with the new framework and become eligible for receiving 'green' subsidies, rather than from their 'green' attitudes. Farmer responses, however, indicated that in many cases farm management decisions also aimed at being aligned with society's preferences. Although this may be partially driven by financial goals (i.e. increase direct marketing), in some cases it was clear that respondents were aiming to improve their social image, in an attempt perhaps to detach the 'polluter' characterisation from their profiles. Moreover, some farmers referred to practical constraining factors either related to the farm itself (i.e. climatic or biophysical characteristic of the farms) or with the amount of effort that farmers were able to invest on their farm (i.e. family cycle, workforce, health). Responses also revealed some constraints related to the current agricultural policy framework. These also reflected some pitfalls of the past, depicting the effect of memory on current land use decisions. Both of these features recommend that policy makers and governments need to build an environment of trust. This will be essential particularly for farmers who are risk averse or do not feel secure due to their tenure status. Finally, some responses indicated the influence of behavioural factors such as attitudes or perceptions, or the way of life that farmers endeavour to adopt on their land-use decisions.

Overall this study in chapter two showed a wide range of factors influencing farmer decisions that related to the individual decision-maker as well as both the narrow (i.e. household) and the wider decision-making environment (i.e. society). These findings support the critique that has been applied to the neoclassical economic approach when used as the basis for the

theorization of farmer behaviour. Although, this framework has managed to explain farmer decisions to a large extent, empirical findings such as these presented here, show that diverse information is neglected when farmers are described as homogeneous and rational in economic terms.

Although taking into account the complexity and diversity associated with farmer decision-making is of utmost importance for understanding the emergence of land-use patterns and LUCC, it is often the case that an accurate description of individual land managers produces an excessive amount of information. In such cases the development and use of approaches that would organise this heterogeneity and make it usable both in LUCC analysis and policy-making is essential.

A generic method used to categorise the inherent heterogeneity of farmer communities is the construction of typologies. For the purpose of this thesis, a typology of farmer profiles was developed using principal component and cluster analysis techniques (Chapter three). Statements describing farmer motivations and objectives formed four components; enhancement of social image, maximization of profit, succession of farm business and improvement of environmental quality, which were used as criteria to classify the participants. The selection of the motivations and objectives used as the basis for the formulation of the classification criteria, was driven by the fact they are both endogenous characteristics of human behaviour and often behave as filters of the opportunities or constraints that are present at the time of the decision-making.

The hierarchical classification revealed four farmer profiles; business-oriented, lifestylers, multifunctionalist and traditionalists. These described a deviation from the conceptualisation of farmers as 'single-minded' profit-maximisers. Despite the existence of statistically significant differences, however, failure to establish clearly distinct descriptions for each of the derived clusters, suggests that farmer behaviour is probably a fuzzy set of identities that individuals may adopt at different moments in time. As in chapter two, the co-existence of ostensibly opposing motivations (i.e. economic and environmental concerns) supports the criticism about the validity of dichotomous behavioural frameworks. Also, evidence of equifinality indicated that farmers may follow different decision-making pathways, yet make the same decisions in the same decision-making environment, or vice versa.

Such findings suggest that individual farmers evaluate opportunities and constraints differently, and indicate that the influence of different factors on farmer land-use decisions should be assessed based on their relative rather than their absolute importance. Chapter four described the application of a method that originates from marketing research; the choice-based conjoint analysis. This is a form of a choice experiment. In this study, the aim of this experiment was to evaluate the trade-offs between a set of farming activity characteristics and explore farmer preferences for them.

Apart from the income change, farmer choices emphasized the importance that farmers place on the type of farming activity. The high preference for activities related to environmental management suggests a shift in farmer decisions away from traditional food-production activities. However, it could not be concluded with certainty whether this shift indicates behavioural change towards greener attitudes or an opportunistic response to the financial incentives associated with those activities. Conversely, non-food activities were identified as the least preferable, reflecting a cultural resistance to activities that are not well-established in the local, social landscape. Participant choices were segmented using the typology constructed in chapter two as covariate. Post-segmentation estimation analyses of trade-offs showed heterogeneity in farmer preferences. Trade-offs estimated for each cluster differed from total sample preferences. The levels of relative importance estimated for the different attributes included in the experiment agreed with the description of the profiles comprising the typology, suggesting a relationship between preferences and behaviour.

In the 'Concept Application' phase, Chapter five explored the effect of farmer preferences on landscape formation and the provision of ecosystem services in alternative futures. This was conducted through the application of agent-based model; Aporia, and the implementation of three integrated socio-economic and climatic scenarios. Findings from previous chapters were used to empirically inform the human sub-model of Aporia. A first set of simulations highlighted the effect of subsidies, social feedback, climate and technology on farmer decisions. A parametric test of indicator values characterising regimes applied by farmers of different clusters revealed a differentiation in farmer decisions with regard to diversity, nuisance and inputs of the applied regimes. Variation between clusters, however, was smaller than what it was expected or seen in reality. Furthermore,

substitution of the four profiles (business-oriented, lifestyler, multifunctional and traditional) by an average profile revealed no differences in the proportion of land cover types at a landscape level. It is believed that the effect of the heterogeneity in farmer profiles might have been confounded by the dominant economic weight in the utility function that underpinned farmers' selection of regimes. However, no evidence exists that could confirm such a hypothesis. Moreover, disagreement of simulated and expected decisions in certain simulations indicated that representing human behaviour in LUCC models is still a challenging area, and perhaps that there are further mechanisms that should be taken into account. As Aporia is still under development, the application presented in this thesis highlighted certain improvements that are still to be made in order to capture the heterogeneity and perplexity of human decision-making process. Some of these are further discussed in the following paragraph.

6.3 Further research

Constraints faced during the conduct of this study or the interpretation of the achieved findings revealed some issues that worth being considered with regard to future research in this field or improvements related to this specific project.

1) Findings from the social survey presented in this thesis provide detail about the factors that influence farmer land-use decisions with regard to the participation in environmental farming practices, farmer behavioural profiles and farmer preferences. These findings relate to a specific region. Application of the same methodology in different study areas as well as different agricultural practices could examine whether or not conclusions from this study are applicable to other geographical areas. Findings from such comparative studies will serve as an indication about the extent to which general conclusions can be drawn from case study specific research. This is particular relevant to policy makers as it would help to evaluate to what extent it is important to consider the heterogeneity in land use decision-making across different areas during the development of policy instruments.

2) The outcome of the social survey presented here should be considered only as a single snapshot in time. The design of the study did not allow the

acquisition of information regarding farmer behavioural evolution. For example, do farmer switch from one profile to another? If yes, which drivers trigger this behavioural change? Agent-based models have the potential to account for human learning or adaptation to different settings. However, there is need for long-term, follow-up surveys to provide the data that will empirically inform this aspect of the model.

3) Focus of this study was the investigation of farmer decisions at the micro-level. Taking into account the fact that study area is located in Switzerland, where forested areas are protected by law and decisions about their management are made at a regional and national level, this was a justifiable decision. Farmers are indeed those who are first and foremost to shape rural landscapes at the local level. Farmer decisions, however, are still largely influenced by agents or processes that operate at higher organisational levels (i.e. policy making, world trade, climate change). Therefore, the introduction of other non-farmer agents, as well as an empirically informed representation of the social network (farmer-farmer and farmer-non-farmer interactions) is a logical next step that will contribute to the model improvement.

4) This study explored only changes in the management of farmland. Changes in the land uses could only be considered with regard to the ecosystem services provided by farmland; food production, meat production, biofuel production. Urbanisation, however, is recognised as one of the most influential drivers of land use change in Europe (Reginster and Rounsevell, 2006). Under the existing political system, surface covered by forests in Switzerland is not expected to change significantly. In the event of further urban expansion, this is anticipated to occur at the expense of farmland. Therefore, it is important to consider the rural-urban interactions and evaluate their impact both on the emerged landscape patterns (i.e. land cover, land use, structural changes) as well on the trade-offs of the provided ecosystem services.

5) Another element that needs to be taken into account is the regional variation in topographic characteristics within the study area. In reality, topography restricts farmer decisions regarding the practices that can be applied on farmland. Taking into account the topographic constraints could potentially lead to the emergence of spatial patterns in farmer decisions.

Although adding more complexity to the Aporia framework might contradict model definition as a simplified and abstract representation of reality, the output of Aporia simulations could benefit from these add-ons.

6) Another aspect of Aporia that is worth exploring in greater depth is that of the utility function that determines farmers' decision-making process. It is suggested that taking into account all of the factors that were included in the conjoint experiment (farming activity, required effort, level of risk, social feedback, environmental impact, change in income) might have revealed differences in the decisions made by farmers of different clusters, which now seem to converge. This recommendation refers in particular to the attribute 'farming activity' which according to the estimated weights was the most important for the lifestyler and the traditionalist farmers.

7) According to the guidelines of ethical research all interviewees responses must be treated anonymously and confidentially at all stages of the project. In order to conform to these guidelines, and avoid possible correlation of the farmers who participated in the survey with any of behavioural or farm characteristics, the constructed behavioural profiles were randomly distributed on the landscape. Statistical analysis, however, showed farm size was one of the attributes that differed significantly among the farmers of different profiles. This finding suggests that random distribution of behavioural profiles and the absence of a relationship between behavioural and farm characteristics may have introduced some bias, and perhaps a redistribution of the farm enterprises based on farmers behavioural profiles would have more accurately reflected the real-world landscape.

8) Finally, the research with Aporia ABM could benefit from extended sensitivity analysis. One aspect of ABM sensitivity was examined by deactivating the initially 'switched-on' factor of technology. This action allowed the investigation farmer decisions, in a world where weather is the only driver influencing vegetation growth. Further testing of the model, however, through a meticulous sensitivity analysis is considered essential. This will allow an in-depth evaluation of the direction and the magnitude of the effects of all the mechanisms/factors included in Aporia, on farmer decisions. However, as Aporia is built on a rather complex and detailed

conceptual model, this task is rather elaborate and time-consuming, and extends the objectives of this thesis.

6.4 Recommendations

Drawing from the findings presented in this thesis as well as the whole experience of conducting research in the field of LUCC this section summarises a number of recommendations that are related to but not restricted to this field.

6.4.1 Interdisciplinary research

Recently there has been an increasing discussion about the limited potential of dialectic approaches to capture the complexity and the dynamics of human-environment interactions. Instead of focusing on the impact of human activities on ecosystems, it is now regarded essential that ecological research considers the socio-ecological system. This approach requires the conduct of interdisciplinary research. This is often confronted by numerous challenges, which explains why there is still only a partial understanding of 'anthropogenic ecosystems' (Ellis and Ramankutty, 2008).

Although the complimentary use of methods that originate from different school of thoughts or disciplines is often criticized for its 'inappropriateness', findings and limitations of this study showed that mixed-methods designs and interdisciplinary research have the potential to provide a holistic understanding of human decisions, to overcome constraints that arise from strictly disciplinary designs and to reveal information that would have been otherwise neglected. For example in this study, the use of in-depth interviews revealed some 'soft factors' that may facilitate or constrain farmer participation in environmental farming practices. These would have been identified with difficulty from binary answers, ranking or rating of pre-defined statements. Moreover, due to practical and ethical consideration, the effect of land manager decisions on landscapes can only be studied in silico. Results from modelling exercises can be improved if human behaviour is described based on real world information. Therefore, it is critical to integrate information from empirical studies to modelling frameworks in order to gain a deeper understanding of human-environment interactions.

6.4.2 Human behaviour

Although, empirical research has provided already a detailed description of human behaviour in a variety of contexts, representing the diversity and the complexity of human behaviour in modelling framework is still a challenge. Chapter three demonstrated the construction of a typology of farmer profiles using principal component and cluster analysis, and Chapter four used the results of a choice experiment to describe the differences in farmer preferences with regard to the economic, ecological and social aspects of their land-use decisions. However, taking into account that each human is unique it is inevitable that any attempt for categorisation will result in a gross oversimplification of reality. At the same time, it has to be accepted that there is little chance to model and explore human behaviour in alternative settings, unless such a simplification is applied (Ellis and Ramankutty, 2008). Incorporating human dimension into modelling techniques can make models very powerful tools (Ohl et al., 2007). Thus it can be argued that the approach presented in this thesis can provide an advanced alternative for the representation of human decision-making process.

6.4.3 Model limitations

Identifying and understanding the limitations in the current version of Aporia does not intend to undermine the sophistication of the model or the value of the simulation output. Instead the purpose of such an assessment is to encourage modelling efforts, to support a better understanding of modelling mechanisms, to increase confidence in model outputs and most importantly to allow the appropriate use of the model. Moreover, as it was demonstrated in Chapter five, model application should be also seen as part of a learning process, as simulation outputs can often reveal pitfalls that have not been considered during the development of the conceptual model.

Agent-based modelling is considered as one of the most promising techniques for future research. It is, however, the great potential of this technique that can be also seen as its main weakness. A number of authors have underlined the difficulty to calibrate, verify and validate ABMs (Berger et al., 2001; Turner II et al., 2007), not only due to the absence of a common framework for the carrying out of these processes, but also due to the high

demands in data. This refers in particular to the human decision making process (Turner II et al., 2007). It is due to such reasons, that some scholars have argued that the use of complex frameworks should be treated with caution, as the hidden assumptions might lead to errors during the 'causal interpretation' process (O'Sullivan and Haklay, 2000; Couclelis, 2001). It is for this reason that other authors have suggested that ABMs should be used as tools to explore and better understand phenomena rather than to predict them (Matthews et al., 2007; Valbuena et al., 2010).

6.4.4 Data limitations

As mentioned above, ABM requires extensive information on human-behavioural responses. As a result, it is rare that ABM parameterisation or validation is based on primary data alone. Thus, data availability and costs can play a significant role in modelling efforts, either facilitating or constraining them. In the present study, access to farmer contact details proved to be a challenging and time consuming task, while access to historic land use and ownership data was impossible. The issue of data confidentiality has been a topic of debate for some time now in many fields. Perhaps, data misuse in the past is one of the main reasons why such restrictions have been set (Schmit, 2006). Nevertheless, this thesis demonstrated the importance and the implications of data access for scientific research, and possibly the opportunities that may arise if restrictions to data access for confidentiality reasons were relaxed.

Chapter Seven

Epilogue

Some final thoughts

A few years ago, at the beginning of my project, I read a quote of the Greek philosopher Anaxagoras (500 BC-428 BC). He said that '…time is limited, our senses are weak and the truth is very well hidden'. After four years, at the end of my research, I am very much convinced that Anaxagoras was right. The real world is complex! However, it is this complexity that makes the world interesting. In this sense, land use and cover change might be one of the most fascinating research topics, as it involves all the complexity of both nature and human societies. Even if Anaxagoras was right, I have come to believe that it is worth taking up the challenge of finding the 'hidden' truth, even if each one of our efforts gets us just a little bit closer to it.

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About the author

Eleni Karali was born on the 13th of February 1984 in Athens, Greece. She attended primary and secondary school in Piraeus, Greece. In 2001, she moved to Lesvos Island to follow her undergraduate studies. In 2005, she earned her BSc in Environmental Science from the Department of the Environment, The University of the Aegean. After having spent a year in Athens, she moved to Scotland. In September 2006 she started an MSc course in Environmental Protection and Management, which was jointly organized by the Scottish Agricultural College and the University of Edinburgh. After her MSc graduation she was awarded a three year scholarship from the University of Edinburgh and the FP6-EU funded Ecochange project for her doctoral studies in Edinburgh. She completed her research and the writing of this dissertation in January 2012.